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LIVING ON THE EDGE: RETHINKING PUEBLO PERIOD: (AD 700 – AD 1225) INDIGENOUS SETTLEMENT PATTERNS WITHIN GRAND CANYON NATIONAL PARK, NORTHERN ARIZONA

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DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Arts and Sciences
at the University of Kentucky

By

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Lexington, Kentucky

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Lexington, Kentucky

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ABSTRACT OF DISSERTATION

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This dissertation challenges traditional interpretations that indigenous groups who settled the Grand Canyon during the Pueblo Period (AD 700 -1225) relied heavily on maize to meet their subsistence needs. Instead they are viewed as dynamic ecosystem engineers who employed fire and natural plant succession to engage in a wild plant subsistence strategy that was supplemented to varying degrees by maize. By examining the relationship between archaeological sites and the natural environment throughout the Canyon, new settlement pattern models were developed. These models attempt to account for the spatial distribution of Virgin people, as represented by Virgin Gray Ware ceramics, Kayenta as represented by Tusayan Gray Ware ceramics, and the Cohonina as represented by San Francisco Mountain Gray Ware ceramics, through an examination of the relationships of sites to various aspects of the natural environment (biotic communities, soils, physical geography, and hydrology).

Inferences constructed from the results of geographic information system analyses of the Park's legacy site data, indicate that Virgin groups were the first to arrive at the Canyon, around AD 700 and leaving around AD 1200. They practiced a split subsistence strategy, which included seasonal movements between maize agricultural areas in the western Inner Canyon and wild resource production areas in the pinyon-juniper forests on the western North Rim plateaus. The Kayenta occupied the North Rim, South Rim and Inner Canyon, throughout the entire Pueblo Period. Their subsistence system relied heavily on wild resource production on both rims supplemented by low-level maize agriculture practiced seasonally on the wide deltas in the eastern Inner Canyon. The Cohonina were the last to arrive and the first to leave, as they occupied the Canyon for about 300 years from AD 800–1100. They were the most prolific maize farmers, practicing it in the Inner Canyon near the mouth of Havasu Creek, but still seasonally exploiting wild resource on the western South Rim.

Based on my interpretations, use of the Canyon from AD 700-1225, is viewed as a dynamic interplay between indigenous groups and their environment. As they settled into the Canyon and managed the diverse ecology to meet their subsistence needs.

KEYWORDS: Southwest Archaeology, Ecological Anthropology, Settlement Patterns, Geographic Information Systems, Grand Canyon

Philip Bruce Mink, II

July 30, 2015

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for Danielle, Stella, and Anthony

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

Chapter 1: Introduction

Traditional interpretations of the Grand Canyon's Pueblo Period (A.D. 700-1225) have relied heavily on Southwestern Puebloan ethnography as the primary source to justify inferences about patterns observed in the archaeological record (Coder 2006, Euler and Chandler 1978, Effland et al. 1981, Powell 1875, Schwartz 1989, 2008, Wheat 1963). These interpretations are primarily grounded in a cultural ecological paradigm and represent the Canyon's residents as settled agriculturalists, similar to the pueblos that were dispersed throughout the Southwest prior to the arrival of European-Americans (Coder 2006, Fairley 2003, Schwartz 2008). To defend these traditional settlement models, researchers tend to argue that site placement on the landscape was dictated by the appropriate environmental conditions for growing maize (Euler 1988, Schwartz 2008, Smiley and Vance 2011), and maize paleo-botanical remains, present in any quantity, are interpreted as confirmation of an agricultural subsistence pattern (Jones 1986, Schoenwetter and DaCosta 1976, Smith and Adams 2011, Wright 2009). These interpretations have been contested by the Upper Basin Archaeological Research Project (UPARP), using archaeological survey and excavation data from the eastern South Rim (Sullivan 2015, Sullivan et. al. 2002, and 2015, Sullivan and Forste 2014). UBARP interpretations are grounded in agentive ecological paradigms (Sullivan 2015, Sullivan and Ruter 2006), such as niche construction theory, and perceive the Canyon's occupants as dynamic ecosystem engineers who employed fire and natural plant succession to engage in a mixed subsistence strategy.

The goal of this study is to challenge traditional interpretations of indigenous settlement at the Grand Canyon from AD 700 -1225 by developing new settlement models based on legacy site file information and modern environmental data. In particular, agentive ecological models that have been successfully employed by Sullivan and his students are expanded beyond the Upper Basin throughout the entire Canyon. By expanding and modifying existing UBARP interpretations it has been possible to develop new inferences concerning when the Grand Canyon was settled and how people adapted to the Canyon's diverse environments during the Pueblo Period. To achieve this goal the traditional cultural ecological models will be critiqued, the newer agentive ecological models will be discussed and expanded, and new settlement models based on my analyses are proposed.

GRAND CANYON AS AN EDGE

Ecologists describe edge effects as changes in population or biological community structure at the boundary of two or more habitats (Levin 2009). Ecologically, Grand Canyon National Park is located at the boundary between two major North American physiographic provinces. Located in northern Arizona, the Park is situated on the southwestern edge of the Colorado Plateau, extending into the Basin and Range province at its western most extent. As the Colorado River cuts though the Plateau it has created a canyon where elevation and topography control the ecology, resulting in a variety of closely compacted ecozones (Carothers and Brown 1999). This ecological verticality provided the human groups who settled in the area over the past 12,000 years a variety of subsistence opportunities as they occupied this seemingly harsh environment (Fairley 2003). How one understands the behavior of the Canyon's Pueblo Period groups is a function of how the culture-environment dichotomy is unraveled and the paradigm that underlies one's settlement models. As van der Leeuw and Redman (2002) note, archaeologists must assume a greater role in investigating human and environmental interactions. Our discipline's data and analyses span multiple temporal and spatial scales and contribute greatly to larger debates on the sustainability of humanity. In a place like the Grand Canyon, where multiple cultural groups interacted within an ecologically diverse environment, there is an opportunity to better understand the role of variation in human behavior, including ecosystems engineering, in creating a sustainable human habitat.

Archaeologically, the Canyon is at the edge of territories ascribed to three archaeologically defined groups (Cohonina, Kayenta, Virgin cultures) who inhabited the region during the Pueblo Period. These three groups are distinguishable from one another based on difference in archaeological assemblages, which indicate they participated in social networks that resulted in the sharing of technology and aesthetic style. The Kayenta principally produced Tusayan Gray Ware Ceramics and were associated to groups in north –central Arizona, while the Virgin people produced Virgin Gray Ware ceramics and related to groups in southwestern Utah, eastern Nevada and in the Arizona Strip, a local group, the Cohonina, whose settlement was centered near present day Williams, Arizona primarily produced San Francisco Mountain Gray Ware ceramics (Euler 1988, Euler and Tikalsky1992, Fairley 2003, Schwartz 1989). How these groups interacted with the diverse ecology of the Canyon and how those associations inform our understanding of Grand Canyon prehistory will be discussed in terms of the overall goal of the dissertation, which is to investigate the application of agentive ecological paradigms as a source of inference about the Grand Canyon archaeological landscapes from AD 700 - 1225.

ENVIRONMENTAL PARADIGMS AND GRAND CANYON ARCHAEOLOGICAL INTERPRETATIONS

The examination of human environmental interactions has a long history in anthropology (Hardesty 1977, Moran 2000) and its sub-discipline archaeology (Butzer 1971, 1982, Dean 2010, Dincauze 2000, Redman 1999). These investigations began in the nineteenth century with Mason's (1894) initial culture area definitions and continue today with the studies of global socio-environmental change in both world systems and earth systems (Hornburg and Crumley 2007) and computational modeling of socioecological dynamics (Barton et al. 2012). Even with such a long history of inquiry, Bruce Smith (2011) notes that, in North America for more than a century, human-environment interactions have focused on three broad questions: (1) how does environment influence culture, (2) how and to what degree did Native Peoples conserve or degrade their environment, and (3) if and to what degree have Native Peoples modified their environments? The popularity of these three broad questions is not just confined to North American Native Peoples, nor to just archaeology. Increasingly, studies of the relationship between humans and the natural world are being interjected into the popular media as we as a species grapple with a rapidly changing global environment. More and more archaeologists are being consulted about addressing these modern problems as we have subject matter expertise and data that address long records of human adaptation to changing environmental conditions.

Previous Grand Canyon Settlement Models

Archaeological sites have been recorded in the Grand Canyon for almost 150 years, beginning with Major John Wesley Powell who in 1869 documented the “Indian-ruins” he encountered during the first successful river trip through the Grand Canyon. Since Powell’s initial voyage, more than 4,000 archaeological sites, documenting 10,000 years of human history, have been recorded in the Grand Canyon by numerous archaeologists. The ethnographic and archaeological records detail a varied relationship between indigenous peoples and the Grand Canyon, ranging from the sacred to the mundane. The ecological diversity created in the Canyon by climate, elevation, and topography has provided those who settled the Canyon with wide-ranging challenges and opportunities to live in this place that today we recognize as being unique. Below, I summarize the previous approaches to understanding indigenous settlement in the Grand Canyon during the Pueblo Period.

SARG Approach

Modern studies of settlement in the Grand Canyon (e.g., Euler and Chandler 1978, Effland et al. 1981, Schwartz 2008) follow what I have termed the SARG Approach (Chapter 2). These models were initially developed by Robert C. Euler as part of a larger effort by the Southwest Archaeological Research Group, who were one of the first to compile computerized regional archaeological databases (Plog and Most 2006). The primary purpose of the SARG database was to develop region-wide inferences about Native American settlement throughout the Southwest (Hantman and Neitzel 2006). Euler and Chandler (1978) contributed data from Grand Canyon National Park and used the database to develop models of Grand Canyon settlement, which are still the foundation for inferences made about Pueblo Period archaeology in the Park today (Balsom 2005, Smiley and Vance 2011).

