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Vegetation Classification, Distribution, and Mapping Report

Casa Grande Ruins National Monument

Natural Resource Report NPS/SODN/NRR—2009/158

ON THE COVER

Casa Grande Ruins National Monument. NPS photo.

Vegetation Classification, Distribution, and Mapping Report

Casa Grande Ruins National Monument

Natural Resource Report NPS/SODN/NRR—2009/158

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Contents

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

Chapter 1: Introduction 1
1.1 Background 1
1.2 Project Overview 1
1.3 The USGS-NPS Vegetation Characterization Program 2
1.4 The National Vegetation Classification Standard 3
1.5 The National Vegetation Classification 4
1.6 Terminology and Naming Conventions 5
1.7 Park Environment 5

Chapter 2: Classification and Mapping of Plant Communities 9
2.1 Methods 9
2.2 Results 13

Chapter 3: Accuracy Assessment 33
3.1 Methods 33
3.2 Results 33
3.3 Spatial Accuracy Assessment 33

Chapter 4: Discussion 35

Chapter 5: Literature Cited 37

Appendices 39
Appendix A: Vegetation Formation Key 39
Appendix B: Field Data Sheets 41
Appendix C: Plant Species List 47
Appendix D: Vegetation Type Descriptions 49
Appendix E: Root Mean Square Error 77

Figures

Figure 2.1.3.2-1. Intermediate plot locations at Casa Grande Ruins NM..... 11

Figure 2.1.3.2-2. Intermediate plot locations at Adamsville unit..... 12

Figure 2.2-1. Vegetation map of the main unit, Casa Grande Ruins National Monument..... 16

Figure 2.2-2. Vegetation map of the proposed Adamsville expansion unit, Casa Grande Ruins National Monument..... 17

Figure 2.2-3. *Prosopis velutina* / *Larrea tridentata* Woodland Alliance..... 18

Figure 2.2-4. *Prosopis velutina* Woodland Alliance. 19

Figure 2.2-5. *Parkinsonia microphylla* / *Larrea tridentata* Wooded Shrubland. 20

Figure 2.2-6. *Larrea tridentata* **- [***Ambrosia deltoidea - Krameria erecta***]** Shrubland. 21

Figure 2.2-7. *Larrea tridentata - Lycium fremontii* Shrubland Alliance. 22

Figure 2.2-8. *Larrrea tridentata* Shrubland Alliance. 23

Figure 2.2-9. *Larrea tridentata* / Mixed Annual Sparse Shrubland. 24

Figure 2.2-10. *Sphaeralcea ambigua* Sparse Shrubland Alliance. 25

Figure 2.2-11. Transitional Areas. 26

Figure 2.2-12. Agriculture. 27

Figure 2.2-13. Horticulture. 28

Figure 2.2.2.1-1. Barrel cactus..... 29

Figure 2.2.2.2-1. Mesquite tree decline. 29

Figure 2.2.2.1-2. Locations of *Ferocactus wislizenii* at Casa Grande Ruins National Monument, March 2008. 30

Figure 2.2.2.2-2. Graphic showing locations of all live *Prosopis* spp. (*P. velutina* & *P. glandulosa*) at Casa Grande Ruins National Monument, March 2008. 31

Tables

Table 1.4. Summary of the National Vegetation Classification Standard hierarchical approach. 4

Table 2.1.3.1. Summary of data collected on classification plots and censused polygons in 2008. 10

Table 2.2.1. Vegetation alliances mapped at Casa Grande Ruins National Monument and the proposed Adamsville expansion. 14

Table 3.3. Spatial accuracy assessment summary for the single piece of imagery containing both the main unit and the Adamsville unit at Casa Grande Ruins National Monument 34

Table 4. Vegetation map type crosswalk to NatureServe codes. 36

Acronyms and Abbreviations

AA	accuracy assessment
ac	acres
CAGR	Casa Grande Ruins National Monument
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 Program
ITIS	Integrated Taxonomic Information System
km	kilometers
m	meters
mi	miles
MMU	minimum mapping unit
NA	not applicable
NAD83	North American Datum of 1983
NM	National Monument
NMAS	National Map Accuracy Standards
NP	national park
NPS	National Park Service
NS	NatureServe
NVCS	National Vegetation Classification Standard (or System)
NVC	National Vegetation Classification
RMSE	root mean square error
RRQRR	Reversed Randomized Quadrant-Recursive Raster
SODN	Sonoran Desert Network (National Park Service)
spp.	species (plural)
TNC	The Nature Conservancy
UNESCO	United Nations Education, Science, and Cultural Organization
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator

Executive Summary

In 2007–2008, the National Park Service, Sonoran Desert Network Inventory and Monitoring Program, in cooperation with the Arizona Remote Sensing Center (University of Arizona, Office of Arid Lands Studies), carried out classification and mapping of vegetation at Casa Grande Ruins National Monument (CAGR), as part of the national U.S. Geological Survey–National Park Service Vegetation Characterization Program. The primary objective of the program is to produce high-quality, standardized maps and associated data sets of vegetation and other land cover occurring within the parks (http://science.nature.nps.gov/im/inventory/veg/index.cfm). In particular, the aim of this project was to create a vegetation map at the National Vegetation Classification alliance level or finer, with a minimum mapping unit of 0.5 hectares, thematic accuracy of 80% or better per map class, and spatial accuracy meeting U.S. National Map Accuracy Standards.

Project scoping was initiated in October of 2007, at a multi-park scoping meeting held at CAGR. Quickbird satellite imagery was acquired on December 3, 2007, as a new, tasked acquisition for this project, covering both the main unit and several surrounding Arizona State Trust land parcels proposed as part of a monument expansion. The total project mapping area was 425 hectares, including a 100-m buffer zone outside monument boundaries. Image preprocessing and initial interpretation to the formation level were done at the Arizona Remote Sensing Center, University of Arizona. The draft formation-level map was produced through visual interpretation of the pan-sharpened imagery and heads-up digitizing in ArcGIS to delineate polygons. Ten formations within 44 polygons were identified, based on the percentages of tree, shrub, and herbaceous cover present.

Field verification of the draft formation map and floristic data collection was conducted simultaneously during March 2008. Crews annotated boundary changes onto hard-copy maps showing imagery overlaid with draft polygons. The monument's small size allowed for a census-style approach to each minimum mapping unit (polygons) identified. Field edits were subsequently incorporated into the digital draft formation map (shapefile) using ArcGIS. In addition to polygon scale data, 25 plots measuring 20 × 50 m were sampled across both units with an aim to sample each of the community types identified. Plot and polygon data was entered into an Access database and quality checked before data analysis was conducted.

In total, 42 polygons were mapped and attributed with National Vegetation Classification Standard alliance-level data or land-cover classes. Urbanized environs outside the monument boundary were assigned one of seven Anderson land use classes. Full descriptions are found in Appendix A, and provide both local and regional context for each vegetation type (to the extent available at the time of this report). Map thematic accuracy was assessed within the total project area by way of a field-based census. Overall thematic map accuracy for the entire effort was assessed at 96%.

Acknowledgements

This project was a cooperative effort between the U.S. Geological Survey, National Park Service, Sonoran Desert Network, and University of Arizona, Office of Arid Lands Studies. Field work was completed by Steve Buckley, Jon Green, and Erica Lee. We would like to thank the staff of Casa Grande Ruins National Monument for their support and assistance during this project. The Arizona State Land Department provided temporary access permission to the Adamsville unit and other proposed expansion lands for the purpose of data collection and accuracy assessment. Data management support and database development was provided by the Sonoran Desert Network data management staff.

Chapter 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. This report describes the methods and results of a two-year project (2007–2008) to classify, describe, and develop a vegetation map database for Casa Grande Ruins National Monument (NM), located in Pinal county, north of of Tucson, Arizona.

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

1.2 Project Overview

1.2.1 USGS-NPS vegetation mapping project

The current effort to create a new vegetation map for Casa Grande Ruins NM is part of the USGS-NPS Vegetation Characterization Program (http://biology.usgs.gov/npsveg/), in cooperation with the SODN and the University of Arizona's Office of Arid Lands Studies. Casa Grande Ruins NM is one of 11 NPS units in the Sonoran Desert Network. The map is required to meet the standards of the USGS-NPS Vegetation Characterization Program, including a minimum mapping unit of 0.5 hectares, 80% thematic accuracy per class, and spatial accuracy meeting the U.S. National Map Accuracy Standards.[1]

1.2.2 Scope and products

The aim of this project is to create a vegetation map at the National Vegetation Classification Standard alliance level or finer for a study area of 425 hectares. This area is made up of two disjunct patches. One patch (Figure 1.2.2-1) includes the main unit and seven small expansion parcels plus a 100-meter buffer (338.6 ha); the other patch (Figure 1.2.2-2) includes the Adamsville expansion unit plus a 100-meter buffer (86.7 ha).

Products developed for Casa Grande Ruins National Monument as part of this project include:

- A final report including a vegetation key and full vegetation community type descriptions;
- Digital photos of each vegetation type (four per polygon mapped);
- A spatial database containing vegetation data, plot data and location, accuracy assessment routes and satellite imagery;
- Hard copy and digital graphics of final map coverages;
- Federal Geographic Data Committee compliant metadata for all spatial database files and field data.

1.3 The USGS-NPS Vegetation Characterization Program

The USGS-NPS Vegetation Characterization Program is a cooperative project between the U.S. Geological Survey (USGS) and the NPS to classify, describe, and map vegetation in more than 270 national park units within the United States.* The USGS Center for Biological Informatics administers the program, in cooperation with the NPS I&M Program.

The Vegetation Characterization Program supports consistent vegetation classification, mapping,

[1]The only polygons smaller than the MMU are those split into smaller polygons by the monument boundary.

[2]Language for the sections on the USGS-NPS Vegetation Characterization Program, National Vegetation Classification Standard, and Federal Geographic Data Committee is from Thomas et al. (2009), modified from Van Loh et al. (2006).

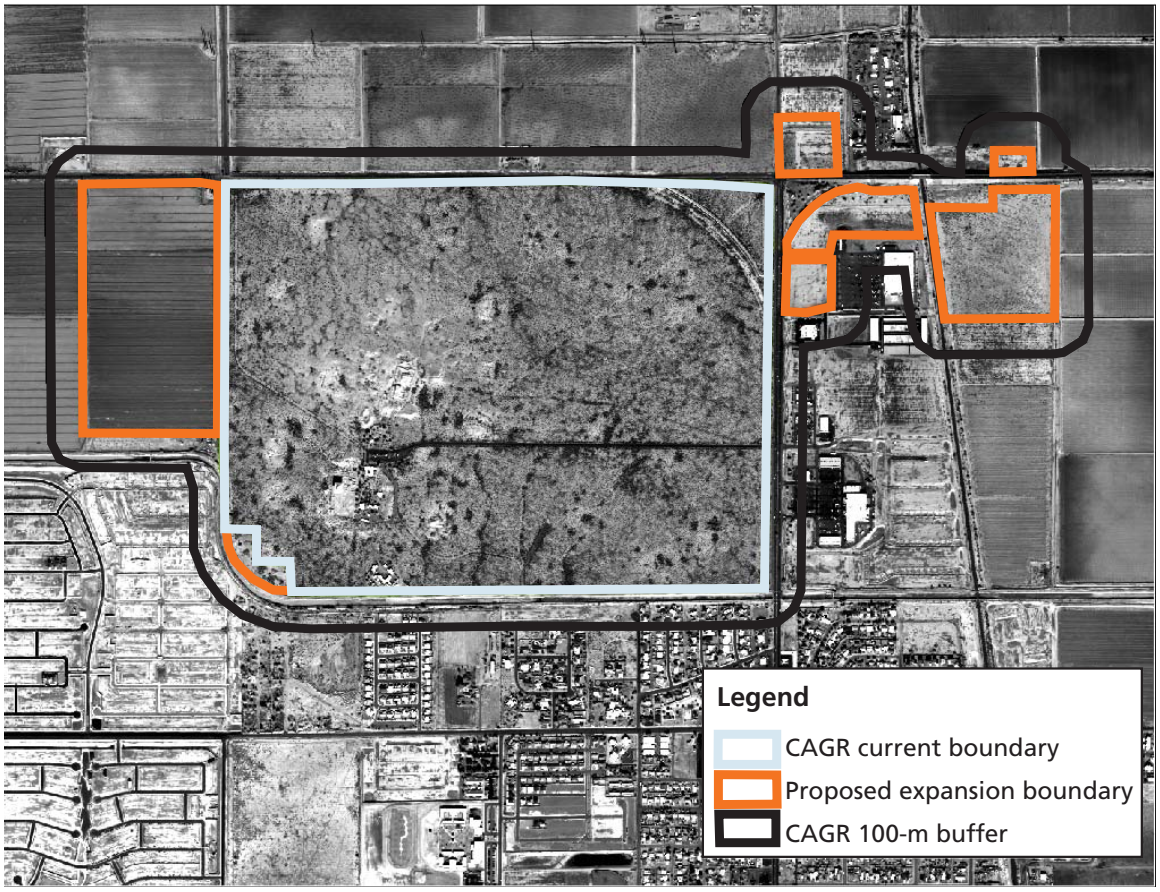


Figure 1.2.2-1. Casa Grande Ruins NM showing current and proposed expansion project boundaries.

and accuracy-assessment protocols and standards across all park-mapping projects. The program has established guidance for all vegetation-mapping projects in four documents:

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

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

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

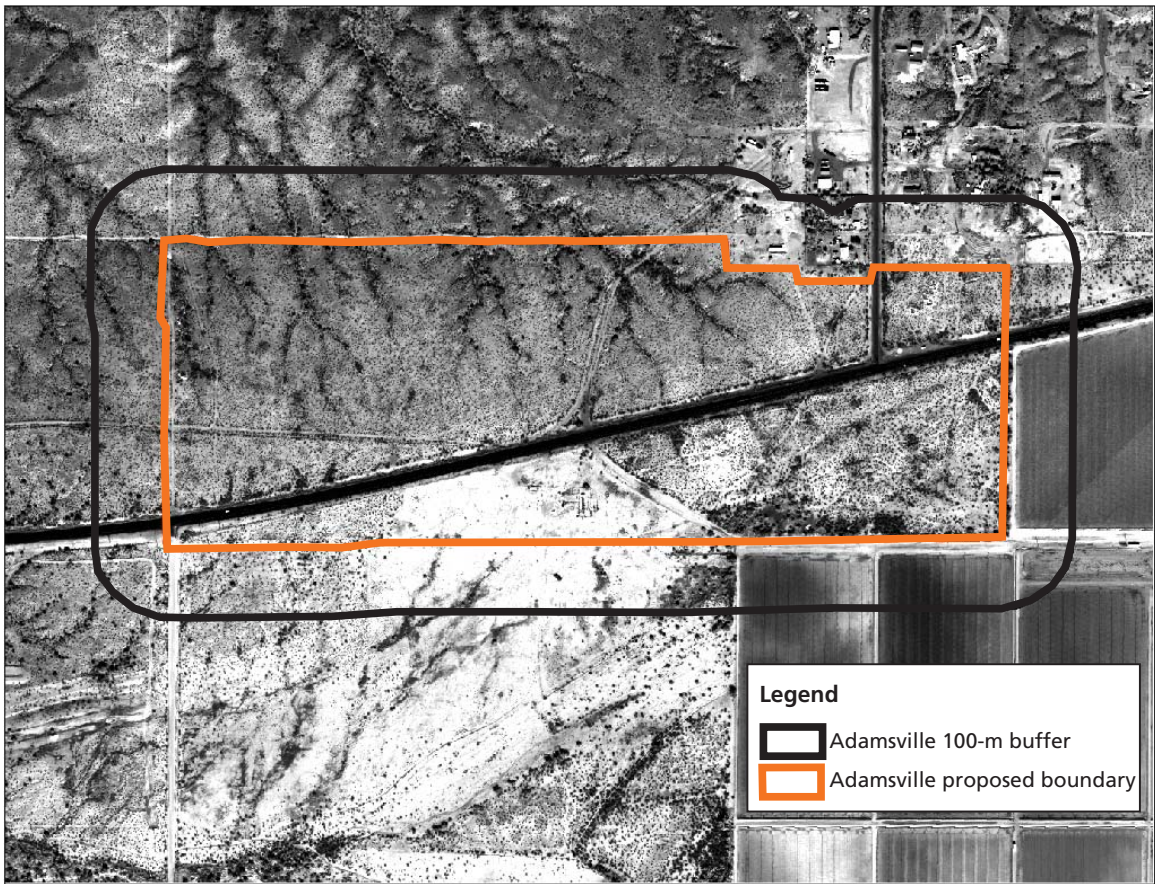


Figure 1.2.2-2. Casa Grande Ruins NM, Adamsville parcel, showing proposed expansion project boundary.

1.4 The National Vegetation Classification Standard

Patterns of vegetation vary continuously over landscapes. Classification systems attempt to categorize those patterns by identifying and describing assemblages of plants that repeat in similar habitats. The National Vegetation Classification Standard (NVCS) provides a classification framework that is the standard for all NPS vegetation mapping projects (Comer et al. 2003, TNC and ESRI 1994a). In 1997, the FGDC formally adopted the NVCS version 1 (FGDC 1997). During the course of this project, version 2 of the NVCS (FGDC 2008), also known as the National Vegetation Classification Standard, was approved, but not yet implemented.

The NVCS is a hierarchical system that allows vegetation classification to occur at multiple scales. In version 1, used for this project, there are seven levels. The upper five are based on the physiognomic characteristics of vegetation, and the lower two are based on the floristic characteristics of the plant community—relative abundance of dominant species. Table 1.4 identifies the seven levels of the NVCS used in this report and depicts their placement in the hierarchical relationship (Maybury 1999).

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

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 filled out by individual vegetation characterization projects, such as the present one, and other sources. The NVC, which is maintained by NatureServe and used by many federal agencies, including the NPS, includes the plant communities (associations and alliances) defined for the United States.

Work on the NVC, conducted primarily by TNC through 1999, provided initial definitions of some plant communities at each level. NatureServe inherited that documentation when it branched from TNC. 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 is the most accessible listing currently available. However, the plant community listings within the NVC are not yet complete.

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

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

1.6 Terminology and naming conventions

Alliances and associations are based on both the dominant (greatest-canopy-cover) species in the upper strata of a stand and on diagnostic species (those consistently found in some land-cover types but not others). Associations are the most specific 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 the 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 the vegetation and one or more dominant species in lower strata (or a diagnostic species in any stratum).

Documentation from NatureServe (2005) describes the naming conventions and syntax for all NVC names:

- A hyphen with a space on either side (-) separates names of species occurring in the same stratum.

Table 1.4. Summary of the National Vegetation Classification Standard hierarchical approach.

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

- 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 within a stratum generally reflects decreasing levels of dominance, constancy, or indicator value.
- Parentheses around a species name indicates the species is less consistently found either in all associations of an alliance, or in all occurrences of an association.
- Alliance names also include the class in which they are classified (e.g., Forest, Woodland, or Herbaceous), but are followed by the word "Alliance" to distinguish them from associations.
- Association names include the dominant species of the significant strata, followed by the class in which they are classified (e.g., Forest, Woodland, or Herbaceous).

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

- *Larrea tridentata* Monotype Shrubland

Examples of alliance names from CAGR:

- *Prosopis velutina* / *Larrea tridentata* Woodland Alliance
- *Sphaeralcea ambigua* Sparse Shrubland Alliance

1.7 Monument Environment

1.7.1 Monument establishment

On June 22, 1892, President Benjamin Harrison created Casa Grande Ruins National Monument by executive order, making it the first cultural or prehistoric site in the United States to receive federal protection. The monument's cultural resources include a four-story Hohokam structure built during the Classic period of Hohokam habitation, from A.D. 1200 to 1450 (Clemensen 1992), and some 60 documented archeological sites surrounding it. Located on the northern edge of Coolidge, Arizona, southeast of Phoenix, the monument encompasses 191 hectares and is bounded by Arizona Highway 87 to the north and east, by the Pima lateral canal to the south, and agricultural fields to the west (Figure 1.7.1). Expansion lands to be acquired by the monument in the future include the prospective Adamsville unit on the opposite side of Highway 87, about seven kilometers east of the main unit, and several small parcels of agricultural land adjacent to or near the main unit.

1.7.2 Physiography and climate

Casa Grande Ruins NM is located in south-central Arizona, in the Basin and Range physiographic province, where expansion of the earth's crust resulted in an alternating pattern of widely separated, steep mountain ranges with large alluvial fans or bajadas that gradually slope to the bottoms of broad, flat valleys (Reichhardt 1992). About 1 km north of the monument is the Gila River, which drains a watershed encompassing much of southern Arizona, along with portions of southwestern New Mexico and northern Sonora, Mexico. The monument averages 23 cm of annual precipitation in a bimodal pattern: gentle winter rains from the remnants of Pacific frontal systems, and heavy monsoon rains in summer, caused by convection of moist air from the Gulf of Mexico. Summer high temperatures usually exceed 40°C and winters are mild, rarely below freezing, with diurnal temperature extremes of 20°C or more during much of the year due to the area's extremely low humidity (Powell et al. 2006).

1.7.3 Environmental history

Human history in the Casa Grande area dates back to 5500 B.C., when Archaic peoples hunted and gathered in the area. Subsistence agriculture was not practiced until well after 1000 B.C., with the introduction of maize (corn); beans were introduced around 350 B.C. (Clemensen 1992). Agricultural expansion contributed to a more sedentary population and the beginnings of hydraulic culture. The Hohokam people, who practiced irrigated agriculture, arrived in the middle Gila River Valley about 300 A.D., and flourished there over the next thousand years. As the population grew, canals became larger and more consolidated, eventually reaching 8' deep × 16' wide in some areas; it is believed that the Hohokam were diverting up to half of the river's volume. Catastrophic flooding of the Gila River, along with several years of low flow, caused the Hohokam to move canal intakes further and further upstream, eventually reaching 18 miles from Casa Grande

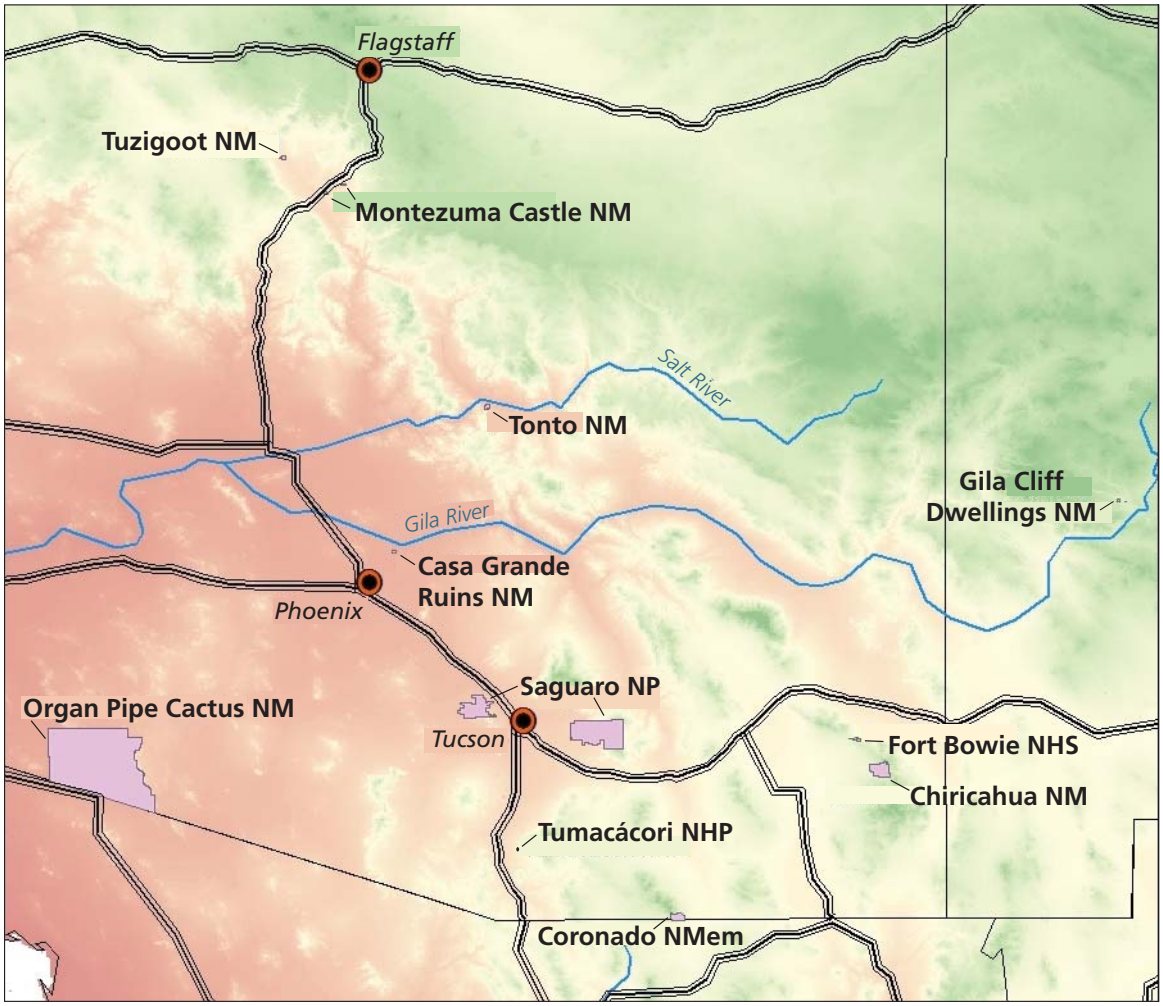


Figure 1.7.1. Location of Sonoran Desert Network parks in Arizona.

