

GEOSPATIAL APPLICATIONS IN SOUTHWEST ARCHAEOLOGY:
AN ENVIRONMENTAL SUITABILITY MODEL FOR PREHISTORIC SURFACE
PUEBLOS

By Abraham Ortega

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Approved:

Kerry Thompson, Ph.D., Chair

Emery Eaves, Ph.D.

Ruihong Huang, Ph.D.

Caitlin Stewart. MA RPA

ABSTRACT

GEOSPATIAL APPLICATIONS IN SOUTHWEST ARCHAEOLOGY: AN ENVIRONMENTAL SUITABILITY MODEL FOR PREHISTORIC SURFACE PUEBLOS

ABRAHAM ORTEGA

Geospatial technologies in archaeology facilitate the interpretation of the spatial context of both historic and prehistoric material culture as it is often expressed in both time and space. The primary focus of this research was to develop an environmental suitability model in ArcGIS Pro to determine high-probability areas for prehistoric habitation sites, primarily focusing on small, medium, and large masonry surface rooms within the Pleasant Valley Ranger District in the Tonto National Forest. By integrating decades of archaeological site records into a unified geodatabase, this research demonstrated viable data collection and organizational methods suitable for future comparative geospatial and statistical analysis of large archaeological datasets. The framework established for this research consisted of three main tasks: *data collection*, *data coding*, and *spatial modeling*. The integration of these three main tasks and the implementation of spatial operators such as *containment*, *intersection*, and *proximity* resulted in the identification of significant relationships between geology, biotic communities, and elevation and the locality of masonry surface pueblos.

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Chapter 1 – Introduction

The Tonto National Forest (TNF) spans approximately three million acres of rugged, mountainous terrain at the southern edge of the Colorado Plateau in central Arizona (Parker et al. 2005). Regarded as one of the most rugged terrains in Arizona, the degree of slope ranges from 2 to 90%. The area is characterized by steep and angular mountains exemplary of Basin and Range physiography, with most elevation rise within the space of three-quarters of a mile (Baril et al. 2019). This emblematic central Arizona landscape, commonly known as the Mogollon highlands or the sub-Mogollon region of the inland Southwest, incorporates four Arizona counties: Yavapai, Gila, Maricopa, and Pinal (Figure 1). In addition, TNF is subdivided into Cave Creek, Globe, Mesa, Payson/Pleasant Valley, and the Tonto Basin Ranger Districts. The study area, Pleasant Valley Ranger District (PVRD), consists of approximately 420,000 acres of chaparral and mixed coniferous forest.

The Sierra Ancha is a rugged mountain range that creates a stark geographic barrier from the gentler topography of the lower Tonto Basin. Similarly, the Sierra Ancha is also considered a transitional area where larger archaeological cultures intersect (Ciolek-Torello et al. 1990). The Sierra Ancha and surrounding territory within the PVRD will be the primary focus of this research. Decades of archaeological data stemming from state and federally-mandated inventories and research projects are integrated into a singular database for this study. The Gila Pueblo Archaeological Foundation, founded by Harold Gladwin in 1928, conducted the earliest research activities in the region in 1930. Archaeologist Emil Haury and a local guide, Dewey Peterson, provide the first scientific

description of the archaeology of the Sierra Ancha and the first use of tree-ring dating in central Arizona (Ciolek-Torello et al. 1990).

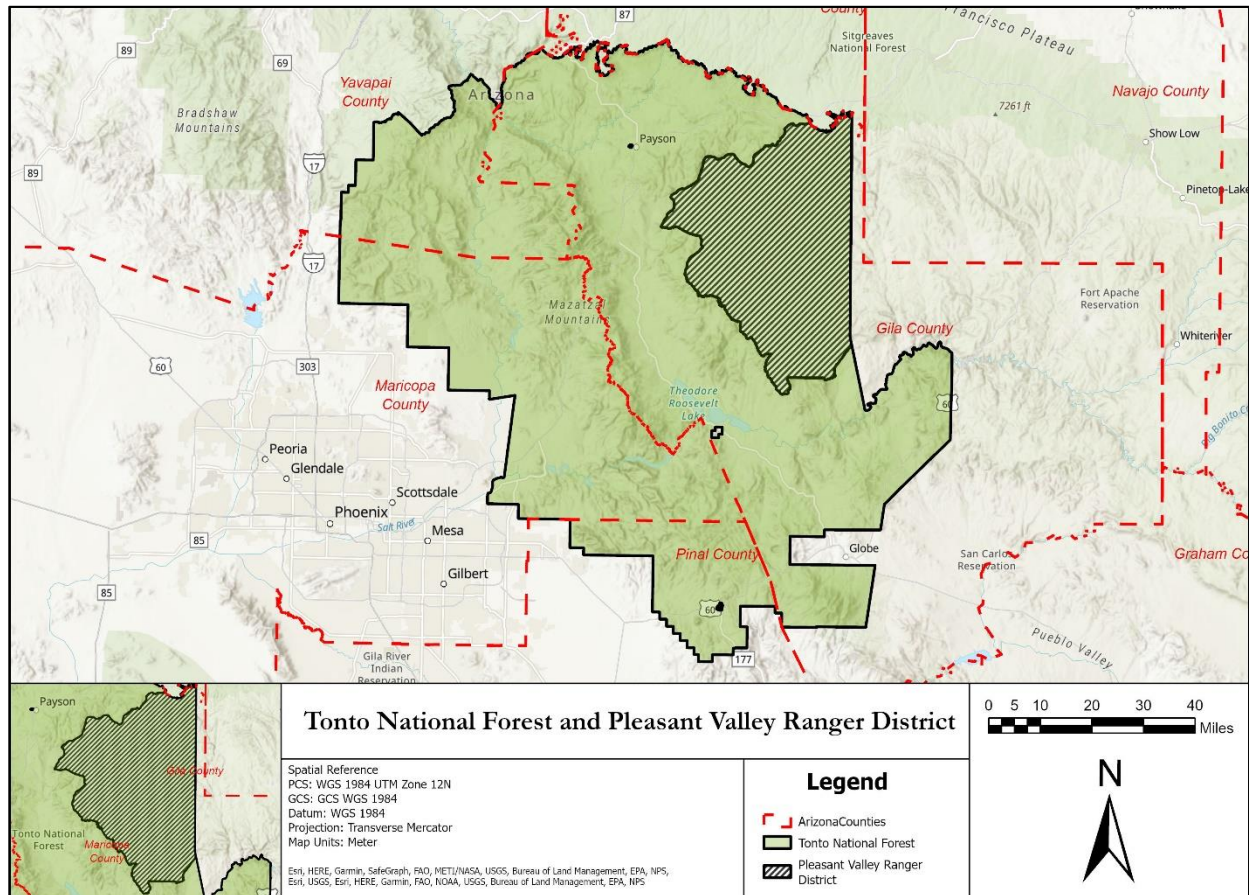


Figure 1. Map of Tonto National Forest and Pleasant Valley Ranger District

The TNF heritage inventory list, provided by TNF for this research, is a vast repository of federal undertakings and land management projects that have taken place in the forest since 1967. In a sense, this heritage inventory list is a vivid representation of a historic shift in federal legislation opting for a more formalized and systematic approach to managing and protecting cultural resources. Between 1966 and 1974, the labor market for archaeologists was completely transformed by the introduction of federal legislation, including the National Historic Preservation Act of 1966, the National Environmental Policy Act of 1969, and the Archaeological and Historical Conservation Act of 1974.

Due to these changes in legislation, a new field of private sector archaeology or Cultural Resource Management (CRM) began, and by the 1980s, were the primary producers of archaeological data collection (Green and Doershuk 1998). As a result, archaeological fieldwork and CRM transmuted into an industry with numerous collaborators involving Native American tribes, academic and museum-based programs, federal and state agencies, and private sector consultants. With so many types of entities collecting data, there has been a wide variety of methodologies and distinct procedures when documenting archaeological sites. As the CRM industry grew, the introduction of modern technologies such as Geographic Information Systems (GIS) provided opportunities to use newer digital technologies that are now integral to archaeological documentation and management. The introduction of newer digital technologies, however, has highlighted the necessity of modernizing and digitizing older print archaeological records. The interlude between digital and “paper and pencil” archaeological documentation itself contributes to the decentralization of archaeological datasets.

The primary purpose of this research was to create an environmental suitability model in ArcGIS Pro to determine the location of high-probability areas for prehistoric habitation sites, primarily focusing on small, medium, and large masonry surface rooms. Secondly, this research demonstrated viable data collection and organizational methods suitable for future comparative geospatial and statistical analysis of large archaeological datasets by integrating decades of both digital and print archaeological site records into a unified geodatabase specifically for the PVRD, which has applicability in a number of jurisdictions. More specifically, the study primarily focused on identifying significant relationships between the localities of small, medium, and large surface masonry pueblos

and their environmental determinants, such as geology (rock types), biotic communities (vegetation types), and elevation.

The framework established for this research consisted of three main tasks: *data collection*, *data coding*, and *spatial modeling*.

Data collection: In cooperation with the TNF, a record search was conducted to include paper site cards currently available for the PVRD to obtain site descriptors, geographic locations, and environmental data from previously recorded archaeological sites. As many previously recorded sites are still in paper format, the obtained records were digitized, sorted, and subsequently integrated into a database with the intent of inventorying all materials collected and digitized.

Data coding: Each previously recorded site with a minimum of locational data and site descriptors was coded into a database for comparative analysis. The database created incorporated locational data (UTM's) and individual site descriptors such as site number; temporality; data source; UTM coordinates; cultural affiliation; site type; architectural styles; approximate number of rooms documented; site size; site area (sqm), and the presence of ceramics. Each of these site descriptors was assigned a unique coding system. For example, a proposed coding system for site type includes Habitation (code = 1); Lithic Scatter (code = 2); and Artifact Scatter (code = 3).

Spatial modeling: The final step of this research involved the consolidation of the previous steps in identifying significant relationships between prehistoric surface rooms and environmental determinants. The surface rooms mapped with ArcGIS Pro were spatially joined with geology and vegetation data layers in order to produce a single table that included all categorical variables needed to determine significant relationships. The

finalized exported table includes surface rooms distinguished by site sizes (small, medium, large); geology (rock types); vegetation types, and elevation of site localities. The first model created (the environmental suitability model) highlighted the relationships between site localities and environmental determinants. The subsequent model (high-probability model) demonstrated the areas most likely to support these masonry surface pueblos based on the environmental suitability model and the incorporation of elevation ranges deriving from previous research. The PVRD high-probability model was a result of the integration of spatial selection and spatial joining methods deriving from spatial operators within ArcGIS Pro, such as *containment*, *intersection*, or *proximity*. In addition, a spatial overlay analysis was conducted, a technique utilized for spatial information integration

In summary, this thesis inventoried and updated decades of archaeological records from the Pleasant Valley Ranger District in an effort to create a centralized geodatabase conditioned for comparative geospatial analysis and model building within ArcGIS Pro. Above all, this research has contributed to the southwest archaeological literature of central Arizona, prioritizing efficient geospatial applications in archaeology. Finally, the PVRD geodatabase intends to assist CRM practitioners in the land management decision-making processes that inherently protect the cultural resources we all enjoy.

Chapter 2 - Environmental Background

Physiography, Terrestrial Vegetation, and Geology

The TNF is situated among the Central Highlands Transition Zone Physiographic Province, characterized by mixed conifer forest and the Basin and Range Province, which corresponds to Sonoran Desert vegetation types (Figure 2). Composed of 2,873,406 acres, the TNF is 50 percent forest land and 50 percent non-forest land or water. The forest land is subdivided into two land categories: timberland and woodland. As a result of occurring in a transition area, it is a floristically diverse semi-arid ecoregion with highly variable precipitation and seasonal air temperature (Studd et al. 2017). Lower elevations