These earliest approaches are most succinctly summarized by Fairley (2003) in her book on the archaeology along the Colorado River. While the volume principally focuses on the archaeology of the Colorado River corridor in Grand Canyon National Park, it is currently the most detailed and up-to-date treatise on Grand Canyon archaeology available. It not only discusses what is known about archaeology along the Colorado, it also summarizes many of the current paradigms driving Grand Canyon archaeology.

Fairley (2003) observes that the two prominent figures of mid- late-twentieth century Grand Canyon archaeology, Robert C. Euler and Douglas W. Schwartz, had different opinions on Pueblo Period settlement in the Park but both agreed that subsistence was dominated by maize agriculture. The earliest model of indigenous settlement in the Grand Canyon during the Pueblo Period was espoused by Euler and his colleagues (Effland et. al. 1981, Euler 1967, 1969, Jones and Euler 1979). According to them, as Fairley notes, it is believed that maize agriculturalists (likely the Cohonina – SFMGW producers) first entered the Canyon sometime between AD 700-800 and their population steadily increased over time. Later, between AD 900 and AD 1000 groups of peoples associated with the Kayenta region (TGW producers), moved into the Canyon and greatly increased the local population. After AD 1150 the population of the area plummeted and it was totally abandoned between AD 1200 and AD 1220 (Jones 1986), due to deteriorating climate changes that adversely affected their agricultural livelihood (Fairley 2003). According to this model, the varied archaeological groups lived side by side for several centuries before the Cohonina disappeared from the archaeological record. Those who subscribe to Euler's interpretation believe the Cohonina were likely subsumed by the incoming Kayenta, and the Canyon was completely abandoned for 50 - 100 years before the ancestors of the modern Havasupai and Hualapai moved into the areas south of the Colorado River, on to lands formerly inhabited by the Cohonina. North of the river the Southern Paiute moved into the areas abandoned by Puebloan farmers (Euler 1958, 1967).

Portions of Euler's SARG model were challenged by Douglas W. Schwartz (1955, 1989, 2008), who viewed the Cohonina not just as a marginal local population but as central to the Grand Canyon Pueblo Period. He believed the Cohonina had settled in the Canyon far earlier than the Kayenta and Virgin groups and, in fact, may have developed from the local late Archaic populations. In Schwartz's explanation, the Cohonina first appear in the archaeological record around AD 600 and never leave the Canyon; instead, he posits, sometime around AD 1200 the Cohonina migrated into Havasu Canyon and later evolved into the Havasupai (Schwartz 1955).

Both of these early interpretations theorize that the Pueblo Period indigenous peoples were settled maize agriculturalists who followed a lifeway similar to that described historically for Puebloan peoples (Fairley 2003) on the Colorado Plateau, such as the Hopi. The Euler and Schwartz SARG models are grounded in a cultural ecological paradigm, which promotes the role of the natural environment in shaping cultural practices that allow people to settle in and adapt to changing environments. In regards to Pueblo Period indigenous settlement strategies, the SARG models are focused on site locations that support the cultivation of maize (Euler and Chandler 1978, Schwartz et al. 1981, Smiley and Vance 2011). These obligate subsistence models, presume that a maize-based agriculture lifeway bound groups to environments that had the appropriate natural conditions for growing maize (frost-free days, precipitation, water-table depth, etc.). While some technological improvements, particularly water control, can be undertaken to improve the odds of a successful harvest, the vast majority of these conditions cannot be mitigated, so people are obligated to find locations that meet the environmental constraints required to grow maize. This mode of thinking underlies all of the SARG interpretations.

From a paleo-botanical perspective, those following the SARG Approach argue that the presence of even one maize cob or a single grain of corn pollen is sufficient to demonstrate that during the Pueblo Period people intensively cultivated maize (e.g., Schoenwetter and DeCosta 1976). The quantity of maize paleo-botanical remains in the Canyon is quite limited, so the assertion that mere presence equals intensive-use is questionable. Prior to 2007, approximately 100 cobs and about 50 grains of corn pollen have been documented in the Grand Canyon archaeological literature (Sullivan and Ruter 2006). Another 134 samples of maize pollen were added to the collection after recent Museum of Northern Arizona excavations along the Colorado River (Smith and Adams 2011), but till the amount of paleo-botanical evidence for maize agriculture is quite low, when compared to other regions in the northern Southwest (Sullivan 1996). In fact, Schwartz et al. (1980) in comparing their findings from Unkar Delta to other Pueblo Period sites [Antelope Cave (1,022 cobs), Mesa Verde Mug House (364 cobs), and Talus Cave (507 cobs)] demonstrate that, in other nearby areas, a single site contains more paleo-botanical evidence for maize that what has been recorded for the entire Grand Canyon.

In many cases, wild resources are dismissed as being unimportant to prehistoric subsistence and settlement. For example, Schwartz and his colleagues record the presence of numerous economically important wild plants from excavations, including the granary at Bright Angel Pueblo (Schwartz et al. 1979), which only contained the remains of wild plants, and at sites on Unkar Delta (Schwartz et al. 1980), however, in both cases the importance of wild resource in subsistence strategies was summarily set aside. In the report on the Walhalla Plateau survey Schwartz et al. (1980) note the existence of economically significant wild plants growing in their study area, however, in the same breath their importance is dismissed with the statement "no quantitative study of plant productivity was carried out, but casual observations suggested that none of the species listed occurs today in sufficient quantity to be an important food source" (Schwartz et al. 1981:29). So, while a single maize pollen grain is enough to indicate intensive maize agriculture, the presence of abundant wild plant material is insufficient to argue for wild plant focused subsistence strategy. This position, which is not unique in Southwest archaeology, should be reconsidered in light of my findings (Chapter 6).

Indigenous Approach

The Grand Canyon is claimed as a sacred space by numerous Native American groups (Fairley 2003), whose beliefs about and understanding of the world are quite different from western-scientific notions. However, in many cases their interpretations of the Pueblo Period settlement strategies are often quite similar to inferences made by archaeologists following the SARG approach (Kuwanwisiwma and Ferguson 2009, Martin 1985). Such similarities in understanding the Pueblo Period settlement are not unexpected because the SARG approach emphasizes drawing inference from the ethnographic and ethno-historic records. The origin stories of the Hopi and the Pai groups all intimately involve the Grand Canyon and many of these groups claim a direct lineage from prehistoric peoples (Kuwanwisiwma and Ferguson 2009), thus it is to be expected that they believe the archaeological remains document a lifeway that is similar to theirs. While this avenue of inquiry has a long history in Southwest archaeology, I argue that ethnographies written long after Spanish and American colonization provide limited information on proto-historic Puebloan archaeological sites and are even less reliable as a source of data for inferences about the origins of prehistoric archaeological sites. This position does not mean that we should not consult these sources but that we recognize they are one of many possible explanatory frameworks that can be employed to understand the Pueblo Period at the Grand Canyon.

UBARP Approach

There is a movement to challenge the cultural ecological paradigm that has informed a majority of previous Grand Canyon archaeological settlement models. Research by Alan Sullivan, beginning in 1986, and continuing thereafter (Berkebile 2014, Noor 1997, Cook 1995, Roos et al 2010, Sullivan 1986, 2015, Sullivan et. al. 2002, 2007, Sullivan and Ruter 2006, Sullivan and Forste 2014, Uphus 2003) in the eastern part of the Park, in an area identified as the Upper Basin, has focused more on how the Pueblo Period inhabitants manipulated their environment, with techniques such as anthropogenic burning (Roos et al. 2010), to create niches that enabled broad flexibility in settlement practices. I term this method the Upper Basin Archaeological Research Project (UBARP) Approach, which is grounded in agentive ecological paradigms, such as niche construction theory (Riede 2012, Smith 2011). Sullivan (2015) refers to his inferences about prehistoric human behavior as facultative subsistence models. Meaning, the UBARP models stipulate that people and economies are not tethered tightly to a particular set of environmental conditions (Sullivan 2015, Sullivan and Forste 2014) and instead implies that people had the ability to manipulate their surroundings to amplify the production of wild resources. By advocating facultative models of human behavior, UBARP interpretations of Pueblo Period subsistence economies highlight the conclusions that emerge when people engineer their environments take advantage of wild resources combined with low-intensity maize horticulture (Sullivan et. al. 2002).

In regard to paleo-botanical evidence of both maize agriculture and wild plant production, the UBARP guiding principle is that one sample is not indicative of intensive usage but that low quantities of macro-botanical and pollen remains of maize and other domesticates likely signify a limited reliance on domesticated cultigens. UBARP has documented a complex paleo-botanical record that demonstrates a subsistence pattern that was dominated by the production of wild resources, such as pinyon nuts and cheno-ams. Results of excavations of production and consumption contexts, at sites in the Upper Basin (Berkebile 2014, Cook 1995, Sullivan and Ruter 2006), suggest a subsistence pattern that had minimal reliance on domesticated cultigens, such as maize, and a much higher reliance on wild resources.

