Hohokam Population Dynamics: Settlement Organization and Migration at the Sabino Canyon Ruin Site, Arizona

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Hohokam Population Dynamics: Settlement Organization and Migration at the Sabino Canyon Ruin Site, Arizona

A Thesis
Presented to
the Faculty of Social Sciences
University of Denver

In Partial Fulfillment
of the Requirements for Degree
Masters of Arts

by
Daniel Shereff
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Advisor: Lawrence Conyers
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Abstract

The Hohokam people occupied the southern Arizona desert for more than one thousand years from approximately 450 A.D. to 1450 A.D. Beginning approximately 1100 A.D., the Hohokam underwent a dramatic cultural change. This change was reflected in many aspects of the Hohokam way of life including architecture, trade, subsistence, and ceramic production. Contemporaneous with these changes, there was an influx of people from the north who migrated into the Tucson Basin. The archaeological record of several Classic Period sites in the Tucson Basin demonstrates the presence of locally produced non-native ceramic styles. The Sabino Canyon Ruin site, located on the eastern portion of the Tucson Basin, contains archaeological evidence of these changes. The results of this research demonstrate at the Sabino Canyon Ruin site, immigrant populations were living spatially separate from the native Hohokam. In addition, the data collected in this research suggests that the Hohokam at the Sabino Canyon Ruin site subsisted through means which are atypical in the Tucson Basin, and were organized economically and socially different from other Hohokam populations living along the major river floodplains.
Acknowledgements

Allen Dart was invaluable in considering the presence of the Hohokam in the region and in helping to understand the archaeological materials found at the site. Dr. Mark Elson, Senior Research Archaeologist at Desert Archaeology, provided guidance regarding the history of Hohokam research, and strategic assistance concerning this project. The University of Arizona provided the use of its field house which was indispensable to this research. Alyssa Cunial, an archaeology student at the University of Arizona, was a valuable research assistant, helping in the classification and cataloguing of the ceramic dataset.

Dr. Chester Walker provided the aerial drone used to acquire the pictures necessary to create the three-dimensional images maps of the Sabino Canyon Ruin site.

Most significantly, Professor Dr. Lawrence Conyers has provided guidance and his substantial expertise throughout this research. Professor Conyers generously shared his knowledge of ground-penetrating radar and its utility in the field of archaeology. In addition, Professor Conyers has provided valuable insight and support throughout the preparation of this thesis.

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Chapter 1: Introduction and Historical Background

The Hohokam people occupied the Sonoran desert of southern Arizona from approximately 450 A.D. to 1450 A.D. (Figure 1; Figure 2). The Hohokam are descendants of other agricultural people who lived in the region as early as 2000 B.C. (Fish and Fish, 2007; Bayman, 2001). By 700 A.D., the Hohokam had developed a successful system of agriculture based on a network of canals and extensive agricultural fields (Noble, 1991). Throughout their history, the Hohokam, who lived in pithouses and pueblo-like compounds organized in village communities, produced intricate red-on-buff pottery (Haury, 1976), and traded with populations as far south as Mexico (Doyel, 2008).

During the one thousand year period which has been described by Drs. Paul and Suzanne Fish as the “Hohokam Millennium” (Fish and Fish, 2007), the Hohokam existed as a distinct cultural group. The Hohokam culture is reflected in the archaeological record of this period, including distinctive ceramics, architecture, and agricultural practices.
Figure 1: Arizona state map showing extent of the Hohokam region.

Figure 2: Hohokam sites in the Tucson Basin (modified from Gregonis and Hartmann, 2011).
The Sonoran desert is different from other deserts in that it has two rainy seasons each year. The presence of two rainy seasons, in combination with the development of advanced desert farming techniques, allowed the Hohokam to grow a variety of newly domesticated crops such as maize, beans, and squash (Haury, 1976). Additionally, the floodplains and washes in the region were comprised of a nutrient rich soil which supported a variety of plant and animal life (Figure 3).

Figure 3: Santa Catalina Mountains as seen from present-day Sabino Canyon Ruin site surface.

Between 450 A.D. and 500 A.D., the Hohokam constructed organized villages in which pithouses, sunken earthen and adobe structures with pounded floors and thatch roofs were arranged in groups around a central garden or communal space (Bayman, 2001). The Pre-Classic Period, starting at approximately 700 A.D., marks the beginning of the creation of prehistoric ballcourts in styles similar to those of ancient Mesoamerican groups in Mexico (Noble, 1991).
The period of greatest Hohokam growth occurred during the Classic Period between 900 and 1100 A.D. (Noble, 1991). During this time, the Hohokam greatly expanded their network of irrigation canals throughout the Sonoran desert. This expansion allowed for increased crop cultivation and the concurrent ability to support larger populations in larger villages (Fish and Fish, 2007).

During the late Classic Period, between 1100 A.D. and 1300 A.D. the Hohokam experienced a “dramatic cultural reorganization” (Fish and Fish, 2007). During this period, the once-significant ballcourts fell into disuse, sites were abandoned and the expansive Hohokam territory decreased. (Waters and Ravesloot, 2001; Lekson, 2008). In addition, the architectural style of Hohokam dwellings changed from the pit houses of the Pre-Classic Period to pueblo style, adobe structures which sat above ground (Figure 4) (Waters and Ravesloot, 2001; Hill, et al., 2004).

Compounds typically contained multiple rooms and were enclosed by high earthen walls. This had the effect of concentrating the population of the Hohokam into small, dense clusters across the landscape. These newly constructed, compound style living structures, suggest that a dramatic cultural change occurred in Hohokam society in which privacy, and perhaps a rigid social structure, were valued (Noble, 1991). Additionally, during the Classic Period, the Hohokam constructed large earthen mounds,
which likely served as ceremonial or religious locations (Haury, 1976; Waters and Ravesloot, 2001). It is this critical cultural change that is the focus of this research.

Figure 4: Compound or enclosure walls and rock foundations visible on present-day Sabino Canyon Ruin site surface.

It is unclear what caused the Hohokam to reorganize and restructure their culture during the Classic Period. However, soon after this reorganization, the Hohokam began their decline in the American Southwest. By 1450 A.D., the once large Hohokam population dispersed widely around the region and the Hohokam no longer functioned as a distinct cultural group (Bayman, 2001).

In attempting to understand the collapse of the Hohokam in Arizona, some archaeologists suggest internal factors within the society led to the decline. Such factors include socio-political strain from a new government and a decline in the religious cohesiveness of the population. In contrast, others have hypothesized that external forces, such as a change in climate or rainfall (Waters and Ravesloot, 2001), or an invasion by
another population (Anderies, 2006), caused the demise of the Hohokam. In the absence of conclusive evidence to explain the decline of the Hohokam population, a truly complete Hohokam history remains elusive.

There have been many archaeological investigations into the Hohokam throughout the history of Southwestern archaeology. Modern Hohokam archaeology began in the Southwest with the work of Emil Haury (Haury, 1976; Haury, et al., 1986). Throughout his long career, Haury excavated numerous Hohokam sites across the region and became known as a preeminent Paleo-Native American archaeologist (Haury, 1976; Haury, et al., 1986). Haury published extensively regarding his excavations and his conclusions about Hohokam culture, ceramics, architecture, tools, and subsistence. Haury's most well-known work was conducted during the 1960's at the Snaketown site, located southeast of present-day Phoenix. The site contained ballcourts, a central plaza, monumental architecture, adobe dwellings, extensive agricultural holdings, and vast quantities of Hohokam artifacts (Haury, 1976). As a result of the complexity and completeness of the excavations, Snaketown has become one of the most significant Hohokam sites. Even today, Haury's early research into the Hohokam is a staple within the field of Southwest archaeology.

Drs. Paul Fish and Suzanne Fish, at the University of Arizona in Tucson, have conducted extensive research into the life, subsistence strategies, cultural organization, and collapse of the Hohokam. Their continued work at the University Indian Ruin site
has led to a more complete understanding of Hohokam social structure through the excavation of the mounds found at the site (Hayden, 1957).

The work of other archaeologists at cultural resource management firms, including Mark Elson and William Doelle at Desert Archaeology Inc., Doug Craig at Northland Research Inc., and Allen Dart at Old Pueblo Archaeology, have been important to the field of Southwest archaeology (Bayman, 2001; Gregonis and Hartmann, 2011; Dart, 1999, Slaughter and Roberts, 1996; Slaughter, 1994). Their research has contributed significantly to an understanding of Hohokam history. Together with many others, these individuals and firms have contributed to the collective knowledge of the Hohokam and have helped frame this research at the Sabino Canyon Ruin site.
Chapter 2: Sabino Canyon Ruin

The Sabino Canyon Ruin site (AZ BB: 9: 32) consists of approximately one hundred acres located on the grounds of a private boarding school in northern Tucson. Over the course of approximately ten weeks during the summer of 2012, I examined the features and artifacts from the Sabino Canyon Ruin site. The collected data was utilized to gain insight into Hohokam population demographics and village organization during the Classic Period. The conclusions drawn are based on the ceramic artifacts, architectural features, and geophysical data collected from the Sabino Canyon Ruin site.

The earliest record of the Sabino Canyon Ruin site dates to 1910 (Dart, 1999). Elsworth Huntington, a professor at Yale University, visited the site and noted stone foundations, ceramics, and chip stone that he observed on the surface. Reconciled with more modern maps of the site, Huntington drew a basic sketch map of what is now known as Compound B (Dart, 1999). During 1920 and 1921, Professors Andrew E. Douglass and H. Leonard conducted an extensive survey of the Sabino Canyon Ruin site on behalf of the University of Arizona. Douglass and Leonard produced a detailed map of the site, making note of a minimum of five compounds as well as other structures associated with Hohokam occupation. The map they created is now located in the
archives of the Arizona State Museum and has since been updated (Figure 5) (Dart, 1999).

Figure 5: Map of compounds, rooms, and pithouses at the Sabino Canyon Ruin site, based on 1921 site map (reproduced from Welsch, 1989).

During 1935 and 1936, William Neil Smith was a student at the Southern Arizona School for Boys (later the Fenster School of Southern Arizona). Together with some of his classmates, Smith excavated part of the Sabino Canyon Ruin site in the area of a mud-walled room and discovered numerous ceramic sherds, stone artifacts, shell jewelry, and a large bird-effigy vessel (Dart, 1999). In 1938, Emil Haury recorded the site for the Arizona State Museum. He classified the site as a village containing at least ten
architectural features, ceramic sherds of varying typology, and arable land to the south (Dart, 1999).

From 1937 to 1950, Don Everitt taught at the Southern Arizona School for Boys. During his tenure at the school, Everitt excavated part of what is now known as Compound D (Dart, 1996, 1999). No records were kept of Everitt's excavations, but a written summary of what was found was given to Allen Dart of Old Pueblo Archaeology (Dart, 1999).


The Sabino Canyon Ruin site was excavated from 1995 to 2001 by archaeologist Allen Dart and Old Pueblo. The site contains numerous pithouse remains, compound and enclosure walls, and dozens of artifact scatters (Figure 6) (Dart, 1999). Allen Dart and his team cataloged a representative sample of the artifacts found during his excavation of the site. These artifacts were held under the purview of Allen Dart prior to my research. In order to conduct this research, I was granted access to this collection. After my research
was complete, the artifacts were accessioned and now reside in the permanent collection of the Arizona State Museum in Tucson, Arizona.

Numerous Pre-Classic and Classic Period sites have been discovered and excavated in the Tucson Basin (Figure 2). The Classic Period site, University Indian Ruin, is located less than ten miles southwest of Sabino Canyon Ruin. University Indian Ruin has been excavated in conjunction with the University of Arizona, and has served as its field school site for many years. Research has demonstrated the University Indian
Ruin site continued to be occupied well after 1300 A.D., when most of the other sites in the region had been abandoned. It has been suggested that this site played an important social role for the Hohokam in the Tucson Basin (Conyers personal communication, 2013).

