

Final Report Saguaro National Park Cultural Resource Mapping Project

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Introduction

Saguaro National Park (SAGU) was established to protect and preserve Sonoran Desert plant and animal species, including the namesake Giant Saguaro (*Carnegiea gigantea*). The park is comprised of two districts, located east (Rincon Mountain District) and west (Tucson Mountain District) of Tucson, Arizona (Figure 1), and includes six biotic communities, ranging from the desert scrub found at the lowest elevations in both districts, to the mixed conifer forest found in the higher elevations of the Rincon Mountains. In addition to these unique natural resources, the Park also preserves and protects cultural resources from prehistoric times through the 20th Century. These include over 500 archaeological sites identified by a number of survey projects. Additionally there are several registered buildings and other structures, most of them built by the Civilian Conservation Corps (CCC) in the 1930s part of the List of Classified Structures (LCS).

There were three goals for this project: 1) determine coordinate accuracy for archaeological sites and LCS features within the Park; 2) verify the location of all LCS features and a sample of archaeological sites in the Park; and 3) construct a spatial database for the LCS features and archaeological sites. In the following paragraphs, this report provides a project overview and discusses the methods used, the spatial database that was created, the analyses of the data collected, the conclusions reached and suggestions for future work.

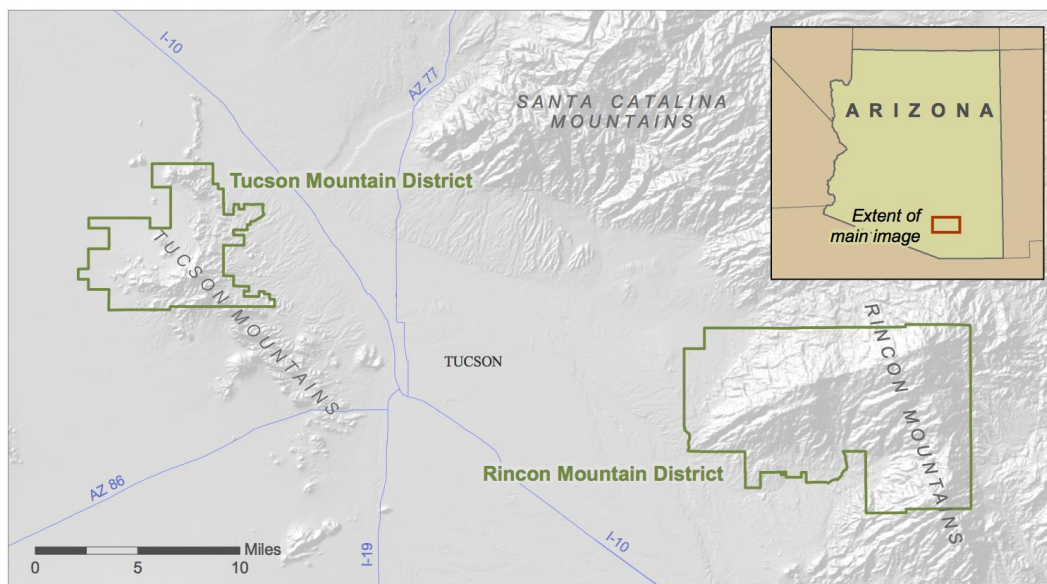


Figure 1: Saguaro National Park, Tucson Mountain and Rincon Mountain Districts (map by Michael Malone)

Project Overview

Saguaro National Park maintains an extensive spatial database using a geographic information system (GIS). This database contained all archaeological sites – generally made up of artifact scatters, stone foundations, or mining features. Also included in this project were *LCS* features, part of a national list of historic structures on National Parks Service lands. In the case of SAGU this included buildings, picnic areas, dams, etc. mostly constructed by the CCC. In total, there were 510 archaeological sites and 44 LCS features in the SAGU database. Of these 316 archaeological sites and 8 LCS features were in the Rincon Mountain District (Figure 2a), 116 archaeological sites and 36 LCS features were in the Tucson Mountain District (Figure 2b), and 78 archaeological sites were in the SAGU database, but outside the boundaries of the park (all near the Rincon Mountain District – Figure 2a).