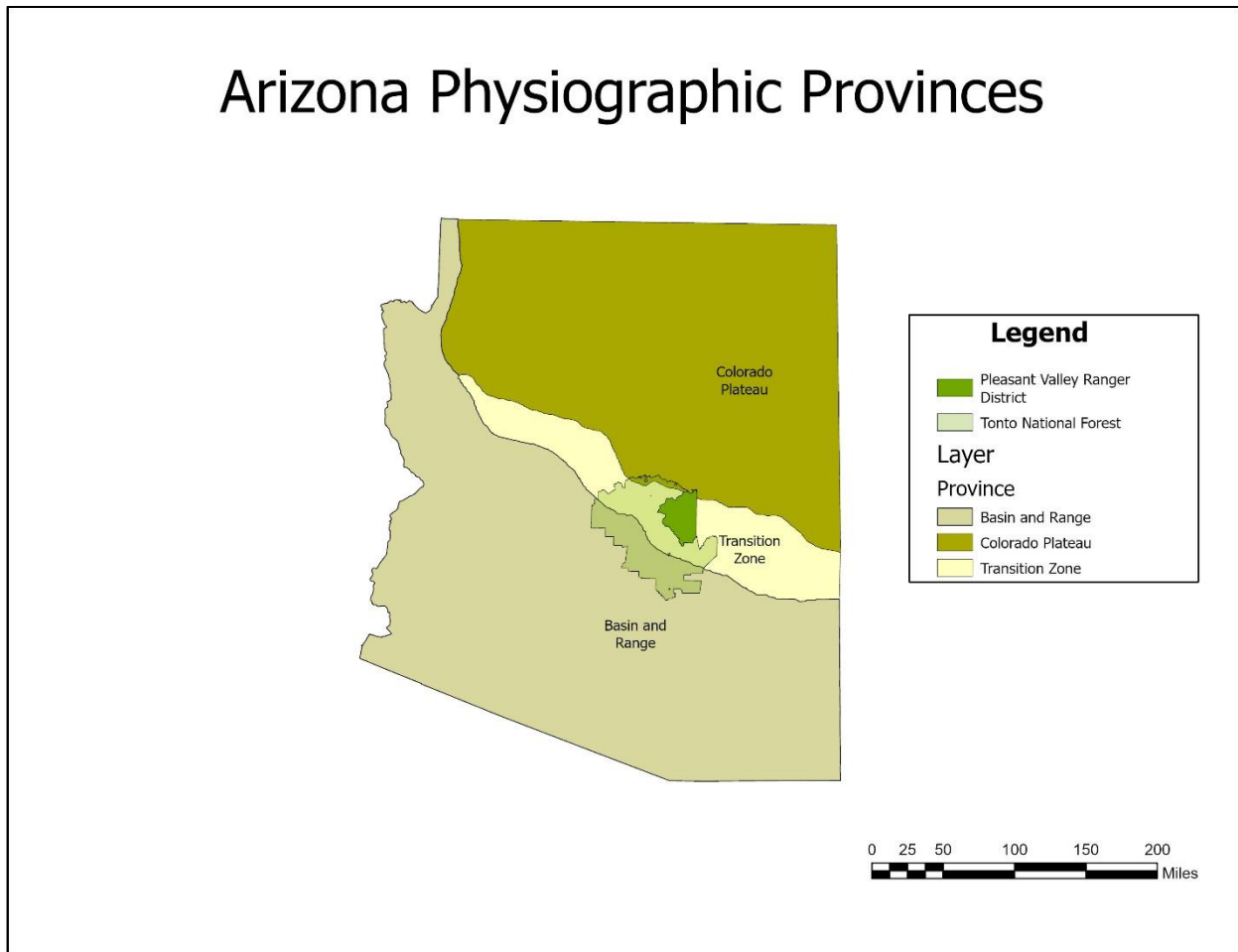


Figure 2. Map of Arizona physiographic provinces.

are distinguished by Sonoran Desert vegetation, while the northern portions are characterized as Pinyon-Juniper and Ponderosa Pine types (Alford 1993). The proximity to the Mogollon Rim and strong topographic gradients has created intermediate or “transitional” plant communities that exhibit characteristics of both the Sonoran Desert and the Apache Highlands ecoregions unique to the Tonto Basin and surrounding areas (Hubbard et al. 2013). Timberland is considered forest land with mostly timber species utilized in the wood products industry, such as ponderosa pine and Douglas-fir. In contrast, the woodland is characterized as mostly woodland species that often have multistem growth and are not typically utilized for industrial wood products. Consequently, approximately 21 percent of all land administered by the TNF is classified as reserved land, such as wilderness areas, indicating a withdraw from management for the production of wood products (Shaw 2004).

Wilderness areas within the TNF include Superstition (160,285 acres); Sierra Ancha (20,850 acres); Salt River Canyon (32,101 acres); Salome (18,531 acres); Mazatzal (250,517 acres); Hell’s Gate (37,440 acres); and Four Peaks (60,743 acres) (Mohlenbrock 2006). The Parker Creek Experimental Forest, established in 1932, was expanded and renamed in April 1938 to the Sierra Ancha Experimental Forest (SAEF). The Sierra Ancha Experimental Forest includes 13,500 acres with elevations ranging from 3,550 to 7,725 feet. The geology of the SAEF range is composed of sedimentary, metamorphic, and igneous rocks. Deep formations of Dripping Springs quartzite with diabase and/or basalt intrusions are common, including Troy sandstone occurring at higher elevations (Gottfried and Neary 2015).

Mixed conifer forests, mountain parks, chaparral, oak woodlands, desert grasslands, desert shrub, and riparian areas make up the vegetation types within SAEF (Gottfried and Neary 2015). The desert portion of TNF contains shrub and cactus dominated vegetation in contrast to the non-desert vegetation, which includes interior chaparral, conifer woodland, conifer forest, semidesert grassland and evergreen woodland. Interior chaparral and conifer woodland occupy an area equal to the area of the desert. The coniferous forest is estimated to cover an area one-fourth the size of the desert area, with semidesert grassland and evergreen woodland occupying smaller areas (Rogers 1986).

The Mogollon highlands are composed of numerous geologic components and consist of Paleozoic sedimentary rocks exposed on the face of the Mogollon Rim, a characterization of the Colorado Plateau. Also, present a system of northwest-southeast trending faults associated with the Basin and Range extensional deformation. Underlying the Paleozoic sedimentary, Proterozoic metamorphic and granitic rocks form the step-like terrain south of the Mogollon Rim. In addition to Proterozoic metamorphic rocks, sedimentary and volcanic rocks naturally form in the Sierra Ancha and Mazatzal Mountain ranges. Late Cenozoic volcanic rocks and basin-fill sediments are located primarily in the lower Tonto Creek Basin (Parker et al. 2005).

The region of the Mogollon Highlands has been structurally shaped from tectonic stresses that have consequently raised the land surface and deformed rock formations. Proterozoic faults and lineaments generally trend northeast southwest and are generally highly silicified. Nonetheless, the most abundant faults and most significant in shaping the modern landscape were a product of a Miocene episode of crustal extension.

Comprehending the geologic history and impacts of tectonic stresses is integral in understanding the shaping of this modern landscape and the natural resources available for the earliest inhabitants of the region. As the structural shaping of the region was determined by tectonic stresses and geologic displacements, it also played a significant role in the development of surface drainage, determination of ground-water flow directions, and the occurrence and distribution of springs below the Mogollon Rim (Parker et al. 2005).

Hydrology

Precipitation in the Mogollon highlands is approximately 21.3 inches per year, with the highest annual amounts occurring in a narrow band along the crest of the Mogollon Rim. The mean monthly maximum temperatures tend to occur during June and July and range from more than 100 degrees Fahrenheit in the Sonoran Desert vegetation-type region. In contrast, the mean monthly maximum temperatures in the ponderosa forests tend to range through the mid-eighties. Precipitation mostly occurs in two types of storms: intense, convective thunderstorms in the summer and less intense but more regional frontal storms during the winter. The Mogollon highlands hydrological system originates on the Colorado Plateau and is often characterized as a surface network of short and steep stream channels that drains the upland regions and flows directly into the Salt River, which also includes Roosevelt Lake and the Verde River (Figure 3) (Parker et al. 2005).

The northern and central higher elevations winter precipitations are often in the form of snow and can accumulate from a few centimeters to 60 cm in depth. Rainfall below the Mogollon Rim is distinguished as a bi-seasonal pattern characterized by winter

precipitation, spring drought, summer precipitation, and fall drought. The Sierra Ancha region receives some of the highest rainfall averages within the state of Arizona. Geological faulting and the permeability or porosity of various formations combine to create pockets of water and seeps or springs. A multitude of seeps run only during the wetter periods and are ephemeral and perennial in nature. The presence of seeps and springs at various elevations indicates that water sources are available at locations other than the major streams or tributaries, which are often viewed as reliable sources of water even during the drier periods (Lange et al. 2006).

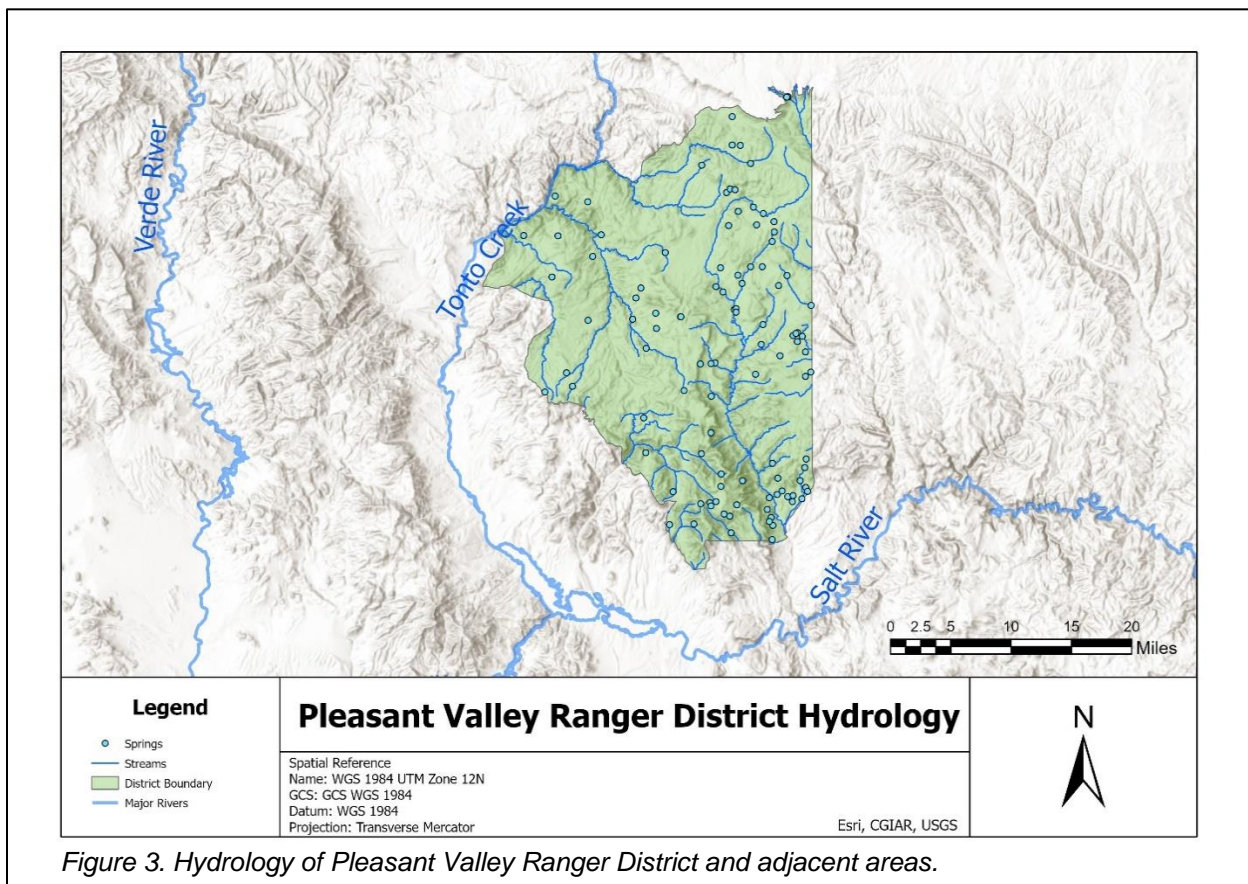


Figure 3. Hydrology of Pleasant Valley Ranger District and adjacent areas.

Chapter 3- Cultural Background

Tonto Basin

The Tonto Basin has been traditionally recognized as the heartland of the Salado culture, often associated with the post AD 1250 Classic period inhabitants of the upper Salt River drainage. The Salado designation is based on the presence and high frequency of Salado Polychrome (Roosevelt Red Ware) ceramics and its geographic restriction to the Tonto-Globe Area. The heartland of the Tonto Basin and the definition of Salado as a homogeneous prehistoric culture are being questioned in light of recent evidence that highlights the equal, if not higher, frequencies of Salado Polychrome found in other areas such as the San Pedro River valley and the White Mountains of southeast and east-central Arizona. In fact, archaeologists now characterize Salado as a pan-southern-Southwest ceramic horizon or a religious or ideological system stemming from numerous small-scale migrations of Ancestral Puebloan peoples who interacted with local Hohokam groups (Elson et al. 2007).

Historically, the Tonto Basin has been characterized as the northeastern Hohokam periphery and is commonly integrated within the “Hohokam Regional System” This cultural association is based on the idea that the prehistoric inhabitants of the Tonto Basin carried ethnic and cultural Hohokam influence. Although Salado is regarded as a distinctive culture in the Tonto Basin, the integration of the Tonto Basin within the Hohokam Regional System implies a more homogenous cultural region than a diverse one (Elson et al. 2007). The Salado Classic period (AD 1275-1450) is of particular interest to archaeologists since settlement patterns, land use, and economic systems appear to have radically shifted during the Classic period (AD 1150 – 1270). These radical shifts

resulted in population expansion to the upland areas as well as populations aggregated into large and nucleated communities (Stark et al. 1998).

A substantial amount of research in the Tonto Basin has particularly focused on understanding the intensity of external contact and cultural influence deriving from Hohokam and the Phoenix Basin. Addressing the intensity of external contact and cultural influence within the Tonto Basin allows archaeologists to deviate from a homogenous model to a more complex and culturally diverse interpretation of the Tonto Basin. As research suggests, cultural influence in the Tonto Basin is significantly divergent from the Hohokam “core area” as well as significantly diverse in the Tonto Basin itself, presenting itself as a region containing Indigenous peoples who interacted and mixed with neighboring populations while maintaining separate and distinct identities (Elson et al. 2007).