The Classic Period site, Whiptail Ruin, sits approximately five miles east of Sabino Canyon Ruin along the Agua Caliente Wash (Figure 2). Whiptail Ruin contains much of the same architecture and artifacts as was found at the Sabino Canyon Ruin site (Dart, 1999; Gregonis and Hartmann, 2011). The Gibbon Springs site, located between Bear Canyon and the Agua Caliente Wash, appears to have been occupied during the same time and by the same people as those who occupied Sabino Canyon Ruin (Gregonis and Hartmann, 2011). The artifact assemblages found at these sites suggests all three were originally Hohokam settlements (Gregonis and Hartmann, 2011; Slaughter and Roberts, 1996; Slaughter, 1994). Research at Gibbon Springs and Whiptail Ruin has yielded greater insight into Hohokam village organization, population migration, and cultural integration during the Classic Period (Gregonis and Hartmann, 2011; Slaughter and Roberts, 1996; Slaughter, 1994).

The large concentration of Hohokam sites in the Tucson Basin may be attributed to the climate in the region and resources available to ancient populations. Predictable patterns of rainfall which flooded the washes located near many of the sites enabled the Hohokam to successfully farm the region. Regional wildlife, attracted to local water
sources, would have provided an additional source of subsistence for the Hohokam. Hohokam populations were thus able to farm and hunt most of the year and sustain substantial populations (Fish and Fish, 1992).

The region also provided significant quantities of valuable raw materials. Large quantities of easily accessible clay allowed the Hohokam to produce the ceramics which are archaeologically unique to the region. In addition, direct access to trade routes allowed the Hohokam to acquire the obsidian and chert needed to make stone tools and projectile points (Noble, 1991). Although relatively rare, timber was available in some areas of the region, facilitating construction of multi-story compounds, such as those seen at Casa Grande (Noble, 1991).

It is understood there are three different types of Classic Period Hohokam settlements consisting of primary villages, hamlets, and seasonal settlements (Ellis and Waters, 1991). Primary villages were generally large, year-round settlements which contained public architecture such as ballcourts (Ellis and Waters, 1991). These villages were typically located on terraces above floodplains along major streams, near arable land (Gregonis and Reinhard, 1979). Hamlets were smaller than primary villages and did not contain public architecture (Ellis and Waters, 1991). These smaller villages were located on ridges at the junctions of mountain slopes and river terraces (Gregonis and Reinhard, 1979). Finally, seasonal settlements were smaller than hamlets and were
occupied for a limited duration, consisting of only a few days a year or during a single season (Ellis and Waters, 1991).

The Sabino Canyon Ruin site does not contain any form of public architecture such as plazas or ballcourts, and is not located near a large amount of arable land. Therefore, the site can not be classified as a primary village, at least as compared to other sites in the Tucson Basin. As determined through the ceramic chronology performed by Allen Dart, the Sabino Canyon Ruin site was occupied from approximately 950 A.D. to about 1350 A.D. (Dart, 1999). The quantity of architecture as well as the location near the mountains and perennial water, suggests the Sabino Canyon Ruin site was occupied all year round. Using this classification system, the site would be considered a hamlet or a smaller village. The location of the Sabino Canyon Ruin site in proximity to larger Hohokam sites may indicate it was economically or socially associated with these larger "parent sites". For the purposes of this research, parent sites are defined as major Hohokam settlements located along the regional river floodplains. The hunter gatherer activities which occurred at the Sabino Canyon Ruin site are consistent with the hamlet settlement classification. In addition, the data supports the hypothesis that the foothills sites may have functioned as satellite which produced goods for the more established sites on the Tucson Basin floodplain.
**Thesis Research**

Archaeological, geophysical, mapping, analytical, and statistical approaches were utilized in this research. The methods used in this research were conducted in accordance with the SAA code of ethics. The techniques employed in this research allow for an improved understanding of the Hohokam without the need for typically invasive archaeological methods. The majority of the archaeological artifacts excavated from Sabino Canyon Ruin are in the form of ceramic sherds (Dart, 1999). Through an examination of form, decoration, and color, Hohokam ceramics can be dated, categorized, and attributed to regional populations (Schroeder, 1982). Thus, Hohokam ceramics are a crucial part of the archaeological record of the region. Analysis of native and non-native ceramics collected from the Sabino Canyon Ruin site allowed for a study of spatial usage and population distribution across the site.

The Hohokam lived in large, complex, and well-organized community groups (Doyle, 2008). During the Pre-Classic Period the Hohokam lived primarily in pithouse structures (Noble, 1991). These pithouses were typically arranged into groups with communal space in the center which served as a location for gathering, and possibly, social differentiation by kin or familial groups (Doyle, 2008). During the Classic Period however, the manner in which the Hohokam lived changed dramatically (Doyle, 2008; Noble, 1991; Bayman, 2001). Pueblo style compounds were built and population density increased. The cause of this change is community organization in not fully understood.
Between 900 A.D. and 1100 A.D., an influx of people from outside the region settled at several Hohokam sites in the Tucson Basin (Gregonis and Hartmann, 2011; Slaughter and Roberts, 1996; Slaughter, 1994). I hypothesized that the change in Hohokam village organization during the Classic Period was caused, in part, by the presence of non-native groups who migrated into the area. Immigrants who migrated to the Tucson Basin joined existing communities. The newly settled immigrant population constructed dwellings and produced their own ceramics types. It is possible the inhabitants of a village group became divided along cultural or ethnic lines (Gregonis and Hartmann, 2011). It was anticipated that evidence of social integration would be reflected in the spatial distribution of non-native ceramics and architecture types. Although other explanations have been suggested, it appears the archaeological record of Sabino Canyon Ruin, particularly in the form of non-native ceramics, reflects this division.

This research included the collection and interpretation of multiple datasets consisting of archaeological, geophysical, and digital information. Field methods used in this research were selected for the purpose of collecting data which could be used to identify aspects of Hohokam cultural change and settlement organization during the Classic Period. The data was analyzed to identify patterns in the distribution and organization of architectural elements and artifact assemblages at the Sabino Canyon Ruin site.
The ceramic dataset from the Sabino Canyon Ruin site contains a significant percentage of non-native ceramics. As will be discussed in Chapter 4, the distribution of corrugated ceramics across the site demonstrates the non-native peoples were living separately from, and possibly in a different manner relative to the native Hohokam.

The geophysical datasets suggest the Sabino Canyon Ruin site was different from many other Hohokam sites in the Tucson Basin. Unlike most of the other sites in the Tucson Basin, the Hohokam at the Sabino Canyon Ruin site lived in a region which was not suitable for intensive agriculture. This would have affected the manner in which the Hohokam subsisted on the landscape and how they were socially organized.
Chapter 3: Field Methods

The central goal of this research was to develop a multi-faceted dataset to evaluate the archaeological record of the Sabino Canyon Ruin site, particularly in relation to social development and organization of the Hohokam during the Classic Period. Data were collected using traditional and geophysical archaeological methods. Site mapping and ceramic analysis were performed together with ground-penetrating radar (GPR) and satellite-based remote sensing. This methodology was used to find evidence regarding Hohokam community organization and cultural change during the Classic Period.

Ceramic Analysis

Ancient populations throughout the Southwest produced their own complex ceramic styles. Ceramics are culturally distinctive and accordingly, play a large role in Southwest archaeology. Ceramics can provide insight into cultural practices, technology, trade, regional movement, and societal organization (Figure 7). For this reason, the majority of time in the field was spent conducting an analysis of the ceramic artifacts previously excavated from the site.

The ceramics dataset consisted of more than 60,000 sherds excavated by Allen Dart of Old Pueblo Archaeology and his archaeological field school. The database
created for this research utilized all of the ceramics which were excavated by Dart, making further excavation unnecessary, and preserving the site for future excavation.

Numerous ceramic typologies were produced by the Hohokam in the Southwest. Tanque Verde Red-on-Brown, Rincon Red, and additional variations of these styles were created during the Hohokam occupation of the Tucson Basin. These types are specifically identified as Hohokam ceramics (Dart, 1999; Noble 1991). As the name suggests, Tanque Verde Red-on-Brown ceramics consist of brown slipped vessels with red painted decorations. These decorations appear as geometric patterns or figural images, typically found on the exterior surfaces of ceramic objects (Figure 8).
Rarely found in the Tucson Basin, corrugated ceramics contain linear or wave-like horizontal banding (Figure 9). Corrugated wares originate in the Colorado Plateau, but first appear in the Tucson Basin between 1000 and 1200 A.D. as regional populations began to migrate southward (Neuzil, 2008; Hill, et al., 2004). Therefore, the presence of corrugated ceramics at the Sabino Canyon Ruin site is significant as it suggests an influx of immigrant populations from the north (Gregonis and Hartmann, 2011; Schroeder, 1982; Slaughter, 1994). Thus, in this research, corrugated ceramics were considered indicative of non-native populations at the Sabino Canyon Ruin site. In order to examine the occupation of the Sabino Canyon Ruin site by immigrant population, it was necessary to conduct an examination of the ceramic dataset, focusing on the presence and distribution of corrugated ceramics.
Excavation and Ceramics at the Sabino Canyon Ruin site

The ceramic history of the Sabino Canyon Ruin site consists of several major typologies. Tanque Verde Red-on-Brown, Rincon Red, Gila and Rincon Polychrome, Rincon Red-on-Brown, and Plain ware were all found at the site during Dart's previous excavation (Dart, 1999). At the Sabino Canyon Ruin site, Tanque Verde Red-on-Brown (Figure 8) and Plain ware dominate the ceramic collection (Figure 10). Other varieties appear in smaller quantities, including Black-on-White polychrome (Figure 11). During Dart's excavation of the site, he noted that corrugated ceramics were found in quantities not normally found at Hohokam sites of the same age in the Tucson Basin.
The ceramics analyzed in this research were excavated by Allen Dart and Old Pueblo Archaeology Center between 1995 and 2001. Dart's excavation of the Sabino Canyon Ruin site was conducted as a field school (personal communication Allen Dart, 2012). Professional archaeologists taught excavation practices as well as how to properly record, classify and analyze the artifacts which were found to field school participants (personal communication Allen Dart, 2012).
Artifacts collected during Dart's field school included shell, chip stone, ground stone, ceramics, figurines, spindle whorls, beads, and animal bones. Field specimen forms were created for each artifact or set of artifacts prior to collection. These forms contained unit number, bag number, provenience number, level, and special notes regarding the collection of the artifacts. Artifacts were then categorized and bagged by unit number and level. A representative sample of dirt excavated was screened using one fourth inch hardware cloth to recover smaller artifacts (Dart, 1999).

After collection and analysis, objects were boxed by artifact type and unit number. Prior to my research, the artifacts were stored at the Old Pueblo Archaeology Center in Tucson, Arizona. The original field specimen forms stored with the artifacts were used in this research. In June of 2012, I was permitted to take custody of the artifacts excavated from the Sabino Canyon ruin site. The artifacts were moved to the secure, on-site laboratory at the University Indian Ruin field house where the artifact analysis for this research was conducted. Only those boxes which contained ceramic artifacts were analyzed. After analysis was complete, the ceramics were replaced back into their respective bags and boxes and delivered to the Arizona State Museum in Tucson, Arizona to become part of its Hohokam collection.

One month was dedicated to ceramic identification and analysis of more than seventy curation boxes, consisting of 1,200 bags of ceramics. Individual bags of
ceramics, sorted by feature number, were opened and sorted by typology. Each bag typically contained hundreds of individual sherds which were each catalogued and counted. Working together with my research assistant, Alyssa Cunial, each ceramic sherd was individually examined and categorized by typology. Sherds large enough to be typologically identified were entered into the database. Those sherds which were too small for identification were not catalogued and have not been considered in this research.

A database was created for all of the decorated and corrugated ceramics, which included provenience and typological information. Feature number, provenience number, unit number, stratigraphic location, level, bag number, and quantity were recorded. Total counts of each type of ceramic within each excavation unit were also recorded together with any secondary information provided in the excavation notes. Microsoft Excel was used as the database platform, as it allowed for easy data entry, sorting, and review.

Once completed, the database consisted of more than 12,000 individual decorated sherds and 1,200 lines of data (Appendix B). After the database was established, descriptive statistics and Chi Squared tests were performed. The descriptive statistics recorded the relative frequency of specific ceramic types and their distribution in geographic areas of the site. The Chi Squared tests allowed for a comparison of concentrations of specific ceramics types throughout the Sabino Canyon Ruin site. By
utilizing Chi Squared tests, the ceramic assemblages from the Sabino Canyon Ruin site could be compared to other sites within the Tucson Basin.