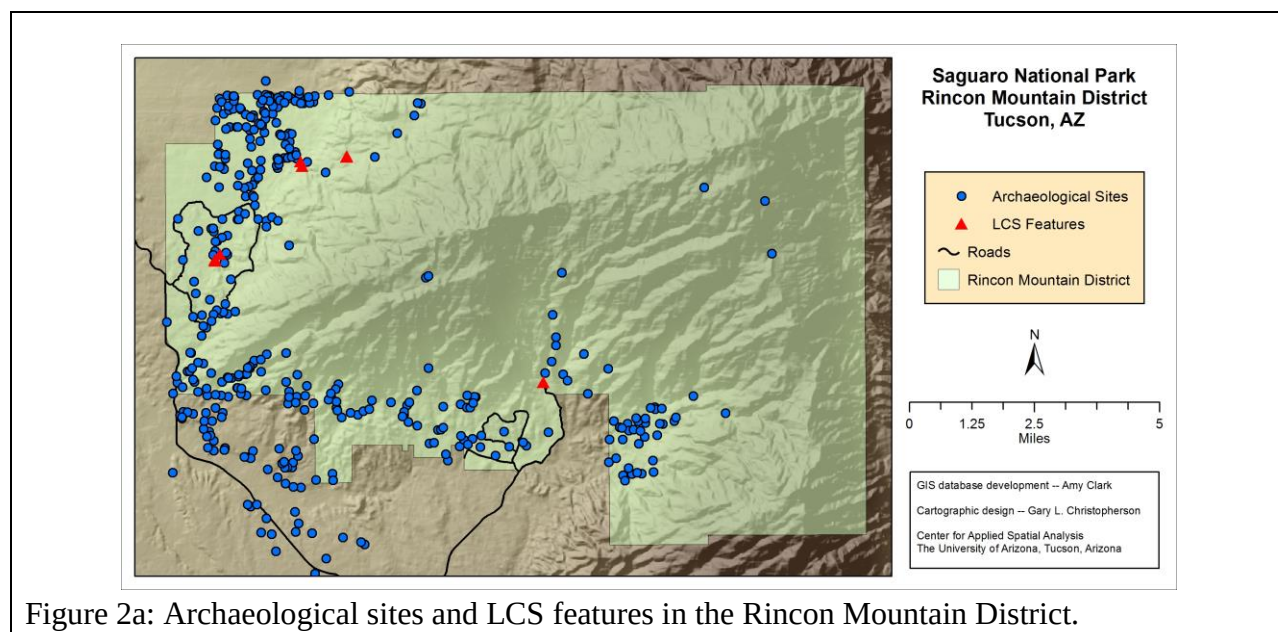
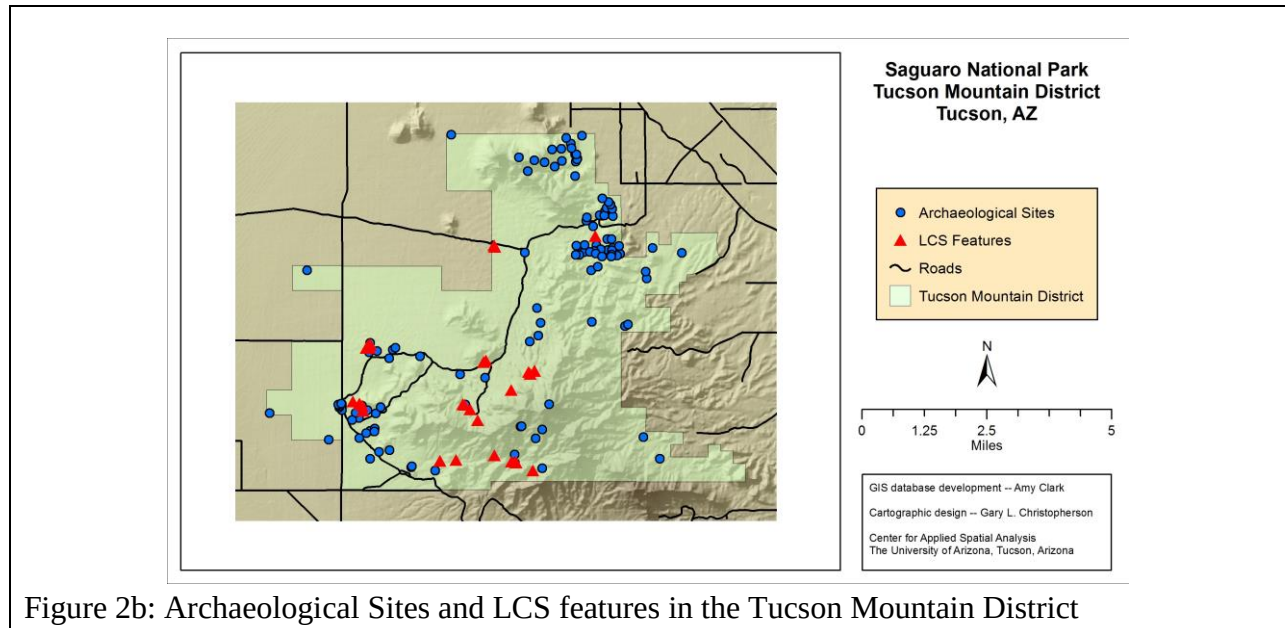


Figure 2a: Archaeological sites and LCS features in the Rincon Mountain District.