All of the previous settlement models proposed for the Grand Canyon Pueblo Period (described above) have deficiencies. Those following the SARG Approach rely on interpretations that are based on limited paleo-botanical data and an agriculture subsistence pattern in a location with very little potential for good maize farming. While the UBARP models do a far better job at capturing the complexity of the subsistence strategies practiced by the prehistoric Canyon occupants they are limited to data from only a small area within the Grand Canyon. Neither of the models does a very good job of handling the variation in subsistence strategies that likely existed among the Cohonina, Kayenta, and Virgin peoples. Based on my analyses (Chapter 6) the SARG interpretations are rejected and the UBARP model will be expanded throughout the Canyon. These interpretations place a greater emphasis on anthropogenic environmental engineering techniques, such as burning, broadcast sowing of seeds, and in-place encouragement of nut-bearing trees, over intensive-maize agriculture, as the underlying subsistence strategy. This method was employed to develop new Pueblo Period indigenous settlement models. The new interpretations presented in Chapter 7 indicate that each of these group practiced different settlement strategies in the Canyon from AD 700 – 1225.

ORGANIZATION OF THIS STUDY

This dissertation is divided into seven chapters ranging from general natural and cultural histories of the project area to a more detailed analysis and discussion on land use in the Canyon from AD 700- 1225. Along the way, the role of variation in theoretical paradigms and models of archaeological landscapes will be explored.

Chapter 2 begins with a brief discussion on the development of ecological approaches in anthropology and finishes with an in-depth assessment of the various settlement models proposed for the Grand Canyon. This chapter will lay out the ecological paradigms that have driven settlement pattern studies in North America for over 100 years. It is important to understand the history of development of ecological approaches in anthropology, which mirror the progression of Canyon settlement models, in order to better understand how and why interpretations of Grand Canyon developed over the past decades. Specifically the latter part of this chapter will focus on discussing and critiquing the development of the earlier cultural ecological and newer agentive ecological models and deliberate the role of modern indigenous perspective in developing models of prehistoric settlement.

In Chapter 3, a natural history of the Canyon is presented. The discussion is divided into four parts: geology, with a focus on the Canyon's formation; ecology, with the primary focus on biotic communities and vegetation associations; climate and paleoecology of the region; and finally a discussion of modern geographic zones with a focus on those that seem to have had an influence on prehistoric settlement.

Chapter 4 presents both an archaeological and cultural history of Grand Canyon National Park. The documentation of archaeological sites in the Grand Canyon began with John Wesley Powell's first expedition down the Colorado River in 1869 and continues today. This chapter presents a concise history of the previous archaeological research conducted at the Canyon and follows with a succinct cultural history of indigenous habitation at the Canyon beginning with the Paleo-Indian and ending with the Protohistoric and Historic utilization of the Canyon. The classification of Pueblo Period sites into traditional temporal and cultural groups is given additional attention, as it is the most germane element to this dissertation.

Geoinformatics is the discipline focused on gathering, storing, and analyzing geographic information. Chapter 5 focuses on how one can employ geospatial analyses to answer questions about human adaptability and cultural variation. After defining what a geoinformatics approach entails, this chapter finishes by describing the datasets utilized in the analyses, including how the sites were parsed into cultural and temporal groupings.

Chapter 6 is the heart of the dissertation where the data on archaeological landscapes in the Grand Canyon from AD 700 – 1225 are presented. It begins by describing the analysis methods that were used to create the data sets presented and discussed in the rest of the chapter. The analyses can be divided into two general categories; (1) large-scale correlations between site locations and environmental variables, and (2) small-scale comparisons of settlement organization. The large-scale correlation, which I refer to as socio-environmental relationships, consists of analyses that identify associations between site locations and a variety of environmental variables. The small-scale comparison of site structure, which I term settlement organization, will center on examining the variation in components present at or near each archaeological site. The data are then presented in two parts; (1) a comparison of land use by ware groups, regardless of time, and (2) a diachronic examination of land use.

Chapter 7 presents the concluding discussions of this dissertation. A critique of the SARG interpretations is presented along with a discussion of expanding the UBARP models throughout the Canyon. Finally, my new agentive ecological models of Grand Canyon Pueblo Period indigenous settlement will be presented. My new explanations provide a more robust interpretation of prehistory, one that includes all of the Canyon's diverse ecology and all three of the groups that inhabited the region from AD 700 - 1225.

Chapter 2: Frameworks of Interpretation, Ecological Paradigms and Grand Canyon Archaeology

INTRODUCTION

The focus of this chapter is on the theoretical frameworks that underlie interpretations of Grand Canyon archaeology. The chapter begins with a selected chronology on the development of ecological approaches in Anthropology, focusing on those that have influenced studies on the prehistory of the Canyon. The history of ecological discourse is important for my analysis, as advances in ecological frameworks within the entire discipline, and the timing of their application, likely had an influence on the development of settlement models for Grand Canyon. The chapter concludes with highlights and critiques of the various ecological paradigms that have guided the development of Pueblo Period settlement models in the Grand Canyon for over 100 years.

A CHRONOLOGY OF ECOLOGICAL ANTHROPOLOGY

Bruce Smith (2011) observes that for more than a century North American archaeological studies that accentuate human-environment interactions have focused on three broad questions: (1) how does environment influence culture, (2) how and to what degree did Native Peoples conserve or degrade their environment, and (3) if and to what degree have Native Peoples modified their environments (i.e. how culture modified the environment)? The analyses presented within this dissertation will address all three of these broader questions by looking specifically at indigenous Grand Canyon settlement from AD 700 - AD 1225. In the chronology presented below I will only present information on the three ecological paradigms that have influenced interpretations of Pueblo Period settlement in the Park.

Evolution and Ecology

The interest in human and environment interactions is rooted in evolutionary studies of human culture (Moran 2000, 2006; Sutton and Anderson 2004). Morgan (1851 [from Hardesty 1977]) based his unilinear evolutionary theory (savagery, barbarism, and civilization) on the need for humans to search for a livelihood, or what we today subsume under the terminology of subsistence and settlement. He believed that people would adapt to their local environments through technological changes, and would eventually progress up the cultural evolutionary ladder. At around the same time, Karl Marx and Friedrich Engels also developed a complementary unilinear cultural evolution theory with six stages that resulted in the social organization principle of communism (Engels 1942). Their theory focused on political economic adaptation rather than technology as a method for taming the environment (Sutton and Anderson 2004).

Unilinear theories of cultural evolution were later opposed by many scholars in the early part of the twentieth century, as evidence from the indigenous people in the Americas recorded by Franz Boas and his students began to contradict the notion that populations followed a neat trajectory of evolution. For example, in the Northwest Coast culture area, complex social and political systems developed without agriculture and in many parts of the world, herding does not always precede agriculture. Boas and later Alfred Kroeber ushered in a new era of examining human and environment interaction that we now term possibilism (Sutton and Anderson 2004).

The proponents of possibilism rejected the notion that the environment was a determining factor in cultural development. Instead, they believed the environment could be seen as a limiting aspect in cultural change (Sutton and Anderson 2004) but could not be an all-encompassing explanatory factor (Hardesty 1977). For example, the arid conditions in the American Southwest ensure that native peoples are not going to live in snow houses but why they choose pithouses, pueblos, or hogans is not due to environmental factors but rather a result of the cultural framework in which they live. Alfred Kroeber was one of the earliest contributors to this theoretical paradigm of possibilism when he expanded on Mason's culture area concept (1939). Kroeber's study of maize cultivation determined that climatic factors, such as a four month growing season and adequate rainfall, were necessary for maize cultivation to be present; and therefore provide a reason why maize agriculture is not identified in the Arctic culture area. However, maize agriculture was not always present in the environments that met the appropriate growing criteria, so another factor must explain why it is absent in areas prime for maize cultivation. In outlining the role of the environment in the culture area concept Kroeber notes "while it is true that cultures are rooted in nature, and can therefore never be completely understood except with reference to that piece of nature in which they occur, they are no more produced by that nature than a plant is produced or caused by the soil in which it is rooted [and] the immediate causes of cultural phenomena are other cultural phenomena" (Kroeber 1939:1). The notion that environment plays only a limiting role in cultural development allowed the practioners of this explanatory framework to acknowledge the role of environment while still focusing on culture or human behaviors as the driving force behind technological and sociopolitical change.

Archaeologically, possibilism was employed as an explanatory mechanism for the variability in prehistoric cultural evolution. Betty Meggers (1954), who was an environmental determinist, argues that environmental factors, in particular the poor soil quality of the Amazon, limited the ability for indigenous peoples to develop a rich agricultural complex and thus advance up the cultural evolutionary scale of complexity. Geertz (1963) in a critique of both the determinism and possibilism perspectives posits that they both focus on culture and environment as two distinct spheres and how one impacts the other (Hardesty 1977), which limits our questions to the grossest or largest scale possible. Instead, a theoretical framework that acknowledges the "interplay" of culture and environment is necessary (Geertz 1963). This framework forms the foundation of the cultural ecology paradigm.

Cultural Ecology

The cultural ecology paradigm is one of the oldest ecological theoretical frameworks to influence anthropological archaeology. The focus of cultural ecology on subsistence economics and environment make it a very attractive theoretical framework for those working on questions of prehistoric livelihoods (Coltrain and Leavitt 2002; Dean 2005; Gummerman 1988). Cultural ecology, whether practiced in archaeology or ethnography, has both a theoretical and methodological link to human ecology. Cultural ecology is the study in how culture provides people with a wide set of options (technological, ritual, social) to adapt to their environment (Sutton and Anderson 2004). Hardesty (1977) argues that a defining feature of cultural ecology is recognition that neither culture nor environment is the driving force; instead they are defined in terms of each other and linked by reciprocal causality or feedback. That is, culture influences the environment and the environment influences culture. However, these relationships are not equal and at times culture has the more active role and other times the environment has the more active role. Julian Steward, often considered the father of the culture ecology approach in anthropology, noted that certain elements of culture, particularly those associated with subsistence economics, were more likely to have a strong relationship to the natural environment (Steward 1977). He called these cultural components the cultural core and argued that features of this cultural core were the only parts of culture that could be examined ecologically and examined cross-culturally for similarities in adaptive responses. His cultural core purposefully excluded social structure and ideological components of culture, which he believed were not directly related to the environment. These exclusions of social structure and ritual are one of the major critiques of cultural ecology (Vayda and Rappaport 1968) and why a new ecological anthropology or ecological anthropology developed (Sutton and Anderson 2004).