(Clemensen 1992). The effort to maintain their hydraulic systems, combined with more floods followed by periods of drought, brought on slow social decay that is thought to have contributed to Hohokam abandonment of the area around 1400 A.D.

For the next 400 years, habitation of the area was sparse. It was not until after 1853, when the area became part of the United States with the Gadsden Purchase, that Euro-American settlement increased. Prior to widespread Euro-American settlement, there are accounts of massive mesquite and cottonwood bosques along the Gila River in the vicinity of Casa Grande, as well as extensive grasslands (Rea 1997). With the increasing presence of Euro-Americans came the increasing pressures that accompanied livestock grazing. The monument itself was grazed until 1934, when it was finally fenced to protect the structures. With the cessation of the Apache Wars in the late 1800s, many Euro-American settlers descended on the area, rapidly expanding agriculture in the Gila River Valley. Upstream from Casa Grande, at Florence, Arizona, Mormon settlers had begun farming after 1866. The rise of their extensive, direct-diversion irrigation works, followed by groundwater pumping by the 1920s, resulted in expansive development of agricultural land as large volumes of both surface and groundwater were used (Powell et al. 2006). By 1928, the construction of Coolidge Dam ended the era of the Gila as a free-flowing river through the area. The conversion of the landscape to agriculture continued unabated, and had encircled the monument by 1932.

Agriculture in the Coolidge area suffered greatly from overpumping of the water table, which was obvious as the water level of the monument's well dropped from 128 feet below the surface, in the early 1940s, to more than 300 feet below the surface by 1956 (Clemensen 1992, Powell et al. 2006). This lowering of the water table, combined with

a widespread mistletoe infestation, contributed to a large scale die-off of the Casa Grande Ruins mesquite population in the 1930s (Judd et al. 1971). The decade of the 1930s also saw the bulk of the development at the monument, with construction of the roof over the structure in 1932 and, by the end of the decade, the visitor center, paths, roads, and several outbuildings. These are the same buildings that constitute the monument today. There has been only one major excavation of the archeological complexes, at which time, vegetation was scraped off the site. Since the 1930s, little has been done to alter or manipulate vegetation at the monument. Some studies have questioned the possibility of pesticide drift from neighboring agricultural land, but little else, beyond the continued decline of the water table, is actively affecting the site today.

1.7.4 Vegetation

Casa Grande Ruins NM is composed primarily of desert shrubland characteristic of the Lower Colorado River division of the Sonoran Desert (Brown et al. 1979). Natural vegetation in the study area is composed of shrubland dominated by creosotebush (*Larrea tridentata*). In some areas, including the bulk of the main unit and portions of the Adamsville unit, the composition is homogeneous, with plants generally spaced a minimum of 2–3 m apart and no other shrub species present. In other areas, shrubs, such as wolfberry (*Lycium fremontii, Lycium andersonii*), cattle saltbush (*Atriplex polycarpa)*, triangle bur ragweed, (*Ambrosia deltoidea*), desertbroom (*Baccharis sarothroides*), or littleleaf ratany (*Krameria erecta*) form a portion of the dominant shrub stratum in association with creosote. Velvet mesquite (*Prosopis velutina*) and barrel cactus (*Ferocactus wislizenii*) are scattered throughout the shrubland, with the barrel cactus usually growing singly and the mesquite frequently in clumps of a few to several individuals. Perennial herbaceous vegetation is notably sparse in the monument, with purple threeawn grass (*Aristida purpurea*) and desert globemallow (*Sphaeralcea ambigua*) found only occasionally. Although annual vegetation may be seasonally abundant, the ground between shrubs usually appears barren. Litter accumulation and humus development are minimal except under large trees and shrubs. In wetter areas at the Adamsville unit, mesquite and foothills paloverde (*Parkinsonia microphylla*) are abundant enough to constitute localized tree canopy above the shrubs, with mesquite occurring primarily near anthropogenic alterations to surface hydrology and paloverde occurring along ephemeral watercourses.

1.7.5 Previous vegetation studies

Reichhardt (1992) conducted a vegetation classification survey in the mid-1980s, producing a baseline map of vegetation communities. This report identified three distinct vegetation communities and follows the format developed by Brown et al. 1979. The resulting map also documented the spatial location of live mesquite trees (*Prosopis* sp). This effort was complemented by the vascular plant inventory of Powell and others (2006), which established permanent monitoring plots and compiled a plant species list that was utilized by this field effort.

Chapter 2
Classification and Mapping of Plant Communities

2.1 Methods

In general, we followed the classification and mapping methodology elaborated in the USGS-NPS Vegetation Characterization Program documentation, including the NVC standards. However, our approach to classification and mapping was more integrated than the traditional practice of having ecologists collect plot data for classification and photointerpreters delineate polygons with particular signatures, then combining the two efforts. Instead, we used an integrated team of observers who collected plot- and polygon-based data for classification while creating map polygons in the field.

Provisional polygons were drafted from interpretation of high spatial-resolution satellite imagery and field reconnaissance, and were characterized at a level ranging from formation to class (see following sections). The field team, including the image interpreters, took this draft map as a starting point and verified or modified boundaries; split polygons into alliance or finer-level, floristically based polygons; and characterized each alliance type with quantitative data on species composition, relative cover, and other factors. Because Casa Grande Ruins NM is a small unit, we were able to census the entire monument in this way.

2.1.1 Satellite imagery

The imagery we used was acquired by DigitalGlobe Inc.'s Quickbird satellite on December 3, 2007, as a new, tasked acquisition for this project. Image preprocessing and initial interpretation to the formation level were done at the Arizona Remote Sensing Center, University of Arizona. The imagery product purchased was the "Ortho-ready Standard" bundle of four spectral bands (blue, green, red and near-infrared) at 2.4-m spatial resolution, plus the broadband panchromatic data at 0.6-m resolution. This imagery is intended to be orthorectified by the user and is only coarsely geo-registered, with a nominal spatial accuracy of 23 m CE90—meaning that 90% of features in the imagery must be within 23 meters of their true location on the ground. More information about the general specifications of this imagery can be found at www.digitalglobe.com/ or, more specifically, at www.digitalglobe.com/product/standard_imagery.shtml.

2.1.2 Image processing

The imagery was orthorectified with ERDAS (Leica) software, using a USGS National Elevation Dataset digital elevation model, ground control points (GCPs) from ca. 2006 digital orthophoto quarter quadrangles (DOQQs), and the Quickbird rational polynomial coefficient model. During the rectification process, the coordinates of GCP locations collected from the reference DOQQs were entered into a table and compared to image coordinates for the same GCP locations. An optimal set of GCPs was selected and the images were rectified using a polynomial model with cubic convolution resampling. The multispectral image had a root mean square error (RMSE) of 1.19 m, calculated from six GCPs. The panchromatic image had an RMSE of 0.65 m, calculated from nine GCPs. These errors are in relation to the 2006 DOQQ reference, the highest-accuracy reference source available.

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

Eleven classes were identified, based on the percentages of tree, shrub, and herbaceous cover present: Woodland, Wooded Shrubland, Shrubland, Sparse Shrubland, Transitional Areas, Agriculture, Horticulture, Non-vegetated, Park

Facilities, Transportation, and Mixed Urban or Built-up Land. These were determined by following the formation key we had previously developed (Appendix A). The latter seven are not true NVC formations, but convenient map-class labels we used to represent other-than-natural or semi-natural vegetation at Casa Grande Ruins NM. Several of these were taken from the Anderson Land Use/Land Cover system (Anderson et al. 1976).

Each polygon in the draft map was assigned a unique alphanumeric identifier (ID) for reference throughout the project. When polygons were split, new, daughter polygons were given appropriate IDs, but still traceable to the parent. We prepared 11 × 17-inch hard-copy prints of the tentative polygons overlaid on the background imagery, at 1:4,000 scale with a 100-m UTM grid, for use in the field-based vegetation alliance mapping. The field team also had the digital draft map and the imagery available on handheld and laptop computers, with the useful ability to zoom in for viewing at multiple scales.

2.1.3 Field-based classification and mapping

2.1.3.1 Polygon data

Field-based mapping and data collection for classification were completed with 26 person-days of work in early March 2008. Working in teams of two or three for a multiple-observer, consensus-based approach, the field crew visited each of the polygons on the draft map of the study area. Assisted by the hard-copy prints and the spatial data loaded on GPS-linked handheld computers (RECONs), the field crew generally walked the boundary and much of the interior of each polygon to make a careful visual assessment of it. They determined whether the image interpreters had labeled it correctly (shrubland vs. woodland, for example) and whether its boundary needed any modifications. Then they looked at species composition and determined whether the polygon was sufficiently homogeneous to consider it a single alliance, or if it needed to be split into more than one alliance. Boundary modifications and splits were sketched on the hard-copy prints and explained in words on field data sheets (Appendix B).

From this point forward, work focused on the alliance-level polygons created. Next, the crews collected semi-quantitative data on canopy cover of dominant species by stratum, plant heights, associated species present, disturbance, and a range of soil/landscape characteristics (Table 2.1.3.1). A sequence of four representative photographs was taken in the four cardinal directions from near the center of the polygon (at a specific point stored in the GPS), and a tentative alliance-type description of the polygon was written.

2.1.3.2 Plot data

The steps described in the previous section were performed for each alliance-level polygon. In addition, a set of 20 × 50-m plot data was collected for each alliance type (not necessarily each

Table 2.1.3.1. Summary of data collected on classification plots and censused polygons in 2008.

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

polygon), with a total of 25 plots sampled across both units (Figures 2.1.3.2-1 and 2.1.3.2-2). Plot locations had been preselected with the spatially balanced RRQRR (Reversed Randomized Quadrant-Recursive Raster) algorithm to provide an objective, park-wide sampling basis for vegetation classification (Theobald et al. 2007). The same information was recorded in the plots as in the whole polygons, with the notable addition of measured basal diameters of trees present (see Table 2.1.3.1). The plots provided a uniform, delimited scale of observation to supplement and corroborate the extensive observations of whole polygons. To the extent that the plots are representative of the polygon or alliance type as a whole, collecting plot data can address the difficulty associated with making accurate visual estimates of the canopy cover of several species in large polygons. As such, evaluating both polygons and plots provides the most robust and useful dataset for characterizing alliances.

The RRQRR points were numbered and sampled in sequential order to maintain the spatial balance and the probabilistic nature of sampling. Each point was understood to serve as any corner of a plot, giving the field crew some flexibility to avoid major changes in vegetation type or distinct, nonrepresentative inclusions. Also, plots were oriented in any direction that most closely corresponded to the formation type in which the RRQRR point fell. Plots that crossed different types were still sampled but were placed to encompass the least amount of variation. If a plot crossed three or more community types, it was not sampled; rather, it was noted as being dropped and the crew moved to the next point. After the plot was established, the bearings of the 20-m and 50-m edges from the RRQRR origin point were recorded on the data sheet, the polygon in which the point was located was noted, and a photograph representative of the plot was taken from the origin point, the coordinates of which were marked in a GPS file in the RECON unit.

Vegetation-cover data were collected across the entire plot, with species ranked by relative dominance and assigned to absolute cover classes. Basal diameters of all individual trees taller than 2 m and larger than 10 cm in diameter were

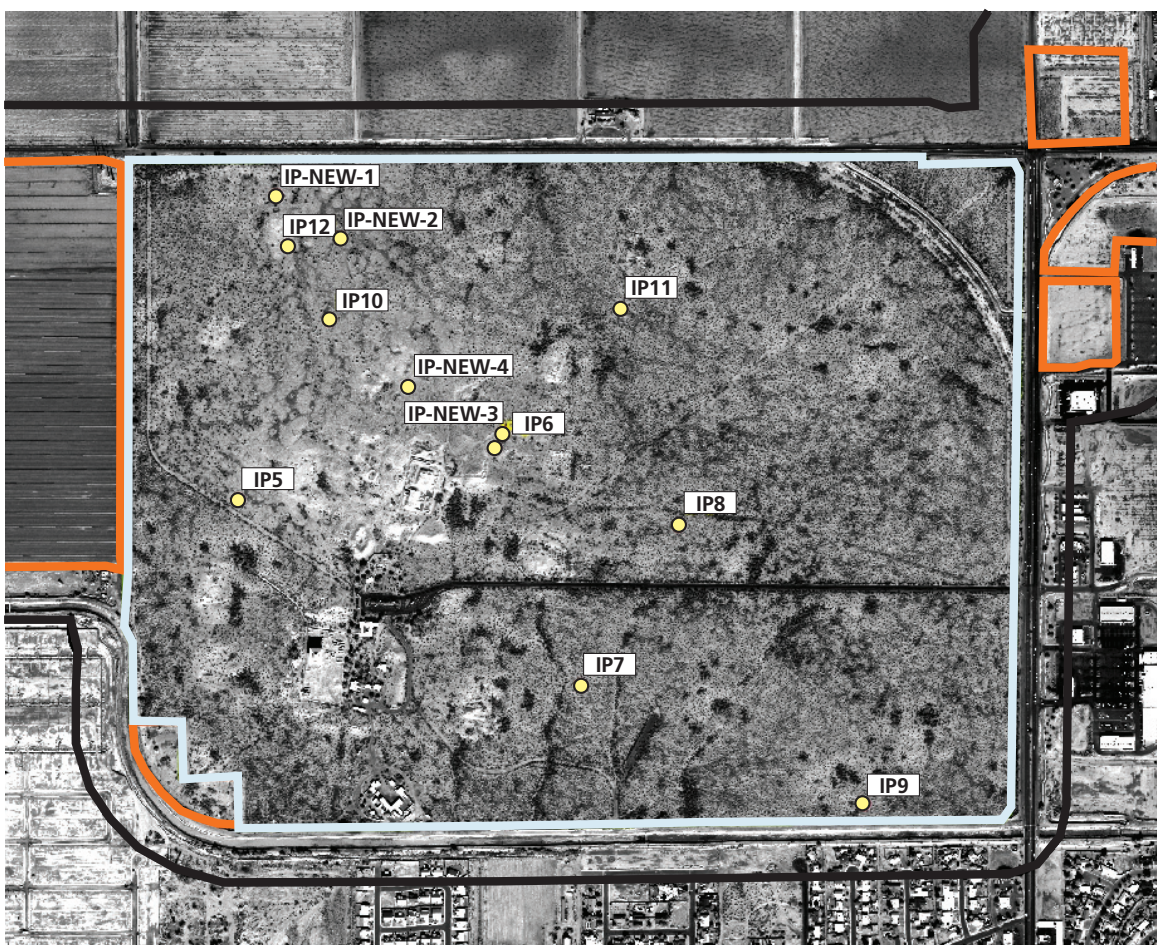


Figure 2.1.3.2-1. Intermediate plot locations at Casa Grande Ruins NM.

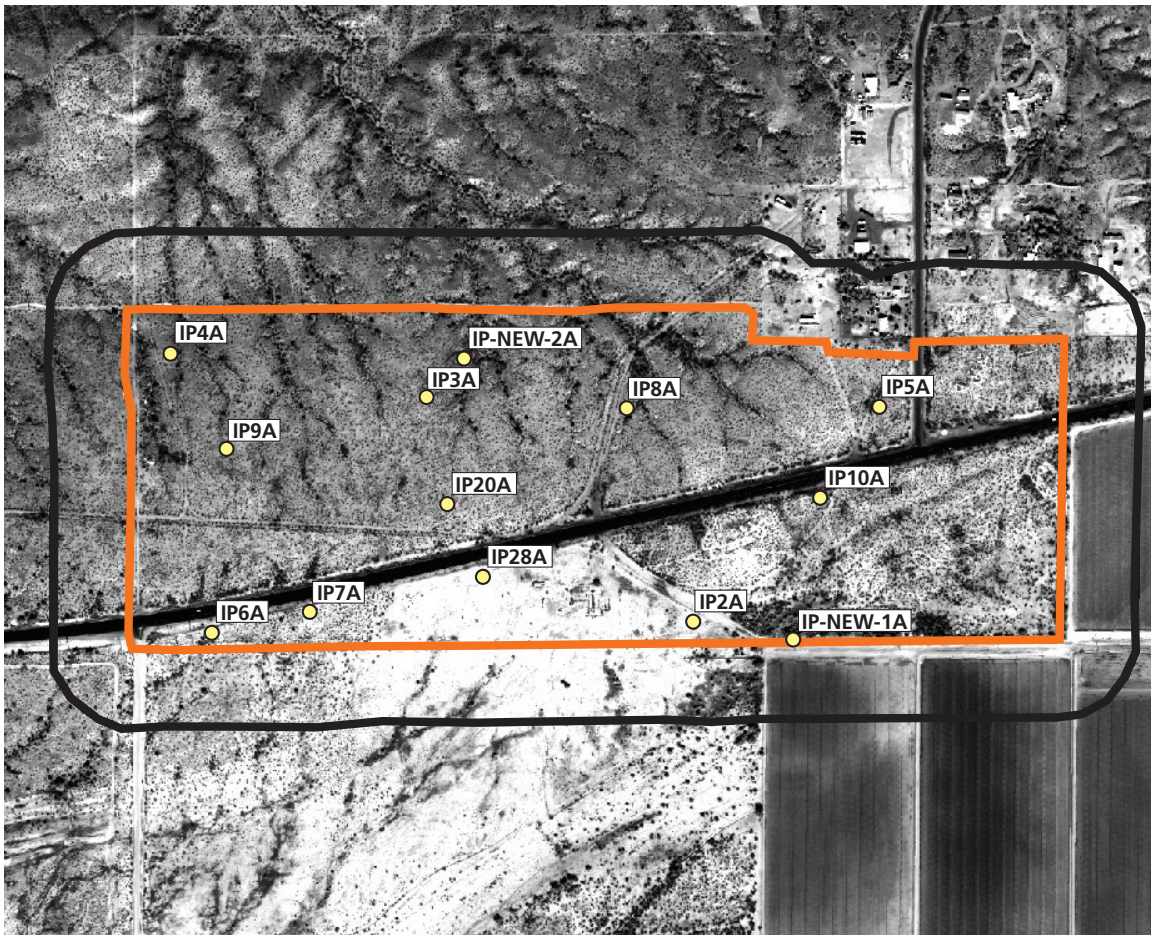


Figure 2.1.3.2-2. Intermediate plot locations at Adamsville unit.

recorded, all stems less than 10 cm in diameter were tallied, and all disturbance types were noted with the constrained vocabulary found in the NVC system. A battery of soil and landscape characterization data were taken (the same as those for polygon assessment), including topographic position, landform, surface cover, parent material, slope, aspect, and erosion features. Finally, narrative descriptions of both vegetation and the landscape/soils were written to best characterize the community found in the plot.

In the study area containing the main unit at Casa Grande Ruins NM, we completed eight plots associated with RRQRR points, but these left some tentative alliance types undersampled, so we sampled an additional four plots, subjectively placed, to represent these types. In the Adamsville study area, we completed 11 RRQRR plots and two additional, subjectively placed plots.

All plot and polygon data were entered into an Access database created by the SODN. 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 procedure document written by the SODN data manager.

When fieldwork was complete, all field data sheets and annotated hard-copy prints were returned to the Arizona Remote Sensing Center for analysis by the whole project team. The digital (shapefile) draft map was extensively edited in ArcMap to incorporate all of the changes indicated on the annotated prints.

Polygon and plot-level data were evaluated to assess the compositional similarities or differences between each distinct area mapped. Final vegetation types were grouped based on species dominance; total cover and characteristic associated species; and an appropriate level of floristic difference from other groups. These types were then matched to the most similar and suitable alliances or associations as described by NatureServe Ex-

plorer. When no corollary was found to a mapped type within the NatureServe database, descriptions were limited to the study-area locality.

2.2 Results

2.2.1 Map classes

Forty-two polygons were mapped within the project boundary: 27 at the main unit and 15 at the Adamsville proposed expansion area (Table 2.2.1). In total, 15 distinct types were identified across the study area. Seven of these types are Anderson Land Use Classes or variations thereof; the others are natural vegetation classes following the NVCS. Map classes were described at the alliance or association level; where known, alliance descriptions also include recognized associations. Due to the small area involved in this project, and to its relatively simple floristic attributes, there is a one-to-one correspondence between the map classes presented here and the community types described. A total of 35 species were recorded during the sampling efforts (Appendix C). Table 2.2.1 shows the finalized list of types, including polygons and plots representing each type, and total area within the project boundaries. Detailed descriptions of these types are provided in Appendix D. Alliances and associations marked with (P) are proposed, not yet accepted into the NVC.

In addition, summarized local descriptions, with example satellite image/signatures and representative photos for each alliance or association, follow this section. These one-page text and spatial summaries are presented over the next several pages; full descriptions of all map classes can be found in Appendix D. The completed maps of the two CAGR study areas are presented in Figures 2.2-1 and 2.2-2. Readers may refer to the digital maps and databases accompanying this report for more detail.

Table 2.2.1. Vegetation alliances and associations mapped at Casa Grande Ruins National Monument and the proposed Adamsville expansion.

				# of polygons			Area (hectares)		
Map class	**Common name**	**Map codes**	**Plots**	**Monument**	**Expansion**	**Total**	**Monument**	**Expansion**	**Total area**
Woodland									
Prosopis velutina / *Larrea tridentata* Woodland Alliance (P)	Velvet mesquite / Creosotebush Woodland Alliance	W-PVLT01-C-A, W-PVLT02-C-A	IP-NEW-1A	0	2	2	0	1.71	1.71
Prosopis velutina Woodland Alliance	Velvet mesquite Woodland Alliance	W-PV01-C-A	N/A	0	1	1	0	0.9	0..9
Wooded Shrubland									
Parkinsonia microphylla / *Larrea tridentata* Wooded Shrubland (P)	Foothills paloverde / Creosotebush Wooded Shrubland	WS-PM01-C-A	IP4A, IP8A, IP-NEW-2A	0	1	1	0	16.4	16.35
Shrubland									
Larrea tridentata - [*Ambrosia deltoidea-Krameria erecta*] Shrubland (P)	Creosotebush - [Triangle bur ragweed - Littleleaf ratany] Shrubland	S-LT07-C-A, S-LT08-C-A, S-LT09-C-A	IP3A, IP6A, IP7A, IP9A, IP20A	0	3	3	0	23.6	23.6
Larrea tridentata - *Lycium fremontii* Shrubland Alliance (P)	Creosotebush - Fremont's wolfberry Shrubland Alliance	S-LTLF01-C, S-LTLF02-C	IP-NEW-1, IP-NEW-2, IP-NEW-3, IP6 and IP12.	2	0	2	5.63	0	5.63
Larrea tridentata Shrubland Alliance	Creosotebush Shrubland Alliance	S-LT01-C, S-LT02-C, S-LT03-C, S-LT04-C-A, S-LT05-C-A, S-LT06-C-A	IP7, IP8, IP9, IP10, IP11, IP10A, IP5A.	3	3	6	162.3	19.7	182
Sparse Shrubland									
Larrea tridentata / Mixed Annual Sparse Shrubland (P)	Creosotebush / Mixed Annual Sparse Shrubland	SS-LT01-C, SS-LT02-C	IP5, IP-NEW-4	2	0	2	12.77	0	12.77
Sphaeralcea ambigua Sparse Shrubland Alliance (P)	Desert globemallow Sparse Shrubland Alliance	SS-SA01-C-A	IP28A, IP2A	0	1	1	0	8.58	8.58

Table 2.2.1. Vegetation alliances and associations mapped at Casa Grande Ruins National Monument and the proposed Adamsville expansion, cont.