**Site Mapping**

As discussed in Chapter 2, numerous excavations have occurred at the Sabino Canyon Ruin site. Various archeological and mapping techniques were employed in these excavations. The resulting collection of maps was produced with different methodologies which highlighted different features.

In April 2012, I began the mapping portion of this research by traveling to the Sabino Canyon Ruin site to collect high resolution aerial photos. With the assistance of Dr. Chester Walker and his specialized equipment, a complete map of the site and surrounding area was created. An accurate GPS base station was established at the site and a series of sub-centimeter accurate ground control points were collected. These ground control points allowed the individual photographs to be stitched together to create a complete map of the site. The map was georeferenced in order to determine the exact location of the image in three dimensions as well as its location on the globe. The final map consists of an accurate composite image which facilitates the locating of archaeological features. In addition, this map can be manipulated in three dimensions, allowing the site to be viewed from numerous perspectives.
The composite map also served as a means to overlay previous excavation maps and pinpoint the exact location of GPR grids and survey information collected in this study (Figure 12; Figure 13) (See attached CD containing digital data). In addition, this highly detailed map allowed for the spatial orientation of the Old Pueblo Archaeology excavation units at the Sabino Canyon Ruin site. By combining Dart's provenience notes, which contain information regarding location of the artifacts, with the more detailed map obtained through aerial photographs, the exact location of the ceramic assemblages were determined and placed on the map. After the ceramics were located on the site map, a statistical evaluation of ceramic distribution was performed.

Figure 12: Three-dimensional composite aerial photo of Sabino Canyon Ruin region.
To examine the distribution of the corrugated ceramics at Sabino Canyon Ruin, the site was divided into three sections using AutoCAD drawings created during Allen Dart's excavation of the site (Figure 14). A nominal north, center, and south were assigned to the AutoCAD drawing and the excavation units which were dug in each section were recorded. A corrugated ceramic assemblage of ten percent was established as the minimum quantity for significance per excavation unit. In establishing a minimum baseline of corrugated ceramics, locations of presumed incidental deposition or movement of corrugated ceramics could be identified. In addition, by setting a minimum quantity for significance, only excavation units which contain significant concentrations of corrugated were identified as locations where immigrant populations settled.
The presence of ceramic types associated with a particular population is understood to indicate the population occupied the area where the ceramics were located. Thus, a thorough distribution analysis of corrugated ceramics at the Sabino Canyon Ruin site enabled testing of the theory that the migrant population were living separately from the native Hohokam.

Figure 14: AutoCAD drawing containing locations of excavation units at the Sabino Canyon Ruin site (Dart personal communication, 2012).
Remote Sensing

Remote sensing was employed as a means to provide a larger landscape map and to establish context of the Sabino Canyon Ruin site within the Tucson Basin. This geological technique is used to view the earth's surface through a series of electromagnetic spectra which are observed and recorded by a satellite sensor. The Landsat 7 ETM+ satellite was used in this research. This satellite collects electromagnetic spectra across eight bands which range from .45 to 12.5 microns. The ground resolution of the Landsat 7 ETM+ satellite is 30 meters, which provides sufficiently fine resolution to facilitate a landscape analysis. The data was collected on March 14, 2001, June 18, 2001, September 6, 2001, and December 27, 2001 to record seasonal changes which occur in the Tucson Basin. The raw data was obtained through the United States Geological Survey, which is publically available through the Earth Explorer program.

The remote sensing data was used to understand the effect of topology and climate on the Hohokam at the Sabino Canyon Ruin site. The data provides insight into how seasonal climate changes and resource availability affected the manner in which the Hohokam subsisted. The data was used in conjunction with the ceramic distribution analysis, described in the following chapter, to better understand why specific locations both in the region and within the site were chosen by the Hohokam. It appears the site selection was made through a consideration of multiple factors, including access to food and water resources as well as to other regionally available raw materials.
Ground-penetrating Radar

Ground-penetrating radar (GPR) data was collected in the field and analyzed to provide further insight into the architecture of the Sabino Canyon Ruin site. GPR is based upon an examination of the manner in which radar energy is propagated through a given material. As radar energy of a specific frequency enters the ground, its amplitude changes as the energy encounters and interacts with different types of subsurface features or geological strata (Conyers, 2013). The changes in amplitude of the energy is then measured and recorded together with time, distance, and frequencies. The resulting images can be viewed as amplitude slice maps of varying thickness to a given depth or as profiles collected along a single transect. Amplitude slice maps provide a means to examine slices of the subsurface at varying depths. These maps allow for an understanding of how the subsurface and the features therein change with depth. Linear profiles are particularly useful in examining the complete geological strata in a specific location. Profile images can be interpreted to locate and map sub-surface features such as pithouses, compound walls, hearths, and trash middens. Using GPR, it is possible to obtain an understanding of a sub-surface area without the need for potentially damaging excavation.

The GPR equipment used in this research consisted of a radar system, a specific frequency shielded antenna, and a survey wheel. The radar system employed was the SIR-3000 manufactured by Geophysical Survey Systems Inc. This system allows for the
viewing and storage of radar data in real-time and saves the data in a format which is suitable for further laboratory processing.

Soil composition, object and feature depth, radar energy interference, water saturation, and antenna choice all affect the quality of the data collected using GPR (Conyers, 2013). Soils which are highly electrically conductive, or contain specific types of clay, or large granitic rocks, can make GPR data difficult to collect (Conyers, 2012). Conversely, conditions such as fully saturated and sandy soils can be favorable for the collection of GPR data (Conyers 2013). Therefore, in order to accurately collect and analyze GPR data, it is important to consider regional geology and soil conditions. In the Tucson Basin, high quality GPR data can be collected because the soil in the region consists primarily of aeolian and fluvial sedimentary deposits (Conyers, 2012). As discussed more fully below, the challenges to data collection at the Sabino Canyon Ruin site were a result of surface vegetation, rather than specific soil or geological characteristics.

The depth to which radar energy can penetrate is, in part, dictated by the frequency of the antenna chosen (Conyers, 2012). The selection of an antenna inherently involves compromise. Lower frequency antennas, such as 250 MHz, allow for deeper energy penetration but have low spatial resolution as they are unable to resolve small objects or features. Higher frequency units, such as 900 MHz, collect high resolution data but have shallow depth penetration (Conyers, 2012). A 400 MHz antenna was selected
for this research due to its ability to resolve relatively small objects, while at the same
time having sufficiently deep energy penetration to ensure location of buried features at
the Sabino Canyon Ruin site.

Loss or attenuation of radar energy can have a dramatic effect on the success of
GPR. Energy loss or attenuation occurs both naturally and as a result of specific features
of the sub-surface. Natural energy loss occurs due to the diminishing energy strength, as
well as the conical shape of the transmitted radar energy. Known as geometric spreading,
radar energy, once transmitted from the antenna, begins to broaden and dissipate in
strength (Conyers, 2013). The deeper the radar energy travels, the more spread out it
becomes. The consequence of geometric spreading is that as depth increases, a smaller
amount of energy is available to reflect off buried features and return to the receiving
antenna on the ground surface.

Some objects or discontinuities cause radar energy to be redirected away from the
receiving antenna, resulting in data not being recorded. Objects such as pipes, and
geological features such as large canals, ditches, or mounds can cause radar energy to be
redirected away from the antenna, and thereby not collected (Figure, 15). At the Sabino
Canyon Ruin site, the largest obstacle to GPR data collection was the surface vegetation
which covered the site. Large surface vegetation such as trees, bushes, and cacti can
interfere with data collection by causing a deviation from the linear transects. In addition,
low-lying plants can become lodged beneath the radar antenna, which results in high
amplitude near surface reflections, and can have a detrimental effect on the resulting amplitude slice maps.

Raw GPR data consists of numerous individual successive traces. These traces occur at set distances within a GPR grid. This information can be stacked to form linear profiles. When evenly spaced transects are collected, traces can be arranged and sliced in three dimensions to create amplitude slice maps. All of the GPR grids collected at the Sabino Canyon Ruin site had the same distance between transects. A spacing of 0.5 meters was selected to provide ample data with which to resolve highly nuanced

Figure 15: Reflection and scattering of radar energy caused by changes in the subsurface (used with permission from Conyers, 2013)
geological and archaeological features. Other radar parameters including gain, time window, and samples per unit were adjusted for each grid collected. Grids were established using measuring tapes and their exact dimensions and location were noted. The locations of the corners of each GPR grid were measured using a GPS unit. This allowed the grids to be orientated in space and placed on the previously described georeferenced compound map (Figure 13).

GPR equipment was carried into the field early in the morning on each day of data collection. As previously discussed, a 400 MHz shielded radar antenna was used in conjunction with the SIR-3000 radar system. During data collection, locations of interest and associated file numbers were noted for consideration during post-fieldwork processing.

After GPR data collection was concluded each day, the data was removed from the GPR unit and stored on a flash drive. These files were then converted and renamed using the GPR_Process program, designed by Dr. Conyers, to prepare the files for further processing. Once converted and renamed, each transect file was examined in the GPR_Viewer program, also designed by Dr. Conyers, where gain points were adjusted and background noise removed. Again, files containing features of interest were noted for future study. GPR_Process was used to align and fit the individual transects into the parameters of the established grid. Finally, preliminary amplitude slice maps were created using the Surfer 9 software, made by Golden Software, to identify regions of
interest and to make note of any collection or processing errors which may have occurred. After fieldwork was complete, the GPR data was fully processed again in the method described above to create the best possible maps and profiles for use in this research.

In total, four grids were collected at the site. Two grids were collected in locations which contained lower concentrations of corrugated ceramics. Two grids were located in regions which, according to the ceramic distribution, contained high levels of corrugated wares. The objective was to detect possible differences in the types of construction, or in the density of the construction, at varying locations. By selecting the locations for GPR using the corrugated ceramics distribution information, the goal was to be able to relate the concentrations of corrugated ceramics (i.e. non-native population centers) to potential differences in architecture across the Sabino Canyon Ruin site.
Chapter 4: Data Analysis

The Classic Period represents a critical bridge between the 1,000 year period during which the Hohokam flourished in the Tucson Basin, and the following 350 years, when they almost entirely left the region. This research used the different datasets from the Sabino Canyon Ruin site to gain evidence of social integration between the Hohokam and immigrant populations moving into the Tucson Basin during the Classic Period.

Statistical Analysis

Descriptive statistics and Chi Squared tests were conducted to understand temporal and spatial distribution of corrugated wares across the Sabino Canyon Ruin site. Descriptive statistics provided baseline quantities of the diagnostic ceramics (Figure 16). Diagnostic ceramics consist of those which could be typologically identified by decoration or style. The database consisted primarily of Tanque Verde Red-on-Brown, comprising 92.999% of the total diagnostic ceramic dataset, while corrugated and other decorated wares make up the remaining 7.001% of the collection.
Corrugated ceramics comprised 6.4543% of the diagnostic assemblage (Figure 16). The relatively large quantity of corrugated ceramics in the dataset supports the hypothesis that during the occupation of the site, an influx of non-native peoples immigrated to the site. These non-native peoples brought with them the corrugated ceramic style which is distinctly different than the ceramics produced by the Hohokam. Based on the presence of large quantities of corrugated ceramics, it has been suggested the Sabino Canyon Ruin site is related to the Gibbon Springs and Whiptail Ruin sites, both of which also contained large quantities of corrugated wares (Gregonis and Hartmann, 2011; Slaughter and Roberts, 1996; Slaughter, 1994). Although fewer corrugated ceramics were found at the Sabino Canyon Ruin site than were found at the Gibbon Springs or Whiptail Ruin sites, the presence of these ceramics suggests an influx of non-native peoples into the Tucson Basin (Gregonis and Hartmann, 2011; Slaughter and Roberts, 1996; Slaughter, 1994).
The remainder of the diagnostic dataset consisted of .2648% Black-on-White polychrome and .2813% other decorated wares (Figure 16). The other decorated wares are typologies associated with the Hohokam, including an incised sherd, undecorated red ware, and three polychrome sherds. These typologies are associated with the latter part of the occupation of the Sabino Canyon Ruin site, between approximately 1200 A.D. and 1300 A.D. (Gregonis and Hartmann, 2011; Slaughter and Roberts, 1996;).

Descriptive statistics facilitated a basic understanding of the presence and distribution of specific ceramic types across the site. However, further testing was required in order to determine if a significant relationship existed between the quantities and locations of corrugated ceramics (Figure 16).