While ecological anthropology continued to expand its focus throughout the twentieth century at the Grand Canyon the cultural ecological paradigm continued to underlie the interpretations of Pueblo Period archaeology throughout the twentieth century. In fact, cultural ecology is the theoretical framework still employed today by most Grand Canyon archaeologists in their interpretations of the Park's past. Beginning in the 1990s agentive ecological paradigms, such as Niche Construction Theory, was adopted by archaeologists working in the Upper Basin on the eastern South Rim.

Niche Construction Theory

Niche construction theory is one of the newest ecological paradigms embraced by archaeologists, including some Grand Canyon archaeologists. It is of particular use to environmental archaeologists whose methodological rigor is often countered with limited theoretical sophistication (Barker 2001), as it provides a theoretical paradigm to ground those methodologically driven studies. Riede (2012) posits that environmental archaeology can be viewed as a record of human niche construction that provides for new models that explore the interplay between materiality, technology, and human cognition. Riede further argues that Niche Construction Theory provides an alternative to Systems Theory, which is the primary theoretical framework of most environmental archaeology. Riede believes that the niche construction model integrates many of the most useful insights from functionalism and systems theory but differs from them "in being non-teleological, never at equilibrium, and by firmly placing individual agents and their actions centrally, rather than taking societies or cultures (whatever these may be) as units of analysis" (Riede 2012:1).

Niche Construction Theory originated in evolutionary biology as an alternate way of thinking about evolution (Odling-Smee et. al. 2003), one that stresses the ability of organisms to modify the natural selection of the environment in which they live and by doing so co-directing its own and other species evolution (Laland and O'Brien 2010). Niche Construction Theory is also termed triple-inheritance theory (Day et. al. 2003, Laland and Brown 2006, Laland and O'Brien 2010), where in addition to socially transmitted traditions being passed through time, innovative anthropogenic social, cultural, and natural environments are created and inherited as well. These hereditary environments endow future generations' selective conditions for cultural practices, social strategies, and subsistence activities (Riede 2012).

There are four principal kinds of niche construction (Table 2.1): perturbation, relocation, inceptive, and counteractive (Laland and O'Brien 2010, Riede 2012, Odling-Smee et. al. 2003). The first two categories of niche constructions (perturbation and relocation) refer to the methods that organisms use to change the selective pressure to which they are exposed. Perturbation niche construction occurs when an organism actively modifies one or more factors in its environment by physically changing it at a particular time (Laland and O'Brien 2010). Relocation niche construction is when an organism actively travels, choosing the direction, distance and time of travel, all of which exposes them to alternative habitats at various times and under variable environmental factors (Odling-Smee et. al. 2003). The final two categories of niche construction (inceptive and counteractive) concern whether an organism initiates or responds to environmental change. Inceptive niche construction occurs when an organism initiates change, either through perturbation or relocation, resulting in a change to the environment (Riede 2012). While Counteractive niche construction occurs when an organism opposes or cancels out an environmental change thereby restoring an adaptive advantage between a specified trait and the environment (Odling-Smee et. al. 2003). As Table 2.1 indicates humans are active participants in all types of niche construction.

Bruce Smith (2011) posits that a primary goal of niche construction amongst human populations is to increase their share of annual ecosystem productivity by increasing the abundance and reliability of the plant and animal resource they rely upon. He identifies six general categories of niche construction practiced by humans: (1)

general modification of vegetation communities: creating mosaics and edge areas and resetting successional sequence, (2) broadcast sowing of wild annuals creating wilds strands of seed-bearing plants in river and lake edge zones exposed by receiving high water, (3) transplantation of perennial fruit bearing species: creating orchards and berry patches in proximity to settlements, (4) in place encouragement of perennial fruit and nut bearing species, creating landscapes patterned with point resources, (5) transplantation and in-place encouragement of perennial root crops; creating root gardens and expanding the habitat of wild stands, (6) landscape modification to increase prey abundance in specific locations: enhancing salmon streams and creating clam gardens, fish ponds weirs and drive lines

I contend that in the Grand Canyon from AD 700 - 1225, anthropogenic environmental engineering can be characterized by three of Smith's (2011) niche construction categories: (1) modification of the vegetation communities, typically by fire, creating mosaics and edge areas that reset successional sequences, (2) broadcast sowing of wild annuals creating stands of wild seed-bearing plants on the edge of the Colorado River and near seeps and springs, and (3) in-place encouragement of nut-bearing species, creating landscapes patterned with point resources, where peoples could relocate on a seasonal basis. All of these techniques require that human agents chose to modify their surroundings by employing one or all of these engineering methodologies.

Table 2.1. Four principal categories of niche construction (modified from Laland and O'Brien 2010, Riede 2012, Odling-Smee et. al. 2003).

	Perturbation	**Relocation**
Inceptive	Organisms initiate change to a selective environment by physically modifying environment, e.g., land-clearing, caching (raw material or subsistence)	Organisms expose themselves to new environments by moving into or growing into a new environment, e.g. exploration of Oceania, colonization of the Americas
Counteractive	Organisms counteract prior change in environment by modifying surroundings, e.g., building of shelter to keep out elements, terrace building to stop erosion	Organisms respond to environmental change by relocating to a more suitable habitat, e.g., seasonal migration following herd animals during the Pleistocene

The history of the development of ecological anthropology is important for this study because it illustrates why the initial Pueblo Period Grand Canyon settlement models developed with a cultural ecological focus. During the initial florescence of archaeology in the Park in the 1960s and 1970s, archaeology was in the midst of a theoretical upheaval with the development and adoption of processual archaeology. Processual approaches at that time, which moved the focus away from cataloging culture histories and towards controlled scientific studies designed to understand human behavior, were heavily influenced by the culture ecology paradigm. It would make sense that the initial "modern" archaeologists (Euler 1988, Fairley 2003, Schwartz 1989) working in the Canyon would have been drawn to these approaches as they developed their settlement models of this diverse environment. These earliest interpretations of Grand Canyon Pueblo Period settlement remained unchanged, until more recently, when Sullivan (2015) and his students (Sullivan et al. 2002, 2014) began to apply more agentive based approaches to the eastern portion of the Canyon in the Upper Basin. In the section below the contrast between these two approaches will be described and discussed. This dissertation is an attempt to expand the agentive ecological paradigm beyond the Upper Basin to interpretations of Pueblo Period settlement throughout the entire Grand Canyon National Park.

GRAND CANYON SETTLEMENT AD 700 - AD 1225 COMPETING ECOLOGICAL PARADIGMS

Archaeological investigations at the Grand Canyon have been ongoing for over a century. The initial exploration of the Canyon along the Colorado River, by Major John Wesley Powell, resulted in the documentation of several Pueblo Period archaeological sites (Fowler et al. 1981), which Powell attributed to the local Pueblo and Paiute tribes that lived the surrounding areas. Studies in the earliest part of the twentieth century (Gladwin 1935, Hall 1942, Judd 1926) also argued for a continuance between the archaeological remains in the Canyon and the surrounding Native Peoples. This line of thinking is not surprising given that archaeology at this time was being driven principally by the direct historical approach championed by William D. Strong under the guidance of Alfred Kroeber (Strong 1929). Anthropologists during the 1920s and 1930s conducted much broader investigations and a project often documented both the archaeological remains and the contemporary indigenous groups in the same area (Willey and Sabloff

1993). Therefore, it should be no surprise that the earliest settlement models in Grand Canyon archaeology are heavily dependent on inferences based on the indigenous peoples that were present in the area at that time.

The earliest modern archaeological studies of settlement in the Grand Canyon National Park (e.g., Euler and Chandler 1978, Effland et al. 1981, Schwartz 1989) have focused on "interdisciplinary perspectives to interpret environmental parameters affecting archaeological sites in the Grand Canyon" (Fairley and Hereford 2002:39) and fitting those into broader environmental and cultural historical perspectives. This SARG approach is grounded in a cultural ecology paradigm and promotes the role of the natural environment in shaping settlement patterns (Euler 1988). The SARG interpretations still drive the majority of settlement research conducted in the Grand Canyon today (Fairley 2003, Schwartz 2008, Smiley and Vance 2011).

SARG Approach

The SARG interpretations posit that the Pueblo Period Grand Canyon peoples were settled farmers that followed a lifeway similar to what has been ascribed to other Pueblo groups on the Colorado Plateau during historic and modern times (Fairley 2003). These prehistoric peoples, it is assumed, grew corn, beans, and squash and placed their settlements in areas that were prime for growing these plants. As Schwartz and colleagues note "The Grand Canyon appears to be a poor place for farming, but it contains a few small areas that area as good as many of those where prehistoric farmers grew corn in Glen Canyon or along the San Juan river" (Schwartz et al. 1980:209).