Map class	Common name	Map codes	Plots	# of polygons			Area (hectares)		
				Monument	Expansion	Total	Monument	Expansion	Total area
Anderson Land Use Classes									
Transitional areas	Transitional Areas	TA-01-C, TA-02-C, TA-03-C, TA-04-C, TA-05-C, TA-06-C	N/A	6	0	6	33.68	0	33.68
Agriculture	Agriculture	A-01-C,A-02-C, A-03-C, A-04-C, A-05-C, A-06-C, A-07-C, A-08-C-A, A-09-C	N/A	8	1	9	60.77	7.45	68.22
Horticulture	Horticulture	H-01-C, H-02-C	N/A	2	0	2	3.46	0	3.46
Non-vegetated	Non-vegetated	NV-01-C, NV-02-C	N/A	2	0	2	1.48	0	1.48
Park Facilites	Park Facilites	PF-01-C	N/A	1	0	1	3.85	0	3.85
Transportation	Transportation	T-01-C-A	N/A	0	1	1	0	3.85	3.85
Mixed Urban or Built-up Land	Mixed Urban	MU-01-C, MU-02-C-A, MU-03-C-A	N/A	1	2	3	53.7	4.75	58.45

P = proposed

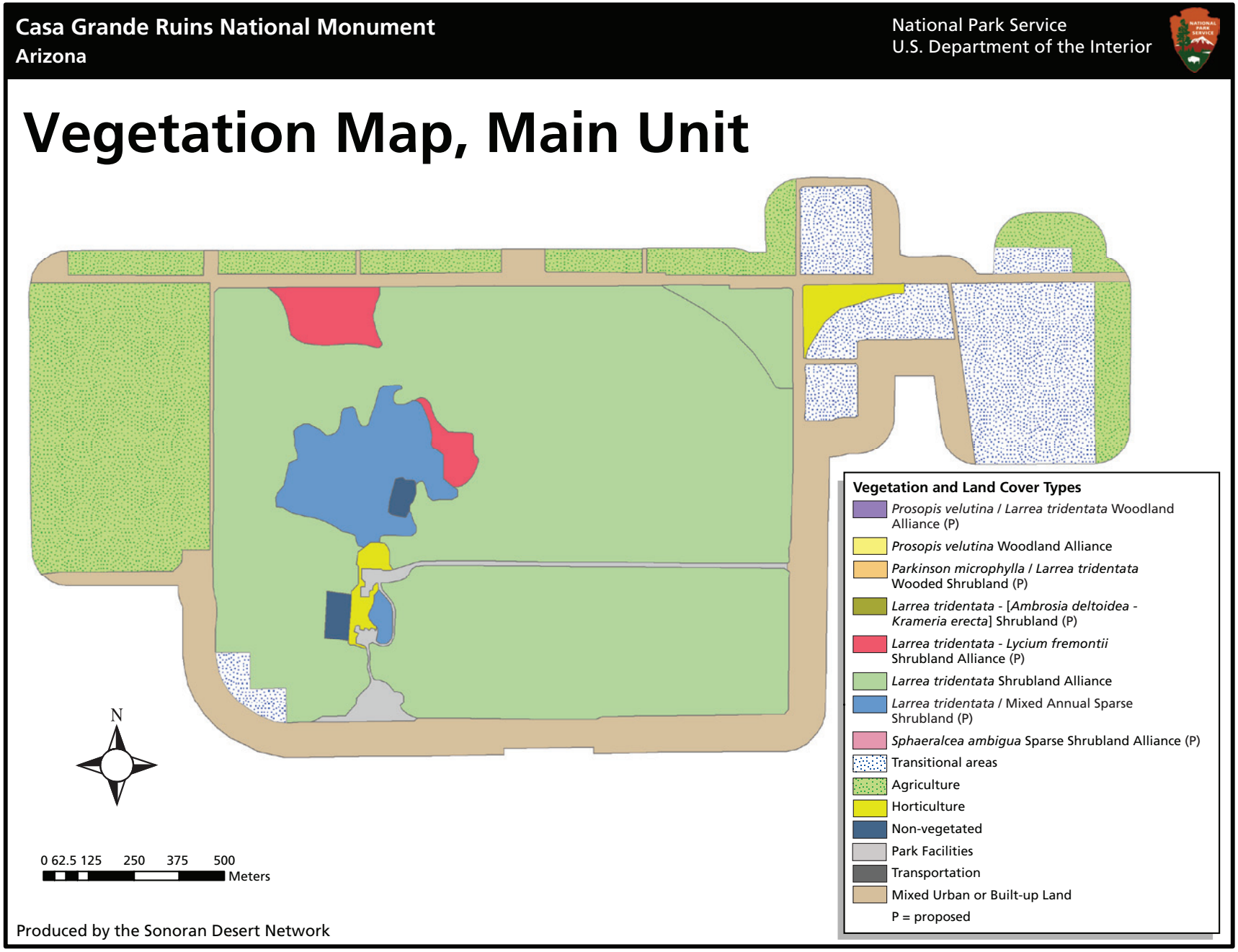
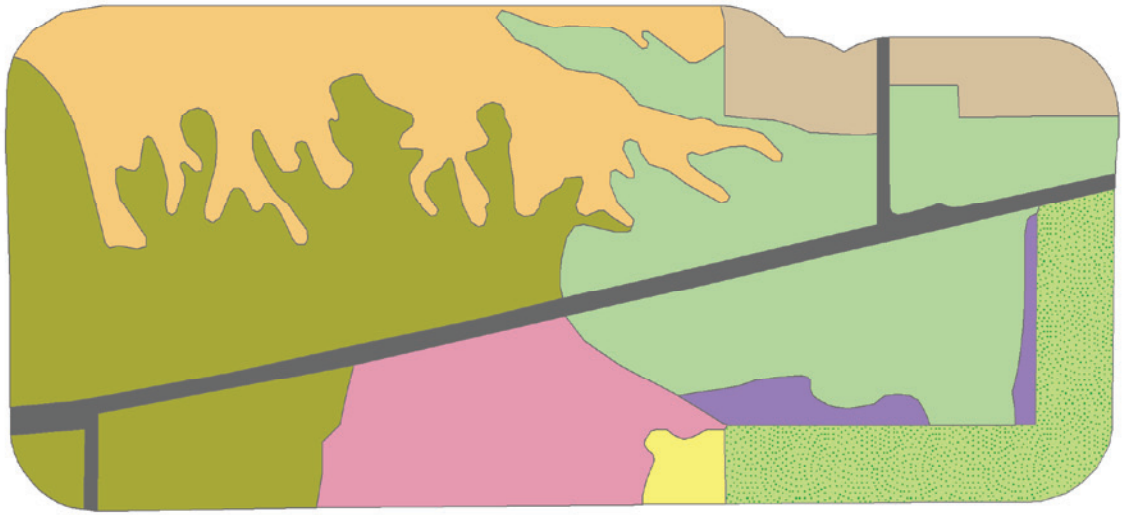


Figure 2.2-1. Vegetation map of the main unit, Casa Grande Ruins National Monument.

Vegetation Map, Adamsville Unit



0 62.5 125 250 375 500
Meters

Vegetation and Land Cover Types

- *Prosopis velutina / Larrea tridentata* Woodland Alliance (P)
- *Prosopis velutina* Woodland Alliance
- *Parkinson microphylla / Larrea tridentata* Wooded Shrubland (P)
- *Larrea tridentata* - [*Ambrosia deltoidea - Krameria erecta*] Shrubland (P)
- *Larrea tridentata - Lycium fremontii* Shrubland Alliance (P)
- *Larrea tridentata* Shrubland Alliance
- *Larrea tridentata* / Mixed Annual Sparse (P) Shrubland
- *Sphaeralcea ambigua* Sparse Shrubland Alliance (P)
- Transitional areas
- Agriculture
- Horticulture
- Non-vegetated
- Park Facilities
- Transportation
- Mixed Urban or Built-up Land

P = proposed

Produced by the Sonoran Desert Network

Figure 2.2-2. Vegetation map of the proposed Adamsville expansion unit, Casa Grande Ruins National Monument..

Prosopis velutina / *Larrea tridentata* Woodland Alliance (P)

Velvet mesquite / Creosotebush Woodland Alliance

Common species
Prosopis velutina
Larrea tridentata

This proposed alliance exists along two agricultural fencelines to the south and east of the large mound and ball court at the Adamsville site. These fencelines contain earthen berms formed by road building and maintenance to support adjacent agricultural operations. These berms capture and concentrate runoff, allowing it to saturate the soil. The moist conditions, perhaps augmented by infiltration of irrigation water from south and east of the fence, results in growth of *Prosopis velutina* up to 7 m tall and *Larrea tridentata* up to 3.5 m. Herbaceous annuals representative of the adjacent uplands thrive here, contributing more litter than is typical in adjacent uplands. This alliance resembles a portion of the *Larrea tridentata* shrubland along the boundary of the main unit, where runoff from adjacent roads permits similar concentrations of larger *P. velutina*.

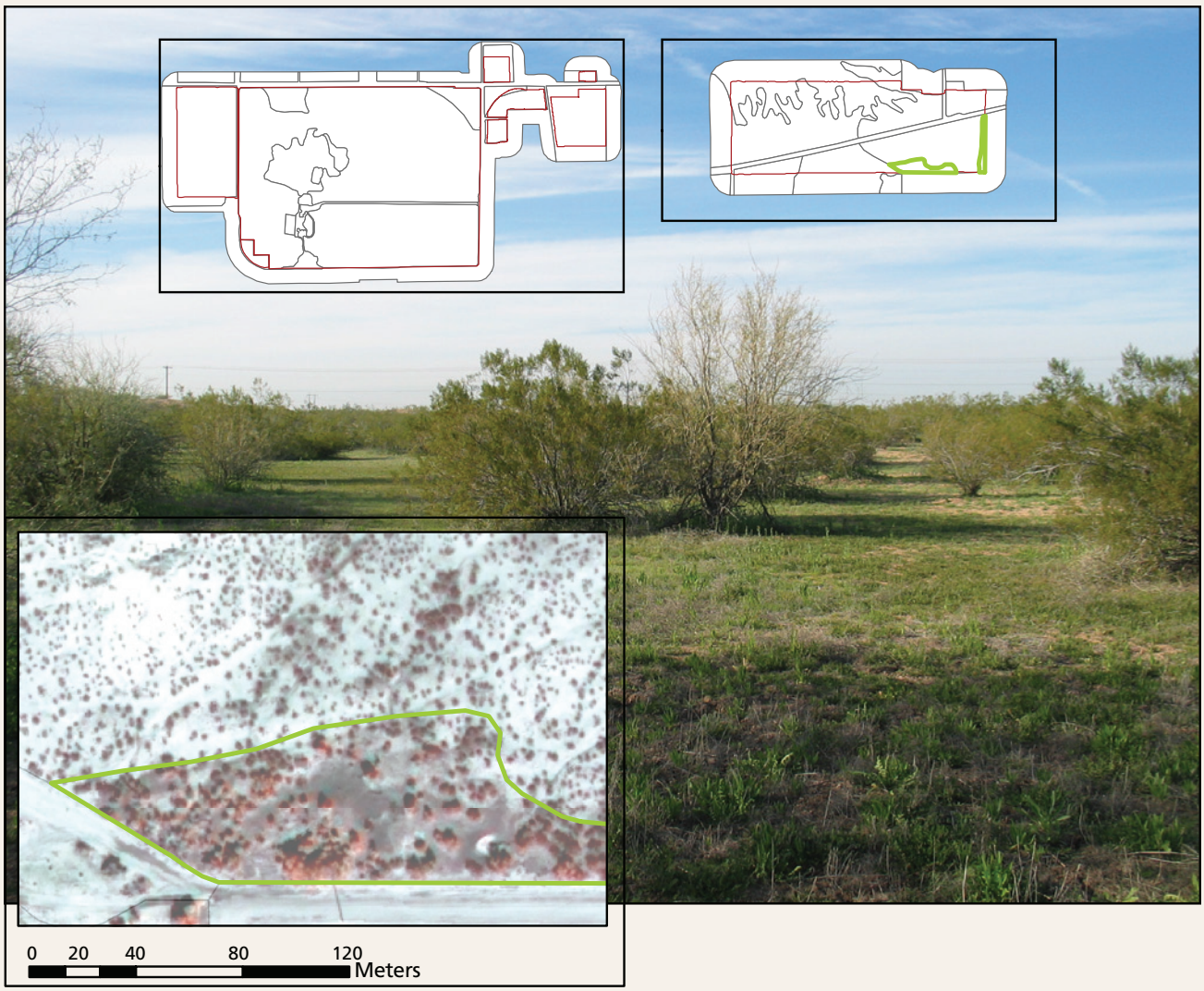


Figure 2.2-3. *Prosopis velutina* / *Larrea tridentata* Woodland Alliance.

***Prosopis velutina* Woodland Alliance**
Velvet mesquite Woodland Alliance

Common species
Prosopis velutina
Isocoma pluriflora
Atriplex canescens
Aristida purpurea
Amaranthus palmeri
Boerhavia coccinea
Ambrosia confertifolia

This alliance exists only in a small patch within the 100-m study-area buffer on the south side of the Adamsville unit, but extends well beyond the buffer to the south and southwest. The dominant feature is a cohort of young, regenerating *Prosopis velutina* trees that are benefiting from runoff that enters from the northeast. The runoff has two sources: excess irrigation water from agricultural fields east of the patch and precipitation runoff from the large Adamsville ruin mound to the north. The runoff flows southwesterly, slowing down and spreading out to form a wide, shallow swale. Vegetation follows a coincident pattern, with the largest and densest growth concentrated in the northeast and gradually diminishing as it follows the swale. Associated shrubs include *Isocoma pluriflora* and *Atriplex canescens*. *Aristida purpurea* is prominent in this type, but rare in the rest of the monument. Herbaceous diversity, percent cover, and biomass are significantly higher here, and include several species not found elsewhere in the monument, including *Amaranthus palmeri*, *Boerhavia coccinea*, and *Ambrosia confertifolia*. Soils are primarily silty, especially where water pools, and contain much more litter than adjacent uplands, but lack humus development.

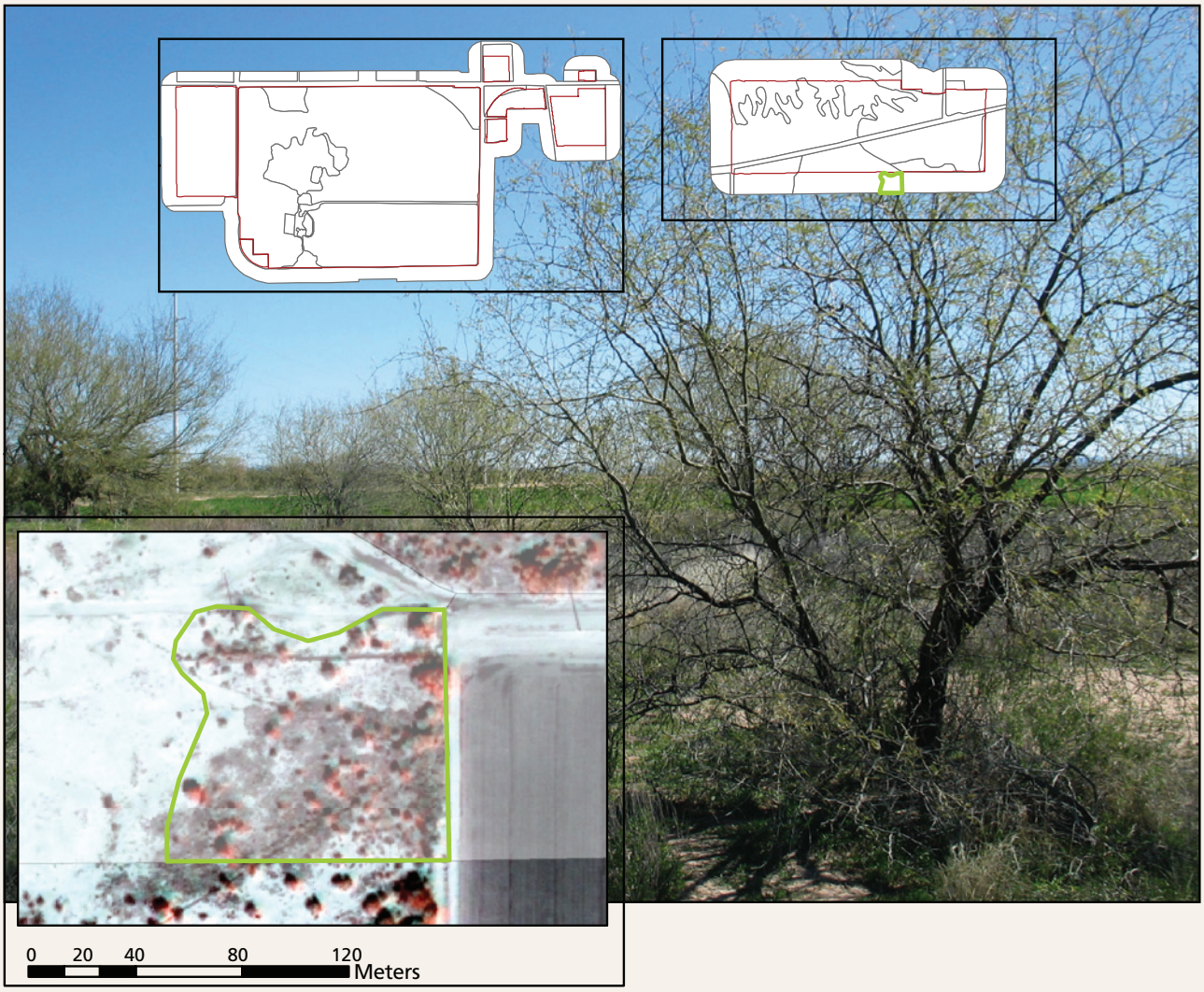


Figure 2.2-4. *Prosopis velutina* Woodland Alliance.

Parkinsonia microphylla / *Larrea tridentata* Wooded Shrubland (P)

Foothill paloverde / Creosotebush Wooded Shrubland

Common species
Parkinsonia microphylla
Larrea tridentata
Acacia greggii
Krameria erecta
Acacia constricta

This proposed association encompasses the headwaters of washes that eventually reach 0.5–2 m deep and up to 6 m wide, with sandy bottoms and steep, rocky sides. Small trees, including *Parkinsonia microphylla*, *Prosopis velutina*, and *Acacia greggii* are irregularly and sparsely scattered along these channels, becoming larger and more frequent as channel size increases. Shrubs within the channels are larger, more densely spaced, and more diverse than on adjacent uplands. While shrubs from the adjacent uplands are still present (*Larrea tridentata*, *Krameria erecta*, and *Ambrosia deltoidea*), this association also contains the only occurrences of *Ephedra trifurca* and *Acacia constricta* in the monument. In wet seasons, the field stratum is occupied primarily by annual forbs. The most common annuals in spring were *Plantago ovata*, *Erodium cicutarium*, and *Brassica tournefortii*. The increased diversity, height, and cover of woody and herbaceous plants in this type are an apparent consequence of the microenvironments created by the topography of the channels. These microenvironments offer increased moisture, a variety of slope aspects, some shelter from wind, and deeper soils not available in the uplands.

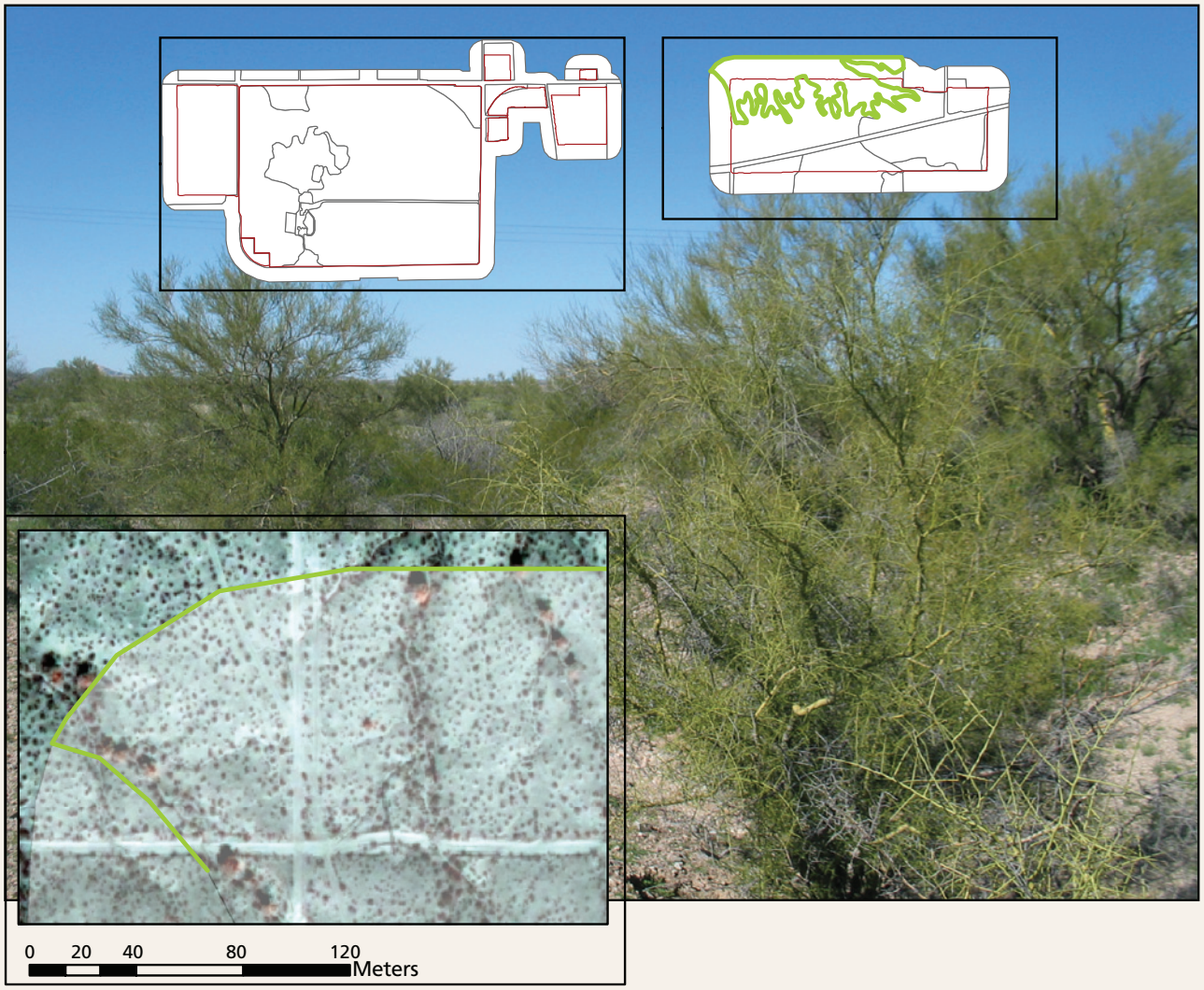


Figure 2.2-5. *Parkinsonia microphylla* / *Larrea tridentata* Wooded Shrubland.

Larrea tridentata - [*Ambrosia deltoidea - Krameria erecta*] Shrubland (P)

Creosotebush - [Triangle bur ragweed - Littleleaf ratany] Shrubland

Common species
Larrea tridentata
Ambrosia deltoidea
Krameria erecta
Parkinsonia microphylla

This proposed association is composed of two main polygons, bisected by U.S. Highway 287 and a small corner area cut off by roads, all at the Adamsville unit. *Larrea tridentata* shrubs dominate here, as they do in most of the monument, but are generally smaller and more widely spaced than in other areas. The distinguishing characteristic of this shrubland is the presence of *Ambrosia deltoidea* and *Krameria erecta* as significant associates to *L. tridentata*. Use of brackets in the type name indicates that these species are co-dominant in places, but their relative abundance differs spatially throughout the area, ranging from absent to common. The space between shrubs contains a variety of annuals, primarily forbs, but is otherwise unvegetated. Soils contain significant gravel, but less than adjacent areas. This type's bisection by U.S. Highway 287 raises the polygon to the north slightly above the landscape and appears to slightly increase water runoff into some areas within this association. Another indicator that this section may be slightly more mesic is the occasional presence of *Parkinsonia microphylla*. The raised highway may also provide increased protection from aeolian erosion, which appears to significantly impact soils on the surrounding landscape and the more southern polygon. The southern polygon of this type has a slightly lower density of shrubs and a finer sandy soil, but overall composition and cover classes are the same.

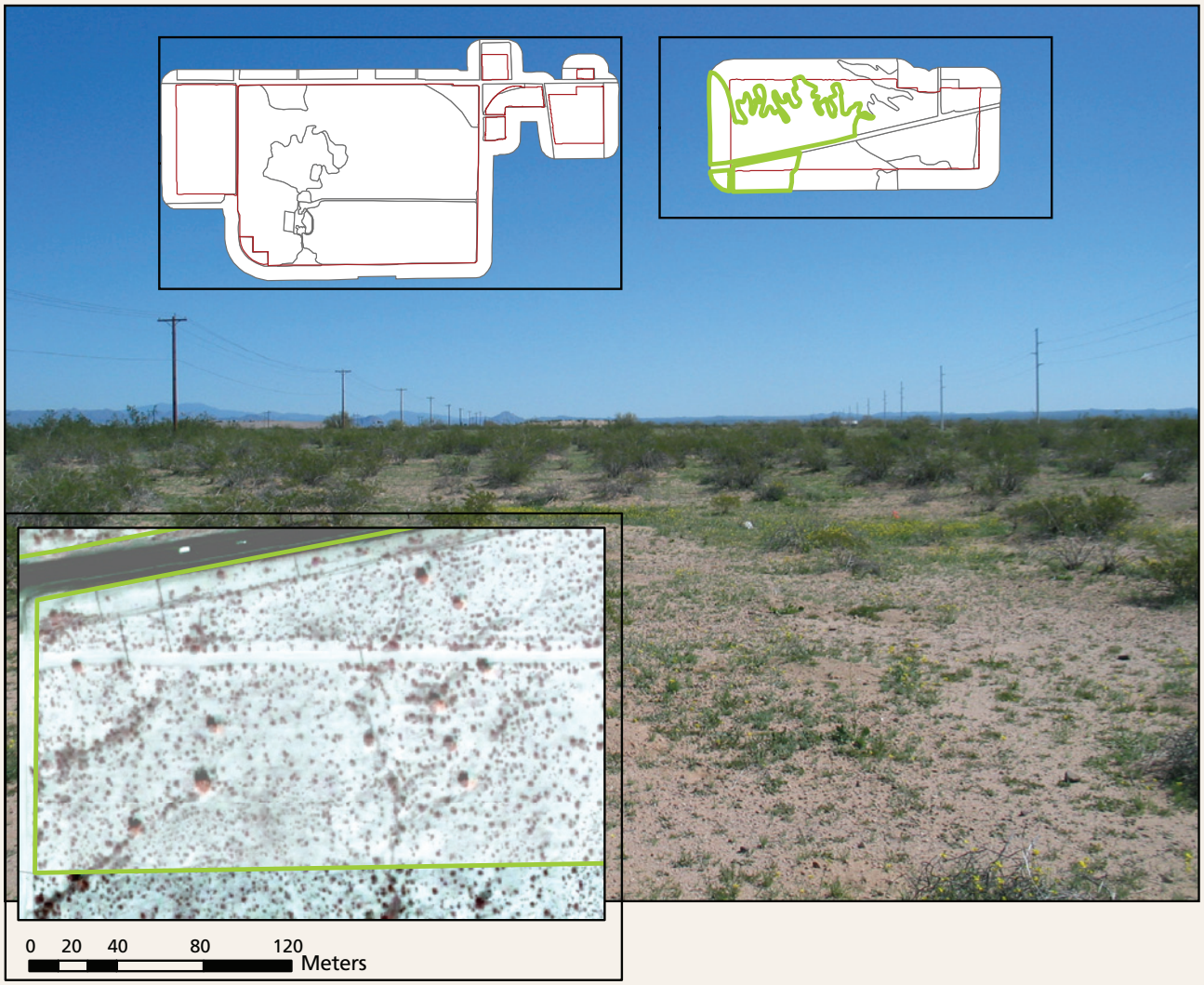


Figure 2.2-6. *Larrea tridentata* - [*Ambrosia deltoidea - Krameria erecta*] Shrubland.