The concept of Salado culture was initially defined by a series of pottery types which included Pinto, Gila, and Tonto Polychrome, Salado Red, Gila Red and Roosevelt Black-on-white (Doyel 1976). Stemming from the predominance of these specific ceramic assemblages, the homeland or “heartland” designation of Salado culture has been highly debated amongst archaeologists and has produced numerous opinions regarding the traditional Salado homeland (Doyel 1976). As summarized by Lindsay and Jennings (1968), four major archaeological perspectives attempt to define what constitutes the Salado cultural tradition originally proposed through the combined efforts of archaeologists Eric Schmidt, Harold and Winifred Gladwin, Florence Hawley Ellis, and Emil Haury.

The first and earliest definable Salado phase, the Roosevelt phase (AD 1100 to 1250), which was restricted to the Tonto-Globe area, was produced by Gladwin and Gladwin (1934:22;1957:353) and eventually concluded that this phase represents a western movement of Little Colorado culture. Between AD 1250 and 1300, the Roosevelt phase transmuted into the Gila phase by the immigration of proto-Hopi people from the Little Colorado area into the Tonto-Globe area. In 1932, Florence Hawley Ellis suggested that the development of Salado Culture in the Tonto-Globe area may have been established by AD 900 by a group of people from the upper Gila area, characterized by black-on-white pottery and small pueblos. In accordance with this narrative, eventually, people who made Little Colorado black-on-red pottery migrated into the area from the north and joined the original arrivals (Doyel 1976).

Presenting a different view, Emil Haury stated that the Salado represents an Ancestral Puebloan-Mogollon blend related to the Little Colorado, which developed in the area below the Mogollon Rim. In accordance with Haury, McGregor (1965) attributes the development of Salado culture to a prolonged southward movement of various Puebloan peoples beginning around AD 1100. Nonetheless, McGregor characterizes Salado as a cultural pattern representing a fusion between Ancestral Puebloan, Mogollon, and Hohokam. In 1953, Schroeder suggested yet another different theory for the origins of the culture pattern found in the Tonto-Globe area. Schroeder proposed a Hohokam-Sinagua blend which was thought to have occurred between AD 1125 and 1150 (Doyel 1976).

The most recent opinion regarding the Salado was produced as a result of excavations at Casas Grandes in Chihuahua, Mexico. Di Peso (1974) suggested that the Salado homeland area could be interpreted as an outpost for Casas Grandes. Di Peso

argues that between the tenth and fifteenth centuries, a vast portion of the American Southwest was part of systematic economic exploitation by exceptionally organized and dynamic *puchteca* traders based at Mesoamerican frontier settlements such as Casas Grandes. Central to this argument is the suggestion that the Salado polychromes may have originated in the Casas Grandes area as early as AD 1060 (Doyel 1976).

Recent Research in the Tonto Basin

Excavations of approximately 200 archaeological sites in the Tonto Basin undertaken by CRM professionals provide a new interpretation of Tonto Basin prehistory (Elson and Clark 2007). The sites investigated were located on both the Salt River and Tonto Creek arms of the Lower Tonto Basin as well as the Upper Tonto Basin. Elson and Clark (2007) note that this is, in fact, the first-time comparative analyses have been conducted among the three distinct subareas. The comparative analyses are the result of three major project undertakings by Desert Archaeology; the Roosevelt Community Development Study (RCD) on the Salt River arm of the Lower Tonto Basin, the Tonto Creek Archaeological Project on the Tonto Creek arm of the Lower Tonto Basin, and the Rye Creek Mitigation Project in the Upper Tonto Basin.

In addition, a revised chronology and phase sequence for the Lower Tonto Basin of central Arizona was developed through work by Desert Archaeology on RCD (Elson 1996). The sites located within the RCD project area demonstrated a great range of functional, temporal, and cultural diversity. The primary objective of the RCD was to investigate the temporal and developmental sequence of prehistoric populations within this region. As a result, the formulation of a new chronology known as the “Roosevelt Tonto Basin Chronology” was determined (Elson 1996) (Table 1). The Roosevelt Tonto

Basin Chronology is the temporal and developmental sequence employed within this research alongside the chronologically sequent periods derived from the Pecos Classification (Table 2).

Table 1. Revised Roosevelt Tonto Basin Chronology

Period	Phase	Dates
Late Classic	Gila	1320/1350 - 1450
Classic	Roosevelt	1250/1270 – 1320/1350
Classic	Miami	1150 – 1250/1270
Late Sedentary	Ash Creek	1025/1075 - 1150
Early Sedentary	Sacaton	950 – 1025/1075
Late Colonial	Santa Cruz	850 - 950
Early Colonial	Gila Butte	750 - 850
Pioneer	Snaketown	600/700 - 750
Early Ceramic	Early Ceramic	100 – 600/700

Table 2. Roosevelt Tonto Basin Chronology contiguous to Pecos Classification.

Dates (AD)	Period	Roosevelt Tonto Basin Phases	Pecos Classification
1600		Apache?	Pueblo IV (P IV)
1500		?	
1450			
1450	Classic	Gila Roosevelt Miami	Pueblo III (P III)
1400			
1300			
1200			
1150			
1150	Sedentary	Ash Creek ? Sacaton	Pueblo II (PII)
1100			
1050			
1000			
950			
950	Colonial	Santa Cruz Gila Butte	Pueblo I (PI)
900			
850			
800			
750			
750		Snaketown	
700			

650	Pioneer	?	Basketmaker III
600		?	(BM III)
600	Early Ceramic	Early Ceramic	
500			
400			Basketmaker II
300			(BM II)
200			
100			

The most recent interpretation of the Tonto Basin prehistory situates the earliest documented occupation in the Tonto Basin during the Middle Archaic and Early Agricultural Periods (3,500 BC–AD 100), which is characterized as seasonal or temporary use sites. The Eagle Ridge site is the earliest permanent occupation site in the Tonto Basin on the Salt River arm, congruent with the Early Ceramic (AD 100-550) Period. Indicative of a relatively stable local population, ninety percent of the Eagle Ridge site ceramic assemblage was locally produced in the Tonto Basin, with architectural and site layouts demonstrating closest affinities with contemporaneous groups in the Mogollon Highlands distinct from groups in the Phoenix and Tucson basins (Elson and Clark 2007).

The Colonial Period (AD 750-950)

The Colonial Period (AD 750-950) is characterized by significant numbers of Hohokam migrants from the Phoenix Basin entering the Tonto Basin. Evidenced by the

appearance of numerous material indicators of Hohokam culture coinciding with the dramatic increase in the number of sites along the Salt River arm, the Tonto Creek arm, and in the Upper Tonto Basin. In contrast, Hohokam influence along the Tonto Creek and in the Upper Tonto Basin is considerably less intense than that observed along the Salt River, which is often regarded as the primary destination for the Phoenix Basin groups. More importantly, this contrast demonstrates that the developments in the Salt River arm were clearly separate from the Tonto Creek arm and the Upper Tonto Basin, indicating different interaction networks (Elson and Clark 2007).

Presumably, the most important element in ascribing distinct cultural affiliation are the differences in the utilitarian ceramic assemblages. Approximately 75 percent of the colonial period plain-ware assemblage along the Salt River arm was tempered with muscovite schist, occurring most likely within the Phoenix Basin and the middle Gila River Valley as opposed to local sands collected from the Tonto Basin. These sharp distinctions between ceramics assemblages demonstrate that utilitarian ceramics along the Tonto Creek and in the Upper Tonto Basin were produced by groups that most likely did not originate in the Phoenix Basin. Similarly, it highlights strong connections between the inhabitants of the Salt River and Phoenix Basin groups which can be explained by population movement between these two areas (Elson and Clark 2007).

Sedentary Period (AD 950-1150)

The first half of the Sedentary Period (AD 950-1150) continued without much change in relation to the Sedentary period. Additional small farmsteads and resource procurement sites were established along the Salt River arm. During the second half of the Sedentary period, intrabasin relationships became the primary focus between the

Tonto Basin inhabitants. A change that is characterized as the retraction and reorganization of the Hohokam regional system is seen through more discernable forms of cultural material such as decorated ceramic and mortuary practices. As illustrated by Elson and Clark (2007), by AD 1050 or 1100, Hohokam Buff Ware ceramics were almost completely replaced by Cibola White Ware and Limited quantities of Little Colorado White Ware. This reorganization suggests new trade relationships and associated exchange of ideas with groups to the north and east played a larger role in the changes taking place rather than the actual migration of Ancestral Puebloan peoples into the Tonto Basin (Elson and Clark 2007).

Sierra Ancha

The brief introduction on the Tonto Basin prehistory was intended to introduce and reflect the diversity and intersection of prehistoric cultures surrounding the region as the Sierra Ancha itself is often regarded as a region archaeologically neglected and subjected to a minimal and sporadic professional investigation (Ciolek-Torello et al. 1990). This limited research has been exclusively conducted in the southeastern Sierra Ancha along the upper and lower areas adjacent to Cherry Creek and particularly focused on large

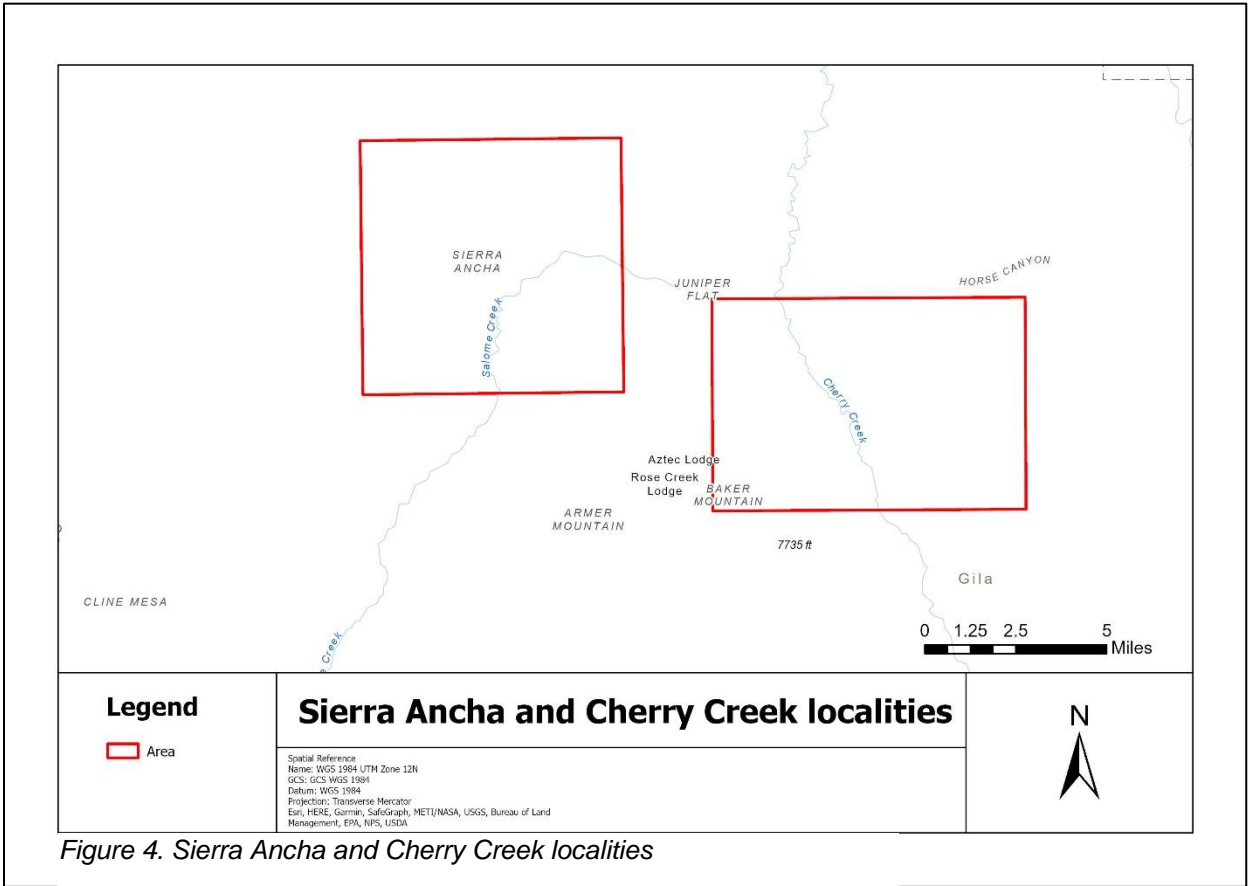


Figure 4. Sierra Ancha and Cherry Creek localities

habitation sites and cliff dwellings (Lange et al. 2006) (Figure 4). The literature guiding this research project derives from these archaeological investigations, a product of the Sierra Ancha Project (SAP). In 1995 and 1996, the SAP conducted two field seasons with

the primary intent of relocating and documenting previously recorded cliff dwellings by the Gila Pueblo. In addition, the SAP was tasked with formally surveying new areas along Cherry Creek and locating new sites on the landscapes (Lange et al. 2006).