Chi Squared tests were performed to provide a robust means by which to draw conclusions regarding the distribution of ceramics found at the site. Chi Squared tests are used to compare many different variables and to determine if an observed frequency of an event, object, or in this case, ceramic type, is different from the frequency of another population or dataset. By performing this test, a comparison was made between the frequency of a ceramic type in one location and a frequency of the same ceramic in another location. These tests provide a statistically sound, repeatable means by which to compare ceramic distribution and frequency.
It was hypothesized that specific locations at the Sabino Canyon Ruin site would statistically vary in their respective quantities of corrugated wares. Eight Chi Squared tests were performed to examine intra-site relationships. In addition, these tests compared the amount of corrugated wares found at the Sabino Canyon Ruin site to those from the Gibbon Springs and Whiptail sites (Appendix B).

The first series of Chi Squared tests compared relative quantities of corrugated wares within the site. The Sabino Canyon Ruin site was divided into three regions: northern, central, and southern (Figure 14). The Chi Squared tests analyzed the quantities of ceramic types, namely Tanque Verde Red-on-Brown, corrugated, and other, for the purpose of examining distribution. The total number of each ceramic style was calculated for each geographic section of the site. The results in each of the three sections were compared to determine if concentrations of corrugated ceramics were present across the site.

The southern and central sections were statistically different from the northern section in terms of their respective quantities of corrugated ceramics (Central: $X^2 = 49.8345$, df= 1, CV= 3.8414. Alpha= .05 South: $X^2 = 10.5014$, df= 1, CV= 3.8414. Alpha= .05). The comparatively large quantity of corrugated wares in the southern and central sections drove the Chi Squared value above the threshold for statistical significance (Figure 17). These initial tests suggest the migrants who brought corrugated ceramics to the region were living separately from the native population.
The second set of Chi Squared tests were used to explore the relationship between the ceramics found at Sabino Canyon Ruin to those found at the Gibbon Springs and Whiptail Ruin sites. Data from Gibbon Springs and Whiptail was found in the published record in the nature of site reports (Slaughter and Roberts, 1996; Gregonis and Hartmann, 2011). The purpose of this set of Chi Squared tests was to compare the respective artifact
assemblages at the three sites. It has been established that both Gibbon Springs and Whiptail Ruin experienced an influx of non-native populations from the San Pedro River Valley (Gregonis and Hartmann, 2011). It is these populations from the San Pedro River Valley that likely brought the corrugated ceramic style into the Tucson Basin.

By comparing the proportionate quantities of corrugated ceramics at the respective sites, the goal was to investigate whether Sabino Canyon Ruin, like its nearby counterparts, functioned as a destination for immigrating populations during the Classic Period. Proportionate differences in the quantity of corrugated ceramics were also used to compare the quantity of immigrants who joined the established communities at the respective sites. That is, the number of corrugated ceramics found at each of the sites can be understood to be a reflection of the total number of immigrants who settled there. These comparisons collectively help to contextualize the Sabino canyon ruin site within the Tucson Basin.

The results of the Chi Squared tests demonstrated the sites are statistically different from one another in their respective amounts of corrugated wares (Sabino Canyon Ruin (SCR)/Whiptail Ruin (WT): $X^2 = 2893.2155$, df= 1, $CV= 3.8414$. Alpha= .05 WT/Gibbon Springs (GS): $X^2 = 196.9230$, df= 1, $CV= 3.8414$. Alpha= .05 SCR/GS: $X^2 = 3096.3786$, df= 1, $CV= 3.8414$. Alpha= .05). That is, based on the quantities of corrugated ceramics found at each of the sites, Gibbon Springs, Whiptail Ruin, and Sabino Canyon Ruin sites are statistically different from one another. Nonetheless, the
The statistical difference, reflecting variations in the quantities of corrugated wares at the three sites, may be the result of varying quantities of people migrating to each site. If more non-native immigrants settled at the Gibbon Springs and Whiptail Ruin sites, the quantities of corrugated ceramics found at the sites would be proportionately larger than that found at Sabino Canyon Ruin. Previous research had determined the quantities of corrugated ceramics found at the Gibbon Springs and Whiptail Ruin sites was greater than those found at Sabino Canyon Ruin (Gregonis and Hartmann, 2011; Slaughter and Roberts, 1996). The difference in the quantities of corrugated ceramics found at the three sites may also reflect varying levels of cultural and social integration at each site. That is, an increase in the quantity of corrugated ceramics may indicate increased social integration as the corrugated style was shared with the Hohokam by the immigrant population. Finally, the differing amounts of corrugated wares may suggest that corrugated wares were widely adopted and used at the Gibbon Springs and Whiptail sites, and therefore present in larger amounts at those sites, as compared to Sabino Canyon Ruin.

The northern section of the Sabino Canyon Ruin site, which had the least corrugated ceramics, is statistically the most different from the Gibbon Springs and
Whiptail Ruin sites in terms of relative quantities of corrugated ceramics (Figure 18). These Chi Squared tests demonstrate that even when the area of maximum difference (the north) is excluded, the respective sites are statistically different based on their respective quantities of corrugated ceramics \((\text{Central (C)} + \text{South (S)} \ SCR/\text{GS}: X^2 = 2662.1911, \ df= 1, \ CV= 3.8414. \ \text{Alpha} = .05)\) (\(\text{C + S SCR/WT}: X^2 = 6648.4804, \ df= 1, \ CV= 3.8414. \ \text{Alpha} = .05\)). Again, in both cases, the frequencies of corrugated wares caused the resulting Chi Squared value to far exceed the critical value required for statistical significance.

![Percent of Corrugated Ceramics Found](image)

Figure 18: Percentages of corrugated ceramics from Gibbon Springs, Whiptail Ruin, and Sabino Canyon Ruin.

The relatively dense concentrations of corrugated ceramics suggests the population which brought the corrugated ceramic style to the site were living separately from the native Hohokam population (Figure 17). In addition, these dense concentrations in specific areas across the site suggest continued production of the non-native ceramics.
by the immigrant population. In summary, the test results indicate the non-native population resided in separate geographic areas of the site which were found to contain large quantities of corrugated ceramics (Figure 17).

The spatially different settlement patterns of the immigrant population, as reflected in the ceramic distribution, may also suggest the most desirable locations within the site were already occupied by the native Hohokam. The original Hohokam group which settled the site would have likely occupied the more desirable or central parts of the site before immigrants arrived. With the prime areas already occupied, the migrant peoples may have been relegated to the perimeter of the site, as reflected in the distribution of corrugated ceramics.

Alternatively, the concentration of corrugated ceramics may merely suggest the absence of native populations in that area. It is possible the original Hohokam builders abandoned the Sabino Canyon Ruin site before immigrant populations came to the region. The immigrant population may have built new dwellings rather than occupy those left by the Hohokam, which would have permitted the immigrant population to develop their own village center rather than conform to the existing village geography as established by the native Hohokam. This hypothesis may explain the lack of corrugated wares in specific areas of the site.
Climate Variability

Satellite based remote sensing was used to obtain a landscape-based perspective of the Sabino Canyon Ruin site. This technique allowed for a better understanding of why Sabino Canyon would have been an attractive settlement location for the Hohokam. Remote sensing was used to quantify healthy vegetation as a marker for available water, which would have been crucial to the success of the Hohokam in the region. To accomplish this, the relationship between specific remotely sensed spectral bands was exploited. The data used for this research was collected in 2001 by the United States Geological Survey.

As indicated, the key to the success of the Hohokam in the region was the availability of water in the region. The biannual rainy seasons provide large quantities of water into the Tucson Basin and onto the Santa Catalina mountains. The ample water in the region allowed the Hohokam to conduct large scale desert farming, which in turn, supported large populations (Fish and Fish, 2008; Noble, 1991).

Landsat 7 ETM+ satellite bands 3 (red) and 4 (infrared) were used to observe the greening and drying of the desert surface over the course of a single year. The relationship between red and near infrared spectrums was examined to determine the quantity of healthy vegetation present in a remotely sensed image. On a spectral reflectance graph, healthy vegetation appears high in the infrared and low in the red band (Figure 19). This occurs because healthy vegetation contains chlorophyll which absorbs
electromagnetic energy within the red wavelength. When there is less healthy vegetation or exposed soil within a remotely sensed image, the reflectance pattern is high in the red band and low in the infrared due to the lack of chlorophyll in the vegetation (Figure 20). When this principle is applied across an entire landscape, and over the course of a given period of time, the progressive greening and drying of a landscape can be seen.

Figure 19: Spectral reflectance graph of Tucson, AZ. (September 2001). X = red band Y = infrared band.

Figure 20: Spectral reflectance graph of Tucson, AZ. (December 2001). X = red band Y = infrared band.
Using remote sensing, changes in the distribution of healthy vegetation were mapped seasonally over a one year period. The results indicate the areas in closest proximity to the Santa Catalina and Rincon Mountains experienced the most dramatic land cover changes. The Santa Catalina Mountains are located in the northeast area of the projection. The Rincon Mountains are located in the eastern section of the projection, just south of the developed city (Figure 21). The washes, which can be found at the foothills of these mountains, would have been productive agricultural lands for the Hohokam. Perennial water sources, such as the Sabino and Bear Creeks, would have provided the Hohokam access to sufficient quantities of water to support limited agriculture. As master desert farmers, the Hohokam likely used the topography of the region to allow gravity to carry the needed water down the basin (Haury, 1976).

Figure 21: Four vegetation indices depicting seasonal variation in healthy vegetation. Images demonstrate the presence of biannual rainy season in Tucson, AZ region. March vegetation index (upper left), June vegetation index (upper right), September vegetation index (lower left), December vegetation index (lower right).
The Sabino Canyon Ruin site, located between the Sabino and Bear Creeks, is situated to take advantage of the perennial water in the region. The site is positioned between two mountain creeks, which would have allowed the Hohokam to use and redirect water. Additionally, the location of the site at the base of the mountains means that even during extremely dry periods, mountain run-off would have provided water to the Sabino and Bear Creeks after many of the creeks and rivers down-stream would have run dry.

While water was available, the area near the Sabino Canyon Ruin site contains minimal arable land. This is due to the poor soil in the area and frequently degrading land near the Sabino and Bear Creeks. Due to the little suitable farmland in the region, the Hohokam may have used the Sabino Canyon Ruin site for purposes other than intensive agriculture. The site may have functioned as a seasonal hunting camp or as a location in which natural resources were collected. Additionally, it is possible the site functioned as a location for the production of trade goods.

Research conducted at other Classic Period sites in the Tucson Basin suggests that movement of people across the landscape could have been the result of larger regional environmental pressures (Fish and Fish, 1992). Changing water availability is often suggested as a possible cause for people to migrate long distances in a desert environment (Fish and Fish, 2001). Populations from the Mogollon Highlands, north of the Tucson
Basin, may have migrated to the region, and specifically to the Sabino Canyon Ruin site, in search of stable and predictable sources of water.

Feature Identification

High resolution aerial images were used to identify features at the Sabino Canyon Ruin site. Approximately 230 aerial images were captured, encompassing the entire site. Spatial orientation was obtained through the use of ground-based GPS coordinates. The photographs were combined to create a single composite image of the site (Figure 22).

Figure 22: High resolution composite aerial map of Sabino Canyon Ruin region (4.5 cm per pixel).
Classic Period compounds were constructed from adobe with stone foundations. Through weathering processes, compound walls melted onto the surrounding landscape. Adobe melt appears in the high resolution images as subtle color differences between the adobe and the surrounding ground material. On ground level, changes in soil color are difficult to detect and may be overlooked. Through the use of highly accurate low elevation images, changes in soil color and consistency become more apparent (Figure 23). Locations of soil color change were confirmed as locations of previously identified compound or enclosure construction. To accomplish this, the 1996 site maps were overlaid on top of current aerial maps (Figure 24). The areas of visible color change are consistent with known locations of Classic Period compounds throughout the site (Figure 25).