Larrea tridentata - Lycium fremontii Shrubland Alliance (P)

Creosotebush - Fremont's wolfberry Shrubland Alliance

Common species
Larrea tridentata
Lycium fremontii
Atriplex polycarpa
Ferocactus wislizenii
Oenothera primiveris

This proposed alliance exists in two areas north of the visitor center complex in the main unit. It is characterized by the presence of *Lycium fremontii* as a co-dominant shrub alongside *Larrea tridentata*. The relative abundance of these species may differ spatially within the type, with density of *Lycium* shrubs increasing substantially in areas gathering additional rainfall via shallow depressions. Both species tend to grow slightly larger than in the adjacent *Larrea tridentata* shrubland, with average canopy heights often 2–2.5 m, but total canopy cover is lower with shrubs widely spaced. *Lycium andersonii* is also present to a lesser degree. *Atriplex polycarpa* is a common associate, especially along the monument's northern boundary. Between shrubs, herbaceous annuals may be present seasonally during years with adequate precipitation, but bare soil predominates much of the time. Soils have higher silt and clay content and less gravel than surrounding areas. Litter is nearly absent and the soil surface has low permeability due to frequent exposure to intense sun, strong prevailing winds, and impacts from heavy monsoon rain. Overall, topography is very flat, but includes several mounds and depressions associated with archeological sites. Soil and plant composition suggest that this type exists in areas that receive a net inflow of surface runoff that is briefly retained in shallow pools.

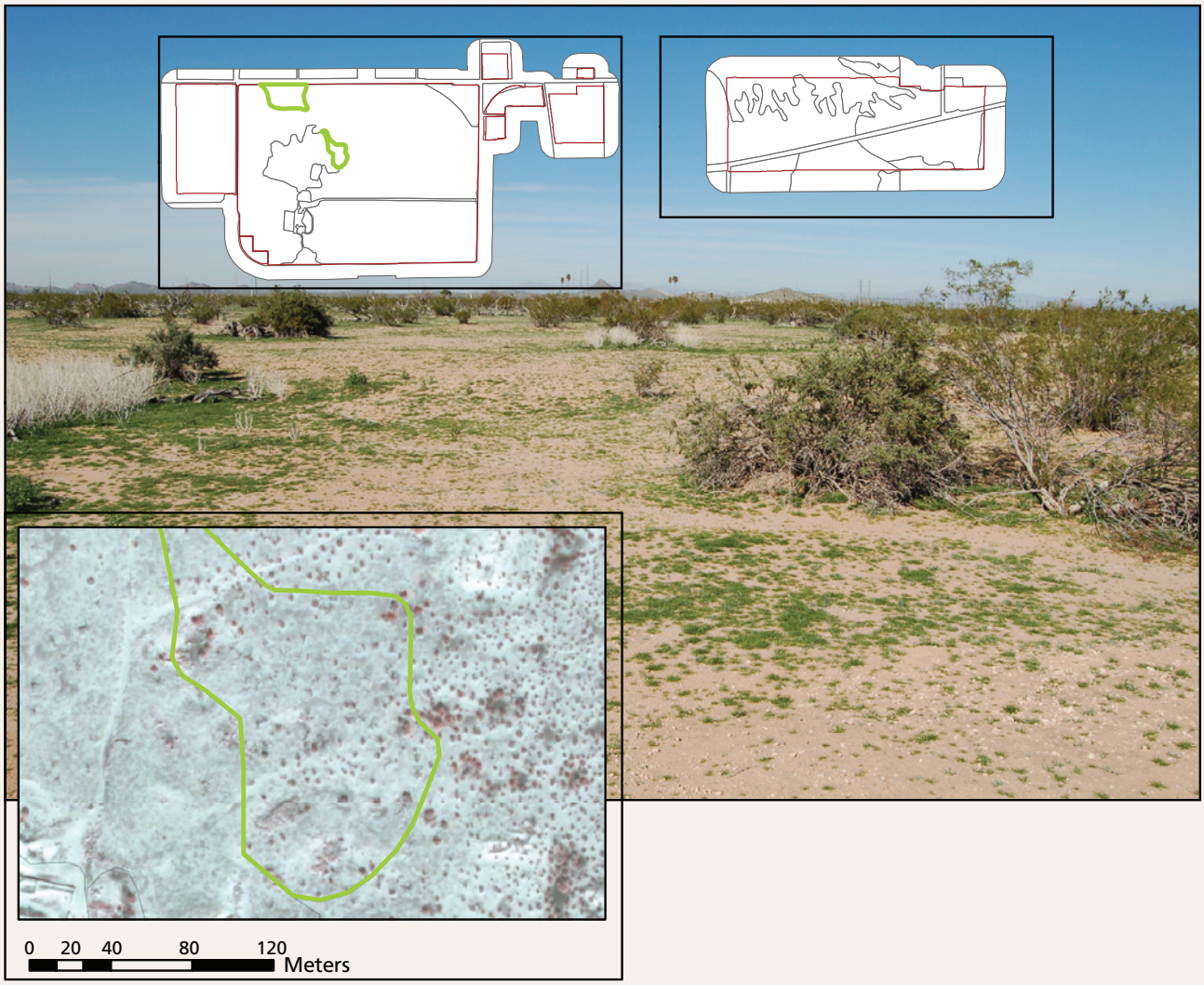


Figure 2.2-7. *Larrea tridentata - Lycium fremontii* Shrubland Alliance.

Larrrea tridentata Shrubland Alliance
Creosotebush Shrubland Alliance

Common species
Larrea tridentata
Baccharis sarothroides
Lycium fremontii
Atriplex polycarpa
Krameria erecta
Ambrosia deltoidea
Ephedra trifurca
Ferocactus wislizenii

This is the dominant vegetation type found in the monument, comprising approximately 80% of the main unit and 30% of the Adamsville unit. It is composed of a *Larrea tridentata* monoculture averaging 1.5–2.5 m tall and usually spaced 2–3 m apart on a flat, level landscape. Areas between shrubs are mostly bare soil or gravel, but may contain a variety of annual plant species during wet seasons. Litter is sparse and soil development poor, except directly under *L. tridentata* shrubs, which tend to grow on low mounds of soil retained by their roots against strong aeolian erosive forces on the landscape. *Baccharis sarothroides* and *Atriplex polycarpa* are interspersed with *L. tridentata*, on opposite ends of the old road. These inclusions are notable because they are the only place where either species is present in the eastern part of the monument. Moreover, herbaceous annuals are significantly less dense in these inclusions. It is likely that these inclusions are the result of the altered soil surface in this portion of the monument.

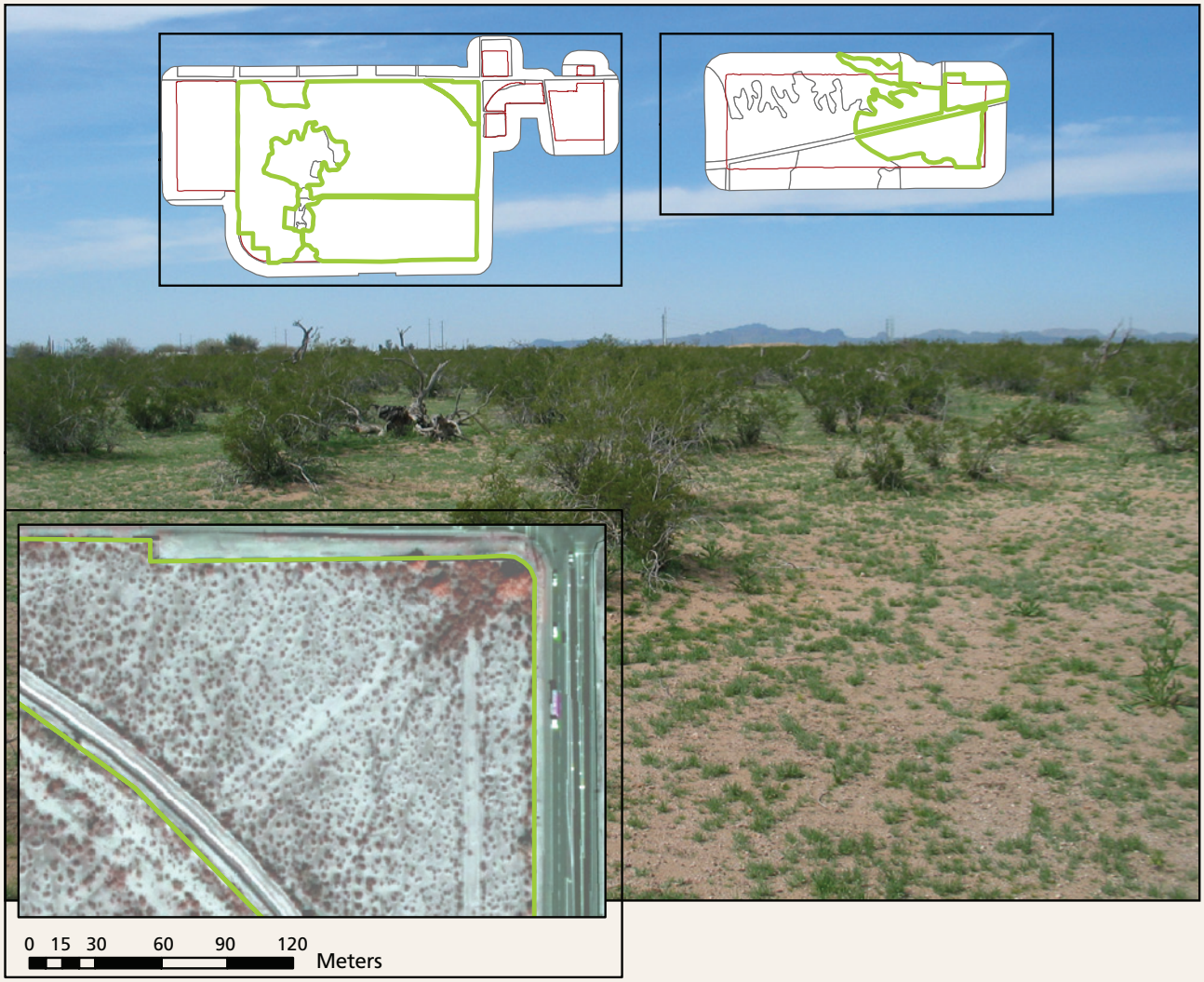


Figure 2.2-8. *Larrrea tridentata* Shrubland Alliance.

Larrea tridentata / Mixed Annual Sparse Shrubland (P)

Creosotebush / Mixed Annual Sparse Shrubland

Common species
Larrea tridentata
Atriplex canescens
Atriplex polycarpa
Lycium spp.
Ferocactus wislizenii

This proposed association, found immediately north of the main visitor center complex, is mostly devoid of perennial vegetation. Shrubs are present in limited numbers (<10% cover), often in widely spaced clusters. *Larrea tridentata* is the most common species, but is accompanied by occasional *Atriplex polycarpa*, *Atriplex canescens*, *Lycium* spp., and *Ferocactus wislizenii*. Shrubs generally grow on low mounds of soil retained by their roots against erosive forces. Areas between shrubs may contain annual forbs and/or grasses immediately following seasonal precipitation but consist primarily of bare soil or gravel during all but the wettest periods. Soils are mostly sandy and poorly developed with minimal litter accumulation. The near absence of vegetative cover exposes bare soil to hot summer sun, strong prevailing winds, and surface compaction due to the impact of heavy monsoon rains. Topography is generally flat but contains frequent shallow depressions where evidence exists of sheet flow and water accumulation. Some dense populations of *Verbesina encelioides* are found in these depressions.

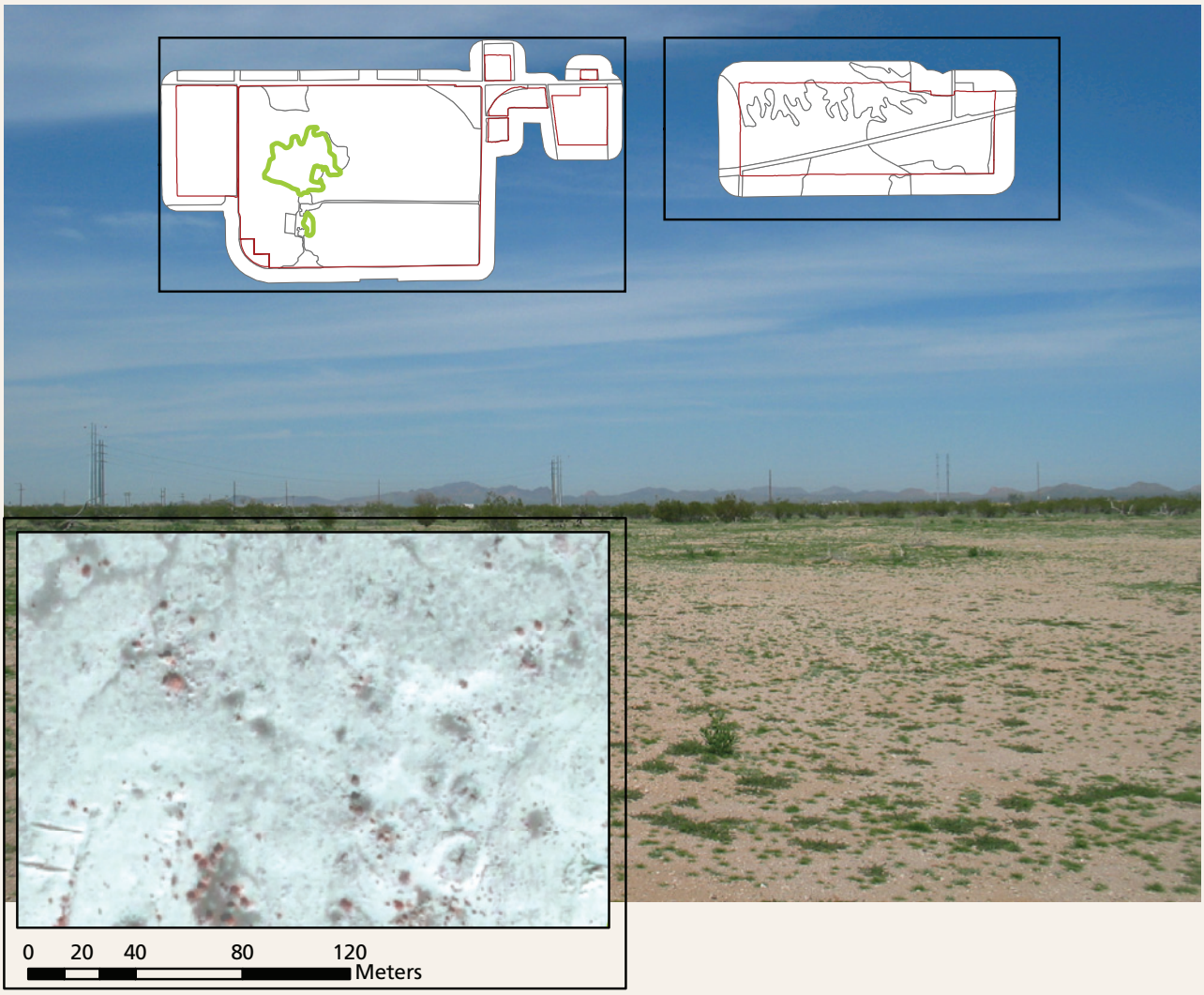


Figure 2.2-9. *Larrea tridentata* / Mixed Annual Sparse Shrubland.

Sphaeralcea ambigua Sparse Shrubland Alliance (P)
Desert globemallow Sparse Shrubland Alliance

Common species
Sphaeralcea ambigua
Larrea tridentata
Ambrosia deltoidea
Baccharis sarothroides
Isocoma pluriflora
Ambrosia dumosa

This proposed alliance is found in the south-central portion of the Adamsville unit, with one half of the polygon surrounding an old cotton-gin site. In the center of the northern part are the concrete remains of the cotton gin, where a single *Prosopis velutina* specimen is found. The remainder of the type is composed of shrubs in limited numbers (<10% cover), predominantly *Sphaeralcea ambigua*, and notable but sparse growth of *Larrea tridentata* throughout. Associated shrub species found here are *Ambrosia deltoidea*, *Baccharis sarothroides*, *Isocoma pluriflora*, and *Ambrosia dumosa*. Shrubs generally grow on low mounds of soil retained by their roots against erosive forces. Areas between shrubs may contain annual forbs and/or grasses immediately following seasonal precipitation but consist primarily of bare soil or gravel during all but the wettest periods.

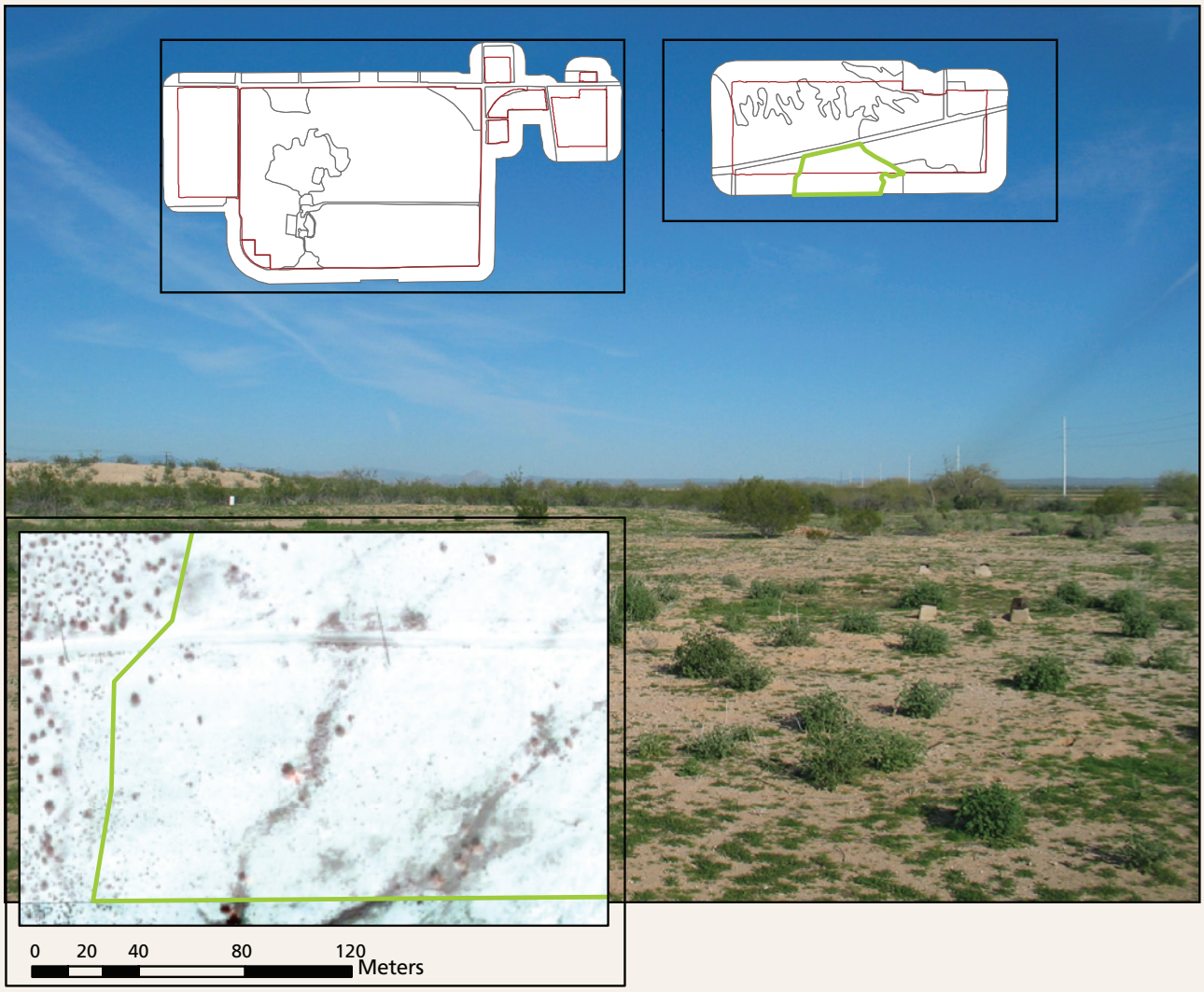


Figure 2.2-10. *Sphaeralcea ambigua* Sparse Shrubland Alliance.

Transitional Areas

Common species
Isocoma pluriflora
Aristida purpurea
Erodium cicutarium
Salsola kali
Brassica tournefortii

Transitional areas are former agricultural lands, having been cultivated at various times in the past. The vegetation and soils on these lands distinctly indicate that they are abandoned agricultural fields. The transitional area category is used here to represent land upon which former activities have ceased but future use has not been determined and, as per Anderson (1976), all that can be determined is that a transition is in progress. The vegetation is dominated by agricultural weeds, and there is little in the way of natural vegetation colonizing these sites, partly because of the lack of native vegetation immediately around them. There are several patches of *Isocoma pluriflora* on three of the sites, as well as rare scatterings of the perennial grass, *Aristida purpurea*. Annual forbs, such as *Erodium cicutarium*, *Salsola kali*, and *Brassica tournefortii*, dominate the sites. Rare on these sites are isolated *Prosopis velutina* and *Baccharis sarothroides* shrubs, as well as *Sphaeralcea ambigua* and *Boerhavia* spp.

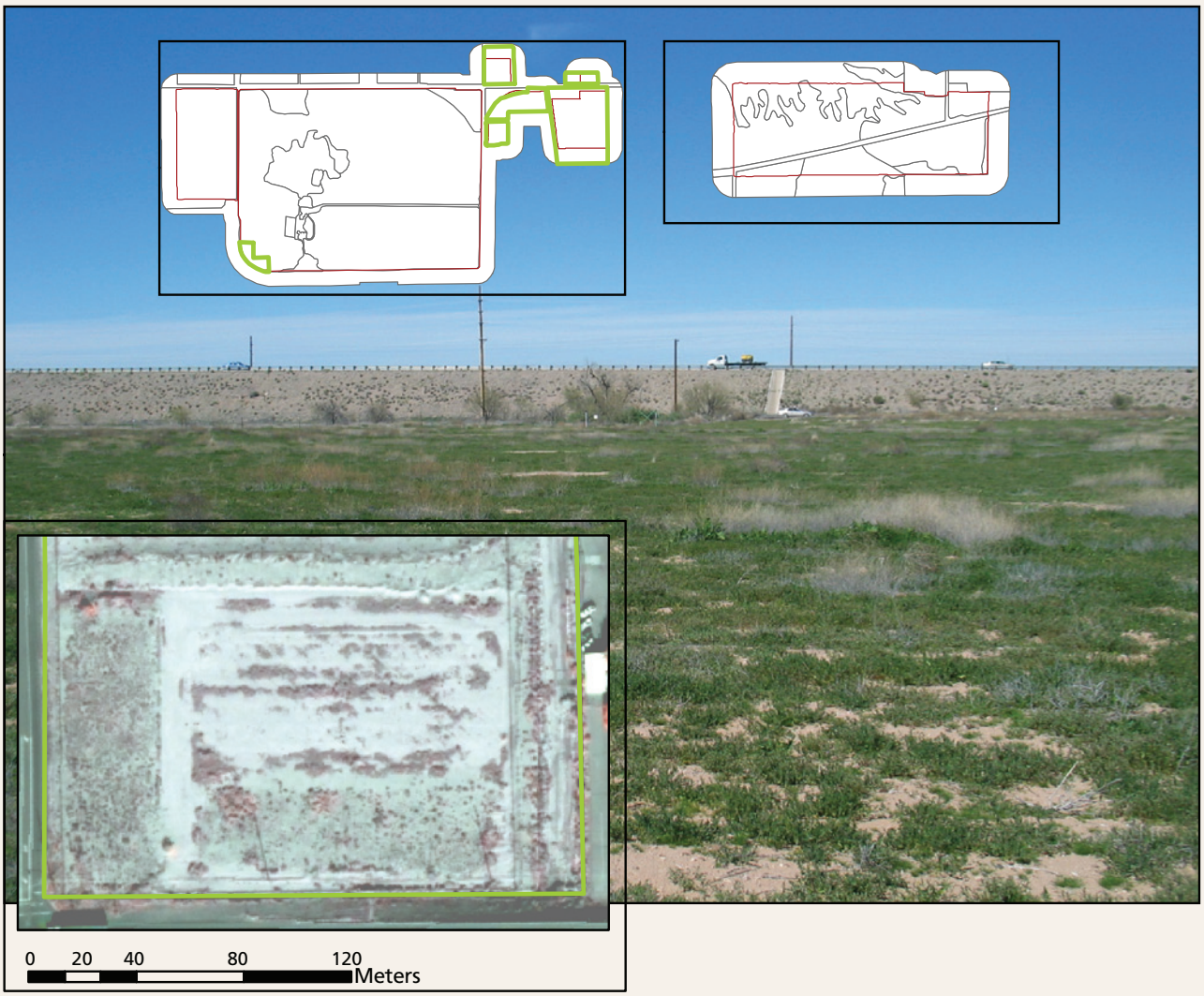


Figure 2.2-11. Transitional Areas.