The brief introduction to the Tonto Basin and the unsettled archaeological quandary regarding Salado's "external" cultural influences and unique distinctiveness illustrates a similar predicament in understanding and interpreting prehistoric lifeways in the Sierra Ancha. It was not until the thirteenth century that the population aggregated into moderate- to large-sized settlements. At the same time, a diversified settlement system occurred characterized by variability in site size and function, including large-scale site complexes centered around a large site, often containing a structure morphologically similar to Hohokam platform mounds. These large sites are surrounded by clusters of small sites and agricultural features and have been interpreted as major prehistoric communities, although the exact temporal association and functions have not been determined.

The region of central Arizona during the Paleoindian and Early Archaic periods indicates a sparse use with increasing evidence of occupation in the Middle and Late Archaic periods. Individuals or small groups of people may have passed through, camped, or lived in the middle stretch of the Cherry Creek Valley. Nonetheless, little or no evidence exists of occupation during these early periods. In the middle Cherry Creek, Archaic period populations are primarily recognized through the rock art styles they created. Deeply incised and heavily patinated petroglyphs and Mogollon Red-style pictographs are the principal indicators of the inhabitants of Middle Cherry Creek during the Archaic period. Archaic peoples may have been the first group to inhabit the rock shelters and

caves located throughout middle Cherry Creek, although any evidence of structures may have been erased or covered by thirteenth-century occupants (Lange et al. 2006).
Preclassic Period: Colonial and Sedentary (Pueblo I through Pueblo III Periods).

The earliest potential periods of occupation are considered to be the Colonial and Sedentary periods, or Pueblo I (PI) and Pueblo II (PII) periods. Nonetheless, evidence suggests low-level and ephemeral use of middle Cherry Creek. Dramatic changes occurred during the thirteenth century as there was a substantial population established in the late AD 1200s during the Classic Period (Roosevelt Phase or Late Pueblo III). This period is characterized by the aggregation of populations into large, nucleated settlements as well as the construction of settlements in canyons and other protected areas. During this time, the cultural history of middle Cherry Creek closely resembles that of the Tonto Basin to the south and west. At this time, the Hohokam Regional System expanded throughout central Arizona, perpetuating certain architectural characteristics of village organization. Although Hohokam influences are seen in the upper and lower Cherry Creek area, they don't seem to be present within the middle Cherry Creek (Lange et al. 2006). During the fourteenth century, aggregation and settlement diversity appeared to have reached its climax and a wide variety of areas, such as river terraces, canyons, and mesas, were intensively settled and exploited at that time. The aggregated and diversified settlement system in the Tonto Basin has been interpreted as part of the Classic period Hohokam system centered in the Gila and Salt River basins. In contrast, the aggregation and diversification of settlement systems within the Sierra Ancha region did not begin until the fourteenth century. Prior to the thirteenth century, the largest sites in the region had about 20 rooms, but by AD 1320, several large pueblos were present,

including pueblos with hundreds of rooms. Cliff Dwellings, recognized as a hallmark of the intensive exploitation of canyon areas, did not begin until the late 1320s, which have been interpreted as the product of a population influx during the fourteenth century (Ciolek-Torello et al. 1990).

Classic Period (Roosevelt Phase)

During the Classic Period, lower and middle Cherry Creek both took on characteristics of the Tonto Basin settlements having smaller versions of communities with residential compounds and rooms clustered around platform mounds. In middle Cherry Creek, an interesting change occurred during the Classic Period as cliff dwellings and hilltop sites proliferated in the late thirteenth and early fourteenth centuries, with most of these sites abandoned around AD 1330. The concentration of cliff dwellings in the southeastern Sierra Ancha, Coon Creek, Mustang Ridge, and middle Cherry Creek areas do not occur anywhere else in the Sierra Ancha or Mazatzal mountains on the western side of the Tonto Basin. Pueblos of various sizes were also situated on high and often isolated topographic features serving as vantage points for observation into the side canyons where cliff dwellings were built (Lange et al. 2006).

Late Classic Period: Gila Phase or Pueblo IV (AD 1350-1450)

The Late Classic Period, also known as the Gila Phase or Pueblo IV (AD 1350-1450), was characterized by process of abandonment and continuation of aggregation of the population into fewer but larger nucleated settlements. Pueblo IV pueblos are distinguished by a ceramic assemblage that includes but is not restricted to ceramic types dating after AD 1320. The ceramic assemblage consists of Pinedale Black-on-white, late White Mountain Red Ware types such as Pinedale Black-on-red and Polychrome and

Fourmile Polychrome, Gila and Tonto Polychromes and other types of polychromes. By the mid-fourteenth century, few sites were occupied in Cherry Creek, and the focus of the community had focused on Granite Pueblo. The period of settlement organization was followed by the complete abandonment of the entire region between Mogollon Rim and the Salt River (Lange et al. 2006).

The abandonment of the entire region is difficult to explain, although numerous interpretations have attributed it to social factors, environmental conditions, or some combination of the two. Archaeological interpretations based on social forces infer population movements from the Four Corners and Upper Little Colorado River areas to better-watered regions below the Mogollon Rim as a major contributing factor spurred by the Great Drought. By the end of the Roosevelt Phase (AD 1300-1350), there may be evidence suggesting widespread conflict within the Tonto Basin. The conflict was suggested based on the identification of bodies with indications of wounds and traumatic fractures found in unburied room floors (Lange et al. 2006).

During the AD 1300's, at about the time of the Roosevelt Phase and Gila Phase transition, a severe 20-year drought reduced productivity which may have exceeded the ability to support the diverse and densely settled system. The combination of social, economic, and environmental problems may have been catastrophic for the large, nucleated Gila Phase populations and most likely hastened their demise. Nonetheless, comprehending the complete abandonment of the region resulting from the failure to develop a new social order remains misunderstood to this day (Lange et al. 2006).

Chapter 4- GIS in Archaeology

Integral to modern data collection and data management in cultural resource management is geographic information systems, or GIS which plays a major role in planning and executing archaeological surveys. As a result, GIS allows us to store, organize, and visualize large datasets (João and Fonseca 1996). Geospatial technologies such as geographic information systems (GIS), Global Positioning Systems (GPS), remote sensing images, and Light Detection and Ranging (LIDAR) are now routinely utilized within the field of archaeology and are even considered frontrunners in implementing it within the humanities and social sciences (Gupta and Devillers 2017). The first applications were, for the most part, developed in North America and mainly consisted of the modeling of surfaces related to materials of archaeological interest through polynomial functions, the production of Digital Elevation Models (DEMs) and digital thematic maps of archaeological sites or excavation areas (Scianna and Villa 2011). Nonetheless, GIS in cultural resource management has been limited to data inventory and management, confining a vast potential of spatial analytics to depictive visualizations (Scianna and Villa 2011).

In efforts to address the limitations of GIS in cultural resource management, Ebert (2004) offers a hierarchy of three levels of application in archaeology: visualization, management, and analysis. According to Ebert, *visualization* is categorized as the lowest level of GIS use and requires little analytical capabilities because it focuses on graphical functions. Furthermore, *management* is illustrated as a step above visualization in terms of complexity and is widely utilized by CRM practitioners who regulate archaeological resources, prioritizing management of locations rather than focusing on the analytical

capabilities that may assist in understanding human behavior, such as settlement patterns. Finally, *analysis* is categorized as the highest level of GIS both in technical terms and as a means of generating and testing theories.

Archaeology and geospatial technologies are perfectly suited for each other as archaeological data is distributed in both time and space and allows for analyzing the spatial context of historic and prehistoric data. Common GIS applications in archaeology have been centered around predictive location modeling based on geographic data aiming to support archaeological surveys. Predictive models are often recognized as deductive or inductive formulations set to predict unknown events. Particularly for archaeological research, predicting site location can be seen as a form of promoting knowledge and protecting sites at risk from the development of modern settlements (Scianna and Villa 2011).

Predictive models attempt to predict the location of sites or materials in a region based on either a sample of sites in the region or theories of human behavior, serving as tools for projecting patterns or known relationships. Composed of three elements, predictive models incorporate available knowledge or information from which a model is derived. Secondly, they utilize a *method* to transform this information into predictions, and finally, they generate predictions. In addition, predictive models tend to formulate based on either deductive or inductive models. *Deductive modeling* incorporates prior archaeological or anthropological knowledge, such as derived from a theory of general human behavior. In contrast, *inductive models* have been termed intuitive, associational, and empiric-correlative, often regarded as analogous to pattern recognition procedures employed in remote sensing image classification (Ebert 2004).

A prominent inductive model within the field of archaeology is the weighted map layer modeling approach has been the most popular inductive modeling method implementing categorical or class-based map layers, with each classification being assigned a weight relative to conditions observed at an archaeological site. The weighted map approach allows specific variables to have more influence over predicted site locations than other classes or variables. This modeling procedure proposes a method that allows us to determine the relationship between the distribution of sites and the environment. Criticisms surrounding this model include questions about the accuracy of site locational data, the accuracy of the environmental data set, and how areas of archaeological potential are defined. Moreover, Ebert (2004) illustrates that one of the greatest failings of traditional inductive modeling is the lack of any non-environmental predictor variables. Thus, the role of social, ideological, and political factors receives little to no attention in the prediction of site locations which in itself may be difficult to discern from cultural material.

Geographic Information Systems (GIS) have been widely used to support real-world decision-making processes that involve finding regions capable of supporting certain land uses (Qiu et al., 2014). The identification and delineation of priority areas for conservation is a fundamental issue for the effective application of conservation resources and often implements a landscape approach necessary for identifying appropriate focal areas for conservation (Kaminski et al., 2013). Suitability evaluation is also known as multi-criteria evaluation, site selection, or resource allocation analysis (Qiu et al., 2014). Archaeological site descriptors are important factors representing site

characteristics under consideration and are usually available as attributes of vector or raster layers in GIS (Qiu et al., 2014).

Prominent characteristics may include common measures such as precipitation, temperature, slope, or aspect (Qiu et al., 2014). These characteristics may also be derived from measurements representing spatial relationships with land features such as proximity to major roads, distance from the previous distribution of a subclass, or any other metric deemed appropriate for the analysis (Qiu et al., 2014). A limitation of any sample-based modeling approach is that the results completely depend on the characteristics of the site samples employed (Kvamme 1992). The incorporation of environmental factors in this research is a major component guiding the potential locational suitability of prehistoric surface rooms. Environmental factors are generally viewed as being intimately related to locational decisions made by hunter gatherers and play a major role in patterns of land use and settlement in more complex societies (Kvamme 1992).

The relationship between material culture and landscapes is constructed based on the belief that all archaeological evidence and cultural material have a landscape dimension. In light of this, archaeological research interests tend to focus on understanding the interrelationships between cultural practices, conditions, and trends in the natural environments as well as the characteristic of built environments. These particular research interests derive from current archaeological perspectives, which tend to think that environmental conditions and environmental changes are forces that shape or accelerate cultural changes. More importantly, it is a cultural activity and cultural knowledge that give meaning to particular spaces in the landscape, which has led to

recent research focusing on cultural and symbolic aspects of landscapes, architecture, and monuments (Rodning 2009).

As Hritz (2014) illustrates, thousands of years of continuous settlement in a modern landscape combined with superimposed layers of ancient features and archaeological material visible on the surface can act as a record of the broad set of complex relationships between people and their physical and social environments, ultimately designating the landscape as a cultural entity that can be interpreted. The interpretation of a landscape as a cultural entity can be modeled from the “*Landscape Paradigm*” and its four interrelated premises presented by Anschuetz et al. (2001):

1. Landscapes are not synonymous with natural environments but synthetic with cultural systems structuring and organizing people’s lives with their natural environments.
2. Landscapes are worlds of cultural product and transform physical spaces into meaningful places.
3. Landscapes are the arena for all of a community’s activities in which populations survive and sustain themselves.
4. Landscapes are dynamic constructions with each community and generation imposing its own cognitive map on an anthropogenic world of interconnected morphology, arrangement, and coherent meaning.

In order to begin to address the landscape as a cultural entity, it is important to reject the notions that the nature of landscapes is static and the product of chance or random events. In contrast, an alternative perspective is to envision landscapes as being shaped and modified by human actions and conscious design to provide housing, accommodate a system of production, facilitate communication and transportation, and

express aesthetics. More importantly, the landscape should be interpreted as an active force in creating social order, legitimizing it, and bringing changes in it (Rubertone 1989).

Chapter 5 – Methodology

Data Collection

The integration of decades of archaeological data collected for TNF and PVRD is the most fundamental element of this research. The PVRD collection consists of approximately 1,227 site records filed into individual manilla folders per site. These 1,227 folders were subsequently digitized from paper forms onto a hard drive as a means to institute a more versatile approach for future data entry. The digitization process is an instrumental key component that allowed me to inventory and distinguished the quality of data each site description retains. For this purpose, an inventory list was created in Excel to keep track of the folders that have been digitized along with the quality of content for each individual site. The quality of the content was classified as follows: *complete*; indicating reliable and quality data, *incomplete*; indicating limited data potential, and *empty*; indicating no data within the folders.

The completion of the PVRD inventory list was subsequently followed by the creation of the master PVRD geodatabase in Excel. This geodatabase was created as a means to incorporate locational data (UTM's) and individual site descriptors such as: site number; temporality; data source; UTM coordinates; cultural affiliation; site type; architectural styles; approximate number of rooms documented; site size; site area (sqm), and the presence of ceramics. These site descriptors are characteristics that CRM practitioners prioritize when documenting an archaeological site which is significant in determining site functions, temporality, cultural affiliations, and the spatial distribution amongst the landscape. The site descriptors mentioned above were all implemented as

individual fields, and a numerical coding system was created for each subclass pertaining to each field.