The SARG interpretations of Canyon peoples as agriculturalists is based on paleo-botanical data excavated from archaeological sites on the North Rim (Schoenwetter and

DeCosta 1976, Schwartz et al. 1981), South Rim (Balsom 1986), and Inner Canyon (Euler and Jones 1987, Schwartz et al. 1979, 1980, Smith and Adams 2011, Jones 1986). In total, these studies document approximately 100 maize cobs, around 50 grains of maize pollen, and a couple of squash and bean samples recorded prior to 2007. Between 2007 and 2011 another 134 botanical samples were recorded as part of a recent Museum of Northern Arizona (MNA) investigation at several sites along the river (Smith and Adams 2011). By any measure, the quantity of paleo-botanical data seems quite limited, even more so when compared to Schwartz's own tally of remains from other Pueblo Period sites: Antelope Cave (1,022 cobs), Mesa Verde Mug House (364 cobs), and Talus Cave (507 cobs), each of which individually contain more cobs than have been recovered in the entire Grand Canyon. In the assessment of those following the SARG Approach, quantity does not matter, - the mere presence of cultigen pollen or macro-botanics, confirms the widespread use of these plants. The SARG position in this regard is best summed up by Schoenwetter and DeCosta when they state, "The occurrence of one pollen grain of Cucurbita in the sample…documents the presence of this taxon at the check dam locale in the past. In all likelihood this reflects the occurrence of cultivated plants considering the context of the sample. Thus this single pollen grain essentially serves to demonstrate both the proposition that the check dams are prehistoric and the proposition that they were constructed to establish plots of arable land" (Schoenwetter and DeCosta 1976:2) . I would posit that the presence of maize designating these peoples as intensive agriculturalists should be further scrutinized, which I will do at the end of this chapter.

In regards to utilization of wild plants, Schwartz does indicate the presence of wild plant resources from all of his excavations, including the granary at Bright Angel Pueblo, which only contained the remains of wild plants, and he also notes the existence of economically important plants on the Walhalla Plateau. However, in the same breath the importance of wild resources is dismissed with the statement "no quantitative study of plant productivity was carried out, but casual observations suggested that none of the species listed occurs today in sufficient quantity to be an important food source," (Schwartz et al. 1981:29). This casual observation fails to account for the fact that the land has not been managed for those resources in almost 800 years, and using that same logic one could also argue that there was also no maize present. Again, the SARG models may recognize the use of wild plants prehistorically but their importance is significantly downplayed.

In terms of settlement patterns, the SARG approach is focused on locations that support the cultivation of maize (Euler and Chandler 1978, Schwartz et al. 1981, Smiley and Vance 2011). In the initial development of the SARG approach, Euler and Chandler note that sites were located with regards to critical environmental variables such as access to water and level topography but not in regards to the presence of animals or wild plants. They also conclude that most of the sites, especially the larger sites, are located with regards to arable land and that habitation sites are located principally in areas where at least 5 percent of the land was arable (defined by Euler and Chandler 1978 as the alluvial model, which typically included areas with deep soil near permanent water sources). Again, this quantity seems too low to be considered a driver of settlement and arable land could have also been utilized to grow wild resources like chenopods or amaranth.

One of the more interesting arguments and experiments to demonstrate the potential for agriculture on the North Rim was presented by Schwartz et al. (1981) in their publication on the Walhalla survey. They posit that the topography of the plateau, which is a peninsula jetting out into the Canyon, resulted in a phenomenon where warm Inner Canyon updrafts would have increased the growing season on the North Rim to one long enough to support a maize subsistence system. Another more recent site distribution study that argues for a maize agricultural economy by Smiley and Vance (2011), argues that while they could not detect any statistically valid correlations between archaeological sites and soil types in their GIS analysis, they did indicate there was evidence, though not calculable in GIS, that sites were placed on ledges just below the ridge tops and near drainage heads, giving access to lower elevation unspecified resources and large flat areas for agriculture.

Excavation data and settlement pattern information have been employed by those who follow the SARG approach to argue that the Pueblo Period peoples of the Grand Canyon were settled maize agriculturalists. These models are rooted initially in the Direct Historical Approach interpretations of the Canyon begun by Powell and Hall in the late nineteenth and early twentieth centuries and continued with models proposed by Schwartz (1989) and Euler (1988) that are grounded in a processual archaeological methods and a cultural ecological paradigm. While these approaches were a great beginning, as our understanding of human and environmental interactions have become more sophisticated (van der Leeuw and Redman 2002), it is time to expand our understanding of the Pueblo Period Grand Canyon and to develop robust models of settlement that view the prehistoric inhabitants of the canyons as active agents who shape their environment. This dissertation will present such a model in the discussions below.

UBARP Approach

Recent research (Sullivan 2015, Sullivan et. al. 2002, 2007, 2014, and 2015) in the Upper Basin located in the eastern part of the Park has focused on how the Pueblo Period inhabitants of the Canyon manipulated their surroundings to construct niches that would increase wild plant productivity and allow them greater flexibility in settlement practices. The UBARP Approach is grounded in a niche construction paradigm (Berg et. al. 2012, Smith 2011) and based on research undertaken in an area of Grand Canyon National Park and Kaibab National Forest, known as the Upper Basin. This project is directed by Alan Sullivan of the University of Cincinnati and along with his students he has been conducting a 25-year long research project into indigenous settlement in the region. UBARP interpretations promote the role of human agency in shaping the environment, thereby giving partiality to human behavior and decision making over environmental constraint.

UBARP analyses and interpretations of paleo-botanical data follow the guiding principle that one sample does not indicate intensive usage, instead the low quantity of maize macro-botanical and pollen data likely signifies a limited reliance on domesticated cultigens. Beginning with the investigation of Site 17, Sullivan (1986) has documented a complex paleo-botanical record that reveals a subsistence pattern that was dominated by the production of wild resources such as pinyon nuts and cheno-ams. Excavations of sites in the Upper Basin (Berkebile 2014, Cook 1995, Sullivan and Ruter 2006) suggest a mixed subsistence pattern with minimal reliance on domesticated cultigens, such as maize, and a much higher reliance on wild resources. In Berkebile's recent study (2014), of the archaeo-botanical remains from archaeological site MU125, small amounts of maize and beans were identified but the vast majority of the paleo-botanical remains were from wild resources such as purslane, globe mallow, chenopodium, pinyon, and juniper. Her data along with other data compiled by Sullivan and his students were used to propose a ruderal model of agriculture in the Upper Basin where fire was employed by the Canyon's Pueblo Period inhabitants to develop a reliable wild plant subsistence strategy (Sullivan and Forste 2014).

Sullivan (2015) recently synthesized data from his 25 year project and parsed existing Grand Canyon subsistence strategies into two broad categories, obligate models and facultative models of subsistence. Obligate models, which include the SARG interpretations, perceive the Pueblo Period Grand Canyon peoples as maize agriculturalists, bound to environments that supported this lifestyle. Exemplifying, essentially a cultural ecological paradigm, these models stipulate simply that Pueblo Period peoples were confined to settling in areas that would support their maize adapted economies (Euler 1988, Fairley 2003, Schwartz 1989). While some cultural behaviors, such as terrace construction or seasonal migrations, provided these peoples with the ability to adapt to the Canyon, they were still tethered to areas that had the appropriate number of frost-free days, soil-productivity, precipitation, etc. required for maize agriculture.

Sullivan (2015) posits that he UBARP interpretations are predicated on facultative models of human behavior. These facultative models are based on Niche Construction Theory, and stipulate that people and economies are not tethered so tightly to a particular set of environmental conditions (Sullivan 2015, Sullivan and Forste 2014). By following these facultative models of human behavior, interpretations of subsistence economies are based on Pueblo Period peoples engineering their environments to take advantage of wild resources and mingling the non-domesticates with a low-level maize horticulture that resulted in a mixed subsistence practice (Sullivan et. al. 2002).

The UBARP approach is most widely criticized for being focused on a limited area of the Canyon (Fairley 2003). While this is a fair critique it ignores that fact that the Upper Basin project, by design, is a high-resolution examination of the Canyon's archaeological record and thus focused more intently and in greater detail on one region of the Park. This narrow focus has allowed for a more intensive survey that collected a more detailed sample of data (Sullivan et al. 2007), which in turn has permitted the project to more fully investigate the complexities that created this continuously used landscape for over 400 years. One goal of this dissertation is to address this critique by expanding the UBARP agentive ecological paradigm, to interpretation of entire Grand Canyon National Park archaeological site file database.

Indigenous Perspective

Both of the aforementioned approaches to developing inferences about the prehistory of the Canyon are based on western scientific thought. However, the Grand Canyon is claimed as a sacred space by over 22 Native American groups (Fairley 2003), whose beliefs about how, why and when the Canyon was utilized sometimes differ from archaeologists' but whose interpretation of Pueblo Period settlement strategies are often quite similar to interpretations promoted by archaeologists following the SARG approach (Kuwanwisiwma and Ferguson 2009, Martin 1985). The similarities in interpretations are not surprising as the SARG approach emphasizes drawing inference from the ethnographic and ethno-historic records.

The Hopi who refer to the Grand Canyon as Ongtupqa (Kuwanwisiwma and Ferguson 2009) believe that a travertine dome located near the intersection of the Colorado and Little Colorado rivers is where they entered the Fourth Way of Life (our current world). Here they met the deity Maasaw, guardian of the earth, who gave them a bag of seeds and a digging stick, so they could farm the land (Kuwanwisiwma and Ferguson 2009). The Hopi made a pact with Maasaw that the deity would let them use the land and they would be good stewards of the land. Following the instructions of Maasaw, the Hopi migrated throughout what we recognize as the Southwest until all of the clans arrived at their respective mesa. The material they left behind during this migration is called itaakuku, or footprints, which are how they describe the archaeological material found throughout the Southwest (Kuwanwisiwma and Ferguson 2009). These remains they believe tell the story of the clans and reveal the history of the Hopi. Those in the Grand Canyon are given special meaning because they are close to the emergence spot where the Hopi entered this world.