Agriculture

Common species
Gossypium hirsutum
Medicago sativa

Anderson Level 2 class, applied to active irrigated pasture and cultivated areas. Primary use of this land is crop production; the predominant crops historically have been *Gossypium hirsutum* (upland cotton) and *Medicago sativa* (alfalfa), but these may vary across fields and years.

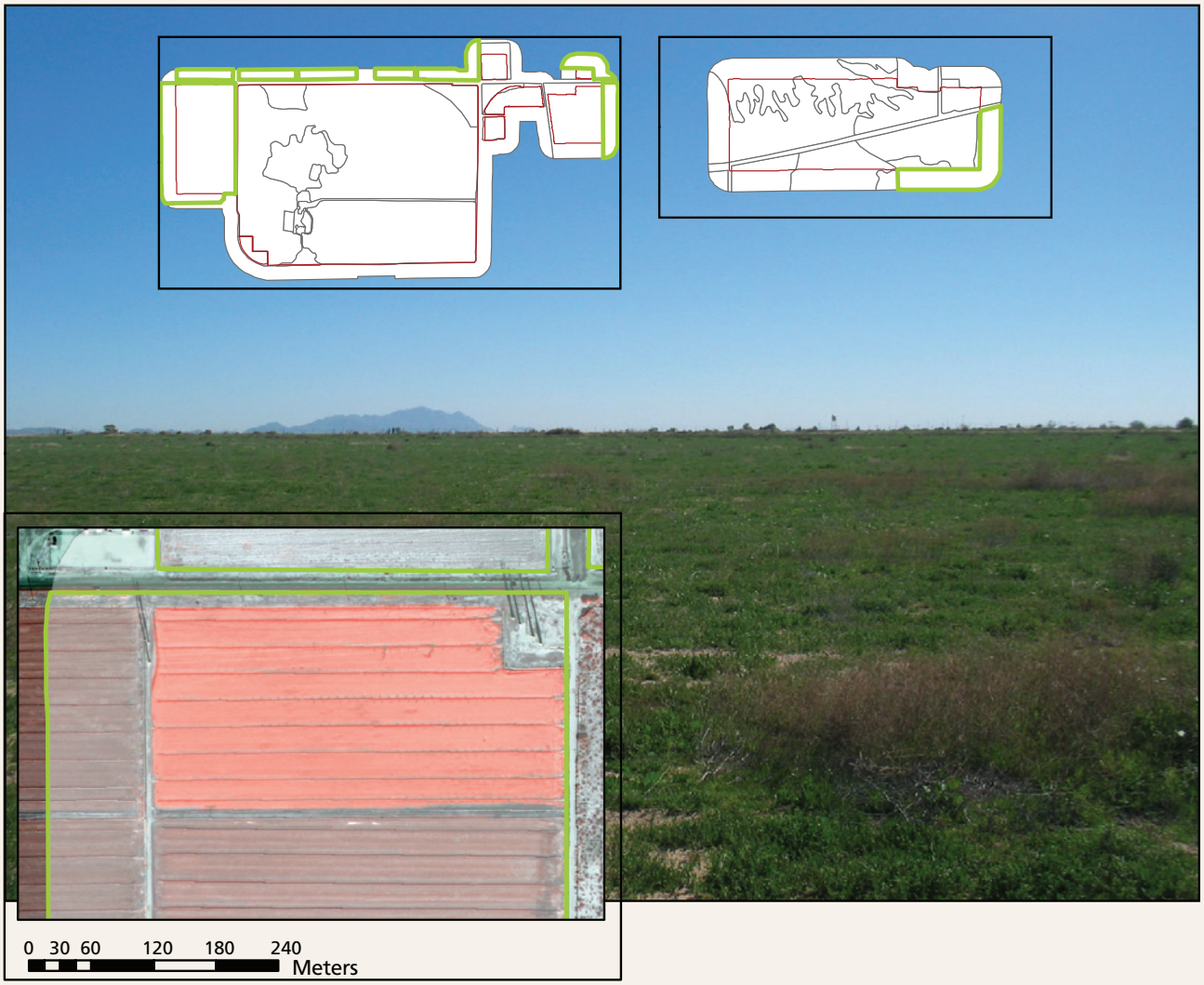


Figure 2.2-12. Agriculture.

Horticulture

One consequence of the development of the visitor center and other buildings at CAGR is an intentionally developed area of horticultural plants surrounding them. This area includes a variety of native trees, such as *Prosopis velutina, Olneya tesota*, *Parkinsonia microphylla*, and *Acacia greggii*; native cacti, such as *Peniocereus greggii, Carnegiea gigantea, Ferocactus wislizenii*, and *Opuntia* spp.; and ocotillo, *Fouquieria splendens*. Additionally, a variety of shrubs are present, including *Larrea tridentata* and *Encelia farinosa*, with a wide variety of herbaceous plants. The area is regularly maintained by monument staff. Also included in this type is a small, landscaped city park northeast of the main unit, in the study-area buffer. Vegetation in this polygon comprises a variety of planted trees and shrubs, with some wild growth of *Baccharis sarothroides*, *Cynodon dactylon, Salsola kali*, and other annual forbs along its edges. Tree species include *Parkinsonia florida, Prosopis velutina, Parkinsonia praecox*, *Chilopsis linearis*, *Olneya tesota*, and *Lysiloma watsonii*. The most dominant shrub by cover is *Leucophyllum frutescens*, with *Fouquieria splendens, Larrea tridentata, Ferocactus wislizenii, Carnegiea gigantea*, and *Agave* spp. also present.

Common species
Prosopis velutina
Olneya tesota
Parkinsonia microphylla
Acacia greggii
Peniocereus greggii
Carnegiea gigantea
Ferocactus wislizenii
Fouquieria splendens
Parkinsonia florida
Chilopsis linearis
Leucophyllum frutescens

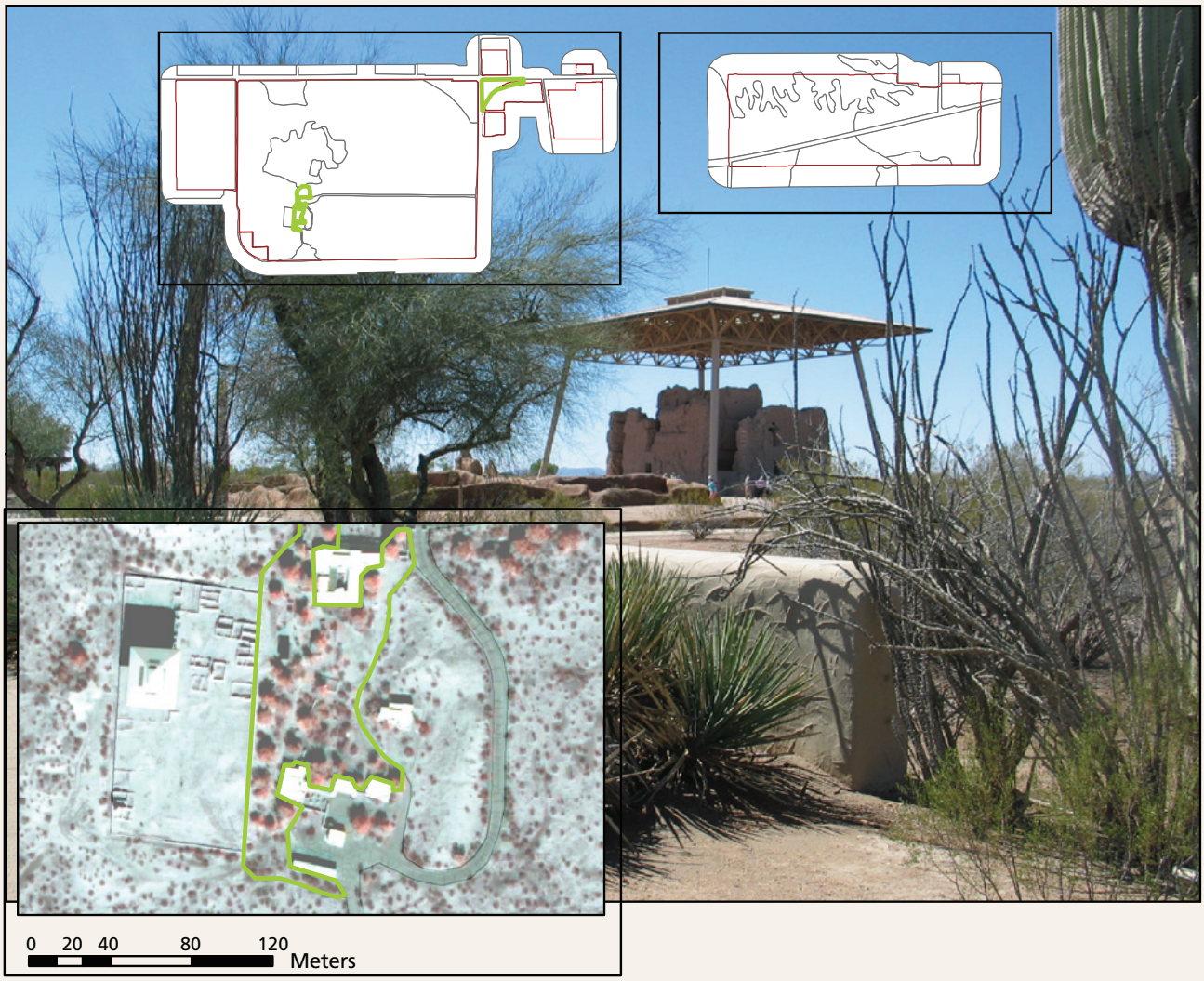


Figure 2.2-13. Horticulture.

2.2.2 Additional areas of interest

A scoping meeting was held at CAGR on October 2, 2007, to discuss proposed project specifics, introduce involved parties, and identify any park-specific mapping activities that could be achieved. CAGR personnel identified several specific areas of interest to the park: (1) the location of barrel cactus (*Ferocactus wislizenii*) individuals; (2) the identification and location of trees in the park; and (3) the incidental location of a variety of other resources, including raptors, snakes, notable archeological features, and other cactus species. Data collection for these subjects was conducted in a non-systematic way, incidental to and in the course of data collection for vegetation classification and mapping. For the *Ferocactus* and tree surveys, an effort was made to achieve comprehensive coverage of the park. The other observations were strictly opportunistic. Results of these surveys are discussed below.*

2.2.2.1 Barrel cactus survey

Barrel cacti (*Ferocactus wislizenii*; Figure 2.2.2.1-1) are easy to see among the widely spaced creosotebush at Casa Grande Ruins NM. On a roughly polygon-by-polygon basis, during the course of vegetation surveying and mapping, the locations of *Ferocactus* individuals were marked as waypoints on a handheld mapping unit with integrated GPS. Each point was attributed with the species name and the relative health of the plant (dead, damaged, or alive). In most cases, this required only minimal extra effort. In large, homogeneous polygons not intensively surveyed for mapping, the field teams made a special effort to rapidly search the whole polygon for *Ferocactus* and record their locations.

In all, 264 live, 96 dead, and 49 damaged barrel cacti were found (Figure 2.2.2.1-2, next page). Live cacti ranged in size from 0.25 to nearly 2 m tall. Unhealthy specimens often had what appeared to be damage from rodents and/or rabbits having chewed around the base of the plant, some with a partially orange-ish coloration and a degree of "deflation." Others had been partially uprooted. Dead cacti ranged from recently dead specimens that exhibited chewing to long-dead specimens with only a few spines remaining.

Figure 2.2.2.1-1. Barrel cactus.

Figure 2.2.2.2-1. Mesquite tree decline.

2.2.2.2 Mesquite tree survey

Park managers also wished to have all live trees within the park's main unit mapped. Outside the horticultural area around the visitor center and other facilities, the trees present are exclusively velvet mesquite (*Prosopis velutina*; Figure 2.2.2.2-1). Past studies, park records, and anecdotal reports, dating to the 1860s, have documented a steady decline in the population of mesquite trees at the park (Clemensen 1992, Reichhardt 1992,

*It was also determined during this meeting that specific soils-characterization data would be useful to the staff for ongoing archeological management activities. These data included nitrogen and calcium carbonate content, electrical conductance, particle size distribution, and soil texture. While most of these soils measures require laboratory analysis and were outside of the bounds of this project, many will be evaluated as part of the long-term vegetation and soils monitoring efforts conducted by the SODN.

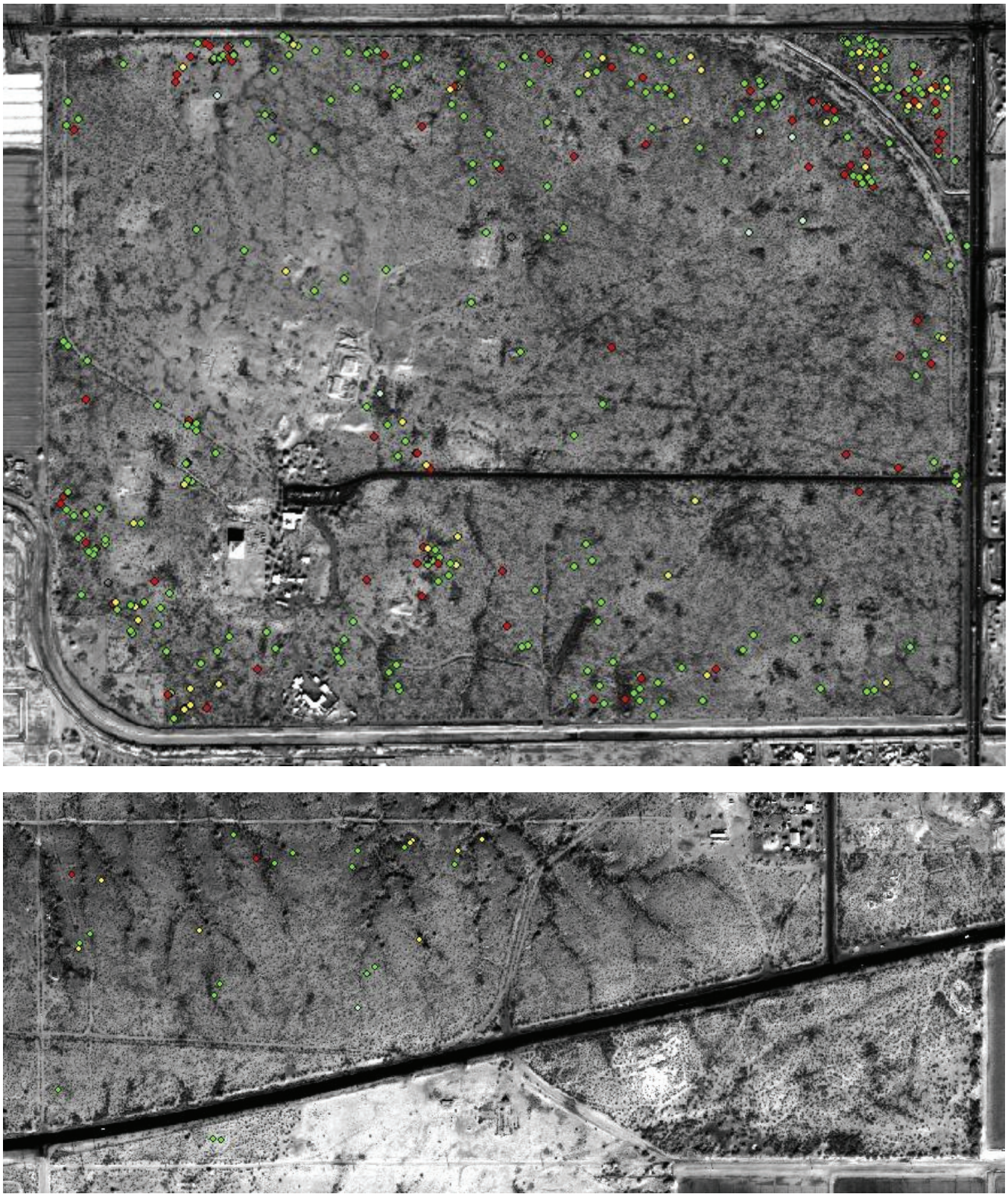


Figure 2.2.2.1-2. Locations of *Ferocactus wislizenii* at Casa Grande Ruins National Monument, March 2008. *Top:* main unit. *Bottom:* Adamsville unit (proposed acquisition). Green dots = live individuals, yellow dots = damaged individuals, red dots = dead individuals.

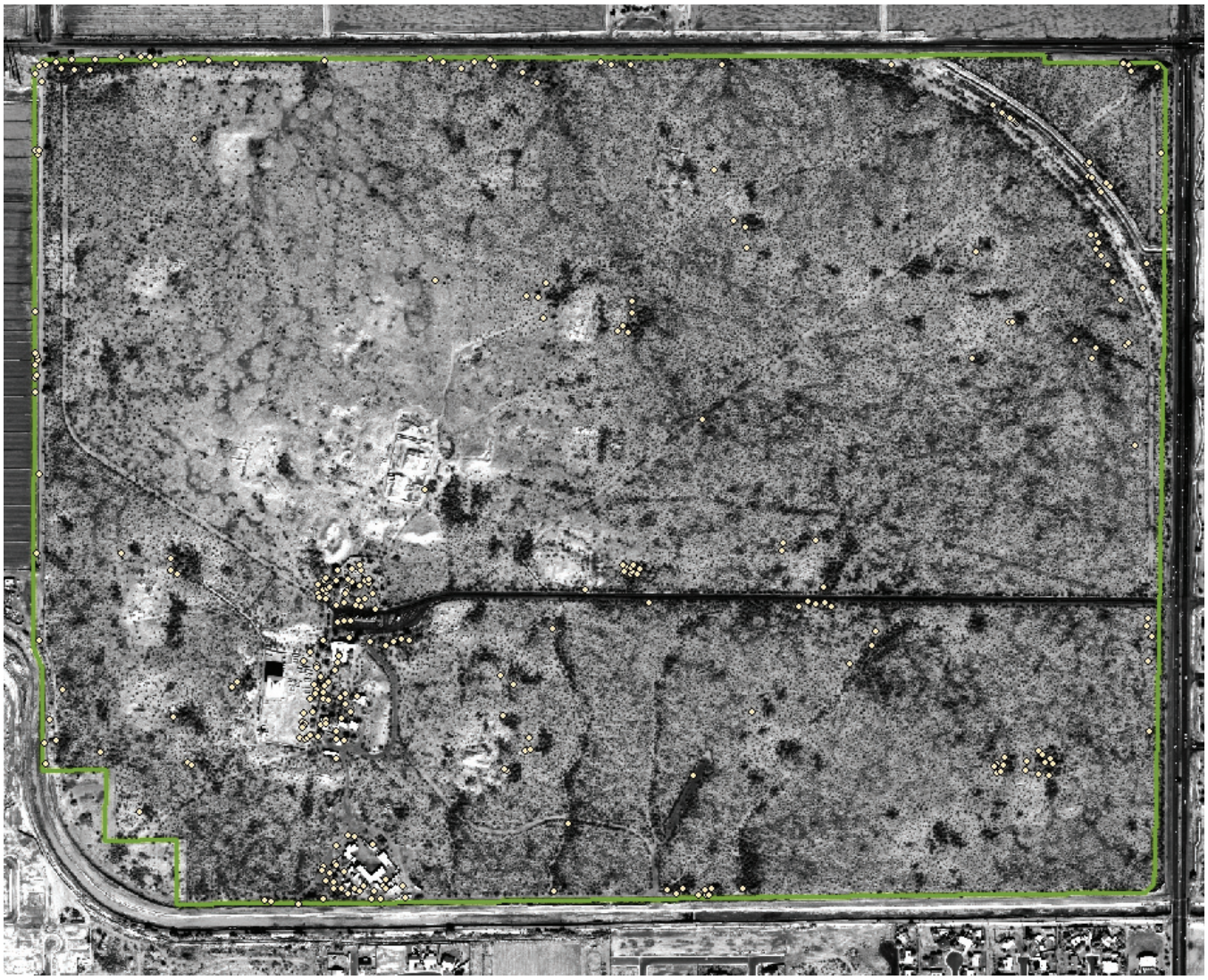


Figure 2.2.2.2-2. Graphic showing locations of all live *Prosopis* spp. (*P. velutina* & *P. glandulosa*) at Casa Grande Ruins National Monument, March 2008.

Judd et al. 1971). Accounts written by early Spanish and Anglo visitors described a sufficient number of large mesquites to hide the Casa Grande structures from view (at an unspecified distance, possibly 50–100 m) (Clemensen 1992). The most rapid period of decline, 1931–present, followed a dramatic, 170-foot drop in the groundwater table between 1902 and 1952 (Judd et al. 1971). In 1936, an infestation of mistletoe (*Phoradendron californicum*, an epiphytic parasite) caused concern among park personnel and may have played a role in tree mortality. Other possible contributing causes included climatic conditions, such as drought, and infestation by insects or diseases. Presently, mesquites are found only sparsely throughout the park, generally in areas where surface runoff collects (especially along the perimeter of the main unit) and as irrigated horticultural specimens near park buildings.

Like the barrel cactus survey described above, the mesquite survey was carried out in a manner that was non-systematic but strived for full areal coverage. Field crews conducted a comprehensive search of the main unit over the course of four days in March 2008 and, during a different mapping effort, three days in 2006. All live individuals were mapped as points and attributed with the species name (see Figure 2.2.2.2-2). Although no standardized measurements or other descriptive data were collected, one observer noted that very few individuals were "seedlings" shorter than approx 1.5 m. A total of 333 individuals were mapped.

2.2.2.3 Opportunistic sightings

Other species of cactus found in the course of our survey included saguaro cactus (*Carnegiea gigantea*), Christmas cactus (*Opuntia leptocaulis*), globe cactus (*Mammillaria* sp.), and hedgehog cactus (*Echinocereus* sp.) Christmas cactus was found in a single location at the Adamsville site, and hedgehog cactus only along the eastern fence of the main unit—apparently, the latter are escaped cultivars. Spatial point files are attributed with appropriate species identification and the health of the cacti.

Only five specimens of saguaro cactus were mapped at the main unit: three near the entrance gate, a single specimen in the southwestern portion of the main unit, and one along the northern boundary. Several specimens were growing in the horticultural area, but these were not mapped. Four more were recorded at the Adamsville site, along the watercourses in the northern portion of the unit.

Other opportunistic sightings were inconsequential. No significant new archeological features or artifacts were noted, and no snakes were sighted (unsurprisingly, for early March). Conversely, raptors (primarily red-tailed hawks, *Buteo jamaicensis*) were commonly seen flying over the monument's remaining patch of open desert. Sightings were frequent and spatially vague.

Chapter 3
Accuracy Assessment

3.1 Methods

Accuracy assessment (AA) procedures followed the guidelines outlined in the "Small Park Alternative Method Guidelines_032508," available from the national program office. These guidelines suggest that a census-style assessment should be done for parks whose total size is less than 300 acres, whereby each minimum mapping unit (MMU) within a map polygon network is surveyed for thematic accuracy.

Prior to AA field work, the final draft of each map was verified for proper attribution and small errors of omission. Alliance and association names that had been applied to map polygons were cross-referenced against those documented in the vegetation type descriptions (Appendix D) and in the field data sheets to ensure that simple transcription errors did not unnecessarily affect the AA results.

Accuracy assessment took place over two days: January 26 and February 5, 2009. On the first day, the assessor ground-verified each polygon on foot and assigned the vegetation type (from a list) that best fit the community at hand. Excellence of fit was noted for each and notes were taken when the fit was either fair or poor, or questions remained as to the alliance type (see example data sheet in Appendix B). These datasheets were subsequently returned to the SODN office, where results were compared between the final map class and the AA data. The second field day consisted of a few hours of work collecting and verifying species identification of several plants within the genus *Lycium*.