The TNF provided GIS data for 751 sites that were already integrated as site points in ArcGIS Pro. The shapefiles provided were derived from NRM and Legacy sources specified within the data table via the “source” column. I subsequently exported the shapefiles as a table within ArcGIS Pro and converted it into an Excel data table to serve as the basis of the PVRD geodatabase. The exported data table had limited data consisting of site number; site temporality, data source, UTM locational data, and brief site type descriptions. These fields remained a part of the master PVRD geodatabase, and the aforementioned site descriptors above were subsequently incorporated as fields to the finalized Excel table derived from the original GIS dataset provided by the TNF. In addition, a third “source” subclass was assigned as “PDF”, which represents sites that did not have any GIS locational data and were inputted manually from UTM’s collected during the original documentation site cards.

Coding System

The numerical coding system was established on an as-you-go basis which was determined from previous archaeologists’ observations and interpretations of the sites at hand. It is imperative to address that these interpretations are all from different CRM practitioners and are subjective in nature. This innate subjectivity when interpreting archaeological sites highlights the difficulty in generalizing and classifying cultural traditions, temporality, and site functions. Similarly, the vast repertoire of decades of archaeological inventories demonstrates a lack of uniformity in regard to site documentation with a wide range of discrepancies with respect to data quality. As the

field of CRM has evolved, so has the quality of data being produced. Nonetheless, all the site records implemented in this model were revised, and the most uniform and least subjective site components necessary to create my model consisted primarily of distinguishing site type subclasses (Table 3) and architectural styles of habitation site subclasses (

Table 4) which are demonstrated below.

Table 3. Coding system for site type subclasses.

Site type	Code
Habitation	1
Lithic Scatter	2
Artifact Scatter	3

Table 4. Coding system for architectural style subclasses.

Architectural Style	Code
No data	0
Cliff dwelling	1
Surface rooms (masonry)	2
Rock shelter / Cave dwelling	3
Subsurface rooms (pithouse)	4

It became apparent that site number, site temporality, UTM coordinates, site type, architectural style, and approximate measures of room blocks observed were the most consistent and uniform data fields. Fields such as cultural affiliation, site size, and the

presence of ceramics were often missing, incomplete, or expressed a level of incertitude in the site forms. A majority of the archaeological site forms implemented in this study contained fields for features and structures simply subclassified as either surface or subsurface rooms. Remarks in the general site descriptions and site characteristics detailed whether the architectural style was coursed masonry, cliff dwelling, or potential pithouses. These designations were incorporated into the master PVRD geodatabase under the “architectural style” field.

A total of 398 sites were assessed and incorporated into the final master PVRD geodatabase for this research, consisting of approximately one-third of the PVRD (Figure 5Error! Reference source not found.). The sites were assessed and incorporated in sequential site number ordering, beginning with AR-03-12-05-00001 and ending with AR-

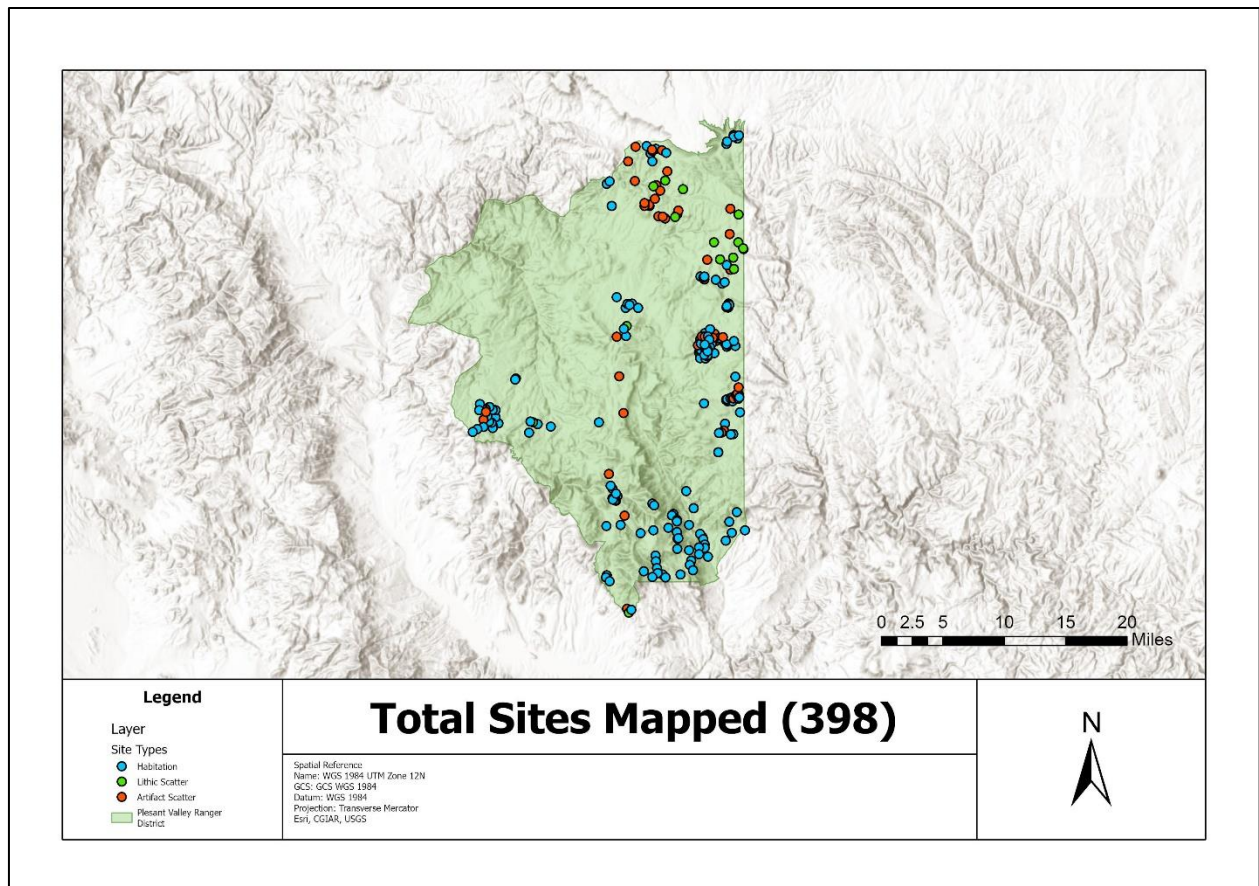


Figure 5. Total sites mapped based on site types.

03-12-05-00510. I subsequently created a new ArcGIS Pro project and specified *WGS 1984 UTM Zone 12N* as the output coordinate system, which will allow geoprocessing results to be projected to this coordinate system. The completed PVRD geodatabase was imported into ArcGIS Pro as a table, and a point feature class was subsequently created by employing the “Display XY Data” tool, which creates a point feature class based on x,y values from the table which is specified as *UTM_X_East* and *UTM_Y_North*.

Spatial Selection

The 398 sites mapped within ArcGIS Pro are made up of a variety of distinctive site types and codes. Since the primary intent of this research focuses on habitation sites, spatial selection will be implemented to identify all the habitation sites (code = 1) within

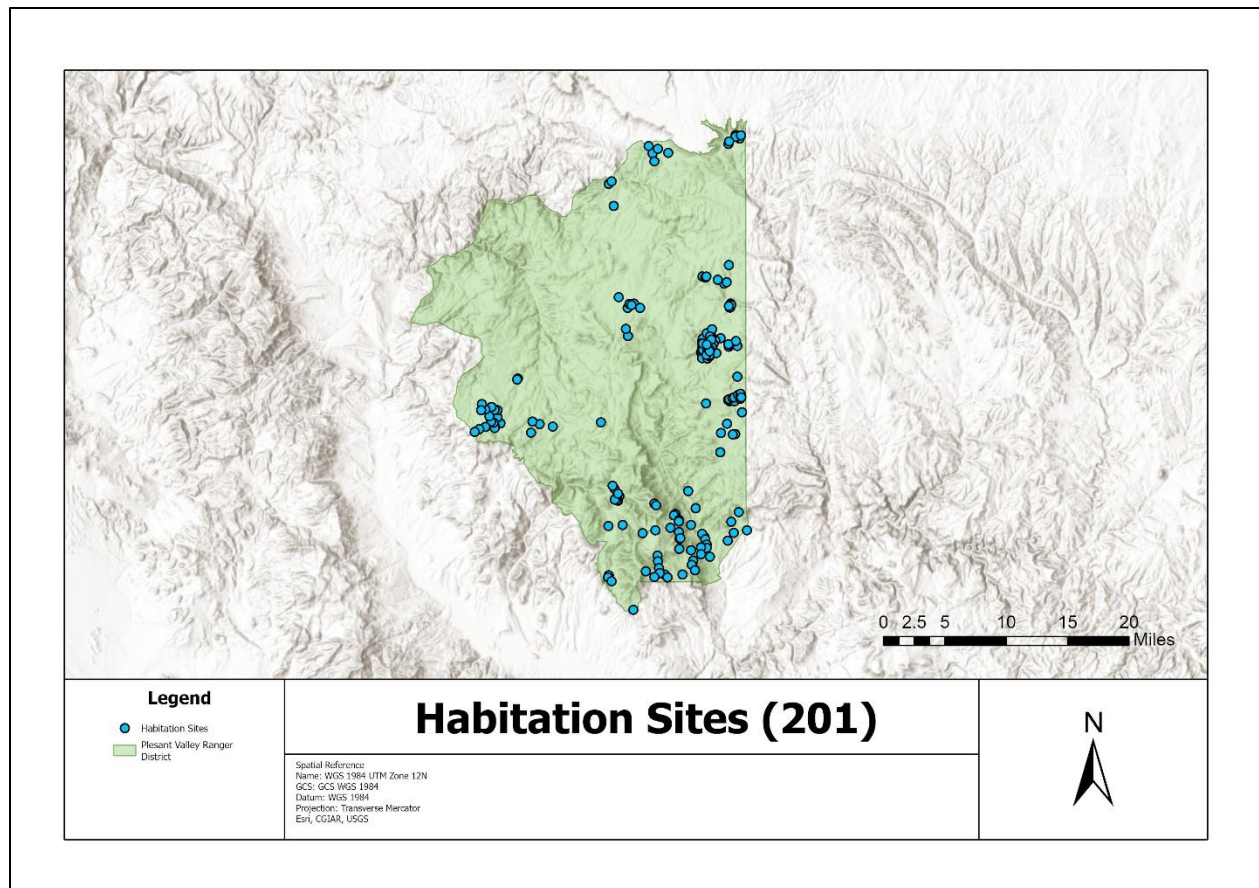


Figure 6. Map of habitation sites.

the PVRD geodatabase. Using the *Select by Attributes* tool, I selected “Site Type A” field *is equal to* “1” and created a new feature class called “Habitation Sites.” A total of 201 habitation sites were subsequently exported onto the new feature class (see Figure 6). Once the habitation sites were selected, I repeated the process with the following spatial feature selectors: from “Habitation Sites” feature class, *Select by Attributes*, select *Architectural Style*, select “2”. A total of 149 “Surface Rooms” were exported onto the new feature class integrated onto the suitability model (Figure 7).