Figure 23: High resolution aerial photograph of northern region of the Sabino Canyon Ruin site. Noted are locations of soil color change.
Figure 24: Three-dimensional composite aerial photo of Sabino Canyon Ruin site overlaid with 1996 feature map
Three-dimensional aerial photographs were used in conjunction with traditional archaeological methods. Aerial mapping is particularly advantageous in areas which are difficult to access. The composite map obtained from the individual aerial images serve as a platform on which newly collected data can be overlaid onto existing data (Figure 22; Figure 24). When georeferenced, the composite map establishes a baseline from which accurate locations of archaeological features and artifacts were measured (Figure 26).
At the Sabino Canyon Ruin site, this technique of feature identification and site mapping was used to better understand the specific orientation of the site on the landscape. As previously discussed, the immigrant population may have settled in a different region of the site from the native Hohokam because the more desirable locations were already occupied. The occupation and construction by the Hohokam and immigrant population is evident in the soil color changes within the high resolution aerial images. These regions contained more dense architectural features, including compounds and enclosures (Figure 25).

**Architectural Distribution**

GPR was used to identify subsurface archaeological features including pithouses and Classic Period compounds. The Sabino Canyon Ruin site was occupied from approximately 1000 A.D. to 1300 A.D., coinciding with notable changes in the
architecture throughout the Hohokam region (Dart, Rutherfoord, and Pine, 1999; Noble, 1991; Neuzil, 2008). During the early part of their history in the region, the Hohokam constructed shallow pithouses which were built of wood, compacted mud, and thatch. (Nobel, 1991; Fish and Fish, 2001). Between 700 A.D. and 1000 A.D., larger pithouses were constructed at some of the sites in the region including Snaketown (Haury, 1976). At the beginning of the Classic Period, a shift to different domestic architecture occurred (Crown and Fish, 1996; Schroeder, 1953; Doyel, 2008). During this period, many of the older sites were abandoned and populations began to live in walled compounds made of adobe (Noble, 1991; Fish and Fish, 2001). Adobe compound structures were constructed at many of the sites in the Tucson Basin and appear to have been occupied until the Hohokam population left the region approximately 1350 A.D. (Hayden, 1957).

As discussed in Chapter 3, GPR data was processed using Dr. Lawrence Conyers' software, including GPR Viewer and GPR Process. Once processed, slice maps were produced using the Surfer 9 program. Processing methods remained consistent to facilitate the comparison of grids collected. Maps of subsurface features were produced (Figures 27; Figure 28).
Figure 27: GPR slice map of Grid 3. Noted are regions of high amplitude point source reflections. Possibly caused by foundation stones used in the construction of compound or enclosure walls.

Figure 28: GPR slice map of Grid 1. Noted are regions of low amplitude reflections.
As discussed in Chapter 3, four GPR grids were collected to enable comparison of architectural features in different areas of the site. Grid locations were selected based on concentrations of corrugated ceramics (Figure 29). It was hypothesized that architectural differences between the native Hohokam and the immigrant population could be identified using GPR.

Figure 29: 1996 feature map. Noted are locations of ground-penetrating radar grids.
GPR was successfully used to identify and locate archaeological features at the site (Figure 30; Figure 31). However, in examining both the amplitude slice maps and the previously created site maps, there was no correlation between architectural style and location throughout the site. That is, compounds and pithouses were found throughout the Sabino Canyon Ruin site in relatively similar quantities, suggesting that the native Hohokam and the immigrant population may have lived in the same types of dwelling.

Figure 30: GPR profile from Grid 2. Noted is the location of high amplitude planar reflection found, possibly caused by a pithouse or structure floor.

Figure 31: GPR profile from Grid 4. High amplitude concave reflection containing high amplitude point source reflections, suggestive of a subsurface pit or ditch into which material has been deposited.
Allen Dart conducted archaeomagnetic dating within southern pithouses, just south of Enclosure A. Based on the archaeomagnetic dates and dates of the excavated ceramics, pithouse architecture was likely abandoned at the Sabino Canyon Ruin site by approximately 1200 A.D. (Dart, 1999). In considering the GPR data in relation to Hohokam development, it appears that between 1050 A.D. and 1200 A.D., there was a transition from use of pithouses toward adobe compound architecture.

It is possible that the immigrant population and Hohokam population occupied the site at different times. As previously discussed, the original population may have abandoned the Sabino Canyon Ruin site in the early Classic Period prior to the arrival of the immigrant people. This serial occupation of the site would be reflected in the archaeology by corrugated ceramic concentrations found on top of the native Hohokam ceramic assemblages. If the immigrant occupation followed the Hohokam abandonment, the immigrants may have occupied the site according to their own tradition. However, the ceramic and archaeomagnetic dates suggest the Hohokam and immigrant population occupied the site simultaneously.

Summary

The different archaeological techniques employed in this research produced significantly different types of data. Together, these different datasets were used to examine Hohokam social patterns and cultural change during the Classic Period. The ceramic analysis and associated statistical study suggests the immigrant population,
which brought corrugated ceramics to the Sabino Canyon Ruin site, were living separately from the native Hohokam. GPR and three-dimensional aerial photography were used to study the architecture at the Sabino Canyon Ruin site to determine the extent to which the immigrant population was integrated with the Hohokam. An examination of the settlement patterns of non-native populations at the Sabino Canyon Ruin site provides insight into the cultural organization of the Hohokam during the Classic Period. Remote sensing enabled a more complete understanding of Hohokam subsistence strategies as well as how the environment and topography of the Tucson Basin affected the Hohokam way of life.
Chapter 5: Interpretation

When the results of the four datasets are analyzed and interpreted, greater insight is gained regarding Hohokam social organization and subsistence at the Sabino Canyon Ruin site. The high resolution three-dimensional aerial photographs and resulting composite map provide a better understanding of the physical layout of the Sabino Canyon Ruin site, particularly architectural features, settlement organization, and accessibility to resources. The satellite images demonstrate both the impact of seasonal rainfall on the site and surrounding area and, the extent to which the surrounding land is arable. Interpretation of the GPR data leads to a greater understanding of the architecture of the site, including the native Hohokam structures and those of the immigrant population. The examination of the ceramic data provides insight into the nature of social integration between immigrants and the native Hohokam. The interpretation of these four datasets was further aided by earlier research from other Hohokam sites in the Tucson Basin.

High Resolution Aerial Photographs

In April of 2012, more than 500 aerial photographs of the Sabino Canyon Ruin site were collected using a low altitude aircraft. Specialized software was used to
combine the individual photographs into a single composite image of the Sabino Canyon Ruin site (Figure 32).

Figure 32: High resolution composite map of Sabino Canyon Ruin site, divided into numbered quadrants.

Figure 32 consists of a composite map of the Sabino Canyon Ruin site, created using the aerial photographs overlaid with a numbered grid to aid in discussion of specific locations. As discussed in Chapter 4, changes in soil color were used to identify locations of compounds, pithouses, and enclosures. While such color changes are difficult to detect on the ground surface, subtle soil color changes become apparent when analyzing the high resolution composite map. The areas of the site containing the most
dramatic soil color change are concentrated in Quadrants 3, 4, 5, 9, and 10. The soil color change in these quadrants is the result of the weathering of adobe structures over an extended period of time, mixed with charcoal and other anthropogenic material commonly found near human habitation. To confirm this hypothesis, the 1996 Pueblo Archaeology site map (Figure 6), which included feature locations, was overlaid on this aerial photograph (Figure 24). The locations of architectural features as drawn in the 1996 site map correspond with the regions of maximum soil color change (Figure 32). A strong correlation can thus be observed between the darker red-brown hued soil and the previously identified locations of compounds at the Sabino Canyon Ruin site.

Compounds A, B, C, and, D, and enclosure A are grouped together in the area of the site closer to the Santa Catalina Mountains (Figure 32). This area contains the red-brown hued soil which is associated with construction. These features are also located in close proximity to the Sabino Creek which runs along the western perimeter of the site, corresponding to the more vegetated areas (Quadrants 2, 8, 14, 20, and 26) (Figure 32). The vegetation near the Sabino Creek would have been attractive to animals such as rabbits, small rodents, and other small animals. The foothills location provided access to other plant resources, such as cactus fruit and agave. It thus appears the Hohokam at the Sabino Canyon Ruin site selected the location of compounds to optimize access to the resources necessary to support the settlement. Compounds were located near canyon resources and fresh water from the Sabino Creek, both pivotal to Hohokam success at the Sabino Canyon Ruin site.
The central area of the site located furthest from both the Sabino and Bear Creeks (Quadrants 11, 15, 16, 17, and 21) is consistently light brown in color (Figure 32). The lack of red-brown hues suggests these areas were not occupied. This finding is consistent with the 1996 feature map (Figure 6). The lack of construction in these central areas further suggests the Hohokam settlements were deliberately established near the Sabino Creek and the Santa Catalina Mountains.

When the compound map is placed in regional context using Google Earth or similar software, the subsistence strategies at the Sabino Canyon Ruin site can be more readily understood (Figure 33). Sabino Creek and Bear Creek flank the site, providing ample regional water. Coupled with the long growing season, this water enabled the Hohokam to practice limited agriculture at the site. Water also enabled the growth of vegetation which, in turn, supported animal life, including rabbit, deer, and rodents (Gregonis and Reinhard, 1979). The nearby mountains and desert provided additional vegetation, including mesquite, cactus fruit, and acorns. As discussed in Chapter 4, the nearby Whiptail Ruin and Gibbon Springs sites are also located in the Santa Catalina Mountain foothills. The bones of small game mammals were recovered from the Whiptail Ruin and Gibbon Springs sites. Animal bones and projectile points were also found at the Sabino Canyon Ruin site (Dart, 1999). The presence of animal bones and projectile points in combination with the location of the sites suggests that the Hohokam in this eastern portion of the Tucson Basin depended, at least in part, on hunting and gathering.
wild foods for subsistence (Gregonis, et al., 2009; Gregonis and Hartmann, 2011; Slaughter, 1994). Based on the geographic and environmental similarities of the Whiptail Ruin, Gibbon Springs, and Sabino Canyon Ruin sites, future research will likely conclude the Hohokam hunted similar types of animals at all three sites.

It has been suggested that Hohokam sites located in the foothills functioned differently, but were still integrated with Hohokam at the sites located along major river floodplains (Roth, 2013). Hohokam at sites situated along the Santa Cruz River
floodplain had access to extensive arable land with which to support large, mostly sedentary populations. In contrast, sites such as the Sabino Canyon Ruin site were located in the foothills, without access to proximate arable land. The foothills sites were only able to support smaller population groups who were mobile hunter gatherers. As previously noted, the foothills of the Santa Catalina Mountains likely provided resources which were important to the Classic Period Hohokam such as cactus fruit, and animal products. Foothills sites may have functioned as centers of production for local goods intended for trade or consumption by Hohokam populations located along the Santa Cruz and Rillito Rivers (Roth, 2013). It is therefore possible the Hohokam, who settled the Sabino Canyon Ruin site, did so to gain better access to the raw materials found in the foothills region, which could then be traded to Hohokam populations located along the floodplains.

The Hohokam at the Sabino Canyon Ruin site would have thus relied on a combination of limited agriculture as well as hunting, gathering, and foraging. Goods from foothills sites could have been exchanged for basic staple foodstuffs obtained from nearby parent sites. This subsistence strategy is atypical of Classic Period Hohokam settlements in the Tucson Basin which were mostly agriculturally intensive (Bayman, 2001). These differing subsistence activities demonstrate a material difference between the Hohokam at sites located along the floodplain and those located on the periphery (Figure 34).
Other peripheral Hohokam sites, including Marana Mound, have been found which, like Sabino Canyon Ruin, demonstrate a departure from typical Classic Period Hohokam social organization and behavior (Bayman, 1995, 2002). The economy of Marana Mound was centered on the production and trade of shell goods (Bayman, 1995, 2002; Fish, et al., 1992). The trade of shell goods allowed the Hohokam at Marana Mound to trade for resources needed to sustain the settlement. Thus, the Hohokam at the Marana site were able to subsist without the need for more traditional Hohokam agricultural techniques utilized in the floodplains. To determine if this type of specialization occurred at the Sabino Canyon Ruin site, further research is required. It is
also possible that sites such as Marana Mound, Gibbon Springs, Whiptail Ruin, and Sabino Canyon Ruin (Figure 34) reflect a changing social dynamic or economy among the Hohokam in the Tucson Basin.