While Hopi beliefs suggest they have a more spiritual understating of the origins of the archaeological landscape, their inferences about the Pueblo Period settlement is similar to the traditional interpretations developed by archaeologists following the SARG approach (Euler 1988, Fairley 2003, Schwartz 2008). Both groups regard the Pueblo Period Canyon inhabitants as settled maize agriculturalists. Likewise the Havasupai and other Pai groups equally believe their ancestors practiced maize agriculture. As previously noted the similarity between SARG archaeologists' interpretations and Native

Peoples beliefs is not surprising since the various tribes believe the archaeological remains provide a record of their ancestors, which would have followed a lifeway similar to theirs, and because the SARG archaeologist often looked to the ethnographic record as a source of inference. While the variety of indigenous perspectives provides an interesting interpretation of Grand Canyon prehistory, they are outside the scope of this dissertation.

CHAPTER SUMMARY

The focus of Chapter 2 is on the paradigms that have driven Grand Canyon archaeological interpretation for over 100 years. The Chapter begins with a history of the development of Ecological Anthropology, focusing on those theoretical frameworks that are most important to the development of Grand Canyon settlement models. This discussion on the development of Ecological Anthropology is important as it provides insight into why many models of Grand Canyon settlement have a heavy cultural ecological focus. The chapter ends with specific highlights and critiques of both the SARG and UBARP approaches and sets the groundwork for the rethinking these interpretations in Chapters 6 and 7.

The development of ecological anthropology is rooted in the earliest studies of the evolution of human culture. Morgan's cultural evolutionary theory is based on changes to a group's subsistence pattern. His thinking was that as groups adapted to their environments through technological change that they would increasingly develop more complex social systems. This evolutionary trajectory argues that groups moved from minimal complexity (savagery) to extensive complexity (civilization) based on an adoption of agriculture.

In the early part of the twentieth century, Morgan's unilinear theory of cultural evolution was rejected by early anthropologists such as Franz Boas and Alfred Kroeber, whose studies of indigenous people of North America demonstrated that complexity was not always linked to the adoption of agriculture. Instead of seeing environment as the limiting factor that humans had to adapt to, they instead believed the environment could be a limiting factor in cultural development but was not an all-encompassing factor that could be used to explain human development. Instead these early anthropologists viewed culture as the driving force of technological and social change.

The next major development in ecological anthropology was the creation of the cultural ecological paradigm. Cultural ecology, which is the study of how people adapt to their environment, was established by Julian Steward a student of Kroeber's at the University of California, Berkeley. The premise of cultural ecology is that neither culture nor environment is the driving force and instead they are defined in terms of each other and linked by reciprocal causality or feedback. The relationship between culture and environment is not always equal, with the environment sometimes taking the active role and other times culture taking the active role. Steward posited that certain elements of culture and in particular those associated with subsistence often had a strong relationship to the natural environment. He identified these elements as the cultural core and argues that these parts of the culture were the only ones that could be studied from an ecological context and examined cross-cultural for similarities in adaptation. He purposefully excluded social structure and ideology components in ecological analyses as he believed they were not directly related to the environment.

Niche construction theory is one of the newest approaches being adopted by archaeologists as an explanatory framework to understand human adaptation. Niche construction emphasizes an organism's ability to modify natural selection in in its environment and while doing so the modifying organism co-directs its own and other species evolution. In archaeology, niche construction studies have primarily focused on studies of plant domestication and subsistence economies.

The earliest models perceive the Pueblo Period inhabitants of the Grand Canyon as farmers who settled in areas that were conducive to a maize agricultural lifeway. These initial models were created from data amassed in the Park's earliest archaeological database and are indicative of what I term the SARG Approach. The SARG interpretations promote the natural environment and the search for areas where maize agriculture can be practiced, as the driving force that shaped prehistoric settlement in the Canyon.

These earliest inferences are being challenged by work conducted in the eastern portion of the Canyon in the Upper Basin. These newer models have been developed from what I term the UBARP Approach, which are grounded in an agentive ecological paradigm that focus on how people engineer their surroundings to effectively live within and exploit their environs. One of the biggest critiques of the UBARP settlement models is that they are based only on data from one small region of the Canyon.

The goal of this dissertation is to challenge the traditional interpretations of indigenous settlement at the Grand Canyon from AD 700 – 1225. This study utilizes legacy site file data and GIS analyses as a method to investigate if archaeological sites are distributed in regards to areas appropriate for maize agriculture, wild plant production, both, or neither. As I discuss in later chapters, the distribution of sites related to modern environmental variables supports a more complex understanding than what is currently presented in the traditional maize agriculture models. By applying agentive paradigms to inferences about the patterns observed in my analyses of the entire Grand Canyon database, suggests that Pueblo Period indigenous peoples practiced varied subsistence strategies in the Canyon. However, all of the peoples were reliant upon manipulating their surroundings to increase the abundance and reliance of wild plants, which were supplemented to varying degrees with maize agriculture. As will be highlighted in Chapter 7, these new interpretations are only possible based on a willingness to apply agentive ecological paradigms to our interpretation of the Grand Canyon archaeological record after accepting the weaknesses that are present in the traditional cultural ecological models.

Chapter 3: A Brief Overview of Grand Canyon Natural History

The central theme of this dissertation is challenging the traditional cultural ecological interpretations of Grand Canyon settlement from AD 700 - 1225. An integral component of any investigation into settlement patterns is consideration of the natural environment where the inhabitants settled and that they would have manipulated. In this chapter I describe the natural environment of the Grand Canyon, within a larger dialogue of the Park's natural history, and will center the discussion on the environmental factors employed in the analyses of this dissertation. Though the discussion begins with a focus on the modern environment, the later part of the chapter argues that paleo-ecological studies demonstrate that overall the environment from AD700 – 1225 would have been very similar to today, so correlating archaeological site data and modern environmental spatial layers can be successfully employed to develop inferences about prehistoric settlement.

GRAND CANYON: AN INTRODUCTION

The Grand Canyon has been designated a World Heritage site by the United Nations, and is one of the jewels (Anderson 2000) of the United States National Park System (NPS). Its geology is featured in almost every introductory Geoscience textbook (Fletcher 2011, McConnell et. al. 2009, Reynolds et. al. 2012), as almost 2-billion years of the Earth's history is laid bare in the Canyon's exposed stratigraphy. However, exactly how and when the Canyon formed is hotly contested, with dates ranging from 70 to 5 million years ago (Karlstrom et. al. 2014). Biologically, the Canyon acts as both a barrier and corridor for a complex web of species (Carothers and Brown 1991, Schmidt

1993) that have adapted to the plethora of ecozones created and controlled by the variable topography. A trip in the Park, from the lowest deserts near Lake Mead to the high elevation alpine environments on the North Rim, would expose an intrepid explorer to the same ecology they would encounter hiking from Mexico to Canada. However, this hypothetical Canyon journey, would occur in a compacted space barely over 100 miles, as the raven flies, from Lake Mead to the Kaibab Plateau, and is constrained by a little over 5000 feet in vertical relief. The verticality created by these compressed ecozones, provided prehistoric peoples with a wide variety of niches to exploit as they lived in this diverse environment.

Location

Grand Canyon National Park (GRCA) is located in northern Arizona where the Colorado River slices through the western edge of the Colorado Plateau (Figure 3.1). It is over 277 miles (446 km) long and begins at Lees Ferry, 15 miles downriver from the Glen Canyon Dam and Lake Powell (under which Glen Canyon is submerged), which straddles the Utah and Arizona borders. The first 61.5 miles of GRCA (from Lees Ferry to the Little Colorado River) are defined by a very narrow gorge that was originally named Marble Canyon by John Wesley Powell, but has been subsequently consumed by the National Park and considered the Grand Canyon proper in most modern studies of the natural and cultural history of the area (Morehouse 1996, Schmidt 1993). The Canyon ends beneath the waters of Lake Mead, at the Grand Wash Cliffs near the Arizona and Nevada border and encompasses less than a quarter of the 1450 mile (2333 km) course of the Colorado River, which begins in the Rocky Mountains of Colorado and extends to the Gulf of California in Mexico. Over the 277 mile course that the Colorado River flows through the Park it drops more than 2,215 feet, cascading over more than 150 rapids that create some of the most challenging whitewater in the world. The Canyon is between 3,500 to 6,000 feet (1,067 – 1,829 meters) deep (measured by changing elevation from rim to river) and the rims are from one to fifteen miles (1.6 – 24.2 kilometers) apart.

The Park includes 1,199,489 acres (485,416 hectares) or 1,874 square miles (4854 square kilometers) of land, including most, but not all of Canyon below the rims and portions of the surrounding plateaus (Schmidt 1993). It was originally protected by the United States Federal Government as a Forest Reserve in 1893, later becoming a National Monument and finally designated as a National Park in 1919, three years after the formation of the NPS (Anderson 2000).

Grand Canyon National Park is surrounded (Figure 3.2) on the north by the Kaibab National Forest and Arizona Strip Bureau of Land Management lands, to the south by the Kaibab National Forest and the Hualapai and Havasupai Indian reservations, to the east by the Navajo Indian Reservation, and to the west by Lake Mead National Recreation Area. The Park receives over 5-million visitors annually and is one of the most popular NPS units (Anderson 2000).