3.2 Results

Littleleaf wolfberry (*Lycium exsertum*) was identified as characteristic or dominant on two polygon areas during this project; however, further field examination showed these to be individuals of Fremont's wolfberry (*Lycium fremontii*). Appropriate changes were made to all data sources. Specimens were identified by an expert botanist at the University of Arizona herbarium. Assessments also led to one type change from *Larrea tridentata* / *Sphaeralcea ambigua* Sparse Shrubland to *Sphaeralcea ambigua* Sparse Shrubland. Here, the original mapping crew had underestimated relative abundance of the dominant shrub because they had not surveyed the full polygon area (having only mapped to the unit boundary rather than the buffer boundary). Both plots measured in this type seem unrepresentative of the whole, perhaps because they were both located in highly disturbed zones on the periphery of the type. Therefore, confidence was taken from the censused field data of the polygon and the agreement from the accuracy assessment.

All other types (32 of 33 polygons) were assessed to be good-to-excellent fits. Overall accuracy for both large units and small parcels combined was 96%.

3.3 Spatial Accuracy Assessment

The U.S. National Map Accuracy Standards (NMAS) for spatial or positional accuracy, in use since 1947, stipulate that no more than 10% of tested points on a 1:24,000-scale map can be in error by more than 0.02 inch (0.51 millimeter), or 40 feet (12.2 m) ground distance. The revised National Cartographic Standards for Spatial Accuracy state accuracy as a standard error (RMSE) in the x- and y-coordinate directions, rather than as a circular error with a 90% confidence level (as is indirectly implied by the NMAS of 1947). For a Class 1 product of 1:24,000 scale, the maximum allowable RMSE is 6.0 meters (20 feet) ground distance; for a Class 2 product, the RMSE must be no more than 12.0 meters (39 feet). For digital products with no set scale, the reference to a 1:24,000 standard scale loses some relevance, but the implied ground distances can still be used as benchmarks.

The positional accuracy being measured is that of "well-defined points" on the map; that is, discrete features that can be clearly identified and located in the map product as well as the source of higher accuracy used for comparison (i.e., the reference data). Boundaries subject to interpretive judgment or certain natural boundaries subject to environmental fluctuations (e.g., river

banks) generally do not qualify as well-defined points, even if they form intersections. Because vegetation boundaries are nearly always interpretive, positional accuracy statements for the CAGR vegetation map do not directly apply to the primary mapped features in the product, but instead should be understood to indicate how well the map product is registered (geocoded) to its control, and not to indicate how well the vegetation polygon boundaries reflect their true positions on the ground (ESRI et al. 1994).

For this project, the highest-accuracy spatial reference data available were a set of DOQQs from 2005; our spatial accuracy measurements were done in comparison with these. Both units at CAGR (main unit and Adamsville) were contained in one continuous swath of Quickbird imagery, and this single piece of imagery was assessed as a whole for spatial accuracy. A total of 20 test points were used, distributed across both units of the park. The test points selected were small, discrete features that could be definitively located in both the base satellite imagery used for mapping and in the DOQQs. Most of these were individual shrub canopies against a contrasting background. The georeferencing tool in ArcGIS was used to visually select point pairs (one in the imagery and a corresponding one in the DOQQ), record coordinates, and calculate an overall RMS error (Appendix E). MS Excel was used to calculate additional error values (Table 3.3) from the point coordinates.

As shown in Table 3.3, the CAGR vegetation map easily meets the spatial accuracy standards. Features are estimated to lie within three meters—generally much less—of their "true" position on the DOQQ reference imagery. None of the test points approached the 12 m error allowable (for 10% of tested points) under the NMAS, and the maximum measured RMS error of 0.90 meters is well below the 6.0-meter limit imposed by the National Cartographic Standards for a Class 1 product.

Table 3.3. Spatial accuracy assessment summary for the single piece of imagery containing both the main unit and the Adamsville unit at Casa Grande Ruins National Monument.

	Absolute error		RMS Error		
	Max-X	Max-Y	RMS-X	RMS-Y	RMS-All
CAGR	1.54	-2.78	0.66	0.90	0.60

RMS = root mean square. Values are in meters, ground distance. A total of 20 test points were used.

Chapter 4
Discussion

This project benefited from concurrent classification and mapping efforts due to the small size of the project area and relatively homogeneous vegetation communities. Field-mapping crews were able to collect association-level data (all associates) in all polygons mapped. This data will be available to the parks within the database even though some of the map classes reflect alliance-level data. It is hoped that CAGR managers will use this mapping product in management and planning efforts, especially any related to conservation or rehabilitation of vegetation types.

Of all the community types described at Casa Grande Ruins NM, two had corresponding alliance types recognized by NatureServe, and one had a corresponding association (see Table 4, next page). For these, both local (CAGR-specific) and global (regional) descriptions are provided (Appendix D).

NatureServe develops global descriptions by incorporating multiple data sets over a broad geographic range. Where data are lacking or limited, either the classification confidence will be lower or a given alliance or association will not yet have been described. None of the other six proposed types at CAGR has a global alliance-or association-level description and code within the current NatureServe explorer database (Table 4). As more data are collected and submitted, some of the currently undescribed alliances listed in this report may become available, and this report and associated spatial data files can be updated.

Table 4. Vegetation map type crosswalk to NatureServe codes.

Alliance name	NS CES code	NS alliance code	NS CEGL code
Woodland			
Prosopis velutina / *Larrea tridentata* Woodland Alliance (P)			
Prosopis velutina Woodland Alliance	CES302.752	A.661	
Wooded Shrubland			
Parkinsonia microphylla / *Larrea tridentata* Wooded Shrubland (P)			
Shrubland			
Larrea tridentata-(Ambrosia deltoidea - Krameria erecta) Shrubland (P)			
Larrea tridentata - Lycium fremontii Shrubland Alliance (P)			
Larrea tridentata Shrubland Alliance *Larrea tridentata* Monotype Shrubland	CES302.756	A.851	CEGL001261
Sparse Shrubland			
Larrea tridentata / Mixed Annual Sparse Shrubland (P)			
Sphaeralcea ambigua Sparse Shrubland Alliance			
Anderson Land Use Classes			
Transitional areas		Anderson Level 2	
Agriculture		Anderson Level 2	
Horticulture		Anderson Level 2	
Non-Vegetated		Anderson Level 2	
Park Facilites		Anderson Level 2	
Transportation		Anderson Level 2	
Mixed Urban or Built-up Land		Anderson Level 2	

NS = NatureServe
CES = NS ecological system
CEGL = NS association

Chapter 5
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Appendix A
Vegetation Formation Key

1. What is the dominant surface cover?

Trees .....go to **2**
Shrubs.....go to **3**
Herbaceous .....go to **4**
Non-vascular .....go to **5**
Rock/Bare Soil .....go to 6

2. Trees

A. Tree Cover >60%?
YES = Forest
NO = Woodland

3. Shrubs

A. Tree Cover >10%?
YES = Wooded Shrubland
NO = Shrubland

4. Herbaceous

A. Tree cover <10% **AND** Shrub cover <10%?
YES = Herbaceous
NO = go to B.

B. Tree cover > Shrub cover?
YES = Wooded Herbaceous
NO = Shrub Herbaceous

5. Non-vascular

A. Vascular plant cover <10%?
YES = Non-vascular vegetation
NO = go to B.
B. Add a qualifier from **2, 3,** or **4** (e.g., Shrub Non-vascular Vegetation)

6. Rock/Bare Soil

A. Is the total vegetation cover <1%?
YES = Non-Vegetated
NO = go to B.
B. Is the total vegetation cover <10%?
YES = Sparse Vegetation
NO = go to C.
C. Determine dominant vegetation lifeform and go to **2**, **3, 4,** or **5**.

Appendix B
Field Data Sheets

Casa Grande Ruins NM Vegetation Mapping

Field Data Sheet: **Thematic Accuracy Assessment**

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

Keyed Formation:

Dominant Formation-defining species:

Trees Shrubs Herbaceous Other/None

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

	Prosopis velutina woodland
	Prosopis velutina / *Larrea tridentata* Woodland
	Parkinsonia microphylla / *Larrea tridentata* WS

	Larrea tridentata Shrubland
	Larrea tridentata sparse Shrubland
	Larrea tridentata / *Sphaeralcea ambigua* sparse Shrubland
	Larrea tridentata- *Lycium exsertum* Shrubland
	Larrea tri [*Ambrosia deltoidea* -*Krameria grayi* Shrubland

	Horticulture
	Developed Woodland
	Cropland and Pasture
	Park Facilities

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

Excellent Good Fair Poor

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

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

CAGR_AA_Datasheet.ppt

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

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Inventory and Monitoring Program

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Page ____ of ____

USGS-NPS Vegetation Mapping Program Field Data Sheet: **Intermediate Plot Soil/Landscape** Version: 0.00

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

Location and Event Information

Park:	Sub-Map #:	Date (mm/dd/yyyy):	Time (00:00):
Poly ID(s):		Field Poly ID:	Plot ID:
Observer(s):	Recorder:	Tentative Formation:	Keyed Formation:
UTM NAD83:		Protocol Name: VegMap	Protocol Version: 0.04

Soil/Landscape Parameters

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

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

Area Surface Cover (circle one class per feature)

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

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

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

Erosion Features (circle one class per feature)

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

Aspect (circle all that apply)

N NW W SW S SE E NE

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

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

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Inventory and Monitoring Program

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U.S. Department of the Interior

Page ____ of ____

USGS-NPS Vegetation Mapping Program Field Data Sheet: **Intermediate Plot Vegetation** Version: 0.00

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

Park:	Sub-Map #:		Date (mm/dd/yyyy):	Time (00:00):	
Poly ID(s):			Field Poly ID:	Plot ID:	
Observer(s):	Recorder:	Tentative Formation:		Keyed Formation:	
UTM NAD83:		20m Bearing:	50m Bearing:	Protocol Name: VegMap	Protocol Version: 0.04

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

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

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

Disturbance Types

Camera Name & Photo Number(s):

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

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

Basal Diameter and Pole Count for Tree Species

Species	Basal Diameter(s) over 10 cm	Pole/Stem Count

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

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

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Page ____ of ____

USGS-NPS Vegetation Mapping Program Field Data Sheet: **Polygon Soil/Landscape** Version: 0.04

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

Location and Event Information

Park:	Sub-Map #:	Date (mm/dd/yyyy):	Time (00:00):
Poly ID(s):		Field Poly ID:	
Observer(s):	Recorder:	Tentative Formation:	Keyed Formation:
Protocol Name: VegMap		Protocol Version: 0.04	

Soil/Landscape Parameters

(X)	Topographic Position (X all that apply)
	Crest/summit
	Upper slope
	Midslope
	Footslope
	Toeslope
	High flat
	Low flat
	Basin floor
	Channel bed/ gully
	Other:

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

Area Surface Cover (circle one class per feature)

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

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

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

Erosion Features (circle one class per feature)

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

Aspect (circle all that apply)

N NW W SW S SE E NE

Polygon_Soil_Landscape_Datasheet_v004.ppt

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

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

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

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

Location and Event Information

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

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

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

Canopy >5m	LF	R	C	H	Canopy 2 – 5m	LF	R	C	H	Sub-canopy 0.5 – 2m	LF	R	C	Field 0 – 0.5m	R	C
Total cover all species					Total cover all sp					Total cover all sp				Total cover all sp		

List other common associates

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

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

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

Disturbance Types:

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

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

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

Camera Name:
North
East
South
West

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

Appendix C
Plant Species List

All plant species documented within project area during 2008 Casa Grande Ruins National Monument vegetation mapping field work.

Family	Scientific name	Common name
Asteraceae	*Ambrosia deltoidea*	triangle bur ragweed
Asteraceae	*Ambrosia dumosa*	burrobush
Asteraceae	*Baccharis sarothroides*	desertbroom
Asteraceae	*Isocoma acradenia*	alkali goldenbush
Asteraceae	*Isocoma pluriflora*	southern goldenbush
Asteraceae	*Verbesina encelioides*	golden crownbeard
Cactaceae	*Carnegia gigantea*	saguaro cactus
Cactaceae	*Echinocereus* sp.	hedgehog cactus
Cactaceae	*Ferocactus wislizenii*	barrel cactus
Cactaceae	*Mammillaria* sp.	globe cactus
Cactaceae	*Opuntia leptocaulis*	Christmas cactus
Chenopodiaceae	*Atriplex canescens*	fourwing saltbush
Chenopodiaceae	*Atriplex polycarpa*	cattle saltbush
Chenopodiaceae	*Monolepis nuttalliana*	Nuttall's povertyweed
Ephedraceae	*Ephedra trifurca*	longleaf jointfir
Fabaceae	*Acacia constricta*	whitethorn acacia
Fabaceae	*Acacia greggii*	catclaw acacia
Fabaceae	*Astragalus didymocarpus*	dwarf white milkvetch
Fabaceae	*Lupinus sparsiflorus*	Mojave lupine
Fabaceae	*Olneya tesota*	ironwood
Fabaceae	*Parkinsonia microphylla*	foothills paloverde
Fabaceae	*Prosopis velutina*	velvet mesquite
Geraniaceae	*Erodium cicutarium*	redstem stork's bill
Krameriaceae	*Krameria erecta*	littleleaf ratany
Malvaceae	*Malva neglecta*	common mallow
Malvaceae	*Sphaeralcea* sp.	globemallow
Malvaceae	*Sphaeralcea ambigua*	desert globemallow
Nyctaginaceae	*Boerhavia* sp.	boerhavia
Poaceae	*Aristida purpurea*	purple threeawn
Poaceae	*Schismus arabicus*	Arabian schismus
Rhamnaceae	*Ziziphus obtusifolia*	lotebush
Solanaceae	*Lycium andersonii*	Anderson's wolfberry
Solanaceae	*Lycium exsertum*	Arizona desert-thorn
Solanaceae	*Lycium fremontii*	Fremont's wolfberry
Zygophyllaceae	*Larrea tridentata*	creosotebush

Taxonomic names follow the PLANTS Database (http://plants.usda.gov, 16 Septemebr 2009). National Plant Data Center, Baton, Rouge, LA 70874.

Appendix D
Vegetation Type Descriptions

This appendix includes information on the vegetation type descriptions identified for Casa Grande Ruins NM. All information not identified as specific to CAGR was collected from NatureServe Explorer (http://www.natureserve.org/explorer) accessed Winter 2008–Spring 2009.

Woodland
Prosopis velutina / *Larrea tridentata* Woodland Alliance (P)
Prosopis velutina Woodland Alliance
Wooded Shrubland
Parkinsonia microphylla / *Larrea tridentata* Wooded Shrubland (P)
Shrubland
Larrea tridentata - [*Ambrosia deltoidea* - *Krameria erecta*] Shrubland (P)
Larrea tridentata - *Lycium fremontii* Shrubland Alliance (P)
Larrea tridentata Shrubland Alliance
Larrea tridentata Monotype Shrubland
Sparse Shrubland
Larrea tridentata / Mixed Annual Sparse Shrubland (P)
Sphaeralcea ambigua Sparse Shrubland Alliance (P)
Anderson Land Use Classes
Transitional Areas
Agriculture
Horticulture
Non-vegetated
Park Facilites
Transportation
Mixed Urban or Built-up Land

P = proposed

D.1 Woodland

D.1.1 Prosopis velutina / Larrea tridentata Woodland Alliance (proposed)

Translated name: Velvet mesquite / Creosotebush Woodland Alliance
NatureServe code: Data not available.

Summary

Globally—Data not available.
Casa Grande Ruins NM—This proposed alliance exists along two agricultural fencelines to the south and east of the large mound and ball court at the Adamsville site. These fencelines contain earthen berms formed by road-building and maintenance to support adjacent agricultural operations. These berms capture and concentrate runoff, allowing it to saturate the soil. The moist conditions, perhaps augmented by infiltration of irrigation water from south and east of the fence, result in growth of *Prosopis velutina* up to 7 m tall and *Larrea tridentata* up to 3.5 m. Herbaceous annuals representative of the adjacent uplands thrive here, contributing more litter than is typical in adjacent uplands. This alliance resembles a portion of the *Larrea tridentata* shrubland along the boundary of the main unit, where runoff from adjacent roads permits similar concentrations of larger *P. velutina*.

Classification

Classification confidence: Data not available.
Classification comments: Globally—Data not available.
Casa Grande Ruins NM—This alliance is based on field data collected in 2008 from one censused polygon and one classification plot : IP-NEW-1A.

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II. B	Deciduous woodland
Formation group	II.B.3	Extremely xeromorphic deciduous woodland
Formation subgroup	II.B.3.N	Natural/Semi-natural extremely xeromorphic deciduous woodland
Formation name	II.B.3.N.a	Thorn extremely xeromorphic deciduous woodland
Alliance name	*Prosopis velutina / Larrea tridentata* Woodland Alliance	

NatureServe conservation status

Global status: Data not available.
Rounded global status: Data not available.

Distribution

Globally—Data not available.
Casa Grande Ruins NM—This alliance exists along two agricultural fencelines to the south and east of the large mound and ball court at the Adamsville site. It is found in two polygons: W-PVLT01-C-A (1.21 ha) and W-PVLT02-C-A (0.5 ha).

Environmental setting

USFWS Wetland System: No

Environmental summary

Globally—Data not available.
Casa Grande Ruins NM—This alliance exists along two agricultural fencelines to the south

and east of the large mound and ball court at the Adamsville site. These fencelines contain earthen berms formed by road-building and maintenance to support adjacent agricultural operations. These berms capture and concentrate runoff, allowing it to saturate the soil. Soils are sandy, as in other locations, but the presence of the road immediately adjacent to the south clearly affects the movement of water off the site. Cracked silty soils indicate pooling from runoff.

Vegetation

Globally—Data not available.
Casa Grande Ruins NM—The moist conditions, perhaps augmented by infiltration of irrigation water from south and east of the fence, result in growth of *Prosopis velutina* up to 7 m tall and *Larrea tridentata* up to 3.5 m. Herbaceous annuals representative of the adjacent uplands thrive here, contributing more litter than is typical in adjacent uplands. This alliance resembles a portion of the *Larrea tridentata* shrubland along the boundary of the main unit, where runoff from adjacent roads permits similar concentrations of larger *P. velutina*.

Most abundant species

Globally—Data not available.
Casa Grande Ruins NM—

Stratum	Species
Top canopy	*Prosopis velutina*
Canopy	*Prosopis velutina*, *Larrea tridentata*
Sub-canopy	*Larrea tridentata*
Field	Annual forbs, annual grasses

Other noteworthy species

Globally—Data not available.
Casa Grande Ruins NM—Data not available.

Element sources

Global description authors: Data not available.
Local description authors: J. Greene, S. Buckley, and S. Drake
References: Data not available.

D.1.2 Prosopis velutina Woodland Alliance

Translated name: Velvet mesquite Woodland Alliance
NatureServe code: **A.661**

Summary

Globally—This alliance occurs in southern California, Arizona, and possibly southwestern New Mexico and adjacent Mexico, on a variety of sites. Sites include mesic areas, such as floodplains, streambanks, intermittently flooded arroyo terraces, alkali sinks, and washes, and extends into the upland on dry terraces above streams and arroyos. Substrates are generally coarse-textured, gravelly alluvium. *Prosopis* spp. trees extract groundwater with extensive root systems, but grow best where water tables are shallow, such as along drainages. Woodlands included in this alliance are characterized by a moderate-to-dense, tall, woody canopy dominated by *Prosopis glandulosa* and/or *Prosopis velutina*. The diversity of other species can vary greatly with geography and substrate. The dominant understory shrubs are often species of *Atriplex*, but may include many other species. Succulents may include several species of *Opuntia* and *Yucca*. The herbaceous layer varies from moderately dense to nearly absent. Characteristic perennial grasses may include *Aristida* spp., *Bouteloua* spp., *Buchloe dactyloides*, *Pleuraphis mutica* (= *Hilaria mutica*), *Muhlenbergia porteri*, and *Sporobolus* spp. Sparse annual grasses may also be present. Forb cover is sparse, but can be relatively diverse. Common forbs may include species of *Amaranthus*, *Chenopodium*, *Croton*, *Eriogonum*, *Euphorbia*, *Solanum*, and *Zinnia*. Diagnostic of this woodland alliance is the dominance of tree-sized *Prosopis glandulosa* or *Prosopis velutina* in the upper canopy.

Casa Grande Ruins NM—This alliance exists only in a small patch within the 100-m study-area buffer on the south side of the Adamsville unit, but extends south and southwest well beyond the buffer. The dominant feature is a cohort of young, regenerating *Prosopis velutina* trees that are benefiting from runoff entering from the northeast. The runoff has two sources: excess irrigation water from agricultural fields east of the patch and precipitation runoff from the large Adamsville ruin mound to the north. The runoff flows southwesterly, slowing down and spreading out to form a wide, shallow swale. Vegetation follows a coincident pattern, with the largest and densest growth concentrated in the northeast and gradually diminishing as it follows the swale. Associated shrubs include *Isocoma pluriflora* and *Atriplex canescens*. *Aristida purpurea* is prominent in this type but is rare in the remainder of the monument. Herbaceous diversity, percent cover, and biomass are significantly higher here and include several species not found elsewhere in the monument, including *Amaranthus palmeri*, *Boerhavia coccinea*, and *Ambrosia confertifolia*. Soils are primarily silty, especially where water pools, and contain much more litter than adjacent uplands, but lack humus development.

Classification

Classification confidence: Data not available.
Classification comments: Globally—Classification of *Prosopis glandulosa*- and *Prosopis velutina*-dominated stands needs clarification. Because *Prosopis glandulosa* and *Prosopis velutina* can have both shrub and tree growth forms, there may be confusion when classifying a given stand, for example, when trying to identify which characteristic separates a *Prosopis glandulosa* or *Prosopis velutina* arroyo riparian shrubland from a *Prosopis glandulosa* and/or *Prosopis velutina* "bosque" or riparian woodland. Riparian shrublands can mature into woodlands if given time and adequate water resources. Currently, this alliance has only one proposed association from California and Arizona, with possible occurrences in New Mexico and Baja California and Sonora, Mexico. There are several references to *Prosopis* (*glandulosa*, *velutina*) riparian woodland/forests from sub-Mogollon Arizona, such as Minckley and Clark (1981, 1984) and Szaro (1989). Warren et al. (1981) describe *Prosopis glandulosa* riparian woodlands from southwestern Arizona that could be included in the proposed association within *Prosopis* (*glandulosa*, *velutina*) Woodland Alliance (A.661). Another proposed association may need to be created for the *Prosopis glandulosa* woodlands occurring in the San Joaquin Valley

in California. Some arroyo riparian stands in Arizona are similar to stands in the *Parkinsonia florida - Olneya tesota* Woodland Alliance (A.588) in terms of species composition and must be separated mainly by dominance. The taxonomy of *Prosopis* may further complicate the classification. *Prosopis velutina* is restricted to California, Arizona, and New Mexico. Szaro (1989) described a *Prosopis velutina* riparian community type (shrublands and woodlands) from southwestern New Mexico to western Arizona. In addition, *Prosopis glandulosa* var. *torreyana* and *Prosopis velutina* are known to intergrade where ranges overlap in southern Arizona (Kearney and Pebbles 1969). See Benson and Darrow (1981) for more discussion.

Casa Grande Ruins NM—This alliance is based on field data collected from a censused polygon in 2008. The alliance existed entirely within the 100-m buffer found outside the park boundary; thus, there was no plot assigned to the polygon.

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.B	Deciduous woodland
Formation group	II.B.3	Extremely xeromorphic deciduous woodland
Formation subgroup	II.B.3.N	Natural/Semi-natural extremely xeromorphic deciduous woodland
Formation name	II.B.3.N.a	Thorn extremely xeromorphic deciduous woodland
Alliance name	*Prosopis* (*glandulosa*, *velutina*) Woodland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES302.752	North American Warm Desert Riparian Mesquite Bosque

NatureServe conservation status

Global status: Data not available.
Rounded global status: Data not available.

Distribution

Globally—Woodlands included in this alliance occur along drainages in southern California, Arizona, and possibly in southwestern New Mexico, and the Mexican states of Baja California, Sonora, and Chihuahua.
Casa Grande Ruins NM—This alliance exists only in a small patch within the 100-m study-area buffer on the south side of the Adamsville unit, but extends south and southwest well beyond the buffer. The alliance is found nowhere else in the unit in similar form. Polygon: W-PV01-C-A (0.9 ha).

Environmental setting

USFWS Wetland System: No

Environmental summary

Globally—Woodlands included in this alliance occur in southern California, Arizona, and possibly southwestern New Mexico and adjacent Mexico. Elevations range from sea level to 1,200 m. Climate is arid to semi-arid. Amount and season of precipitation varies with geography. Mean annual precipitation ranges from 23 cm distributed bimodally with about half occurring during the late summer monsoons and half in the winter in southwestern New Mexico, to approximately 15 cm of mostly winter precipitation in southeastern California. This vegetation occurs on a variety of sites. Mesic sites include floodplains, streambanks, intermittently flooded arroyo terraces, alkali sinks, and washes. Sites are generally flat or gently sloping on any aspect. Parent material is usually sandy or gravelly alluvium. Substrates are

generally coarse-textured, but may include gravelly silty loams. Some soils are moderately saline. *Prosopis* spp. trees extract groundwater with extensive root systems, but grow best where water tables are shallow, such as along drainages. These woodlands may grade into upland grasslands dominated by species of *Bouteloua*, *Sporobolus*, or *Hilaria*, or be surrounded by a matrix of desertscrub dominated by *Larrea tridentata* or *Ambrosia* spp. In the San Joaquin Valley, Holland (1986) described sites occurring on sandy loams with high water tables; hot, dry summers; and foggy winters. The water table is fed from Sierran snowmelt. *Prosopis* and other shrubs have extensive root systems that allow them to exploit deep soil water that is unavailable to shallower rooted grasses and cacti (Burgess 1995). This strategy works well except on sites that have well-developed argillic or calcic soil horizons that limit infiltration and storage of winter moisture in the deeper soil layers (McAuliffe 1995). McAuliffe (1995) found *Prosopis* spp. invasion on these sites limited to a few, small individuals. This has implications in plant geography and grassland revegetation work in the southwestern U.S.