**Remote Sensing**

The remote sensing datasets used in this research were collected during 2001 and provide insight into seasonal conditions in the greater Tucson region. The 2001 images should not be regarded as an entirely accurate reflection of the desert conditions existing during the Classic Period. Recent removal of plant cover from the foothills of the Santa Catalina Mountains and overuse of ground water has caused increased desert run-off, flooding, and arroyo cutting (Gregonis and Reinhard, 1979). This has caused the drying of some of the once perennial streams and creeks. Nonetheless, the 2001 images of the Tucson Basin provide an important record of seasonal periods of rainfall and of the variety of plant and animal life in the Tucson Basin. The Sabino Canyon Ruin site is situated in northern Tucson in the eastern section of the Tucson Basin. This section of the Tucson Basin is notable because perennial streams flow through the region.

The modern annual climate features two periods of heavy rainfall, one occurring in late winter and the other in late summer, during the so-called "monsoon" (Gregonis and Reinhard, 1979). Analysis of the remote sensing images provides insight into the effect of this seasonal rainfall on the Tucson Basin landscape. The vegetation indices in Figure 35 indicate the significant seasonal variability of vegetation. The first image was
collected in March, 2001. The northeast area of the projection map shows the Santa Catalina Mountains. The bright yellow and red on the image indicates areas of bare soil or brown vegetation. The Santa Catalina Mountains were dry and devoid of vegetation at this time, as indicated by the bright yellow and red color. In contrast, the foothills region, where the Sabino Canyon Ruin site is located, was green in those areas near the perennial water supply. As indicated by the aerial photographs, the Hohokam chose to locate their compounds close to perennial water sources which would have supported settlements.

The June 2001 image reflects the effect of heavy rain. In 2001, it appears the summer monsoon season began earlier than is typical in the Tucson Basin. The majority
of the map is green, denoting the presence of extensive vegetation. The tops and steep slopes of the Santa Catalina Mountains appear bright red on the map, as vegetation is unable to grow in this region.

The September 2001 image shows that while almost the entire basin is green, there is a limited amount of vegetation on the tops of the Santa Catalina Mountains. Little vegetation grows near the tops of the mountains and therefore, most of the water flows down slope to the foothills region.

Towards the end of winter, the Tucson area typically experiences a second rainy season (Gregonis and Reinhard, 1979). The data collected from December, 2001 indicates this second rainy period had not yet occurred when these images were produced. Most of the area lacks green vegetation as a result of the delayed winter rains. However, the image shows that the perennial water sources near the base of the Santa Catalina Mountains kept the immediately surrounding area green.

In 2001, March and December appear to have been the driest part of the year. While the March and December data collected in this study is not typical of the region, variation in seasonal rainfall does occur. Even during the driest part of the year, the foothills of the Santa Catalina Mountains in the northeast section of the projection remain green. These areas of green are located along the perennial water sources, including Sabino and Bear Creeks and regional river valleys. The biannual pattern of rainfall in the
Sonora Desert, reflected in the June and September projections, also contributes to the permanent presence of water in these areas.

The narrow floodplains of the Sabino and Bear Creeks provided the only land suitable for farming near the Sabino Canyon Ruin site. The long growing season in southern Arizona, consisting of 250 days, enabled the Hohokam to maximize the productivity of the limited arable land proximate to the site (Gregonis and Reinhard, 1979). However, the Sabino and Bear Creeks are prone to flooding throughout much of the year. The land near the edges of the creeks would have been regularly degrading, making long term agriculture difficult. Even as maximized, farming would not have been sufficiently productive to support the entire population of the Sabino Canyon Ruin site. The remote sensing data suggests the Hohokam at the Sabino Canyon Ruin site participated in limited agriculture as well as hunter gatherer subsistence activities.

Floral and faunal research at other Hohokam sites in the region demonstrates the Hohokam in the foothills (Figure 34) relied on multi-faceted subsistence strategies (Gregonis and Hartmann, 2011). The Sabino Creek region and the Santa Catalina Mountains supported hunter gatherer subsistence strategies practiced by the Hohokam. The settling of the foothills sites may have been the result of a lack of available productive lands on the floodplains or a determined effort to gain access to specific resources found nearer the Santa Catalina Mountains.
As indicated in Figure 34, other than a few sites such as Gibbon Springs, Whiptail Ruin, Marana, and Sabino Canyon Ruin, Classic Period Hohokam sites elsewhere in the Tucson Basin are typically located near floodplains (Gregonis and Reinhard, 1979; Ellis and Waters, 1991). In contrast, the Sabino Canyon Ruin, Gibbon Springs and Whiptail Ruin sites are located in the foothills, apart from many other sites in the Tucson Basin, and away from the productive floodplains. Whiptail Ruin, located approximately 4.5 miles southeast of Sabino Canyon Ruin, is situated just west of the Agua Caliente Wash on top of an alluvial fan (Gregonis and Hartmann, 2011). Like Sabino Canyon Ruin, Whiptail is located at the base of the Santa Catalina Mountains, near perennial springs which would have provided sufficient water for the settlement (Gregonis and Hartmann, 2011). However, poor soil development and water containing dissolved solids including sulfur and iron made large scale agriculture difficult at the Whiptail Ruin site (Gregonis and Hartmann, 2011). The Gibbon Springs site, located approximately 2.5 miles east of Sabino Canyon Ruin, is also located near perennial streams and contained limited arable land (Slaughter, 1994). The Gibbon Springs and Whiptail Ruin sites contain evidence of canal features which directed water from the perennial streams to the limited arable land, or were used for domestic supply, as was the case at Marana (Fish, et al., 1992; Slaughter, 1994).

In summary, evidence supports the hypothesis that regional environmental limitations forced the Hohokam at foothills sites to rely on forms of subsistence other than intensive agriculture (Gregonis and Hartmann, 2011). The Hohokam at the Sabino
Canyon Ruin site were likely able to subsist through limited agriculture and by exploiting the plant and animal life present in the foothills region. In addition, it is plausible the Hohokam at the Sabino Canyon Ruin site participated in regional trade to acquire staple foodstuffs. These subsistence strategies are not conventional relative to other major Hohokam floodplain sites in the Tucson Basin. The geographic location of the Marana, Gibbon Springs, Whiptail Ruin, and Sabino Canyon Ruin sites serve as a reflection of how these sites functioned within Hohokam society in the Tucson Basin.

The remote sensing and high resolution aerial images demonstrate the environmental and regional limitations and resources of the foothills. It can therefore be suggested that even though the Hohokam during the Classic Period were largely sedentary, some Hohokam populations, including those at the Sabino Canyon Ruin site, were only semi-sedentary. Those populations which were less sedentary were likely foraging for resources and conducting desert farming in dry areas or on alluvial fans away from the floodplains. The environmental data collected from the Sabino Canyon Ruin site suggests regional trade was necessary to obtain the staple agricultural foodstuffs required to support the settlement. The Hohokam at the Sabino Canyon Ruin site likely traded with parent sites along the agriculturally productive floodplain. This reliance on parent sites for foodstuffs demonstrates a changing social dynamic between primary villages along the floodplain and peripheral sites located in the foothills within the Tucson Basin.
Ceramics

As discussed in Chapter 4, the presence of corrugated ceramics at Hohokam sites in the Tucson Basin has been attributed to immigrant populations from the Mogollon Highlands who passed through the San Pedro River Valley on the way to the Tucson Basin (Gregonis and Hartmann, 2011; Slaughter, 1994). Areas containing higher percentages of corrugated ceramics are thought to reflect immigrant inhabitation (Gregonis and Hartmann, 2011; Slaughter, 1994). The ceramic dataset studied in this research includes all of the sherds recovered from the Sabino Canyon Ruin site during Allen Dart's excavation (Dart personal communication, 2012). As discussed in Chapter 4, Chi Squared tests were performed, comparing the distribution of corrugated ceramics within the Sabino Canyon Ruin site, and comparing the relative amount of corrugated ceramics found at the Sabino Canyon Ruin site to the amounts found at Gibbon Springs and Whiptail Ruin. The locations of corrugated ceramic assemblages are significant as this data can provide information regarding integration between Hohokam and immigrant populations during the Classic Period. Widely dispersed non-native ceramics can be seen as a reflection of greater integration between immigrant and native populations. Conversely, concentrations of non-native ceramics reflect less integration.

The results from the first set of Chi Squared tests demonstrate compounds C, D and enclosure A, located in the southern section of the site, contain a high percentage of corrugated ceramics (Figure 25) (Appendix D). The percentage of corrugated ceramics found within these features suggests that compounds C, D and enclosure A were
occupied by the immigrant population. Compounds A and B, which contained small quantities of corrugated ceramics, were likely occupied by the native Hohokam, living separately from the immigrant population (Figure 25).

Corrugated ceramics are rarely found at sites in the central and western Tucson Basin (Gregonis and Hartmann, 2011). The Gibbon Springs, Whiptail Ruin, and Sabino Canyon Ruin sites are unusual in that these sites yielded considerable quantities of this non-native ceramic typology (Gregonis and Hartmann, 2011). The shared presence of corrugated ceramics suggests the Gibbon Springs, Whiptail Ruin, and Sabino Canyon Ruin sites formed an immigrant corridor or "migrant enclave" as proposed by Elson and Cook (2007).

The results of the second set of Chi Squared tests suggest that while the Gibbon Springs, Whiptail Ruin, and Sabino Canyon Ruin sites all contain corrugated ceramics, each site is statistically different from one another with respect to the amount of corrugated ceramic assemblages (Appendix D). The different quantities of corrugated ceramics found at these sites maybe the result of different quantities of immigrants settling at each of the sites. This difference may have been a result of the Hohokam and immigrant population interacting in different ways at each of the sites. The quantity of corrugated ceramics, which are associated with immigrant populations, can be compared with the amount of native ceramics to better understand the relationship between the immigrants and the native Hohokam populations.
As discussed in Chapter 4, the immigrants who came to the Tucson Basin originated from the San Pedro River Valley, located east of modern Tucson (Slaughter, 1994; Gregonis and Hartmann, 2011; Clark, et al., 2011). As indicated by Figure 36, the San Pedro River Valley is connected to the Tucson Basin by the Redington Pass. This immigrant population migrated through the Redington Pass to the Tucson Basin, to sites including Whiptail Ruin, Gibbon Springs, and Sabino Canyon Ruin (Gregonis and Hartmann, 2011). It is understood the immigrant population from the San Pedro River Valley was comprised of people from the Mogollon Highlands, who are associated with corrugated ceramics indicative of that region (Gregonis and Hartmann, 2011; Clark, et al., 2011).

Figure 36: Google Earth/ Landsat regional map demonstrating proximity of the Redington Pass to the Sabino Canyon Ruin site and Tucson Basin
The geographic relationship between the Gibbon Springs, Whiptail Ruin, and Sabino Canyon Ruin sites and the Redington Pass suggests the manner in which immigrant populations entered the Tucson Basin as well as the extent to which they populated these sites. The differing quantities of corrugated wares found at these sites demonstrate the direction from which the immigrant population entered the Tucson Basin. With larger quantities of corrugated ceramics found in the eastern Tucson Basin, specifically at the Gibbon Springs and Whiptail Ruin sites, it appears the immigrants entered the Tucson Basin by means of a branch of the Redington Pass located near the Gibbon Springs and Whiptail Ruin sites (Gregonis and Hartmann, 2011). This path of immigration could explain why more corrugated ceramics have been found at the Whiptail Ruin and Gibbon Springs than at the Sabino Canyon Ruin site, which is located farther west relative to the Redington Pass.

Other explanations exist to explain the differing quantities of corrugated ceramics found at the Gibbon Springs, Whiptail Ruin, and Sabino Canyon Ruin sites. One hypothesis is that the quantity of corrugated ceramics may reflect the duration of immigrant occupation. The larger quantity of corrugated ceramics found at Gibbon Springs and Whiptail Ruin indicates these sites were occupied by immigrants for a longer period of time as compared to Sabino Canyon Ruin, where less corrugated ceramics were found. The quantity of corrugated ceramics may alternatively suggest the presence of immigrant potters, rather than an influx of an entire immigrant population (Slaughter,
However, it is likely the larger quantities of corrugated ceramics found at Gibbon Springs and Whiptail Ruin indicate there were a greater number of immigrants at these sites relative to the Sabino Canyon Ruin site.