As the prehistoric sites containing surface rooms within the PVRD geodatabase have been determined, I reutilized the *Select by Attributes* tool to identify the number of small, medium, and large sites by implementing the following selectors:

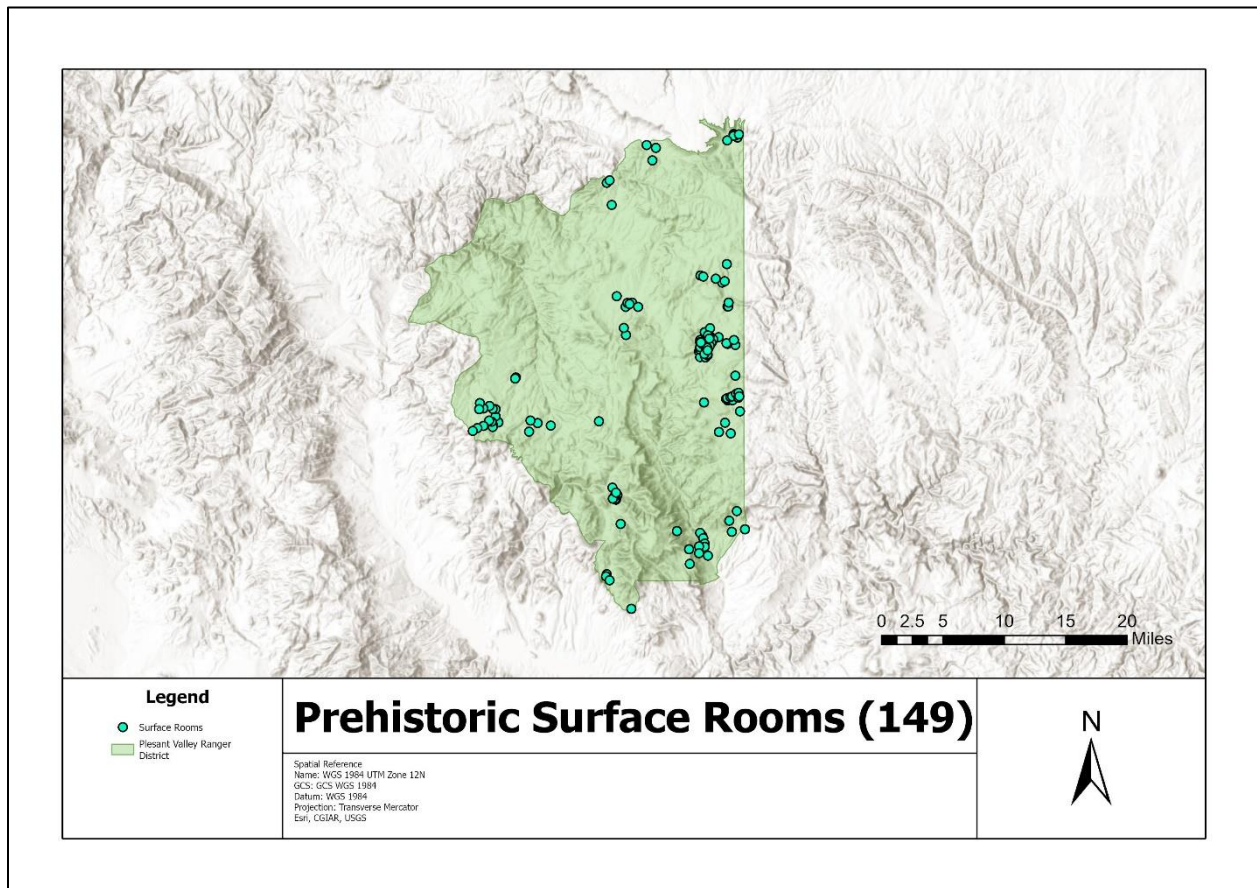


Figure 7. Map of sites with prehistoric surface rooms documented.

- From “Surface Rooms”, *Select by Attributes*, “Number of Rooms”, *is less than or equal to 3* (small).
- From “Surface Rooms”, *Select by Attributes*, “Number of Rooms”, *is less than or equal to 8* or “Number of Rooms” *is greater or equal to 4* (medium).
- From “Surface Rooms”, *Select by Attributes*, “Number of Rooms”, *is greater than 9* (large).

A total of 72 (small) , 37 (medium), and 33 (large) sites were selected with 7 sites containing no information. A “Hab_Size” text field was created within the “Surface Rooms” feature class in order to unify a range of different values based on the small, medium, and large site size designations. After each spatial selection process, I selected the *Attributes* button located within the “Selection” pane, which displays all of the selected sites based on the criteria from my spatial selectors. The *Attributes* window displays the fields that are incorporated in the “Surface Rooms” feature class including “Hab_Size”. By selecting the “Hab_Size” text field, I modified attribute values for multiple selected features at the same time, designating each selection process as either small, medium, or large, resulting in the total numbers below (Table 5).

The spatial selection results which allowed me to display the localities of surface masonry pueblos subsequently allowed me to incorporate past research components deriving from the SAP investigations in the middle Cherry Creek area. Ultimately, the SAP documented a total of 151 sites in the middle Cherry Creek area with most sites dating to PIII, PIII/IV, or PIV. These designations are assigned based on ceramic assemblages and tree-ring dating which indicate an intensive use of the middle Cherry Creek valley in the AD 1200’s and 1300’s (Lange et al., 2006). Surface pueblos are

Table 5. Spatial selection results

Total habitation sites	201
Surface room sites	149
Small surface room sites	72
Medium surface room sites	37
Large surface room sites	33
No room data available	7

the most numerous site type with 66 sites divided into three distinct classes: the smallest class consisting of 1 to 3 rooms dating to PIII, PIII/PIV and PIV often representing temporarily occupied field houses (Lange et al., 2006). Medium sized surface pueblos consisting of 4 to 8 rooms are the next most numerous of the surface pueblos dating to PIII/PIV to PIV with an emphasis on PIV (Lange et al., 2006). Larger pueblos (more than 9 rooms) are dated to PIII/PIV and PIV are generally located at lower elevations in Cherry Creek (Lange et al., 2006).

Surface room pueblos tend to be grouped rooms with no discernable interior plazas and no surrounding walls. Small surface pueblos such as field houses are located at low elevations (2500-3999 ft) on terraces and slopes near drainages and are often associated with the tending of agricultural fields. Medium surface pueblos are the only site type dominated by PIV period and are mostly located at low elevations but also middle elevations. Large surface pueblos were the least common in the Cherry Creek area and were observed to have 20 or more rooms and dated to PIII and PIV, located in both lower

and middle elevations. Compounds, other than small surface pueblos, are the most numerous site types observed and are located at lower elevations west of Cherry Creek. Compounds consist of a few to many attached rooms, interior plazas, and are surrounded by a wall (Lange et al. 2006).

The data collected on surface room pueblos by the SAP is constricted uniquely to the middle Cherry Creek and southeastern Sierra Ancha region. Nonetheless, the temporal component and the observed elevation ranges will be incorporated into my suitability analysis in order to predict areas of high probability for each site type of surface pueblo throughout the Pleasant Valley Ranger District. small, medium, and large surface pueblos shown below (Table 6) will be the primary source of investigation as it has been previously stated that much of the previous research efforts have been involving large compounds and cliff dwellings.

Table 6. Surface room pueblos size, temporality, and elevation ranges

Surface Pueblo Size	Temporal Affiliation	Elevation Ranges (ft)
Small (1-3 Rooms)	PIII, PIII/PIV, PIV	Low (2500-3999)
Medium (4-8 Rooms)	PIV	Low (2500-3999) and Medium (4000-5999)
Large (more than 9)	PIII, PIV	Low (2500-3999) and Medium (4000-5999)

Data Layers

Additional spatial data layers were implemented in this analysis and consist of a variety of polygon layers and digital elevation models obtained from ArcGIS Online and the USGS National Map Download and Visualization Services.

1.) *Brown and Lowe's Biotic Communities of the Southwest (1:1,000,000)* is a polygon layer consisting of a digital representation of Brown and Lowe's "Biotic Communities of the Southwest" map, which was developed in 1979. This map is intended for broad, regional, and landscape-scale analysis (Figure 8).

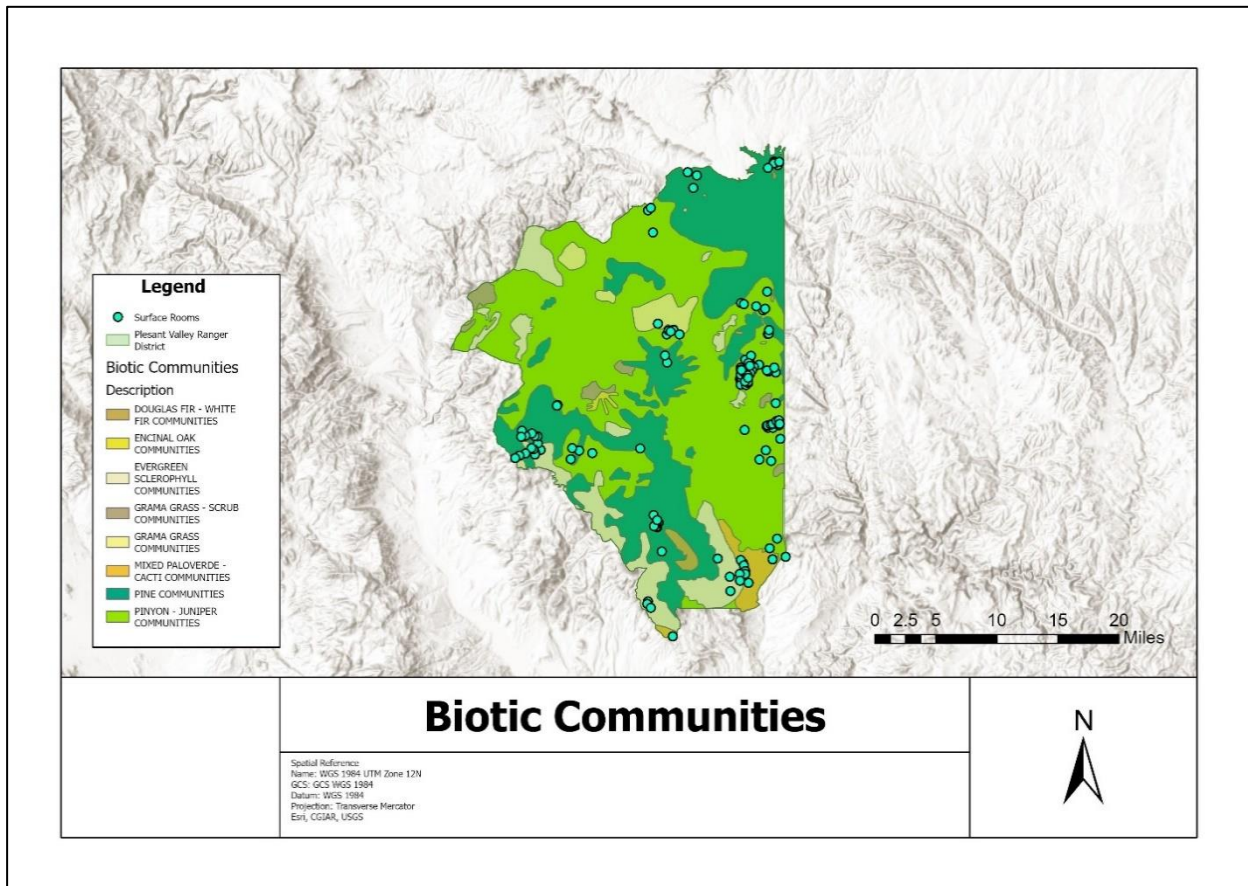


Figure 8. Biotic communities within the Pleasant Valley Ranger District.

2.) *Geology of Arizona, USA (Data Basin Dataset)* is a layer package consisting of digital maps and are a reformulation of previously published maps, including two national-scale digital geologic maps (Figure 9).

3.) *Forest Service Ranger Districts* is a feature layer displaying the boundaries that encompass Ranger Districts in the United States per USFS.

4.) *R03_AdministrativeForest* is a polygon layer describing the spatial location of the administrative boundary of the lands managed by the Forest Supervisor's office.

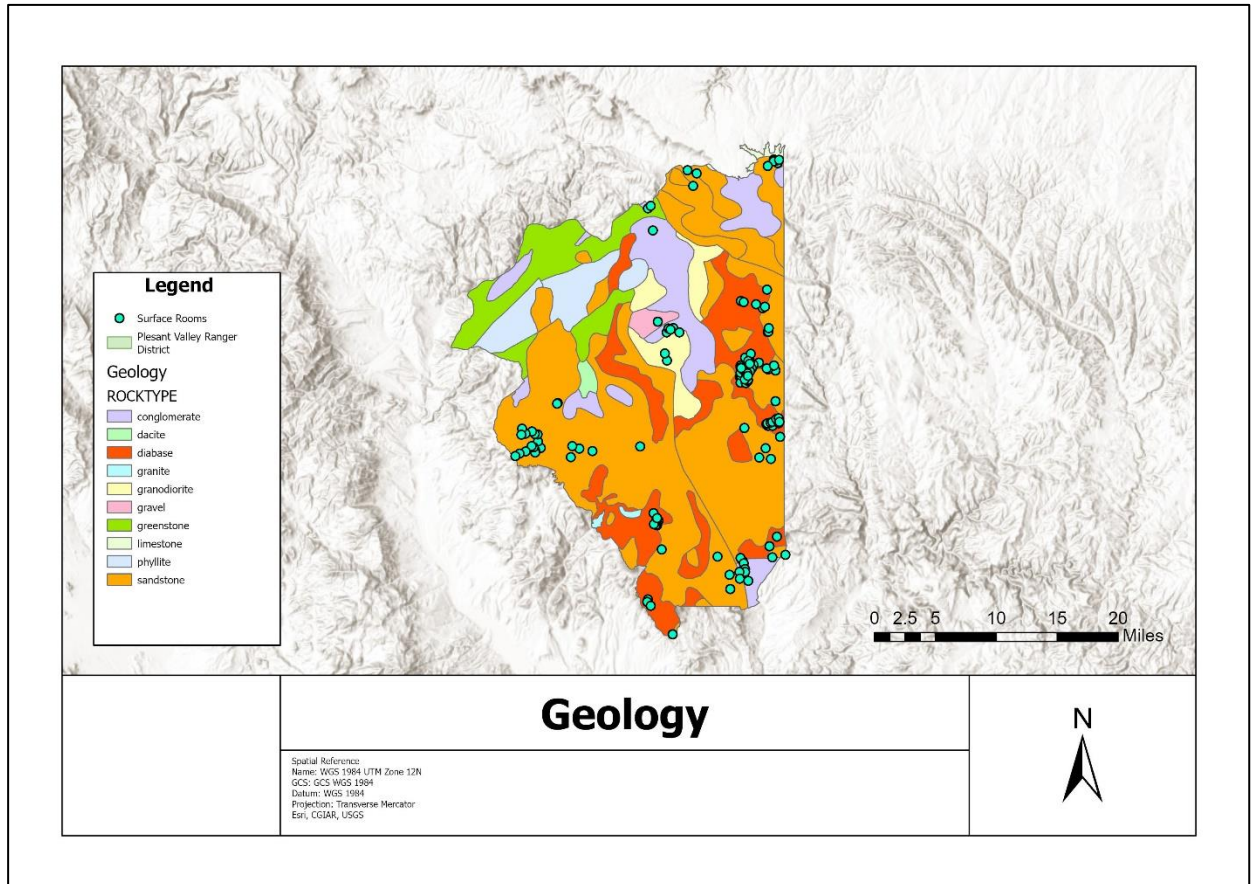


Figure 9. Geology (rock types) within the Pleasant Valley Ranger District.