The impetus for this project was the unknown accuracy of the coordinates attached to archaeological sites and LCS features in the Park database. Archaeological surveys were carried out during three different eras, each of which used a different technology to determine coordinates: pre-GPS; pre-2000 GPS technology; and post-2000 GPS technology. Many of the prehistoric and historic features were recorded before the ready availability of Global Positioning System (GPS) technology. For those of us who remember those days, the position of an archaeological site was estimated on a map, and then coordinates were estimated for that map location. For sites recorded with GPS, accuracy was largely dependent on whether they were recorded before or after the year 2000. Prior to 2000, the U.S. military deliberately altered satellite time stamps (a procedure known as *selective availability*) to degrade the accuracy of coordinate calculations in order to lessen their utility as targeting devices. Accuracy would vary between 1 and > 100 meters depending on the GPS device and the level of signal degradation. This practice was discontinued in 2000, and accuracy of GPS improved to the point that today even inexpensive GPS units are usually accurate with 5 meters or less.

These differing technologies have led to uncertainty about the accuracy of coordinate locations for both LCS features and archeological sites. The improved GPS technology available today offered the opportunity to improve coordinate accuracy and this project was designed as a pilot in order to determine the time and cost to upgrade coordinates for all archaeological sites and LCS features.

The second objective was to verify the location of archaeological sites and LCS features in the SAGU database, a natural bi-product of coordinate normalization. This identification was based on visits to all but one LCS feature, and to 120 of the 510 archaeological sites in the database.

The third objective of this project was the construction of an ESRI based geodatabase. This geodatabase would allow for the consolidation of spatial data archived by the Park in a number of different formats (shapefiles, coverages, etc.) into a single database. This new database provides a framework for continued work by future projects.

Methods

In this section, the discussion will provide a more detailed look at database design and development, and field methods for locating and recording LCS features and archaeological sites.

The Spatial Database

The database was designed and built using ESRI's File Geodatabase structure. It was divided into four feature datasets, each containing related feature classes (Figure 3). 1) *SAGU*

Boundaries which includes the limits of the Park and each of the districts. Additionally, there are data boundaries which served to limit the area shown in cartographic products for each district. 2) *Roads and Trails*; as the name implies, this feature dataset includes all the roads and trails in the project area. This feature class also contains parking spots along the roads in and surrounding the Park districts. These were used to help identify the best location from which to begin pedestrian navigation to archaeological sites and LCS features. 3) *cultural_features*; The primary feature class in this dataset is *arch_and_LCS* which includes all archaeological sites and LCS features provided by SAGU. Also included in this feature dataset are *arch_sites* (just SAGU archaeological sites) and *LCS* (just LCS features in SAGU). 4) *CASA features*; this feature dataset contains feature classes that contain either new coordinates for old LCS features or archaeological sites, or new archaeological sites and features discovered opportunistically during the course of

this project. *Feature_line*, *Feature_point* and *Feature_poly* contain archaeological features. In addition, *Feature_point* contains the sample of archaeological sites/features that were visited during this survey. Finally, this feature dataset also includes the feature class *site*. This is a polygon which can be used to group features that the field archaeologist believed to be part of the same site. For

Geodatabase: A database or file structure used primarily to store, query, and manipulate spatial data. Geodatabases store geometry, a spatial reference system, attributes, and behavioral rules for data. Various types of geographic datasets can be collected within a geodatabase, including feature classes, attribute tables, raster datasets, network datasets, topologies, and many others. Geodatabases can be stored in IBM DB2, IBM Informix, Oracle, Microsoft Access, Microsoft SQL Server, and PostgreSQL relational database management systems, or in a system of files, such as a file geodatabase.

ESRI Online Dictionary:

<http://support.esri.com/en/knowledgebase/GISDictionary/term/geodatabase>

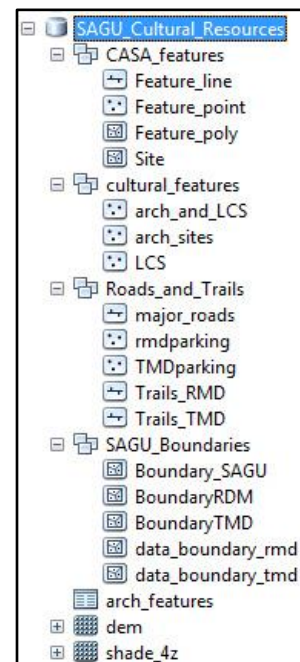


Figure 3: Geodatabase structure

example, if a site has two dense clusters of artifacts and a point is taken at the centroid of each cluster, these points would be grouped together under “site”.

There are also two rasters included in this geodatabase. The first is a digital elevation model named *dem*, and the second is a hillshade named *shade_4z* (so named because a z factor of 4 was used to create the hillshade). Both rasters have a resolution of 30 meters. Each of them These two rasters have been clipped to include both districts of the Park, and were used primarily for cartographic products.