Casa Grande Ruins NM—This alliance exists only in a small patch within the 100-m study-area buffer on the south side of the Adamsville unit, but extends south and southwest well beyond the buffer. Soils are primarily silty, especially where water pools, and contain much more litter than adjacent uplands, but lack humus development.

Vegetation

Globally—Woodlands included in this alliance occur primarily along drainages in southern California and possibly southwestern New Mexico, Arizona, and adjacent Mexico. Stands have moderate-to-dense cover dominated by the xeromorphic deciduous shrubs, *Prosopis glandulosa* and/or *Prosopis velutina*. The diversity of other species can vary greatly with geography and substrate. The dominant understory shrubs are often species of *Atriplex*, but may include *Acacia greggii*, *Acacia constricta*, *Ambrosia* spp., *Artemisia filifolia*, *Baccharis* spp., *Chilopsis linearis*, *Ericameria laricifolia*, *Gutierrezia sarothrae*, *Larrea tridentata*, *Lycium* spp., *Parkinsonia* spp., *Olneya tesota*, and *Ziziphus obtusifolia*. Succulents may include *Opuntia acanthocarpa*, *Opuntia leptocaulis*, *Opuntia imbricata*, *Opuntia phaeacantha*, *Yucca baccata*, and *Yucca elata*. The herbaceous layer can be moderately dense to insignificant, depending on geography, substrate, land-use history. Annual precipitation the herbaceous layer can be moderately dense-to-insignificant. Characteristic perennial grasses may include *Aristida* spp., *Bouteloua curtipendula*, *Bouteloua eriopoda*, *Bouteloua gracilis*, *Buchloe dactyloides*, *Pleuraphis mutica* (= *Hilaria mutica*), *Muhlenbergia porteri*, *Sporobolus flexuosus*, and *Sporobolus wrightii*. Sparse annual grasses may include *Aristida adscensionis*, *Bouteloua barbata*, and *Dasyochloa pulchella* (= *Erioneuron pulchellum*). Forb cover is also sparse, but it can be relatively diverse. Common forbs may include species of *Amaranthus*, *Chenopodium*, *Croton*, *Eriogonum*, *Euphorbia*, *Solanum*, and *Zinnia*. In more saline areas, shrubs are more sparse and grasses and forbs are more common, including *Sporobolus airoides*, *Distichlis spicata*, and *Sesuvium verrucosum*. Holland (1986) described open *Prosopis glandulosa* woodlands in the San Joaquin Valley in southern California, that have a shrub layer dominated by *Atriplex polycarpa* with *Isocoma acradenia* var. *bracteosa*. The herbaceous layer is sparse, except during wet years, when annual cover, dominated by the exotic grass *Bromus rubens*, is abundant. Perennial plant cover is sparse.

Casa Grande Ruins NM—The dominant feature of the vegetation is a cohort of young, regenerating *Prosopis velutina* trees that are benefiting from runoff entering from the northeast. The runoff has two sources: excess irrigation water from agricultural fields east of the patch and precipitation runoff from the large Adamsville ruin mound to the north. The runoff flows southwesterly, slowing down and spreading out to form a wide, shallow swale. Vegetation follows a coincident pattern, with the largest and densest growth concentrated in the northeast and gradually diminishing as it follows the swale. Associated shrubs include *Isocoma pluriflora* and *Atriplex canescens*. *Aristida purpurea* is prominent in this type but rare in the remainder of the monument. Herbaceous diversity, percent cover, and biomass are significantly higher here and include several species not found elsewhere in the monument, including *Amaranthus palmeri*, *Boerhavia coccinea* and *Ambrosia confertifolia*.

Most abundant species

Globally—Data not available.
Casa Grande Ruins NM—

Stratum	Species
Top canopy	No species
Canopy	*Prosopis velutina*
Sub-canopy	*Isocoma acradenia, Prosopis velutina, Atriplex canescens*
Field	Annual forbs, annual grasses

Other noteworthy species

Globally—Data not available.
Casa Grande Ruins NM—*Boerhavia coccinea*, *Aristida purpure*, *Ambrosia confertifolia*

Element sources

Global description authors: K. Schulz
Local description authors: J. Greene, S. Buckley, and S. Drake
References: NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 15, 2009).

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D.2 Wooded Shrubland

D.2.1 Parkinsonia microphylla / Larrea tridentata Wooded Shrubland (proposed)

Translated name: Foothill paloverde / Creosotebush Wooded Shrubland
NatureServe code: Data not available.

Summary

Globally—Data not available.
Casa Grande Ruins NM—This proposed community is found in the northern portion of the Adamsville site and is defined by the dendritic, ephemeral watercourses trending north toward the Gila River. This association encompasses the headwaters of the washes that eventually reach 0.5–2 m deep and up to 6 m wide with sandy bottoms; steep, rocky sides; and active downcutting and headward erosion. Small trees, including *Parkinsonia microphylla*, *Prosopis velutina*, and *Acacia greggii*, are irregularly and sparsely scattered along these channels, becoming larger and more frequent as channel size increases. Shrubs within the channels are larger, more densely spaced, and more diverse than on the adjacent uplands. While shrubs from the adjacent uplands are still present (*Larrea tridentata*, *Krameria erecta*, and *Ambrosia deltoidea*), this association also contains the only occurrences of *Ephedra trifurca* and *Acacia constricta* in the park. The field stratum is occupied primarily by annual forbs in wet seasons. The most common annuals in spring 2008 were *Plantago ovata*, *Erodium cicutarium*, and *Brassica tournefortii*. The increased diversity, height, and cover of woody and herbaceous plants in this type are apparent consequences of the microenvironments created by the topography of the channels. These microenvironments offer increased moisture, a variety of slope aspects, some shelter from wind, and deeper soils not available in the uplands.

Classification

Classification confidence: Data not available.
Classification comments: Globally—NatureServe classifies a *Parkinsonia microphylla - Larrea tridentata* shrubland with moderate (2) confidence. This association tentatively uses the hierarchical classification of this shrubland.

Casa Grande Ruins NM—This association is similar to the NatureServe classification discussed above, although it differs in having both *Olneya tesota* and *Acacia greggii* trees in the top canopy. The greater-than-10% canopy cover of these and *Parkinsonia microphylla* trees indicates a wooded shrubland. This association was based on field data collected in 2008, from a censused polygon and three classification plots: IP4A, IP8A and IP-NEW-2A.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.5	Extremely xeromorphic evergreen shrubland
Formation subgroup	III.A.5.N	Natural/Semi-natural extremely xeromorphic evergreen shrubland
Formation name	III.A.5.N.e	Extremely xermorphic evergreen shrubland with a sparse tree layer
Alliance name	*Parkinsonia microphylla* Shrubland Alliance	
Association name	*Parkinsonia microphylla - Larrea tridentata* Wooded Shrubland	

Ecological systems placement

Data not available.

NatureServe conservation status

Global status: Data not available.
Rounded global status: Data not available.

Distribution

Globally—Data not available.
Casa Grande Ruins NM—This community is found in the northern portion of the Adamsville site and is defined by the dendritic, ephemeral watercourses trending north toward the Gila River. It can be found in a single large polygon: WS-PM01-C-A (16.35 ha).

Environmental setting

USFWS Wetland System: No

Environmental summary

Globally—Data not available.
Casa Grande Ruins NM—This association encompasses the headwaters of the washes that eventually reach 0.5–2 m deep and up to 6 m wide with sandy bottoms; steep, rocky sides; and active downcutting and headward erosion. The increased diversity, height, and cover of woody and herbaceous plants in this type are apparent consequences of the microenvironments created by the topography of the channels. These microenvironments offer increased moisture, a variety of slope aspects, some shelter from wind, and deeper soils not available in the immediately adjacent uplands.

Vegetation

Globally—Data not available.
Casa Grande Ruins NM—Small trees, including *Parkinsonia microphylla*, *Prosopis velutina*, and *Acacia greggii*, are irregularly and sparsely scattered along these channels, becoming larger and more frequent as channel size increases. Shrubs within the channels are larger, more densely spaced, and more diverse than on the adjacent uplands. While shrubs from the adjacent uplands are still present (*Larrea tridentata*, *Krameria erecta*, and *Ambrosia deltoidea*), this association also contains the only occurrences of *Ephedra trifurca* and *Acacia constricta* in the park. The field stratum is occupied primarily by annual forbs in wet seasons. The most common annuals in Spring 2008 were *Plantago ovata*, *Erodium cicutarium*, and *Brassica tournefortii*. The increased diversity, height, and cover of woody and herbaceous plants in this type are an apparent consequence of the microenvironments created by the topography of the channels.

Most abundant species

Globally—Data not available.
Casa Grande Ruins NM—

Stratum	Species
Top canopy	*Parkinsonia microphylla*
Canopy	*Larrea tridentata, Parkinsonia microphylla*
Sub-canopy	*Larrea tridentata, Ambrosia deltoidea, Krameria erecta*
Field	Annual forbs, annual grasses

Other noteworthy species

Globally—Data not available.
Casa Grande Ruins NM—*Acacia greggii*, *Olneya tesota*, *Carneigia gigantea*, *Acacia constricta*

Element sources

Global description authors: Data not available.
Local description authors: J. Greene, S. Buckley, and S. Drake
References: Data not available.

D.3 Shrubland

D.3.1 Larrea tridentata - [*Ambrosia deltoidea - Krameria erecta*] Shrubland (proposed)

Translated name: Creosotebush [Triangle bur ragweed - Littleleaf ratany] Shrubland
NatureServe code: Data not available.

Summary

Globally—Data not available.
Casa Grande Ruins NM—This proposed association is composed of two main polygons bisected by U.S. Highway 287 and a small corner area cut off by roads, all at the Adamsville site of Casa Grande Ruins NM. *Larrea tridentata* shrubs dominate here, as they do in most of the park, but are generally smaller and more widely spaced than in other areas of the park. The distinguishing characteristic of this shrubland is the presence of *Ambrosia deltoidea* and *Krameria erecta* as significant associates to *L. tridentata*. Use of brackets in the type name indicates that these species are co-dominant in places, but their relative abundance differs spatially throughout the area, ranging from absent to common. The space between shrubs contains a variety of annuals, primarily forbs, but is otherwise unvegetated. Soils contain significant gravel, but less than in adjacent areas. This type's bisection by the highway raises the polygon to the north slightly above the landscape and appears to slightly increase water runoff into areas within this association. Another indicator that this type may be slightly more mesic is the occasional presence of *Parkinsonia microphylla*. The raised highway may also provide increased protection from aeolian erosion, which appears to significantly impact soils on the surrounding landscape and the more southern polygon. The southern polygon of this type has a slightly lower density of shrubs and a more fine sandy soil, but overall composition and cover classes are the same.

Classification

Classification confidence: Data not available.
Classification comments: Globally—Data not available.
Casa Grande Ruins NM—This association is based on field data collected in 2008, from three censused polygons and five classification plots: IP3A, IP6A, IP7A, IP9A, and IP20A.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.5	Extremely xeromorphic evergreen shrubland
Formation subgroup	III.A.5.N	Natural/Semi-natural extremely xeromorphic evergreen shrubland
Formation name	III.A.5.N.a	Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland
Alliance name	*Larrea tridentata* Shrubland Alliance	
Association name	*Larrea tridentata* - [*Ambrosia deltoidea - Krameria erecta*] Shrubland	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES302.756	Sonora-Mojave Creosotebush -White Bursage Desert Scrub

NatureServe conservation status

Global status: Data not available.
Rounded global status: Data not available.

Distribution

Globally—Data not available.
Casa Grande Ruins NM—This association is found adjoining U.S. Highway 287 to the north and south as it crosses through the western half of the Adamsville site. The association is developed along the heads of small rills that trend toward the north and northwest and down into the floodplain of the nearby Gila River. It is found in 3 polygons: S-LT07-C-A (4.49), S-LT08-C-A (18.41), and S-LT09-C-A (0.69).

Environmental setting

USFWS Wetland System: No

Environmental summary

Globally—Data not available.
Casa Grande Ruins NM—This association is found adjacent to U.S. Highway 287 as it runs through the Adamsville site. The soils are predominantly sandy to the south, where the area is exposed to more aeolian erosion as a consequence of prevailing winds and has evidence of some recent vehicular traffic. The density of plant cover is slightly less and also has fewer annual species. To the north, it appears shielded from aeolian erosion by U.S. Highway 287 and has more gravelly soils. The shrubs are spaced more evenly and have slightly higher concentration along the emergent rills that trend to the north.

Vegetation

Globally—Data not available.
Casa Grande Ruins NM—This association is composed of the dominant *Larrea tridentata*, while the distinguishing characteristic of this shrubland is the presence of *Ambrosia deltoidea* and *Krameria erecta* as significant associates to *L. tridentata*. Use of brackets in the type name indicates that these species are co-dominant in places, but their relative abundance differs spatially throughout the area, ranging from absent to common. The space between shrubs contains a variety of annuals, primarily forbs, but is otherwise barren.

Most abundant species

Globally—Data not available.
Casa Grande Ruins NM—

Stratum	Species
Top canopy	*Parkinsonia microphylla*, *Prosopis velutina* (both rare)
Canopy	*Parkinsonia microphylla* (rare)
Sub-canopy	*Larrea tridentata, Krameria erecta, Ambrosia deltoidea*
Field	Annual forbs, annual grasses

Other noteworthy species

Globally—Data not available.
Casa Grande Ruins NM—*Aristida purpurea*, *Astragalus humistratus*, *Ferocactus wislizeni*

Element sources

Global description authors: Data not available.
Local description authors: J. Greene, S. Buckley. and S. Drake
References: Data not available.

D.3.2 Larrea tridentata - Lycium fremontii Shrubland Alliance (proposed)

Translated name: Creosotebush - Fremont's wolfberry Shrubland Alliance
NatureServe code: Data not available.

Summary

Globally—Data not available.
Casa Grande Ruins NM—This proposed alliance exists in two areas north of the visitor center complex in the main unit. It is characterized by the presence of *Lycium fremontii* as a co-dominant shrub alongside *Larrea tridentata*. The relative abundance of these species may differ spatially within the type, with density of *Lycium* shrubs increasing substantially in areas gathering additional rainfall via shallow depressions. Both species tend to grow slightly larger than in the adjacent *Larrea tridentata* shrubland, with average canopy heights often 2–2.5 m, but total canopy cover is lower, with shrubs widely spaced. *Lycium andersonii* is also present to a lesser degree. *Atriplex polycarpa* is a common associate, especially along the park's northern boundary. Between shrubs, herbaceous annuals may be present seasonally during years with adequate precipitation, but bare soil predominates much of the time. Soils have higher silt and clay content and less gravel than surrounding areas. Litter is nearly absent and the soil surface has low permeability due to frequent exposure to intense sun, strong prevailing winds, and impacts from heavy monsoon rains. Topography is flat overall, but includes several mounds and depressions associated with archeological sites. Soil and plant composition suggest that this type exists in areas that receive a net inflow of surface runoff that is briefly retained in shallow pools.

Classification

Classification confidence: Data not available.
Classification comments: Globally—Data not available.
Casa Grande Ruins NM—This alliance is based on field data collected from two censused polygons and five classification plots in 2008: IP-NEW-1, IP-NEW-2, IP-NEW-3, IP6 and IP12.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.5	Extremely xeromorphic evergreen shrubland
Formation subgroup	III.A.5.N	Natural/Semi-natural extremely xeromorphic evergreen shrubland
Formation name	III.A.5.N.a	Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland
Alliance name	*Larrea tridentata - Lycium fremontii* Shrubland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES302.756	Sonora-Mojave Creosotebush-White Bursage Desert Scrub

NatureServe conservation status

Global status: Data not available.
Rounded global status: Data not available.

Distribution

Globally—Data not available.

Casa Grande Ruins NM—This alliance exists in two areas north of the visitor center complex in the main unit. This alliance is distributed across a landscape of archeological sites that raise the level of the land above flat or otherwise notable shallow depressions. The distribution of plants is variable and sparse, with many clustered along the margins of the shallow rills that indicate water movement. This alliance is found in S-LTLF01-C (4 ha) and S-LTLF02-C (1.63 ha).

Environmental setting

USFWS Wetland System: No

Environmental summary

Globally—Data not available.
Casa Grande Ruins NM—This alliance exists in two areas north of the visitor center complex in the main unit. The slope of this alliance is minimal, often less than 1%, but overall the slope trends north toward the floodplain of the Gila River. The only relief in the area is that created by archeological sites and the small depressions near some of those sites. Soils have higher silt and clay content and less gravel than surrounding areas. Litter is nearly absent and the soil surface has low permeability due to frequent exposure to intense sun, strong prevailing winds, and impacts from heavy monsoon rains. Topography is very flat overall, but includes several mounds and depressions associated with archeological sites. Soil and plant composition suggest that this type exists in areas that receive a net inflow of surface runoff which is briefly retained in shallow pools.

Vegetation

Globally—Data not available.
Casa Grande Ruins NM—This alliance is characterized by the presence of *Lycium fremontii* as a co-dominant shrub alongside *Larrea tridentata*. The relative abundance of these species may differ spatially within the type. Both species tend to grow slightly larger than in the adjacent *Larrea tridentata* shrubland, with average canopy heights often 2–2.5 m, but total canopy cover is lower with shrubs widely spaced. *Lycium andersonii* is also present to a lesser extent. *Atriplex polycarpa* is a common associate, especially along the park's northern boundary. Between shrubs, herbaceous annuals may be present seasonally during years with adequate precipitation, but bare soil predominates much of the time.

Most abundant species

Globally—Data not available.
Casa Grande Ruins NM—

Stratum	Species
Top canopy	No species
Canopy	*Larrea tridentata, Lycium fremontii*
Sub-canopy	*Larrea tridentata, Lycium fremontii*
Field	Annual forbs, annual grasses

Other noteworthy species

Globally—Data not available.
Casa Grande Ruins NM—*Atriplex polycarpa*, *Lycium andersonii*, *Ferocactus wislizeni*, *Oenothera primiveris*

Element sources

Global description authors: Data not available.
Local description authors: J. Greene, S. Buckley, and S. Drake
References: Data not available.

D.3.3 Larrea tridentata Shrubland Alliance

Larrea tridentata Monotype Shrubland

Translated name: Creosotebush Shrubland Alliance
NatureServe code: **A.851, CEGL001261**

Summary

Globally—The bulk of the distribution of this alliance in the United States is west of Texas, in New Mexico, Arizona, Nevada, and California. Stands found in southeastern to western Texas are on low-elevation flats below 1,050 m (3,500 feet). These shrublands are dominated by *Larrea tridentata*. Associated species in Texas can include *Parthenium incanum*, *Atriplex canescens*, *Flourensia cernua*, *Agave lechuguilla*, *Bouteloua eriopoda*, *Bouteloua ramosa*, *Euphorbia antisyphilitica*, *Dasyochloa pulchella* (= *Erioneuron pulchellum*), *Flourensia cernua*, *Hechtia texensis*, *Jatropha dioica var. graminea*, *Opuntia schottii*, *Prosopis glandulosa*, *Tiquilia greggii*, and *Acacia* spp. This alliance is also a widespread disturbance type that has spread into former desert grasslands and mixed shrublands.

Casa Grande Ruins NM—This is the dominant vegetation type found in the park, comprising approximately 80% of the main unit and 30% of the Adamsville unit. It is composed of a *Larrea tridentata* monoculture averaging 1.5–2.5 m tall and usually spaced 2–3 m apart on a flat, level landscape. In small depressions where runoff is concentrated, usually adjacent to roads (especially around the perimeter of the main unit) or archeological sites, shrubs are slightly taller and more closely spaced. These depressions often contain inclusions of one or more *Prosopis velutina* individuals, but these contribute less than 1% of total cover in this alliance type. It is notable, however, that many large *P. velutina* snags are scattered throughout areas in the main unit occupied by this type. Their decline was documented by Judd (1971). *Ferocactus wislizenii* is the only other common perennial found in this type, with individuals sparsely and irregularly scattered throughout, often growing underneath *L. tridentata* shrubs in apparent nurse relationships. Areas between shrubs are mostly bare soil or gravel, but may contain a variety of annual plant species during wet seasons. Litter is sparse and soil development poor, except directly under *L. tridentata* shrubs, which tend to grow on low mounds of soil retained by their roots against strong aeolian erosive forces on the landscape. Within this association are two small inclusions on an old, defunct asphalt road bordering an old irrigation canal in the northeast corner of the main unit. *Larrea tridentata* still dominates but individuals are larger and more widely spaced than in the rest of the alliance. *Baccharis sarothroides* and *Atriplex polycarpa* are interspersed with *L. tridentata* on opposite ends of the old road. These inclusions are notable because they are the only place where either species is present in the eastern part of the monument. Moreover, herbaceous annuals are significantly less dense in these inclusions. It is likely that these inclusions are the result of the altered soil surface in this portion of the park.

Classification

Classification confidence: Data not available.
Classification comments: Globally—Many stands in this shrubland alliance do not have enough shrub cover to be classified as shrubland and would be better classified in a sparsely vegetated alliance. The widespread desert shrub, *Larrea tridentata*, has three chromosomally distinct ecotypes that roughly correspond to 3 different desert regions. The Chihuahuan ecotype is a monoploid (n=13) and is typically shorter, with sparser foliage and straighter stems than the other types. The Sonoran and Mojavean ecotypes are diploid (n=26) and triploid (n=39), respectively. Both are bushier than the Chihuahuan ecotype, but the Mojave ecotype is typically shorter with denser foliage (Yang 1970, as cited by Brown 1982).

Casa Grande Ruins NM—This shrubland alliance accounts for 80% of the land cover found at Casa Grande Ruins NM. Field data to support the alliance description at CAGR was collected from six censused polygons and seven classification plots in 2008, five at the main unit

and two at Adamsville. Intermediate plots within these polygons: IP7, IP8, IP9, IP10, IP11, IP10A, and IP5A.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.5	Extremely xeromorphic evergreen shrubland
Formation subgroup	III.A.5.N	Natural/Semi-natural extremely xeromorphic evergreen shrubland
Formation name	III.A.5.N.a	Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland
Alliance name	*Larrea tridentata* Shrubland	
Association name	*Larrea tridentata* Monotype Shrubland	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES302.756	Sonora-Mojave Creosotebush-White Bursage Desert Scrub

NatureServe conservation status

Global status: G5(23Feb1994)
Rounded global status: G5–Secure

Distribution

Globally—This widespread southwestern desert shrubland alliance includes stands in the Chihuahuan, Sonoran, Mojave, and Colorado deserts, from western Texas to southern Nevada and southeastern California and south into northern Mexico in the Mexican states of Baja California, Chihuahua, Coahuila, Durango, Nuevo León, San Luis Potosi, and Sonora.

Casa Grande Ruins NM—This alliance is found in six polygons and constitutes the dominant land cover overall. It is found in S-LT01-C (4.7 ha), S-LT02-C (111.6 ha), S-LT03-C (46 ha), S-LT04-C-A (3.29 ha), S-LT05-C-A (9.55 ha) and S-LT06-C-A (6.84 ha).

*E*nvironmental setting

USFWS Wetland System: No

Environmental summary

Globally—Shrublands included in this widespread southwestern desert alliance cover vast areas from west Texas to southeastern California. Elevations range from 1,600 m to below sea level. Climate is semi-arid to arid with hot summers. Potential for freezing winter temperatures depends on latitude and elevation. Desert precipitation varies greatly from year to year. At the Jornada Experimental Range in southwestern New Mexico, annual precipitation ranges from 7 to 45 cm with a mean of 23 cm (Herbel et al. 1972). Amount and season of annual precipitation also varies with geography. Mean annual precipitation ranges from 23 cm, distributed bimodally with half occurring during the late summer monsoons and half in the winter in southwestern New Mexico, to 15 cm or less of mostly winter precipitation in southeastern California. The proportion of summer precipitation decreases from the eastern to the western deserts (Barbour and Major 1977). Sites are generally flat or on gentle-to-moderate slopes of lower bajadas and intermountain basins. Substrate is usually sandy or gravelly alluvium, or eolian sand derived from limestone and metamorphic rocks. Soils are typically shallow, well-drained, and have low salinity. Soil texture is generally coarse, but may include gravelly clay loams. These shrublands may be bisected by arroyo riparian shrublands and woodlands dominated by *Prosopis*, grade into grasslands dominated by *Bouteloua gracilis*, *Sporobolus airoides*,

Pleuraphis mutica, or be part of a matrix of other desert and upland shrublands dominated by *Ambrosia dumosa*, *Atriplex* spp., *Ephedra nevadensis*, *Prosopis* spp., or active dunes.