5.) An area that encompasses all the National Forest System lands within the proclaimed boundaries.

6.) *Digital Elevation Models (DEMS)* consist of four tiles of the 3D Elevation Program (3DEP) and serves as the elevation layer of The National Map and provide basic elevation information of Earth science studies and mapping applications.

- US Geological Survey, 20211004, USGS 1/3 Arc Second
- US Geological Survey, 20220303, USGS 1/3 Arc Second

- US Geological Survey, 20210301, USGS 1/3 Arc Second
- US Geological Survey, 20220811, USGS 1/3 Arc Second

Spatial Join

Rudimentary to building the Pleasant Valley Ranger District suitability model is identifying and delineating priority focal areas based on environmental conditions such as geology and biotic communities. The introduction of the geology and biotic communities' data layers within the PVRD extent allows for the visualization of archaeological site localities within specific rock types and vegetation types present within the study area. More importantly, the superimposition of the rock and vegetation types overlaid by archaeological sites allows for the implementation of the *Spatial Join* analysis tool, which in summary, joins attributes from one feature to another based on spatial relationships. In addition, the *Spatial Join* operation affixes data from one feature layer's attribute table to another, displaying rock and vegetation types pertaining to each individual site.

The merging of attribute fields within a single feature class enables me to export a finalized table that displays all of the sites implemented for this analysis with corresponding site size classification and rock and vegetation types. Subsequently, by implementing the Table to Excel conversion tool within ArcGIS Pro, I can export the feature class into a Microsoft Excel table in order to identify any association between rock types, vegetation types, and site sizes. Identifying the association between site sizes and rock and vegetation types for this research was derived from the Pivot Table tool within Microsoft Excel, which displays the summary statistics of the archaeological sites being analyzed below. The summary statistics presented below demonstrate a high recurrence of sandstone and diabase rock types within small, medium, and large sites containing

masonry surface rooms. A chi-square test of independence was performed to examine the relationship between rock types and site sizes. The relation between these variables was significant where $F = 18.27$; $df = 10$; $p = 0.05$. A total of 124 sites out of 142 are present within these specific rock types making them viable candidates to implement as high-probability areas within suitability model (Table 7). Similarly, the summary statistics presented for the biotic communities demonstrate a high recurrence of pine, and pinyon-juniper communities within small, medium, and large sites containing masonry surface rooms. A second chi-square test of independence was performed to examine the relationship between biotic communities and site sizes. The relation between these variables was significant where $F = 24.11$; $df = 8$; $p = 0.0022$. A total of 122 sites are present within these specific rock types, which also makes them suitable candidates to implement as high-probability areas within the suitability analysis (Table 8).

Table 7. Summary statistics of rock types in relation to site sizes.

Site Size	Conglomerate	Diabase	Granodiorite	Gravel	Greenstone	Sandstone	Total
Large	7	14	-	-	1	11	33
Medium	4	21	-	-	-	12	37
Small	1	33	3	1	1	33	72
Total	12	68	3	1	2	56	142

Table 8. Summary statistics of biotic communities in relation to site sizes.

Site Size	Evergreen Sclerophyll	Gramma Grass	Mixed Paloverde-Cacti	Pine	Pinyon-Juniper	Grand Total
Large	6	-	5	4	18	33
Medium	3	-	1	5	28	37
Small	3	1	1	25	42	72
Grand Total	12	1	7	34	88	142

Spatial Overlay

The summary statistics presented above displayed the most recurring environmental habitats in the form of diabase, sandstone, pine, and pinyon-juniper. Taking this into account, the *Overlay* and *Union* ArcGIS Pro tools are being implemented as a form to conduct a spatial overlay analysis. Spatial overlay is integral for spatial information integration and subsequently produces a new output layer. The *Union* tool allows for the output layer of the union operation to adopt the joined extent of both input layers. In essence, the extent of environmental habitats in the form of diabase, sandstone, pine, and pinyon-juniper are merged into a single output layer in which all environmental characteristics aforementioned intersect. As a result, an environmental suitability analysis is produced that visually displays a region within the study area containing uniquely diabase, sandstone, pine, and pinyon-juniper habitats (Figure 10).

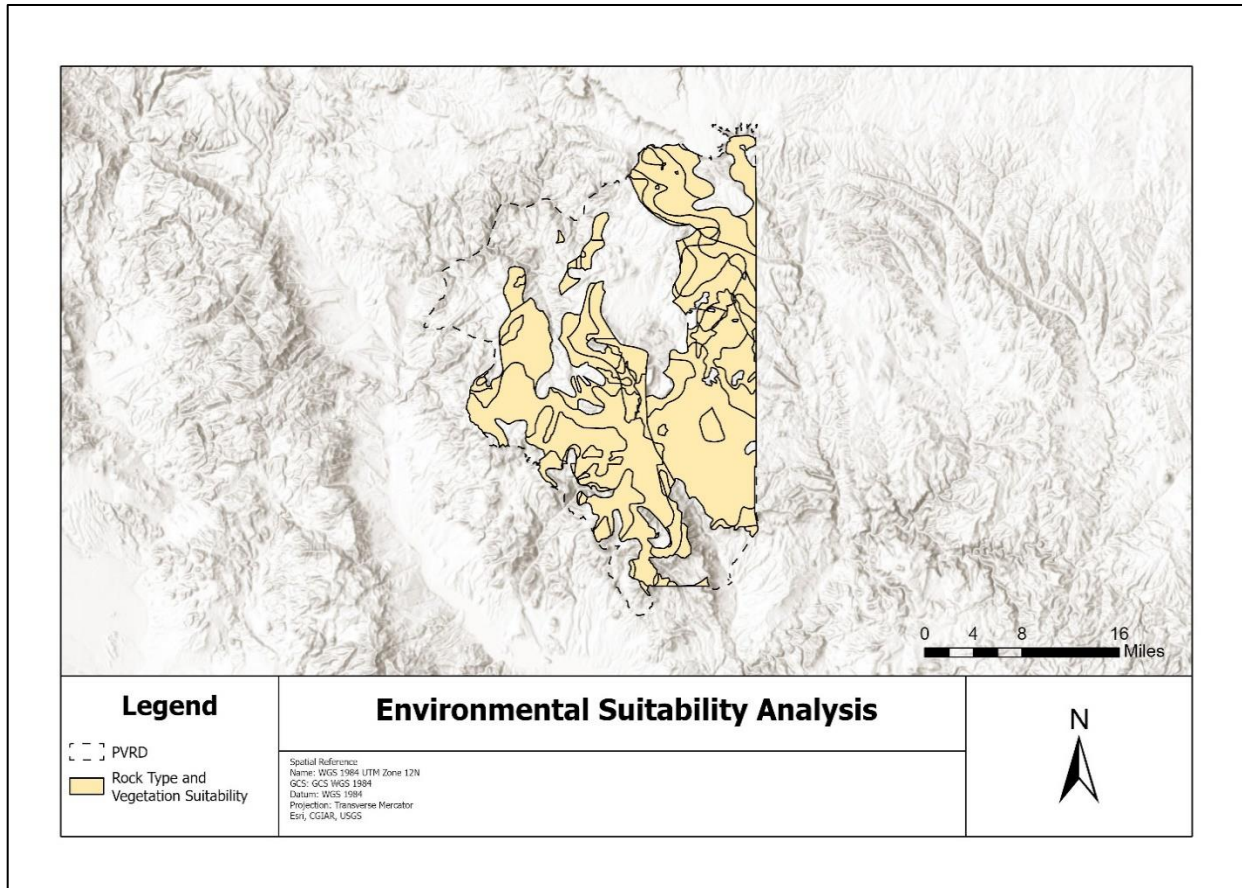


Figure 10. Environmental Suitability Analysis

Digital Terrain Modeling

The incorporation of Digital Elevation Models (DEM) within the environmental suitability analysis is the final step in determining high-probability areas for small, medium, and large pueblos based on environmental characteristics and elevation ranges. As previously illustrated by the data collected on surface room pueblos by the SAP, small pueblos are thought to be located in low elevation ranges (2,500 to 3,999 ft), while medium and large pueblos appear to be located in low and medium elevation ranges (4,000 to 5,999 ft). In order to determine elevation ranges within the proposed environmentally suitable habitat, the four digital elevation model tiles must be incorporated within the study area extent.

Deriving from The National Elevation Dataset (NED), the digital elevation tiles implemented in this study consist of four individual 7.5-minute USGS DEM rasters. Integrating the DEM rasters within the suitable habitat extent will allow me to identify specific elevation ranges within the desired environmental characteristics. In order to incorporate the four individual DEM tiles and make them suitable for spatial analysis, they must be merged within the study area extends into a single unified DEM dataset. The merging of these grids can be conducted via the *Mosaic to New Raster* ArcGIS Pro tool. The merging of the four individual digital elevation tiles results in a single raster illustrating elevation ranges (644 to 2363 meters) within the extent of the study area and its surroundings (Figure 11). As a single DEM dataset, the digital terrain model is now ready

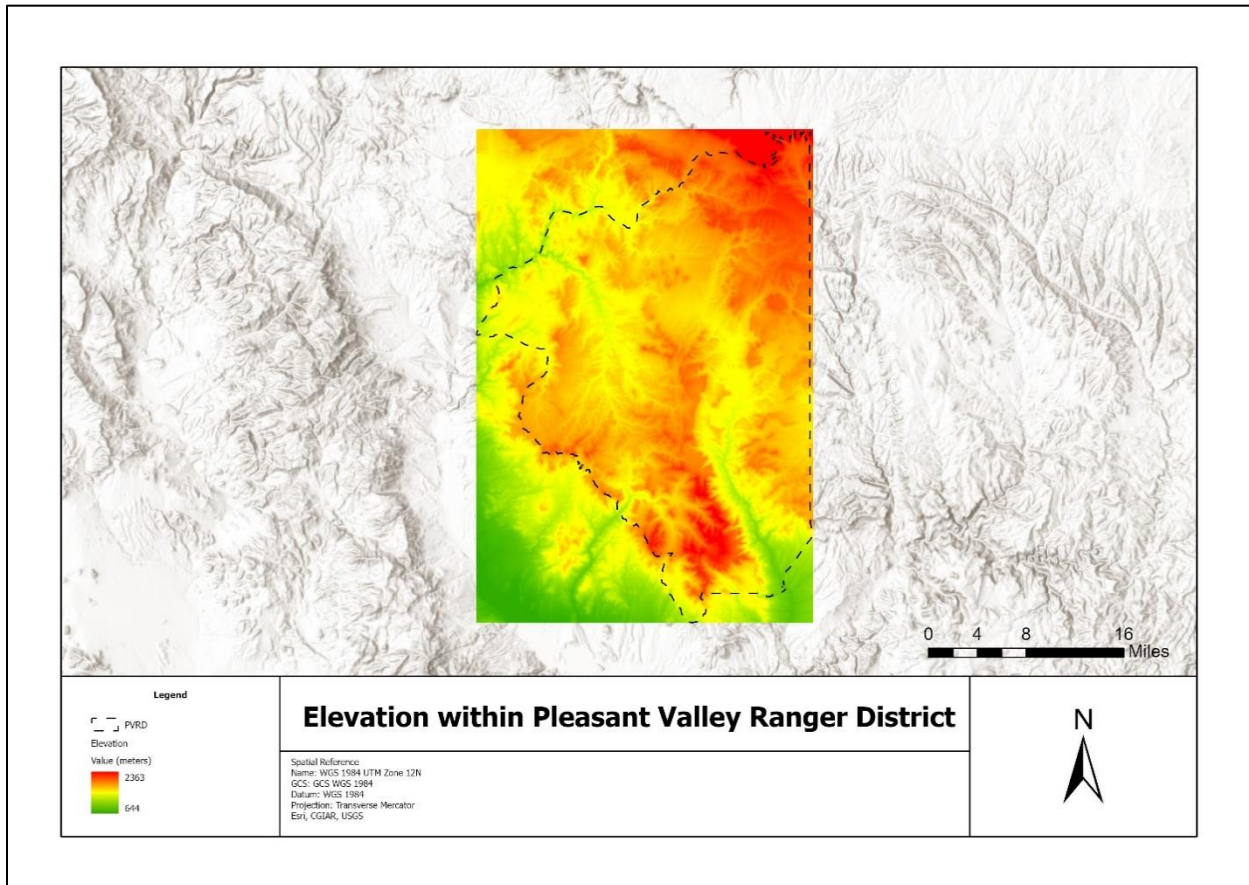


Figure 11. Elevation within Pleasant Valley Ranger District.

to be implemented within the environmental suitability analysis to determine high-probability areas.