There is a table in the geodatabase named *arch_features*. This table includes all known archaeological features for each site.

The spatial domain of all geographic features in this database is as follows:

- Projection: Universal Transverse Mercator (UTM)
- Datum: North American Datum 1983
- UTM Zone: 12
- Units: Meters

FGDC compliant metadata was developed for this geodatabase and can be accessed via ArcCatalog.

Field Collection of Data

The main task of data collection was the identification of LCS features and archaeological sites. This began with the spatial data supplied by SAGU. Coordinates for spatially near LCS features or archaeological sites were selected from the ArcGIS feature class *Arch_and_LCS*. Once selected, a list of coordinates and a map of the local area was printed. In order to facilitate identification, information was also sought through the state of Arizona’s archaeological database (AZSITE). The AZSITE database contains descriptions of archaeological sites throughout Arizona, including descriptions of features at each site. These descriptions were essential to the identification of archaeological sites from the SAGU database.

In the field, a small, handheld GPS was used to navigate to LCS feature and archaeological site coordinates. Locating LCS features was relatively straightforward, with only one, because of its location (see below) evading identification. For archaeological sites, however, reaching the provided site coordinates was only the beginning of what was often a long process. Arriving at the published coordinates, an attempt was made to match features and how they lay in the landscape to descriptions in the AZSITE database. This usually involved searching the landscape because sites were often located far from the coordinates provided (see below, where the mean distance between coordinates for archaeological site coordinates and the actual site location was 45.42 meters).

Following reconnaissance around the coordinates, four scenarios were possible. 1) If features in the area were not found, the site was designated as *not found*. 2) If there were features that might match it designated as *possibly found*. 3) If the features at the site matched the AZSITE description, it was designated as *found*. 4) If features were found but they did not match those described it was designated as a *new site*.

If the site was found, possibly found, or a new site was found, the following data was collected using a Trimble XT GPS:

1. Casa ID and feature ID (these are unique numbers given in the field). Each site has a unique casa ID but may contain several features.
2. The ASMIS ID (i.e. the SAGU number) or the LCS number.
3. The GPS unit and the operator
4. Whether a picture was taken
5. The temporal designation, i.e. Prehistoric, historic, or mixed
6. The type of feature, i.e. artifact scatter, rock alignment, picnic table, etc.
7. The “site confidence” and “sagu confidence”. These refer to whether we are certain if it is even an archaeological site (i.e. could be geological or maybe only consists of a few artifacts) and whether or not we think it corresponds to the sagu site we are attempting to find.
8. The time, date, and (of course) coordinates are automatically recorded.

Once this data was entered in the Trimble, some notes are recorded in the field notebook (it was much easier to enter this in the “comments” section later, rather than trying to enter it into the Trimble while in the field). These notes contained information about artifact density, the variety of artifact types, and the condition of the features.

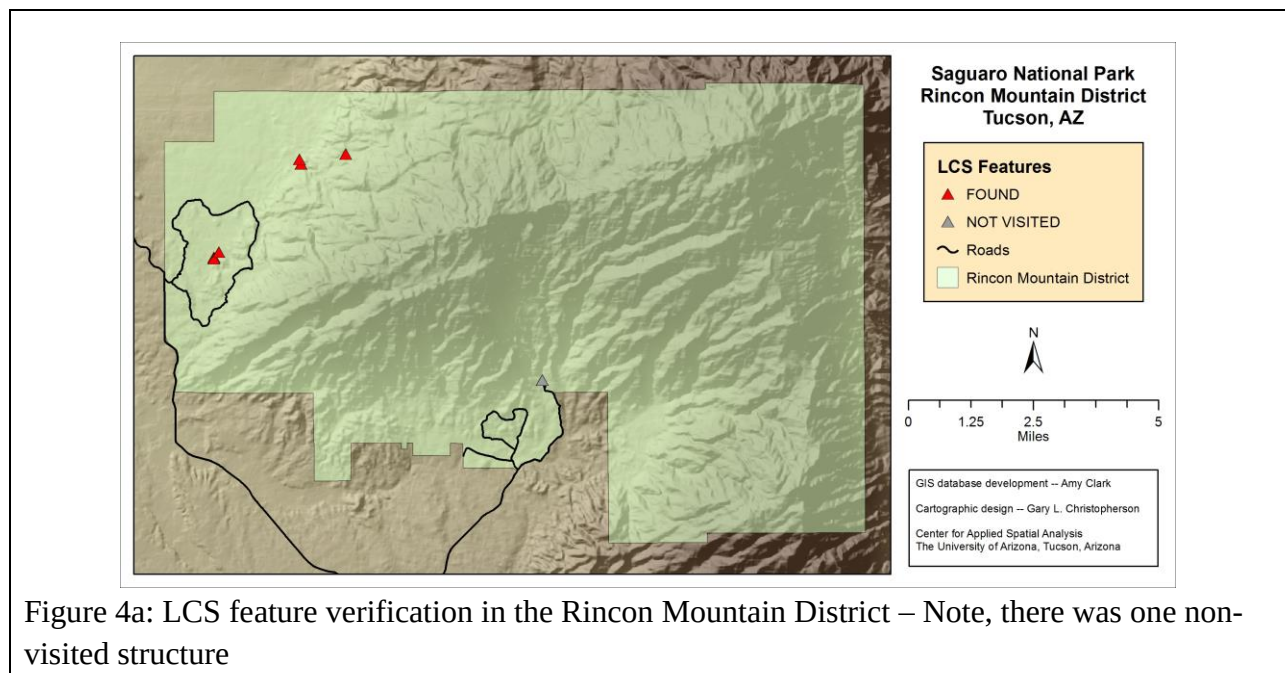
If an archaeological site was discovered while in route but did not match any of the sites from the SAGU database, it was recorded and given a CASA number but it does not have a corresponding AZMIS or LCS number. What will be done with these *sites* will be determined by SAGU personnel.