Immigration is understood to consist of a process, beginning when scouts collect information regarding social conditions and resources in a new area, and return to their home to share this information (Anthony, 1990; Arawaka, et al., 2011). This period is followed by a return migration where scouts and early migrants return home to visit and provide additional information regarding the potential new settlement area. Eventually, well-developed routes are established as a result of cyclical movement by immigrants between home and the new area.

The flow of immigrants from the Mogollon Highlands and San Pedro River Valley may have formed a migration stream towards the Tucson Basin (Elson and Cook, 2007). Migrants likely came through the Redington Pass, and settled at the Hohokam sites closer to the pass, namely Sabino Canyon Ruin, Whiptail Ruin and Gibbon Springs. Consistent with this theory, corrugated ceramics are only rarely reported at other Hohokam sites in the Tucson Basin (Gregonis and Hartmann, 2011). The relative rarity of corrugated ceramics in many sites in the Tucson Basin suggests significant cultural and societal differences between the foothills sites and those located in the floodplains. The presence of immigrant populations at Tucson Basin sites may be interpreted as demonstrating a changing social dynamic in these Hohokam groups. The arrival of
immigrants at the Sabino Canyon Ruin, Whiptail Ruin and Gibbon Springs sites inevitably impacted the social structure of the established Hohokam culture. The characteristics of physical objects, including pottery, architecture would have been effected by exposure to a new culture.

Social integration between the native Hohokam and the immigrant population can be interpreted through the distribution of corrugated ceramics. Locations which contain large quantities of corrugated ceramics are those areas occupied by the immigrant population occupied. Regions of the site which lacked corrugated ceramics can be understood as having not been occupied by the immigrant population. Therefore, by examining the spatial relationship between corrugated and native Hohokam ceramics at a given site, the level of integration between the native and non-native populations can be understood. Greater spatial integration between the Hohokam and immigrant populations is a reflection of increased cultural exchange between the two populations. Lower levels of spatial integration are suggestive of more limited cultural exchange.

The distribution of corrugated ceramics found at the Sabino Canyon Ruin, Whiptail Ruin, and Gibbon Springs sites demonstrate different levels of Hohokam integration occurred at each site. At the Whiptail Ruin site, corrugated ceramics were described as being found evenly distributed throughout the occupied regions of the site. However, not all of the corrugated ceramics found at the site appeared to be in their primary location (Gregonis and Hartmann, 2011). Gregonis and Hartmann (2011)
concluded the distribution of corrugated ceramics across the Whiptail Ruin site suggests the immigrant population was integrated with the native Hohokam.

At Gibbon Springs, few features contained concentrations of corrugated ceramics which appear to be in their primary location (Gregonis and Hartmann, 2011). The spatially distinct assemblages of corrugated ceramics found at the Gibbon Springs site suggests the immigrant population at Gibbon Springs were living separately from the native Hohokam. In addition, this spatial separation of the Hohokam from the immigrant population suggests the immigrants were not well-integrated with the native Hohokam (Gregonis and Hartmann, 2011). However, as primary data from the excavation at Gibbon Springs was not accessible, more specific distribution information was unavailable for this research.

At the Sabino Canyon Ruin site, large assemblages of corrugated ceramics were found in the central and southern loci, while only limited amounts were recovered from the northern locus (Figure 25). As previously discussed, this distribution indicates the native Hohokam occupied the northern section of the Sabino Canyon Ruin site, while the immigrant population settled in the central and southern regions (Figure 25). This distinct spatial distribution of corrugated ceramics demonstrates a low degree of integration between the native Hohokam and the immigrant population.
The differing concentrations of corrugated ceramics found at the foothills sites may reflect cultural exchange, possibly through intermarriage, between the Hohokam and immigrant populations. After the immigrant population settled at the Whiptail Ruin, Gibbon Springs, and Sabino Canyon Ruin sites, it is possible that new kin groups formed, consisting of Hohokam and immigrant peoples. Intermarriage between the Hohokam and immigrant populations may have been mutually beneficial. For immigrants, intermarriage may have represented the opportunity to join the mainstream of an established Hohokam settlement. For the Hohokam, immigrants may have provided access to trade routes and goods. Intermarriage would have provided the opportunity for both groups to share various aspects of culture, including ceramic styles. Combined family or kin groups may have produced both corrugated and native Hohokam ceramics. Accordingly, those regions where large quantities of both corrugated wares and native Hohokam ceramics were found may reflect the existence of combined kin groups or intermarriage, and shared culture.

The presence of an immigrant population, as indicated by corrugated ceramics, further sets the Whiptail Ruin, Gibbon Springs, and Sabino Canyon Ruin sites apart from many of the other Hohokam sites in the Tucson Basin. As indicated, corrugated ceramics are rarely found at other sites in the Tucson Basin (Gregonis and Hartmann, 2011). For example, the University Indian Ruin site, located approximately 4 miles from the Sabino Canyon Ruin site (Figure 34), has yielded few corrugated ceramics (Hayden, 1957). Corrugated ceramics are rarely, if ever, found at sites further to the west or south. In
addition, the Hohokam in the foothills practiced distinct subsistence strategies, were geographically isolated, and likely traded with sites in more agriculturally productive regions for staple foodstuffs. It is therefore possible the different social structure or cultural organization at the Whiptail Ruin, Gibbon Springs, and Sabino Canyon Ruin sites, compared to other sites in the Tucson Basin, led to immigrants settling at the foothills sites. That is, these sites may have been seen as more welcoming as the Hohokam in the foothills did not rigidly adhere to traditional Hohokam cultural practices.

Anna Neuzil incorporates concepts of identity and cultural agency into the field of archaeology (Neuzil, 2008). Neuzil examined the impact of Classic Period migrations in the Safford and Aravaipa valleys, located northeast of Tucson between the Gila and San Pedro Rivers (Figure 37). Architecture and the presence and distribution of corrugated ceramics were examined at multiple sites in this nearby region (Neuzil, 2008). The goal of Neuzil's research was to examine the cultural impact of immigrant populations on native populations. Neuzil asserts that when a migrant population comes into contact with an established population, changes in culture and identity occur. These changes may take the form of new, blended ceramic styles, architecture types, and cultural behaviors. The extent of cultural change is associated with the relative size of each population (Neuzil, 2008). In situations where the established population is larger than the immigrant population, the immigrant population will change its identity and culture to more closely resemble that of the established group. Conversely, when the native population is smaller than the immigrant population, aspects of native population culture will change (Neuzil,
Neuzil determined the first groups of immigrants who arrived in the Safford and Aravaipa areas had their own distinct ceramic style (Neuzil, 2008). Upon arriving, immigrant populations were living spatially separate from the native population. Over time, a blending of ceramic styles and architectural patterns occurred which reflected a new collective culture (Neuzil, 2008). Ceramic styles and architectural patterns both changed, as the immigrants became integrated with the indigenous population.

![Regional map of Aravaipa and Safford Valleys](image)

Figure 37: Regional map of Aravaipa and Safford Valleys (rescaled from Neuzil, 2008).

Applying Neuzil's theory of population change, the quantity of corrugated ceramics found at the Gibbon Springs, Whiptail Ruin, and Sabino Canyon Ruin sites can be viewed as a reflection of the forces which cause enculturation. Based on the lesser amount of corrugated ceramics at the Sabino Canyon Ruin site and assuming the
incursion of people manufacturing corrugated ceramics was short, it appears there were fewer immigrants at the Sabino Canyon Ruin site as compared to the Whiptail Ruin and Gibbon Springs sites. In light of the smaller quantity of immigrants relative to the size of native population at the Sabino Canyon Ruin site, the native Hohokam would not have adopted the non-native corrugated ceramic style. Rather, the smaller immigrant population would have adopted aspects of the native Hohokam culture. Eventually however, some aspects of both cultures would likely have been incorporated into a new combined immigrant/Hohokam culture. The sites which contained an immigrant population, namely Gibbon Springs, Whiptail Ruin, and the Sabino Canyon Ruin site, would have been culturally distinct from Hohokam populations elsewhere in the Tucson Basin.

**Ground-penetrating Radar**

GPR allowed for an examination of the distribution of architecture types in immigrant and Hohokam sections of the Sabino Canyon Ruin site. As discussed in Chapter 4, GPR data was collected at four locations at the site (Figure 29).

Grid 3 was located in the far northern section of the site, approximately 75 meters from compound A (Figure 29). The maps created from this data suggest the presence of a collapsed compound or structure wall section, measuring 3.5 meters in length and approximately 1 meter thick. The high amplitude reflections appear to be individual stones surrounded by material of slightly lower amplitude. This type of reflection is
consistent with Hohokam wall construction in which stones were used as lower foundation for adobe walls. Similar walls have been found at other sites in the region, including Whiptail Ruin (Gregonis and Hartmann, 2011). Therefore, it can be concluded that the population who first settled the Sabino Canyon Ruin site were native Hohokam, similar to those who occupied other sites in the Tucson Basin during this time.

Grid 1 was located just west of compound D (Figure 29). The grid location was selected based on the large quantity of corrugated ceramics found in this compound. Few high amplitude reflections were found in either the linear profiles or the amplitude slice maps. Those found within the grid were likely the result of non-anthropogenic features, such as near surface rocks. While Grid 1 was located near compound D, no evidence of occupation was found. This suggests compound D, located adjacent to the Sabino Creek, is the edge of Hohokam occupation at the Sabino Canyon Ruin site.

Grid 4 was located nearest the compounds which contained the lowest quantities of corrugated ceramics (Figure 29). The data contains what appears to be a ditch or pit feature, measuring approximately two meters wide. In addition, within the feature are multiple high amplitude point-source reflections. These reflections could be caused by clastic material deposited by fluvial processes or by anthropogenic deposition of materials such as in the case of a midden (Figure 38). Gregonis and Reinhard (1979), suggest that at sites in the Tucson Basin, the Hohokam may have dug small irrigation ditches to direct water to their crops and to the domestic regions of the site for
consumption (1979). Although the reflection found in Figure 39 is consistent with a ditch, it is unlikely this feature is an irrigation ditch due to its location on a high terrace above the floodplain (Figure 24; Figure 29). It is more likely this feature is a large roasting pit or buried midden. Without excavation, the precise nature of this feature is difficult to determine.

![Figure 38: Linear GPR profile from Grid 4. Profile shows presence of a collection of point source reflections within a high amplitude concave reflection.](image)

Grid 2, located in the most southern section of the site, contained higher concentrations of corrugated ceramics (Figure 29). This grid measured 5 meters by 15 meters (Appendix E). After the GPR data were collected and processed, a section of a pithouse or structure floor was identified. The floor feature measures approximately 4 meters in length and is located near the walls of compound D in the eastern half of the GPR grid (Figure 39).
Figure 39: Linear GPR profile from Grid 2. Profile shows a high amplitude planar reflection likely caused by a section of a pithouse or structure floor.

It was anticipated that GPR would facilitate identification of differences in the distribution of dwelling types within the Sabino Canyon Ruin site. Using GPR, the frequency of dwelling types in those areas that were identified as occupied by the Hohokam were compared to dwelling types located in areas associated with immigrant populations. As discussed above, these different regions of the site were identified by the distribution of corrugated ceramics. The frequency of dwelling types in each section were noted and compared. In areas where GPR was not conducted, the 1996 feature map was used to note locations of dwellings (Figure 6).

Analysis of the GPR data and the existing features maps indicates there was no difference in the frequency of dwelling types at the Sabino Canyon Ruin site. The results of the GPR survey and ceramic distribution demonstrate that while the Hohokam and the immigrant populations appear to have occupied separate regions of the site, the types of
structures they lived in appears to be the same across the site (Figure 6). The results of
the GPR study are consistent with the theoretical conclusions regarding enculturation and
integration, as discussed above. It is possible the architecture found throughout the site
can be seen as reflecting the beginning of integration between the Hohokam and
immigrant population. The similar use of compounds, pithouses, and enclosures by the
Hohokam and immigrant populations suggests similar social organization and a possible
a blending of cultural practices.