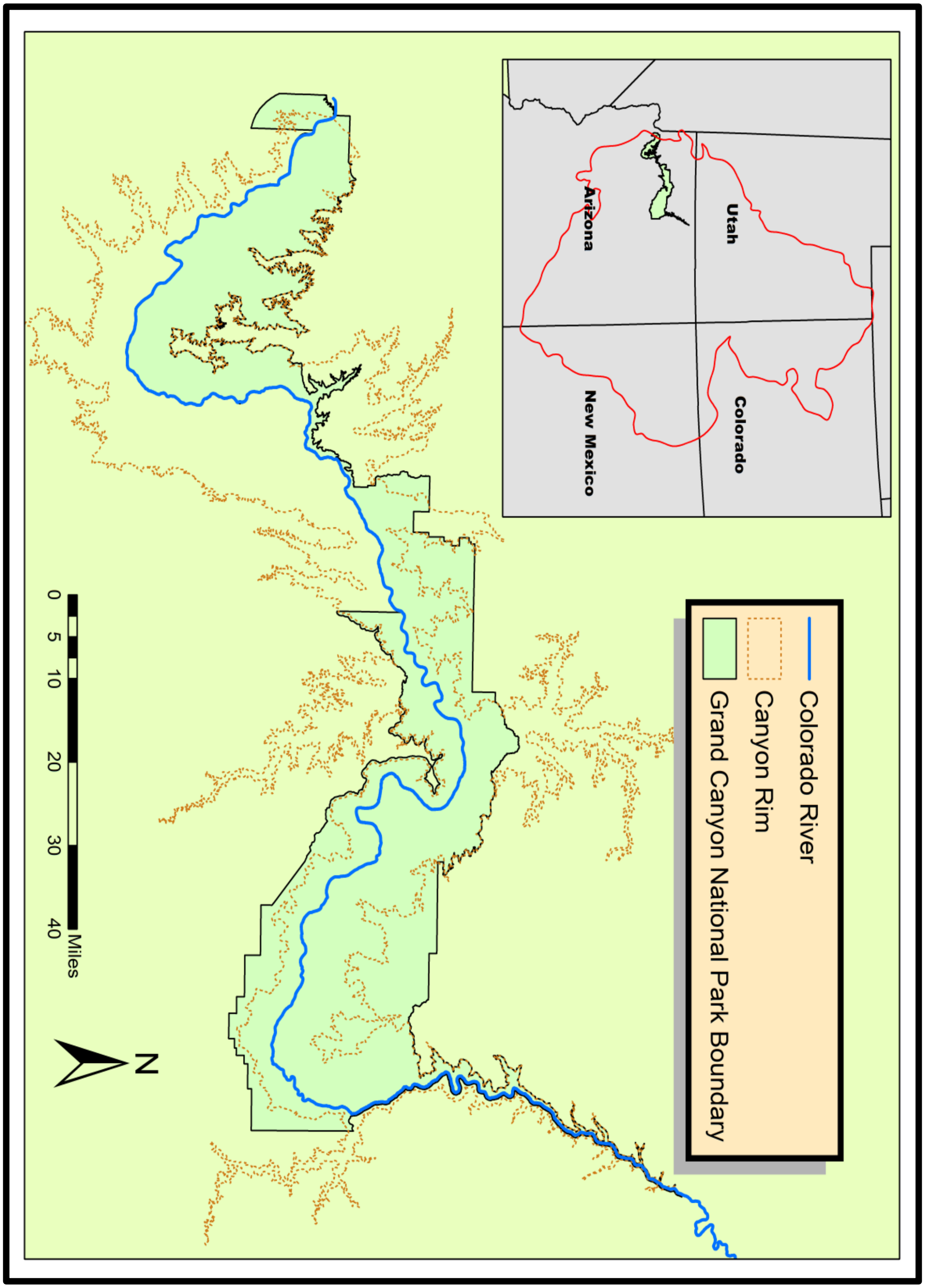

Figure 3.1. Location of Grand Canyon National Park (GRCA).

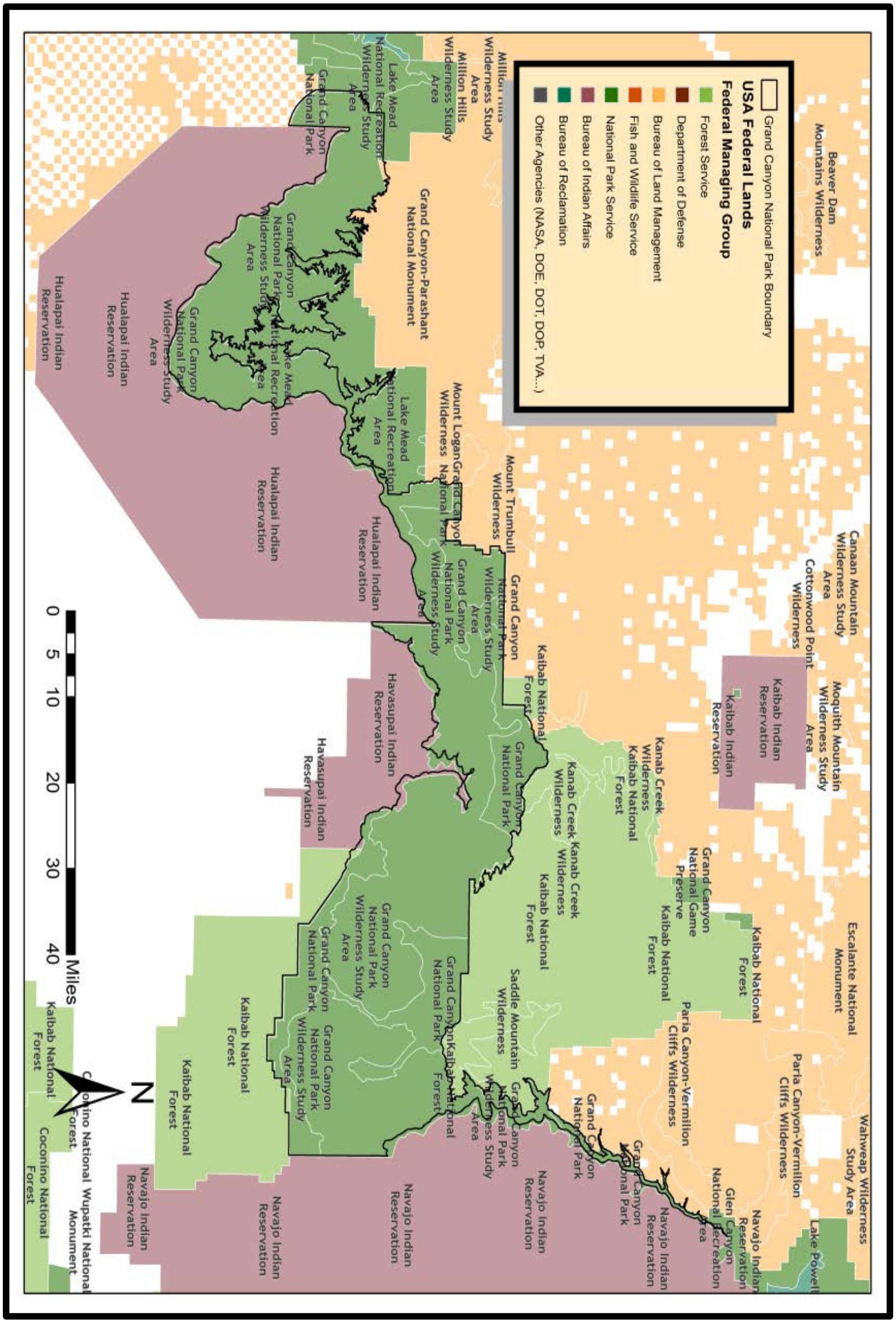

Figure 3.2 Grand Canyon National Park and Surrounding Federal Land Holdings.

GEOLOGY

Geology is one of the most studied aspects of the Grand Canyon, as its stratigraphy spans half of Earth's history (Figure 3.3). Even though the Canyon is not the deepest or longest in the world, it is one of the few places on Earth's surface where so much of Earth's history is readily displayed. The igneous and metamorphic Vishnu basement rocks that line the Inner Gorge, along the Colorado River in the central portion of the Canyon, date to the Paleoproterozoic geologic era (~ 2-billion years old). Above these oldest rock layers lie two vast packages of sedimentary and volcanic rocks dating to the Middle Proterozoic age (~ 1.7 billion years old) and Paleozoic age (~ 544 – 270 million years ago) that form the canyon walls (Beus and Morales 2003).

Formation

The formation of the Grand Canyon has been debated for over a century (Karlstrom et. al. 2014, Luchitta 2003, Schmidt 1993). The Canyon is located in a transition zone between the stable, horizontal platform of the Colorado Plateau and the extensively faulted and rearranged Basin and Range (Schmidt 1993). If one examines the geomorphology of the Colorado River Corridor, and the numerous side canyons, two different formation patterns are present. Most of the side canyons follow natural lines of weakness in the geology (e.g., faults, fractures, soft rock). However, the main corridor of the Canyon seems to defy both physics and reason by traveling across fault lines and against the tilt of the stratigraphy along most of its length. The most obvious example of this peculiar hydrologic behavior can be observed where the Colorado River intersects the Kaibab Plateau. Instead of flowing around the Kaibab Plateau and taking what one would assume to be the path of least resistance, the Colorado River cuts through the

Kaibab Plateau at almost its highest point (Figure 3.4), creating the Kaibab Plateau on the north side of the river and the Coconino Plateau on the south side of the river (Schmidt 1993). Recent investigations by Karlstrom et al. (2014) indicate that these seemingly anomalous features of the Grand Canyon are actually the result of a complex formation history where two older paleo-canyons were merged with two younger canyons around 5-6 million years ago. Below I provide a brief discussion on changing hypotheses on how the Grand Canyon was formed.