Once back at the lab, the data was imported from the Trimble using GPS Pathfinder Office. This data was spatially corrected, providing sub-meter accuracy, exported as ESRI shapefiles and appended to the respective feature class (i.e. point, line, or polygon) in the geodatabase. These data were then examined for errors and the notes mentioned above are added to the “comments” section.

Finally, the feature class *arc_and_LCS* feature class was updated to indicate whether the site was “Found”, “Possibly found”, or “Not found”.

Field collection results

Out of 44 LCS features included in the GIS database, only one was not verified during this project (Figures 4a and 4b). This was due to its inaccessibility, being located at the end of a blocked private road (it can be accessed from the Park but this would likely require an overnight backpacking trip). We also visited 120 coordinate locations tied to archaeological sites/features in the SAGU database (just under 24% of the 510 sites). From the 120 coordinate pairs we were able to identify with certainty 70 archaeological sites, a further 19 were identified as possible archaeological sites (*i.e.* a site was found but it is questionable whether it was the correct site or if it was an archaeological site), and 31 were not found (Figures 5a and 5b). If these trends hold true for the entire corpus of archaeological sites, resurvey should be able to locate and positively identify just over 58%, or 298 sites, while failing to find 26%, or 132 sites.



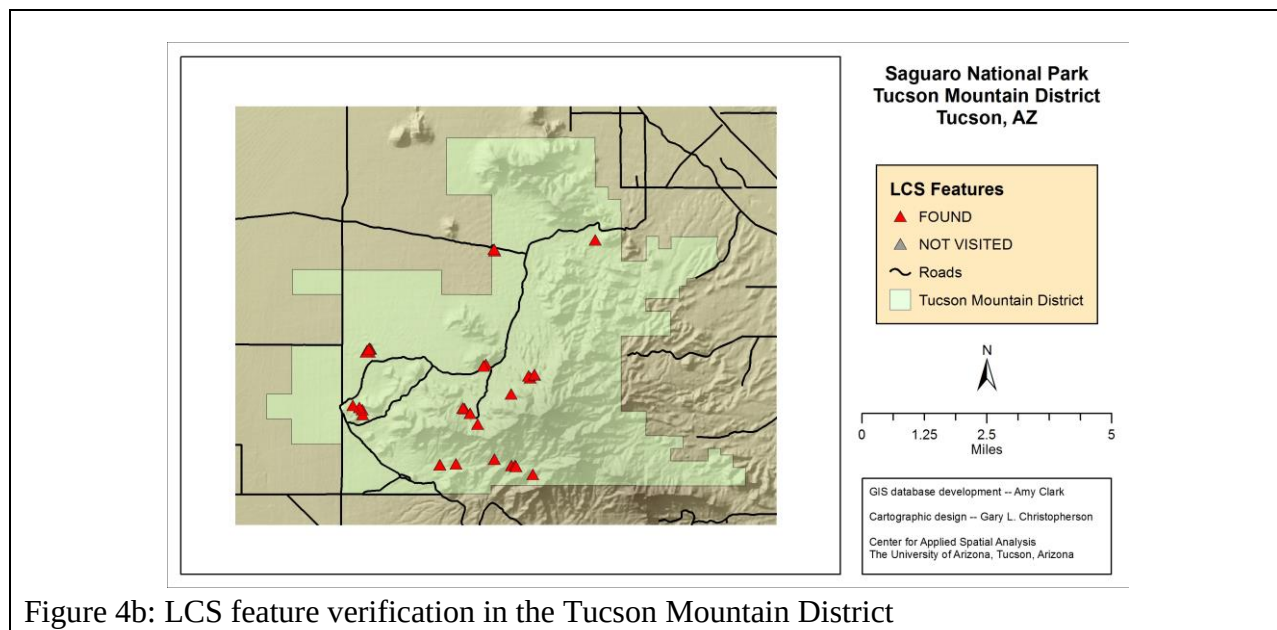


Figure 4b: LCS feature verification in the Tucson Mountain District

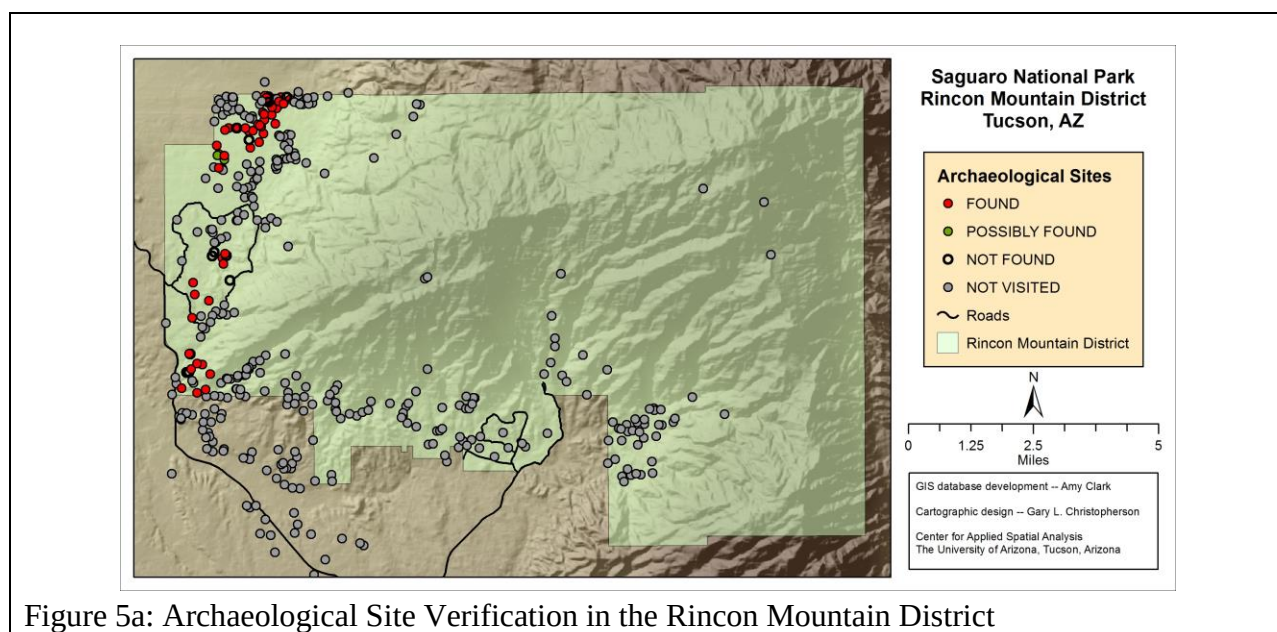


Figure 5a: Archaeological Site Verification in the Rincon Mountain District

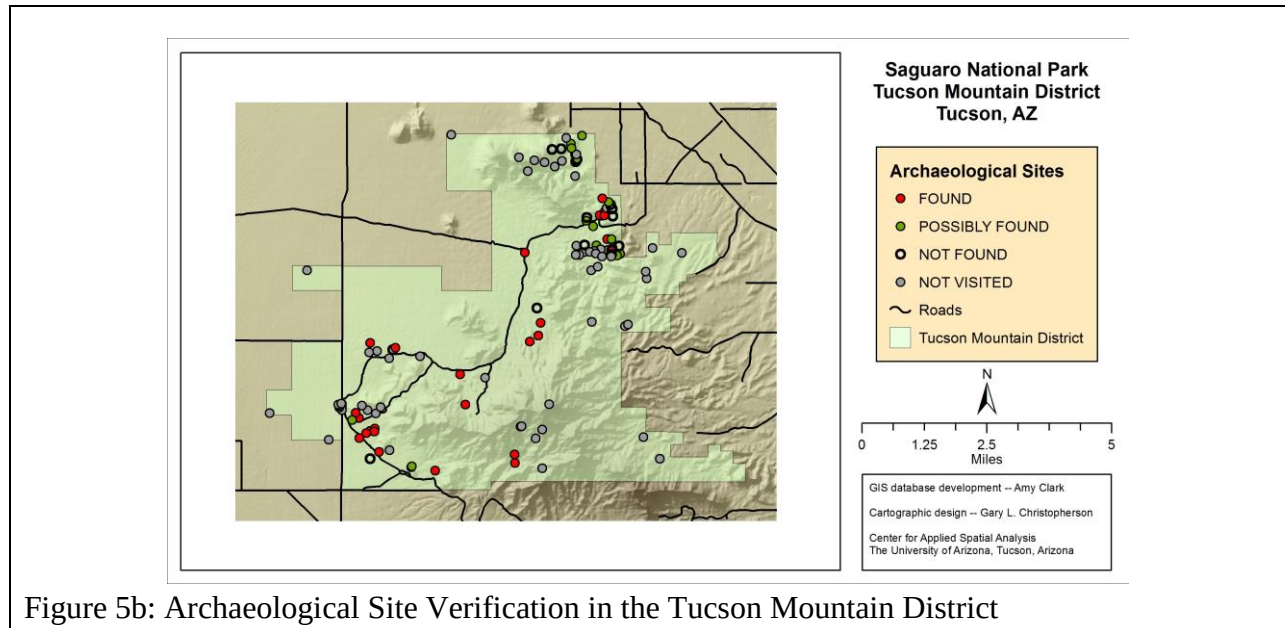


Figure 5b: Archaeological Site Verification in the Tucson Mountain District

Data Analysis and Identified Problems:

To answer questions about the accuracy of coordinates assigned to LCS features and archaeological sites, analysis was carried out to determine the difference between existing coordinates and new coordinates. The following paragraphs discuss the amount of error and potential sources of the error.