Summary

During the Classic Period, the Hohokam in the Tucson Basin consisted of largely
sedentary populations who farmed the floodplains of the Santa Cruz and Rillito Rivers.
They constructed pithouse villages and participated in large scale trade. Then, between
1150 A.D. and 1350 A.D., a major cultural shift occurred had far-reaching effects on the
Hohokam. In the Tucson Basin, this cultural change resulted in the abandonment of
multiple sites such as the Hodges Ruin site, and the construction of multi-room
compounds and enclosures such as those found at University Indian Ruin and Marana
Mound (Hayden, 1957; Fish, et al., 1992). Populations became densely clustered in these
new types of structures within larger sites. During the early Classic Period the Gibbon
Springs, Whiptail Ruin, and Sabino Canyon Ruin sites were settled in the foothills of the
Santa Catalina Mountains.
The geography, ceramic assemblages, subsistence strategies, and populations of the Whiptail Ruin, Gibbon Springs, and Sabino Canyon Ruin sites demonstrate these sites were substantially different from other Classic Period sites in the Tucson Basin. Several hypotheses may explain the difference in these three sites as compared to other Tucson Basin sites. As discussed above, the Sabino Canyon Ruin, Whiptail Ruin, and Gibbon Springs sites may have functioned as satellite sites for larger parent Hohokam sites. These sites, located on the periphery of the Tucson Basin near the mountains, could have functioned as hunting camps or bases for the collection of both mountain and desert resources. It is also possible these three foothills sites were settled by the Hohokam after the prime sites along the Santa Cruz and Tanque Verde Rivers were already established. At these sites, reliance on hunting and gathering caused by regional environmental limitations, and a need to trade for staple foodstuffs, would have changed the societal and economic structure. Finally, the presence of an immigrant population who migrated into the area between approximately 1100 A.D. and 1250 A.D. suggests these three sites may have formed a regional immigrant corridor or "migrant enclave", further distinguishing this area from the rest of the Tucson Basin (Elson and Cook, 2007).
Chapter 6: Conclusion

Analysis of the data collected in this research suggests the Sabino Canyon Ruin site is part of Hohokam history in ways which were unexpected. Hohokam social organization at the Sabino Canyon Ruin site was different from typical Hohokam culture. The ceramics, population, subsistence activities, and settlement location all demonstrate the Sabino Canyon Ruin site was a departure from the Hohokam tradition. These factors suggest the Hohokam at the Sabino Canyon Ruin site were different from Hohokam sites located along the floodplain. It is unclear whether the differences present at the Sabino Canyon Ruin site represent an effort to merely sustain the settlement or an attempt to advance Hohokam culture.

Andrew Duff (2004) examined the cause of migration and the effects of enculturation through a study of Zuni ceramics and settlement organization (Duff, 2003; Schachner, et al., 2011). Duff argued migration is not the result of a single event. Rather, regional depopulation occurs slowly as small, and then larger groups of people leave a region (Duff and Wilshusen, 2000). Duff, like Neuzil, has suggested that when the immigrant group is relatively larger in number, it is more likely to retain its culture and identity when encountering established populations. In contrast, those immigrant groups which are relatively small in number are more likely to adopt the culture of the
established populations (Duff and Wilshusen, 2000). The effect of cultural contact and enculturation is evident through an examination of pre-contact and post-contact ceramics. Duff (2004) argues that a greater distribution of ceramic vessels (which are culturally distinctive) can cause a new collective culture to form.

Duff's theory of Zuni cultural identity as it relates to pottery can be applied in considering the distribution of corrugated ceramics at the Sabino Canyon Ruin site. The ceramic dataset demonstrates the Hohokam remained distinctly different from the migrant population. Based on the ceramic assemblages, it appears that Hohokam culture did not incorporate aspects of migrant culture. The limited cultural integration between the Hohokam and immigrant population suggests the immigrant population was smaller than the Hohokam population. The smaller immigrant population would have been pressured to change their culture to more closely match that of the native Hohokam. As previously discussed, at the Whiptail Ruin and Gibbon Springs sites, different levels of corrugated ceramic distribution were found which suggest different levels of cultural integration between the Hohokam and the migrant population throughout the immigrant corridor.

Hartman H. Lomawaima (1989) examined the effects of outside populations on indigenous culture by considering the arrival of Spanish into the Hopi region. In the 16th and 17th centuries, the Spanish brought new technologies such as agricultural tools and new cultural practices, including Catholicism and a formal system of education, to this
group in the Southwest. After the Pueblo Revolt in 1680, a complete abandonment of everything the Spanish had introduced was called for by many of the Hopi tribes. However, some features of the Spanish system remained, including the use of modern tools and formal education. This process of selective adoption of new practices from immigrant populations demonstrates the malleability of culture and the potential effect of cultural interaction on indigenous populations.

In the case of the Hopi, it took only a few generations for newly adopted Spanish traits to become integrated into Hopi culture and identity. Applying Lomawaima's analysis of the adoption of cultural traits to the Sabino Canyon Ruin site, it can be suggested that the introduction of aspects of a non-native culture, as identified by corrugated ceramics, was not immediately accepted by the Hohokam. It is instead more likely that over time, a cultural blending would have occurred in which parts of both cultures became incorporated into a new, collective identity. The absence of transitional artifacts suggests this cultural blending had yet to occur at the time the site was abandoned.

The different social composition of the population at the Sabino Canyon Ruin site could suggest a change in the Hohokam view of non-native immigrant populations. That is, the presence of non-native immigrants living alongside different Hohokam populations in the Tucson Basin could demonstrate a growing acceptance and willingness to integrate among the Hohokam. The acceptance of immigrants at some of the peripheral
Hohokam sites may further suggest Hohokam culture and social structure was becoming more flexible. Assimilation would have occurred naturally as non-native cultural attributes integrated into Hohokam society. In this way, the Hohokam at the Sabino Canyon Ruin may reflect larger Hohokam cultural changes which occurred during the Classic Period in the Tucson Basin.

The prevalence of native Hohokam ceramics and the smaller proportion of corrugated wares at the Sabino Canyon Ruin site suggests the immigrant population was smaller than the established Hohokam population. It appears Hohokam culture was largely unchanged throughout the occupation of the site. This is supported in the archaeological record by the lack of "transitional" artifacts such as ceramics which contain a combination of both native and non-native characteristics (Duff, 2011; Neuzil, 2008). Instead, the ceramics of the two groups are different and were found in separate and distinct areas of the site. This lack of enculturation or integration suggests the culture and identity of the native Hohokam population dominated that of the migrant population during the Classic Period at the Sabino Canyon Ruin site.

Using a multi-faceted approach to understand the Hohokam at the Sabino Canyon Ruin site was central to this research. By employing a variety of resources, techniques, and perspectives, the Hohokam in the Tucson Basin at the Sabino Canyon Ruin site can be more fully understood. The primary goal of the SAA code of ethics is stewardship. The principle of stewardship requires that all archaeologists work for the preservation of
the archaeological record in situ. The noninvasive methods used in this research allow for a greater understand of the Hohokam at the Sabino Canyon Ruin site while supporting site stewardship. Each dataset collected informed the others, as well as the conclusions drawn. The distribution of corrugated ceramics at the Sabino Canyon Ruin site was studied in order to select the locations of the GPR grids. This approach enabled a comparison of non-native and Hohokam architecture. The aerial images, when used in conjunction with the remote sensing data, provided an understanding of Hohokam subsistence activities and settlement organization at the Sabino Canyon Ruin site. By combining these two datasets, together with research undertaken by others, the social organization of the Sabino Canyon Ruin site could be better understood and compared to other Hohokam sites in the Tucson Basin.

The majority of the Classic Period sites found in the Tucson Basin, including Sabino Canyon Ruin, appear to have been abandoned by 1350 A.D. (Dart, et al., 1999; Gregonis and Hartmann, 2011). Within the field of Hohokam archaeology, many hypotheses have been suggested which attempt to explain the rapid decline of the Hohokam in the region. Environmental stress, changing political structure, and lack of available food are all potentially contributing factors to the decline of a population. Research conducted by J. Brett Hill, Jeffery J. Clark, William H. Doelle and Patrick D. Lyons, 2004 suggests that rather than a single catastrophic event, the decline of the Hohokam likely occurred gradually over a 150 year period. Over the course of many generations the combined effect of a lack of proper nutrition, spread of disease, and
falling birth rates may well have contributed to the eventual decline of the Hohokam in the Tucson Basin (Hill, et al., 2004). Thus, by 1350 A.D., only a few widely spread, sparsely populated villages were left in the region. Soon after, the Hohokam ceased to be archaeologically visible at the majority of the sites in the Tucson Basin.

Numerous studies have been conducted seeking to better understand the dramatic cultural change which occurred within the Hohokam population during the Classic Period. While much of the research previously conducted has concentrated on the major villages and settlements within the region, this research has instead explored Hohokam social organization, population migration, cultural integration, and subsistence at the Sabino Canyon Ruin site, located on the periphery of the Tucson Basin. Future research could explore some of the questions raised in this study. Dating of the ceramic assemblages may reveal information regarding when immigrant populations arrived at the Sabino Canyon Ruin site. An ethnographic analysis may provide data regarding the causes of cultural change and site abandonment in the Tucson Basin. Performing an analysis of trade and exotic goods found at the Sabino Canyon Ruin site could allow for the development of a trade model which may extend beyond the Tucson Basin. There is much left unexamined in Hohokam archaeology, particularly in connection with peripheral sites in the Tucson Basin. This research worked towards a better understanding of the prehistory of the American Southwest and the Hohokam in the Tucson Basin.
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Appendix A

Remote Sensing

False color composite of December 2001, consisting of bands 2, 3, and 4

False color composite of March 2001, consisting of bands 2, 3, and 4
False color composite of September 2001, consisting of bands 2, 3, and 4

False color composite of June 2001, consisting of bands 2, 3, and 4
Multitemporal color composite of December & June 2001 NDVIs, consisting of bands 3 and 4

Multitemporal color composite of March & September 2001 NDVIs, consisting of bands 3 and 4
Multitemporal color composite of December & June 2001, consisting of bands 3 and 4

Multitemporal color composite of March & September 2001, consisting of bands 3 and 4
Appendix B

AutoCAD

AutoCAD map containing unit numbers from Old Pueblo Archaeology excavations, Sabino Canyon Ruin site section 1 (North)

AutoCAD map containing unit numbers from Old Pueblo Archaeology excavations, Sabino Canyon Ruin site section 2 (Center)
AutoCAD map containing unit numbers from Old Pueblo Archaeology excavations, Sabino Canyon Ruin site section 3 (South)
Ceramic Database and Typology Analysis

Database created for ceramic documentation and analysis. Ceramic typology counts by feature number

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Chi Squared Tests

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Chi Squared test comparing all of the ceramics found at Sabino Canyon Ruin to those from Whiptail Ruin.

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Chi Squared test comparing all of the ceramics found at Sabino Canyon Ruin to those from the Gibbon Springs site.

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<th>Difference</th>
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Chi Squared test comparing the central and south assemblages from Sabino Canyon Ruin to all of the ceramics found the Gibbon Springs site.

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Chi Squared test comparing the central and south assemblages from Sabino Canyon Ruin to all of the ceramics found the Whiptail Ruin site.

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Appendix E

Ground-penetrating Radar

Method

Ground-penetrating radar (GPR) was used throughout the site as a means to non-invasively map sub-surface features. GPR works by measuring the time it takes radar energy to leave the transmitting antenna, encounter a sub-surface layer or feature and then return to the receiving antenna. The exact time and returning strength of the radar energy is recorded as the two antennas move across the ground surface. In collecting a single transect, thousands of individual reflections are recorded and when viewed together, create a profile view of the geologic sub-surface. Large grids can be collected by running transects at regular distances from each other to a known distance. During processing, the individual transects can be arranged in order to provide a plan view of the region. Grids are then sliced into specific units of time to allow for a depth or layer specific interpretation of the sub-surface.

Data Collection and Analysis

The four grids were mapped using measuring tapes and collected to maximize grid area while minimizing potential collection issues resulting from the surface vegetation. Transects were spaced at .5 meters apart and the specific time window, and gains were recorded for each of the four grids. The corners of all the grids were located and mapped using GPS and the southwest corner of each grid was placed on the composite digital map (See appended CD).
All data was collected in the same manner to enable cross grid comparison. Geological and archeological features were then identified within the grids and profiles and slice maps were produced for each grid. The exact dimensions of each grid are shown below (all measurements are in meters).
GPR grid 2. Located approximately 50 meters southeast of Compound D.

GPR grid 3. Located approximately 170 meters north of Enclosure A.
GPR grid 4. Located approximately 60 meters north of Enclosure A.