High-probability Analysis

As previously determined, the environmental suitability analysis depicts suitable environmental habitats based on rock (diabase, sandstone) and vegetation (pine, pinyon-juniper) types that were concurrent with archaeological site localities. Furthermore, the data collected by the SAP similarly illustrated elevation ranges that were deemed concurrent with site localities based on pueblo sizes. Incorporating the environmental suitability and DEM data layers into a single dataset by masking (*Extract by Mask*) will

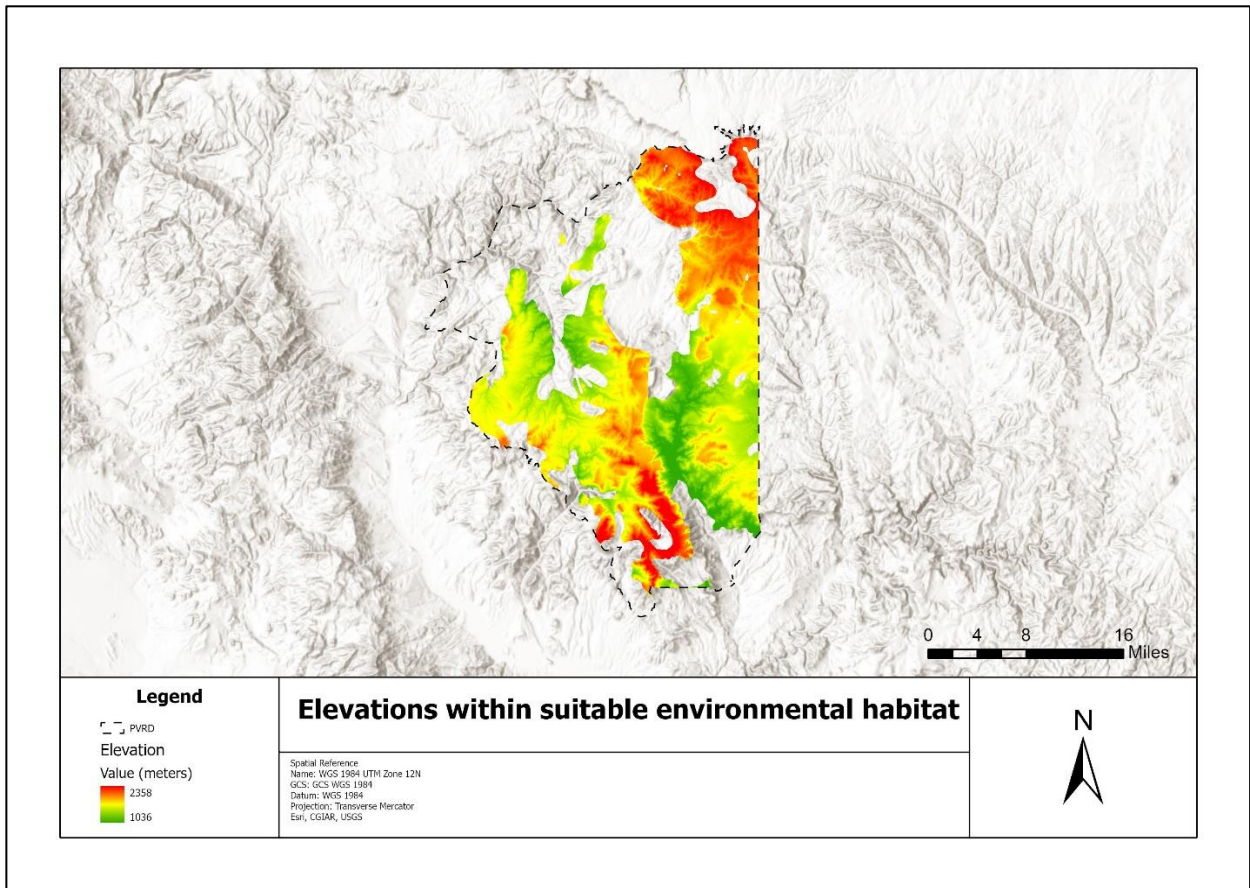


Figure 12. Elevations within suitable environmental habitat.

allow me to select specific elevation ranges within the environmentally suitable habitats presented below (Figure 12).

Prior to conducting the final spatial analysis in which I incorporated specific elevation ranges within the most suitable environmental habitats, elevation units must be converted from meters to feet. In order to convert meters to feet, a new field must be created within the selected feature class. As a new field is created, I utilize the ArcGIS Pro tool *Calculate Field* to produce the elevation ranges in feet. In order to achieve this, an expression must be written as *Value (meters)* multiplied by 3.2808399 ($!Value! * 3.2808399$), which is how many feet are in a meter. This in turn, allows me to display the units within the DEM raster in feet.

As a result of masking, elevation ranges are now selectable within the most suitable environmental habitats and can be displayed as high-probability areas for each exclusive site size. By implementing the geoprocessing tool *Select Layer by Attribute*, I can select specific elevation ranges representative of each site size classification. Initiating with small site elevation ranges, I select the *Elevation* feature class shown in the map above as my input row and create the expression where: *Feet* is less than or equal to 3999. As a result of this selection, a range between 3,400 to 3999 feet is displayed. This specified range does not contain any values between 2500 to 3400 feet since the lowest elevation within the suitable environment habitat is 3400 feet. Nonetheless, the results for high-probability areas of small site localities within the study area appear only within the Cherry Creek area.

To subsequently identify high-probability areas for medium and large sites I will once again be utilizing the geoprocessing tool *Select Layer by Attribute* and create a

similar expression where: *Feet* is less than or equal to 5999. As a result, a range between 3,399 and 5997 feet is displayed encompassing both low and medium elevation criteria. The map illustrated below reflects the high-probability areas for site localities based on site size and elevation ranges (Figure 13). The high-probability areas for small sites based on suitable environmental habitats and a low elevation range (2500 to 3999 ft) are displayed in blue. Similarly, the remaining yellow, orange, and red areas display medium elevation ranges (3999 to 5999 ft) in which both medium and large sites tend to appear.

Chapter 6 – Results

The final map (Figure 13) illustrates high-probability areas of prehistoric surface room pueblos within environmentally suitable areas based on site size. Although the medium elevation ranges are predominant, the lower elevations are barely visible and are situated along the Cherry Creek area. The low elevation range provided by the SAP was categorized as ranging from 2500 to 3999 feet. Presented in the map above, the lower elevation range is displayed as 3399 to 3999 feet since the lowest elevation within the environmentally suitable area is 3399 feet. The resulting high-probability area for small surface pueblos expresses concern in regard to implementing suitability criteria deriving from the SAP survey of the southeastern Sierra Ancha along the upper and lower areas adjacent to Cherry Creek. On the one hand, the illustrated high-probability areas for small pueblos within the suitable environment reflect a positive outcome of the SAP's

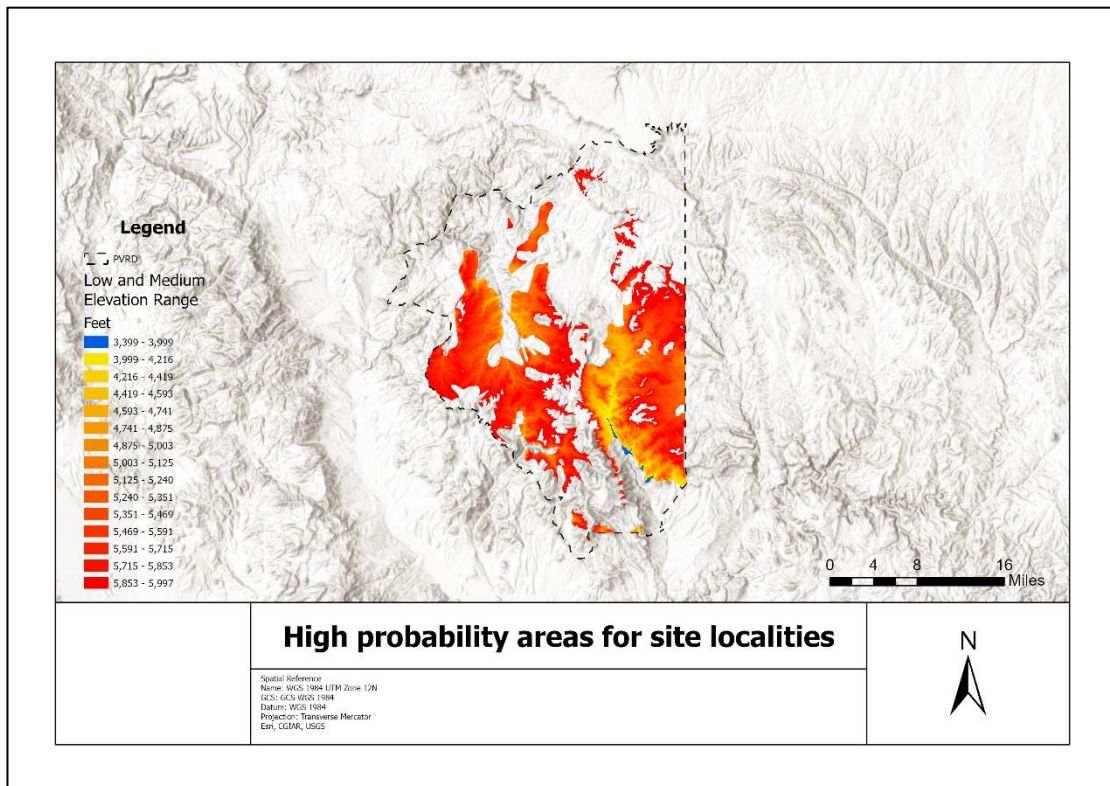


Figure 13. High probability areas for site localities based on elevation ranges.

interpretation of site localities based on elevation ranges. Nonetheless, the absence of high-probability areas for small sites throughout the rest of the map may reflect a lack of applicability of SAP’s components to a broader region outside the Cherry Creek locality.

Furthermore, the high-probability areas for medium and large surface pueblos are displayed in red, yellow, and orange classes representing the medium elevation ranges previously assigned by the SAP. As an attempt to address the possibility of misrepresentation and lack of applicability of SAP components to the broader PVRD region, summary statistics was conducted in order to identify whether the elevation ranges are prone to change with a larger sample of sites mapped throughout the whole region. The summary statistics produced by ArcGIS Pro demonstrated different elevation ranges that seem to better represent the spatial distribution of each site size within the PVRD (Table 9).

Table 9. Summary statistics of site sizes and elevation ranges.

Site Size	Mean	Minimum	Maximum
Small	5,606 ft	3,005 ft.	6,736 ft
Medium	5,387 ft	4,068 ft	6,683 ft
Large	5,087 ft	3,061	6,227 ft

As illustrated above, the generated statistics show a difference between the SAP’s elevation ranges associated with site size. These statistics show a different elevation range for each site size category than previously noted. In regards to the small surface

masonry pueblos, an increase in the low elevation is noted of approximately 500 ft with a maximum elevation of 6,736 ft, reflecting a 2,737 ft increase. These sharp increases in elevation demonstrate that the SAP's components aren't directly applicable to the broader PVRD region. Similarly, medium and large surface masonry pueblos also illustrate an increase in elevation ranges. The medium pueblos demonstrate an increase of 1,568 ft for the minimum and 684 ft for the maximum elevation range. Finally, the large sites also present an increase of 561 ft for the minimum elevation and a 228 ft elevation increase for the maximum elevation.

The newly determined elevation ranges derived from this research implemented other factors such as the environmental habitats most suitable for these site types deriving from statistically significant relationships between rock types and vegetation types in the form of sandstone, diabase, Pinyon-Juniper and Pine. The implementation of statistical analysis seems to have better represented the landscape and broader region of the PVRD as a whole in terms of archaeological significance and the spatial distribution of surface masonry pueblo localities.

In order to address the shortcomings of this research, it is important to identify factors that have influenced the finalized spatial analysis results. Primarily, the integration of suitability criteria deriving from the southeastern Sierra Ancha and the Cherry Creek area may not have been applicable to the whole broader region of the PVRD, highlighting the lack of research conducted within this region. Secondly, the interpretation of archaeological, and cultural material is often ambiguous and subjective. The data collected for this research derives from decades of archaeological fieldwork and is often interpreted by a wide variety of CRM practitioners, perpetuating unique site interpretations

and lack of uniformity when documenting a site. As a result, a large amount of time is needed to assess the functionality and adequacy of archaeological site data to be implemented within the geodatabase in an attempt to pursue constancy in data. Crucial to this research, the data entry phase was arduous and restricted the implementation of all the documented sites within the Pleasant Valley Ranger District due to the amount of time spent assessing and interpreting reliable versus unreliable site cards. In addition, a significant number of locational site data (UTM's) were implemented onto the geodatabase manually, raising potential concerns of wrongly projected site geometries.

In conclusion, this research has demonstrated viable data collection and organizational methods suitable for future comparative geospatial and statistical analysis of large archaeological datasets by integrating decades of both digital and print archaeological site records into a unified geodatabase specifically for the PVRD within the TNF primarily by identifying significant relationships between the localities of small, medium, and large surface pueblos and their environmental determinants such as rock and vegetation types.

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