Error Calculated

Differences between feature coordinates were determined by using the *NEAR* tool in ArcGIS. This tool measures Euclidean distance between features in one feature class to the nearest feature in a second feature class. For this study, the measured difference was between the *old* coordinates in the *arch_and_LCS* feature class and the new coordinates for the same sites and features in the *Feature_point* feature class. This analysis is particularly important for how archaeological sites in the Park should be approached.

With few exceptions, coordinates for the LCS features were fairly accurate. On average, there was a difference of 23.11 meters between old and new coordinates, with a range of 290 - 0.2 meters. This high maximum number is due to the way that the *NEAR* tool treats linear features. It corresponds to the midpoint of a mining road and, thus, the distance is an overestimation. Removing this outlier, the average difference between old and new coordinates drops to 13.56 meters.

In contrast, the error for archaeological sites was considerably higher. The difference between old and new coordinates for archaeological sites ranged from 392 - 0.7 meters with a mean of 45.42 meters. These large distances between old and new coordinates, in tandem with the ephemeral nature of many of the archaeological sites in the Park, means that confidence in identifying specific remains with specific site identifications will be low. That is, you may think you are at Site SAGU00285, but you could be at any of a number of similar artifact scatters within 100 meters, or more, of SAGU00285.

Figure 6 shows the difference between coordinates for 4 sites in Saguaro National Park. These sites were selected at random from the 120 archaeological sites and features visited during this project. The difference between these old and new coordinate pairs for this sub-sample was slightly higher than the mean difference for all 120 sites (45.4) ranging from 63.8 to 216.8 meters.