Casa Grande Ruins NM—At Casa Grande Ruins NM, this alliance is found on predominantly flat land with little relief. Often, the only relief at the main unit of CAGR is found on top of the archeological sites and near park facilities or roads. The alliance is found on sandy, alluvial soil with about equal bare soil and gravel surface cover, generally 35–60% each, with only minimal litter or crust.

Vegetation

Globally—Shrublands included in this widespread southwestern desert alliance occur on mesas, plains, valleys, bajadas, and low hills from west Texas to southern California. The open stands have a sparse-to-moderately dense layer (<50% cover) of xeromorphic microphyllous and broad-leaved evergreen shrubs, dominated by *Larrea tridentata*. Many different shrubs, dwarf-shrubs, cacti, grasses, and forbs may co-dominate or form typically sparse understories in stands in the 27 different associations. Stands in the Chihuahuan Desert are typically co-dominated by *Flourensia cernua*, *Acacia constricta*, or *Acacia neovernicosa*, with scattered individuals of *Atriplex canescens*, *Fouquieria splendens*, *Koeberlinia spinosa*, and *Prosopis glandulosa*. Characteristic woody understory includes *Agave lechuguilla*, *Euphorbia antisyphilitica*, *Jatropha dioica var. graminea*, *Celtis pallida*, *Lycium* spp., *Opuntia schottii*, *Parthenium incanum*, and *Tiquilia* spp. The herbaceous layer may be absent to moderately dense. Common perennial grasses may include *Bouteloua gracilis*, *Bouteloua eriopoda*, *Pleuraphis mutica* (= *Hilaria mutica*), *Muhlenbergia porteri*, *Scleropogon brevifolius*, *Sporobolus airoides or Sporobolus flexuosus*. Forbs, such *as Baileya multiradiata*, *Chamaesyce* spp., *Croton texensis*, and *Dimorphocarpa wislizeni* (= *Dithyrea wislizeni*), may be present, but typically are sparse. In areas of recent desert-scrub expansion, *Yucca elata*, *Acourtia nana* (= *Perezia nana*), and *Dasyochloa pulchella* (= *Erioneuron pulchellum*) are more common (Dick-Peddie 1993). In the Sonoran and Mojave deserts, typical co-dominants include *Ambrosia dumosa*, *Atriplex confertifolia*, *Atriplex hymenelytra*, *Encelia farinosa*, *Ephedra nevadensis*, *Fouquieria splendens*, *Grayia spinosa*, *Lycium andersonii*, or *Opuntia basilaris*. The understory is typically sparse but may be seasonally abundant with ephemerals. *Chamaesyce* spp., *Eriogonum inflatum*, *Dasyochloa pulchella*, *Aristida* spp., *Cryptantha* spp., *Nama* spp., *Phacelia* spp., *Achnatherum speciosum* (= *Stipa speciosa*), and the exotic annual grass, *Bromus rubens*, may be present.

Casa Grande Ruins NM—This alliance is found on flat, alluvial ground at CAGR and at the Adamsville site. It is composed of a *Larrea tridentata* monoculture averaging 1.5–2.5 m tall and usually spaced 2–3 m apart on a flat, level landscape. In small depressions where runoff is concentrated, usually adjacent to roads (especially around the perimeter of the main unit) or archeological sites, shrubs are slightly taller and more closely spaced. These depressions often contain inclusions of one or more *Prosopis velutina* individuals, but these contribute less than 1% of total cover in this alliance type. It is notable, however, that many large *P. velutina* snags are scattered throughout areas in the main unit occupied by this type. Their decline was documented by Judd (1971). *Ferocactus wislizenii* is the only other common perennial found in this type, with individuals sparsely and irregularly scattered throughout, often growing underneath *L. tridentata* shrubs in apparent nurse relationships. Areas between shrubs are mostly bare soil or gravel, but may contain a variety of annual plant species during wet seasons. Litter is sparse and soil development poor, except directly under *L. tridentata* shrubs, which tend to grow on low mounds of soil retained by their roots against strong aeolian erosive forces on the landscape. Within this alliance are two small inclusions on an old, defunct asphalt road bordering an old irrigation canal in the northeast corner of the main unit. *Larrea tridentata* still dominates but individuals are larger and more widely spaced than in the rest of the alliance. *Baccharis sarothroides* and *Atriplex polycarpa* are interspersed with *L. tridentata* on opposite ends of the old road. These inclusions are notable because they are the only place where either species is present in the eastern part of the monument. Moreover, herbaceous annuals are significantly less dense in these inclusions. It is likely that these inclusions are the result of the altered soil surface in this portion of the park.

Most abundant species

Globally—Data not available.
Casa Grande Ruins NM—

Stratum	Species
Top canopy	None
Canopy	*Larrea tridentata, Baccharis sarothroides*
Sub-canopy	*Larrea tridentata*
Field	Annual grasses, annual forbs

Other noteworthy species

Globally—Data not available.
Casa Grande Ruins NM—*Lycium fremontii*, *Atriplex polycarpa*, *Krameria erecta*, *Ambrosia deltoidea*, *Ephedra trifurca*, *Ferocactus wislizeni*

Element sources

Global description authors: A.S. Weakley 2-95, mod. K. Schulz
Local description authors: J. Greene, S. Buckley, and S. Drake
References: NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. http://www.natureserve.org/explorer (Accessed: January 14, 2009).

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D.4 Sparse Shrubland

D.4.1 Larrea tridentata / Mixed Annual Sparse Shrubland (proposed)

Translated name: Creosotebush / Mixed Annual Sparse Shrubland
NatureServe code: Data not available.

Summary

Globally—Data not available.
Casa Grande Ruins NM—This proposed association, found immediately north of the main visitor center complex, is mostly devoid of perennial vegetation. Shrubs are present in limited numbers (<10% cover), often in widely spaced clusters. *Larrea tridentata* is the most common species, accompanied by occasional *Atriplex polycarpa*, *Atriplex canescens*, *Lycium* spp., and *Ferocactus wislizenii*. Shrubs generally grow on low mounds of soil retained by their roots against erosive forces. Areas between shrubs may contain annual forbs and/or grasses immediately following seasonal precipitation but will consist primarily of bare soil or gravel during all but the wettest periods. Soils are mostly sandy and poorly developed with minimal litter accumulation. The near absence of vegetative cover exposes bare soil to hot summer sun, strong prevailing winds, and surface compaction due to the impact of heavy monsoon rains. Topography is generally flat but contains a disproportionate number of shallow depressions where evidence exists of sheet flow and water accumulation. Some dense populations of *Verbesina encelioides* are found in these depressions.

Classification

Classification confidence: Data not available.
Classification comments: Globally—Data not available.
Casa Grande Ruins NM—This proposed association is based on field data collected from a censused polygon and two classification plots in 2008: IP5 and IP-NEW-4.

Vegetation hierarchy

Formation class	VII	Sparse Vegetation
Formation subclass	VII. B	Boulder, gravel, cobble, or talus sparse vegetation
Formation group	VII.B.2.	Sparsely vegetated rock flats
Formation subgroup	VII.B.2.N	Natural/Semi-natural sparsely vegetated rock flats
Formation name	VII.B.2.N.c	Cobble/gravel flats and ridges
Alliance name	*Larrea tridentata* Shrubland Alliance	
Association name	*Larrea tridentata* / Mixed Annual Sparse Shrubland	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES302.756	Sonora-Mojave Creosotebush-White bursage Desert Scrub

NatureServe conservation status

Global status: Data not available.
Rounded global status: Data not available.

Distribution

Globally—Data not available.
Casa Grande Ruins NM—This proposed association is found immediately north of the main visitor center complex surrounding several of the main archeological complexes (Compound B) and to the east of and adjacent to the administrative buildings: SS-LT01-C (12.11 ha) and

SS-LT02-C (0.66 ha).

Environmental setting

USFWS Wetland System: No

Environmental summary

Globally—Data not available.
Casa Grande Ruins NM—This proposed association is best represented by the polygon immediately north of the main visitor center complex. It is an open area, with an aspect on the northern half trending slightly to the north toward the floodplain of the Gila River, and the southern half trending south toward the visitor center complex. This is due to the presence of archeological sites. In this type there are numerous small basins in which the larger specimens of *Larrea tridentata* are found growing. Soils are mostly sandy and poorly developed with minimal litter accumulation. The near absence of vegetative cover exposes bare soil to hot summer sun, strong prevailing winds, and surface compaction due to the impact of heavy monsoon rains. Topography is generally flat but contains a disproportionate number of shallow depressions where evidence exists of sheet flow and water accumulation.

Vegetation

Globally—Data not available.
Casa Grande Ruins NM—This proposed association is mostly devoid of perennial vegetation. Shrubs are present in limited numbers (<10% cover), often in widely spaced clusters. *Larrea tridentata* is the most common species, accompanied by occasional *Atriplex polycarpa*, *Atriplex canescens*, *Lycium fremontii*, and *Ferocactus wislizenii*. Shrubs generally grow on low mounds of soil retained by their roots against erosive forces. Areas between shrubs may contain annual forbs and/or grasses immediately following seasonal precipitation but will consist primarily of bare soil or gravel during all but the wettest periods. Numerous dead *Prosopis velutina* snags are found in this alliance, a phenomenon discussed in Judd (1971).

Most abundant species

Globally—Data not available.
Casa Grande Ruins NM—

Stratum	Species
Top canopy	No species
Canopy	*Larrea tridentata*
Sub-canopy	*Larrea tridentata*
Field	Annual forbs, annual grasses

Other noteworthy species

Globally—Data not available.
Casa Grande Ruins NM—*Atriplex polycarpa*, *Lycium fremontii*, *Ferocactus wislizeni*, *Verbesina encelioides*

Element sources

Global description authors: Data not available.
Local description authors: J. Greene, S. Buckley, and S. Drake
References: Data not available.
Judd, B. I., J. M. Laughlin, H. R. Guenther, and R. Handegarde. 1971. The lethal decline of mesquite on the Casa Grande Ruins NM. Great Basin Naturalist **31**:152–159.

D.4.2 Sphaeralcea ambigua Sparse Shrubland Alliance (proposed)

Translated name: Desert globemallow Sparse Shrubland Alliance
NatureServe code: Data not available.

Summary

Globally—Data not available.
Casa Grande Ruins NM—This proposed alliance is found in the south-central portion of the Adamsville unit, with one half of the polygon surrounding an old cotton-gin site. In the center of the northern part are the concrete remains of the cotton gin, where a single *Prosopis velutina* specimen is found. The remainder of the type is composed of shrubs in limited numbers (<10% cover), predominantly *Sphaeralcea ambigua*, and notable but sparse growth of *Larrea tridentata* throughout. Associated shrub species found here are *Ambrosia deltoidea*, *Baccharis sarothroides*, *Isocoma pluriflora*, and *Ambrosia dumosa*. Shrubs generally grow on low mounds of soil retained by their roots against erosive forces. Areas between shrubs may contain annual forbs and/or grasses immediately following seasonal precipitation but will consist primarily of bare soil or gravel during all but the wettest periods.

Classification

Classification confidence: Data not available.
Classification comments: Globally—Data not available.
Casa Grande Ruins NM—This alliance is based on field data collected from one censused polygon and two classification plots in 2008. Both plots measured in this type seem unrepresentative of the whole, perhaps due to the fact they are both located on the periphery of the type in highly disturbed zones. Therefore, the final alliance name is taken from the censused field data of the polygon and the agreement from the accuracy assessment. Plots: IP28A, IP2A.

Vegetation hierarchy

Formation class	VII	Sparse Vegetation
Formation subclass	VII. B	Boulder, gravel, cobble or talus sparse vegetation
Formation group	VII.B.2.	Sparsely vegetated rock flats
Formation subgroup	VII.B.2.N	Natural/Semi-natural sparsely vegetated rock flats
Formation name	VII.B.2.N.c	Cobble/gravel flats and ridges
Alliance name	*Sphaeralcea ambigua* Sparse Shrubland	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES302.756	Sonora-Mojave Creosotebush-White bursage Desert Scrub

NatureServe conservation status

Global status: Data not available.
Rounded global status: Data not available.

Distribution

Globally—Data not available.
Casa Grande Ruins NM—This alliance is found in the south-central portion of the Adamsville unit, surrounding an old cotton-gin site. It is bisected by a dirt road bisects and bounded to the east by another small dirt road; U.S. Highway 287 is the boundary to the north. This polygon clearly has been impacted historically, as is evidenced by the early successional species and compacted soils. This alliance is found in one polygon: SS-SA01-C-A (8.58 ha).

Environmental setting

USFWS Wetland System: No

Environmental summary

Globally—Data not available.
Casa Grande Ruins NM—This alliance is found, in part, surrounding the remains of an old cotton gin. Several dirt roads either bound or bisect the polygon and the entire alliance exhibits evidence of human influence. The land is largely unvegetated, with shrubs generally growing on low mounds of soil retained by their roots against erosive forces. Areas between shrubs may contain annual forbs and/or grasses immediately following seasonal precipitation but will consist primarily of bare soil or gravel during all but the wettest periods. Trash and remnants of the mill are scattered around the alliance, indicating that the disturbance of the mill site extends far beyond the actual building. The soil is sandy with fine gravel scattered throughout and extensive evidence for sheet erosion in times of heavy rainfall.

Vegetation

Globally—Data not available.
Casa Grande Ruins NM—In the north-central portion of the polygon are the concrete remains of the cotton gin, where a single *Prosopis velutina* specimen is found. The remainder of the type is composed of shrubs in limited numbers (<10% cover), predominantly *Sphaeralcea ambigua*, and notable but sparse growth of *Larrea tridentata* throughout. Associated shrub species found here are *Ambrosia deltoidea*, *Baccharis sarothroides*, *Isocoma pluriflora*, and *Ambrosia dumosa*. Shrubs generally grow on low mounds of soil retained by their roots against erosive forces. Areas between shrubs may contain annual forbs and/or grasses immediately following seasonal precipitation but will consist primarily of bare soil or gravel during all but the wettest periods.

Most abundant species

Globally—Data not available.
Casa Grande Ruins NM—

Stratum	Species
Top canopy	*Prosopis velutina* (single specimen)
Canopy	*Larrea tridentata*
Sub-canopy	*Larrea tridentata, Isocoma pluriflora*
Field	*Sphaeralcea ambigua*, annual forbs, annual grasses

Other noteworthy species

Globally—Data not available.
Casa Grande Ruins NM—*Baccharis sarothroides*, *Aristida purpurea*, *Atriplex canescens*, *Ferocactus wislizeni*, *Ambrosia deltoidea*, *Ambrosia dumos*, *Brassica tournefortii*

Element sources

Global description authors: Data not available.
Local description authors: J. Greene, S. Buckley, and S. Drake
References: Data not available.

D.5 Anderson Land Use Classes

D.5.1 Transitional Areas

Summary

Globally—This category (Anderson 1976) is intended for areas in transition from one land-use activity to another. They are characterized by the lack of any remote-sensor information that would enable the land-use interpreter to reliably discern past use or predict future use. All that can actually be determined is that a transition is in progress, and inference about past or future use should be avoided. This transitional phase occurs when, for example, forest lands are cleared for agriculture, wetlands are drained for development, or when any type of land use ceases and areas become temporarily bare, as when construction is planned for residences, shopping centers, industrial sites, or suburban and rural residential subdivisions. Land being altered by filling, such as occurs in spoil dumps or sanitary landfills, also is indicative of this transitional phase.

Casa Grande Ruins NM—Included as part of the mapping project for Casa Grande Ruins NM are five parcels of land outside the present park boundary under the ownership of the Archaeological Conservancy. These lands are under consideration for park expansion because of their archeological importance. All of these lands are former agricultural lands, having been cultivated at various times in the past. Immediately east of the monument are several large parcels, one adjoining the commercial district and a larger one further east on the far side of the railroad tracks. To the northeast of the park, directly northeast of the junction of Highways 87 and 187, is another site that was surveyed, and still another small site is located 200 meters east and to the north of Highway 187. The vegetation and soils on these lands distinctly indicate that they are abandoned agricultural fields. The vegetation is dominated by agricultural weeds, and there is little in the way of natural vegetation colonizing these sites, partly because of the lack of native vegetation immediately around them. There are several patches of *Isocoma pluriflora* on three of the sites, as well as rare scatterings the perennial grass, *Aristida purpurea*. Annual forbs, such as *Erodium cicutarium*, *Salsola kali*, and *Brassica tournefortii*, dominate the sites. Rare on these sites are isolated *Prosopis velutina* and *Baccharis sarothroides* shrubs, and *Sphaeralcea ambigua* and *Boerhavia* spp.

Classification

Classification confidence: Data not available.
Classification comments: Globally—Data not available.
Casa Grande Ruins NM—This description is based on field observations of six polygons, all located within the buffer or proposed expansion lands, in 2008.

Distribution

Globally—Data not available.
Casa Grande Ruins NM—Immediately east of the monument are several large parcels, one adjoining the commercial district and a larger one further east on the far side of the railroad tracks. To the northeast of the park, directly northeast of the junction of Highways 87 and 187, is another site that was surveyed, and still another small site is located 200 meters east and to the north of Highway 187. This type is represented by six polygons, all situated adjacent to or within the buffer of the Casa Grande Ruins unit: TA-01-C (18.17 ha), TA-02-C (4.85 ha), TA-03-C (5 ha), TA-04-C (2.21 ha), TA-05-C (1.89 ha), TA-06-C (1.56 ha).

Environmental setting

USFWS Wetland System: No

Environmental summary

Globally—Data not available.
Casa Grande Ruins NM—All of these lands are former agricultural lands, having been cultivated at various times in the past. The vegetation and soils on these lands distinctly indicate that they are abandoned agricultural fields. Relief is limited, with the exception of some areas still showing signs of historic plowing.

Vegetation

Globally—Data not available.
Casa Grande Ruins NM—The vegetation is dominated by agricultural weeds, and there is little in the way of natural vegetation colonizing these sites, partly because of the lack of native vegetation immediately around them. There are several patches of *Isocoma pluriflora* on three of the sites, as well as rare scatterings the perennial grass, *Aristida purpurea*. Annual forbs, such as *Erodium cicutarium*, *Salsola kali*, and *Brassica tournefortii*, dominate the sites. Rare on these sites are isolated *Prosopis velutina* and *Baccharis sarothroides* shrubs, and *Sphaeralcea ambigua* and *Boerhavia* spp.

Most abundant species

Globally—Data not available.
Casa Grande Ruins NM—

Stratum	Species
Top canopy	None
Canopy	*Prosopis velutina* (rare)
Sub-canopy	*Isocoma pluriflora*, *Baccharis sarothroides* (rare)
Field	*Aristida purpurea*

Other noteworthy species

Globally—Data not available.
Casa Grande Ruins NM—Data not available.

Element sources

Global description authors: Data not available.
Local description authors: J. Greene, S. Buckley, and S. Drake
References: Anderson, J. R., E. E. Hardy, J. T. Roach, and R. E. Witmer. 1976. A land use and land cover classification system for use with remote sensor data. Geological Survey Professional Paper 964. Washington, D.C.: United States Government Printing Office.

D.5.2 Horticulture

Summary

Globally—Data not available.
Casa Grande Ruins NM—One consequence of the development of the visitor center and other park buildings at Casa Grande Ruins, beginning in the 1920s, is an intentionally developed area of horticultural plants surrounding them. This area includes a variety of native trees, such as *Prosopis velutina*, *Olneya tesota*, *Parkinsonia microphylla*, and *Acacia greggii*; native cacti, such as *Peniocereus greggii*, *Carnegiea gigantea*, *Ferocactus wislizenii*, and *Opuntia* spp.; and ocotillo, *Fouquieria splendens*. Additionally, a variety of shrubs, including *Larrea tridentata* and *Encelia farinosa*, dot the landscape around the buildings, which are connected by both paved and unpaved footpaths. Scattered throughout the areas most visited by the public are a wide variety of herbaceous plants. Most plants in the area are marked with interpretive signs indicating their names. The area is regularly maintained by park staff, as indicated by watering, tree limbs trimmed above head height, active weeding of undesirable plants in the ruin compounds, and active selection and care of a number of herbaceous plants along footpaths. Also included in this type is a small landscaped city park northeast of the main unit, in the study-area buffer. Vegetation in this polygon comprises a variety of planted trees and shrubs with some wild growth of *Baccharis sarothroides*, *Cynodon dactylon*, *Salsola kali*, and other annual forbs along its edges. Tree species include *Parkinsonia florida*, *Prosopis velutina*, *Parkinsonia praecox*, *Chilopsis linearis*, *Olneya tesota*, and *Lysiloma watsonii*. The most dominant shrub by cover is Texas ranger, *Leucophyllum frutescens*, with *Fouquieria splendens*, *Larrea tridentata*, *Ferocactus wislizenii*, *Carnegiea gigantea*, and *Agave* spp. also present. Ground cover is homogeneous landscaping gravel. This park appears rarely used and primarily maintained as a decorative feature.

Classification

Classification confidence: Data not available.
Classification comments: Globally– Data not available.
Casa Grande Ruins NM—Anderson Land Use Class, level II.

Distribution

Globally—Data not available.
Casa Grande Ruins NM—This type is found in one area adjacent to the park facilities buildings and the main ruins house and in another area in the monument buffer consisting of a city park. H-01-C, H-02-C (3.46 ha).

Environmental setting

USFWS Wetland System: No

Environmental summary

Globally—Data not available.
Casa Grande Ruins NM—N/A

Vegetation

Globally—Data not available.
Casa Grande Ruins NM—The polygon at the main unit includes a variety of native trees, such as *Prosopis velutina*, *Olneya tesota*, *Parkinsonia microphylla*, and *Acacia greggii*; native cacti, such as *Peniocereus greggii*, *Carnegiea gigantea*, *Ferocactus wislizenii*, and *Opuntia* spp.; and ocotillo, *Fouquieria splendens*. Additionally, a variety of shrubs, including *Larrea tridentata* and *Encelia farinosa*, dot the landscape around the buildings, which are connected by both paved and unpaved footpaths. Scattered throughout the areas most visited by the public are a wide variety of herbaceous plants. Vegetation in this polygon comprises a variety of planted trees and shrubs with some wild growth of *Baccharis sarothroides*, *Cynodon dactylon*, *Salsola*

kali, and other annual forbs along its edges. Tree species include *Parkinsonia florida*, *Prosopis velutina*, *Parkinsonia praecox*, *Chilopsis linearis*, *Olneya tesota*, and *Lysiloma watsonii*. The most dominant shrub by cover is Texas ranger, *Leucophyllum frutescens*, with *Fouquieria splendens*, *Larrea tridentata*, *Ferocactus wislizenii*, *Carnegiea gigantea*, and *Agave* spp. also present. Ground cover is homogeneous landscaping gravel.

Most abundant species

Globally—Data not available.
Casa Grande Ruins NM—

Stratum	Species
Top canopy	*Prosopis velutina, Olneya tesota, Parkinsonia microphylla, Acacia greggii, Carnegiea gigantea*
Sub-canopy	*Fouquieria splendens, Ferocactus wislizenii, Opuntia spp Leucophyllum frutescens*

Other noteworthy species

Globally—Data not available.
Casa Grande Ruins NM—N/A

Element sources

Global description authors: Data not available.
Local description authors: J. Greene, S. Buckley, and S. Drake
References: Data not available.

Appendix E
Root Mean Square Error

Root mean square error.

GCP	X source	Y source	X map	Y map	X error	Y error
1	451006.615	3651579.668	451006.940	3651580.318	-0.32477	-0.64953
2	449739.136	3651444.560	449738.997	3651444.746	0.13886	-0.18591
3	449728.750	3650320.166	449729.568	3650319.973	-0.81760	0.19280
4	458016.805	3651726.632	458017.458	3651726.591	-0.65301	0.04113
5	458371.342	3652064.288	458371.843	3652064.745	-0.50139	-0.45746
6	457500.817	3652131.523	457501.645	3652131.475	-0.82812	0.04806
7	447540.588	3653469.086	447539.051	3653471.869	**1.53760**	**-2.78274**
8	453845.810	3649710.118	453846.995	3649708.469	-1.18530	1.64880
9	450934.211	3650567.396	450933.995	3650566.449	0.21592	0.94753
10	450323.686	3651016.863	450323.468	3651017.529	0.21761	-0.66655
11	450615.570	3651554.053	450615.368	3651554.357	0.20194	-0.30383
12	454343.060	3651782.956	454343.734	3651783.923	-0.67407	-0.96749
13	457357.240	3651819.838	457357.754	3651819.771	-0.51399	0.06635
14	452771.668	3651666.767	452771.391	3651666.417	0.27661	0.34995
15	449586.420	3650760.761	449586.793	3650761.764	-0.37242	-1.00260
16	449489.987	3651162.427	449489.914	3651162.305	0.07265	0.12199
17	449515.428	3651637.545	449514.871	3651638.073	0.55695	-0.52846
18	451629.202	3651777.955	451628.430	3651777.277	0.77201	0.67818
19	458805.869	3652432.320	458806.511	3652432.948	-0.64209	-0.62767
20	458697.624	3652387.901	458698.155	3652388.634	-0.53160	-0.73328
				Sum of squares	8.60086	16.35732
				Mean squared error value	0.43004	0.81787
				RMS	0.65578	0.90436
				Total RMS error	**0.60133**	

GCP = ground control point
Bolded entries indicate the maximum error values in the table.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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