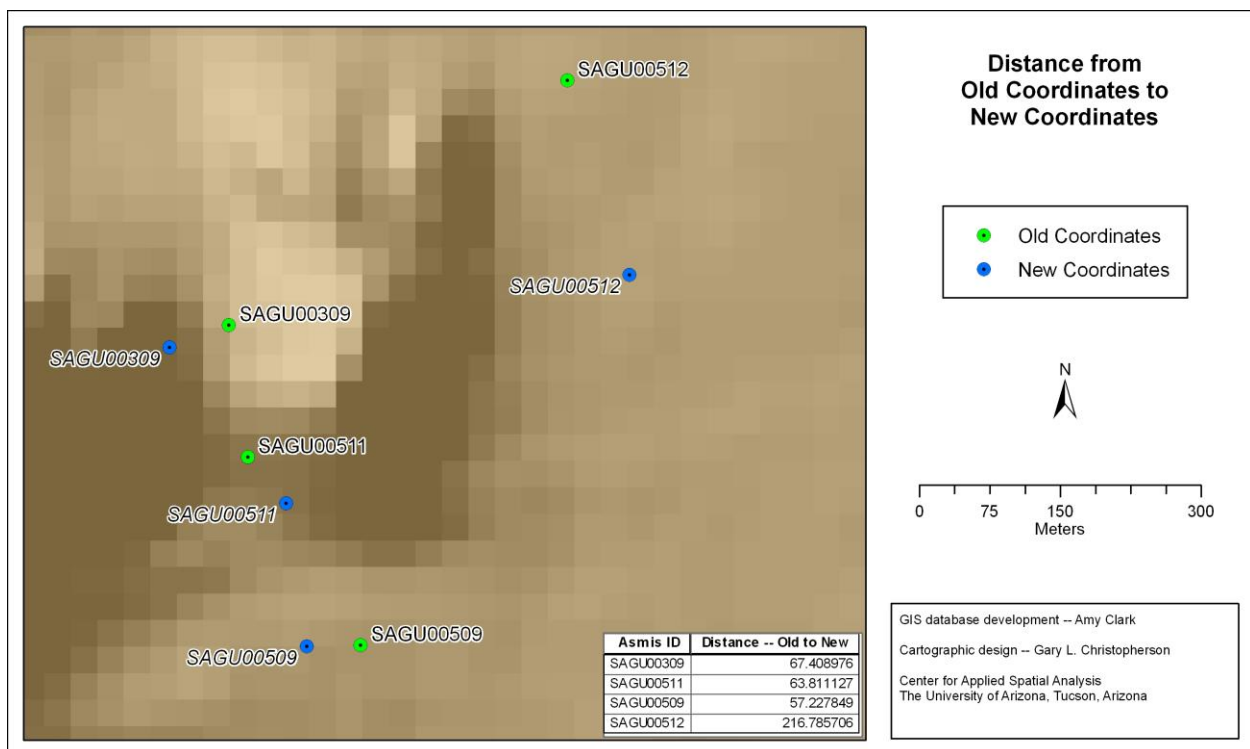


Figure 6: A sample showing the difference in meters between old and new coordinates for four sites in Saguaro National Park.

Error Sources

For the archaeological sites, the error in coordinate values came from a variety of sources, but primarily from problems with the original coordinates or problems with site identification. As noted above, the accuracy of coordinates was dependent on many factors including the use of maps, pre-2000 GPS signals, or post-2000 GPS signals. Even with the most careful approach

errors are common when maps are used to calculate coordinates, and selective availability in pre-2000 GPS signals caused wide ranging errors.

Equally problematic is the misidentification of sites, something particularly easy to do with artifact scatters. Without either distinctive features or direct knowledge of particular sites, one artifact scatter looks pretty much like any other. Adding to this difficulty is the cultural landscape of SAGU where archaeological remains are common. In this landscape the action of stopping and looking more carefully at any one location on the ground will ultimately reveal a site, simply because the time was taken to look. This raises three questions, asked each time that a coordinate pair was located and a few dispersed artifacts were found: is this 1) the site as it originally appeared? 2) the site but diminished due to artifact collection and/or natural processes? or 3) not the site at all? Given the uncertainty of coordinate accuracy for archaeological sites in SAGU, it was often impossible to provide a definitive answer to any of these questions.

Dealing with the Errors

Being unable to answer these questions for a number of sites/coordinate pairs, dealing with the errors was handled in the database. There are two fields, *site_confidence*, and *sagu_confidence*, in the *Features_point* feature class that can be used to identify problematic site identifications. For example, one could be relatively sure that the proper location of the SAGU site was reached (through landscape descriptions given in the AZSITE database, for example) but that there wasn't enough archaeological evidence for it to be classified as a "site", then one could record the site as *Certain* for *sagu_confidence* but *Possible* for *site_confidence*. On the other side of the coin, one could have reached a definitive archaeological site but remain unsure over whether the site corresponds to the SAGU coordinates (either because the coordinates are way off or because the site doesn't match the description in AZSITE). Hopefully, this will help future researchers understand why a site may have been listed as *Possibly* found in this database.

Conclusions and Suggestions for Future Management and Analysis

There are two important conclusions that we reached based on this project. First is that the LCS coordinates were adequate for locating these structures. With the one exception noted above, we were able to locate all of the LCS features in the Park based on the provided coordinate pairs and physical descriptions. Even though it is possible to locate LCS features using the old coordinates, we suggest that the new, more accurate coordinates be used from now on.

More important is our conclusion that there are significant problems with the coordinates for archaeological sites in SAGU. Based on our survey, the mean difference between old and new coordinates makes it difficult to be certain about the location of sites in the Park. This problem is compounded by the ephemeral nature of many of the sites. Unless a site enjoys distinctive features or landscape components noted in AZSITE, it is difficult to be certain that archaeological features located at recorded coordinates are actually the features tagged to those

coordinates. Further, when you arrive at coordinates but find no site, then search for and find features or artifacts, it is problematic to connect these features or artifacts to coordinates that may now be hundreds of meters away.

To improve the archaeological data in SAGU, there should be a systematic resurvey of the Park's archaeological resources. This survey should use quality GPS resources that allow for real-time or differential correction of coordinates. This survey should collect a central point for each site, and it should also record all features at each site as points, lines or polygons. These sites and features should be stored in a GIS database. Taking these steps would remove most of the locational problems for future management and research. Confidence in the coordinates would mean that all sites in the database could be revisited without questions about location. Having features as well as sites marked would clear up any questions about where a particular feature is located, and if it was recorded earlier or is newly discovered.