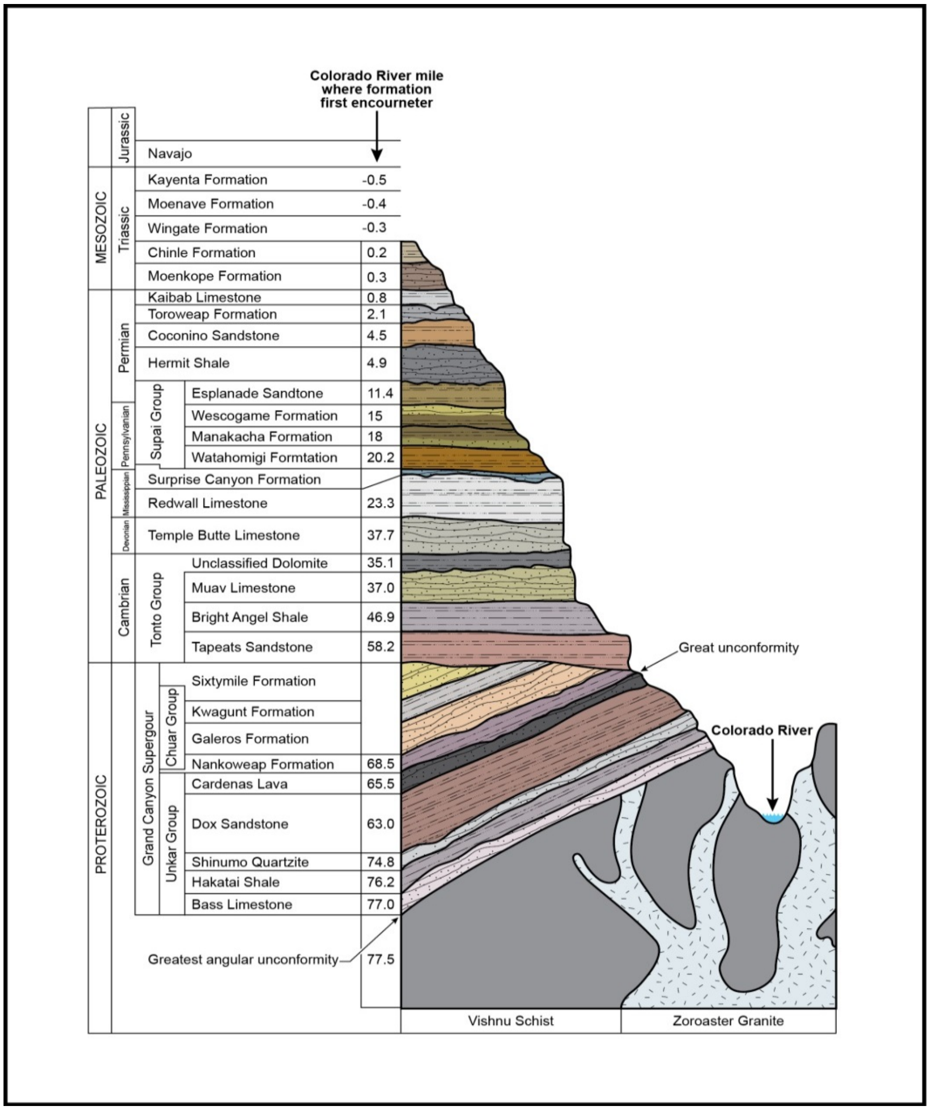

Figure 3.3. Geology of the Grand Canyon region Cross Section (from USGS Open File Report 96-491).

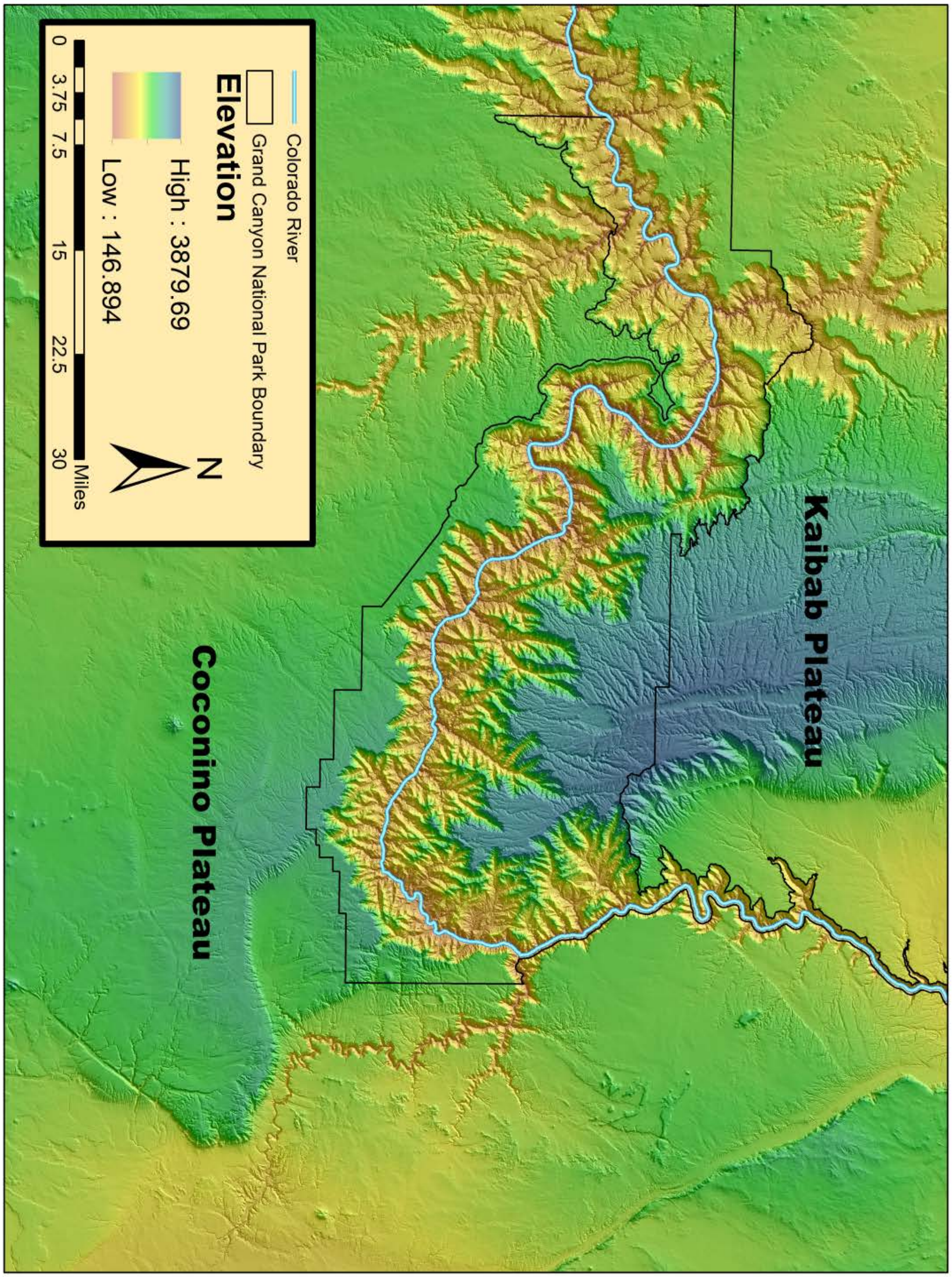

Figure 3.4. The Colorado River cutting through an upwarp, creating the Kaibab Plateau on the north side of the river and the Coconino Plateau on the south side of the river.

Three contrasting views have been developed on the formation of the Grand Canyon (Karlstrom et. al. 2014, Lucchitta 2003). One view initiated by Powell and Dutton (1882) was that the Colorado River developed during a specified time and generally in its current location. Any statements about one part of the river apply to it as a whole, i.e., either the river is old or young. Since the canyon was so deep, compared to other canyons on the Colorado Plateau, it was thought that the formation must have been occurring for a very long time and likely since the recession of the great inland sea that covered large portions of North America, during the early Eocene periods (56-47 million years ago). These hypotheses held for over half-a-century until geologists turned their attention to examining the Canyon's dramatic stratigraphy to answer larger questions about geomorphology.

During the 1930s and 40s, geologists begin to find evidence calling the earlier formation hypotheses of Powell and Dutton into question. First was the discovery of gravel and other deposits all along the Colorado River that ranged in age from 23 million years ago to 2.6 million years ago, and second no evidence of an older drainage system could be found. Instead, the geologists found evidence that the area round the Grand Wash Cliffs (the west end of the Grand Canyon near Lake Mead) was a large basin with no outlet that likely housed a shallow salt lake dating to around 5-6 million years ago. Therefore it was argued, if one follows the monophasic view that the Canyon was formed during one time period, then it could be no older than 6 million years, after the basin around the Grand Wash Cliffs opened into the Gulf of California. Continuing research in the 1950s and 60s (summarized by Hunt 1969), however, discovered widespread evidence of early ancestral drainages in the upstream sections of the river located in the plateau country of Arizona, Utah, and Colorado. These ancestral drainages departed from the present course of the Colorado River, at the latest during the early Miocene (23million years ago), but possibly as far back as the Oligocene (33million years ago). These new data on ancestral drainages resulted in a situation where the Colorado River seemed to date to the Oligocene-Miocene (33-5 million years ago) in its upper reaches and to the Miocene or Pliocene (23-2) in its lower reaches. It was obvious that a new origin theory needed to be developed that allowed for a multiphase development. Continued research in the lower reaches of the river indicated the current canyon is no older than the late Miocene (5million years ago), when rifting eventually opened the Gulf of California. In the upper reaches of the river several possible routes emerged as plausible courses for an ancestral Colorado River, with both the Little Colorado and Rio Grande drainages hypothesized as possible routes (Mckee et al. 1967). Research by Lucchitta (1984, 2003) seems to indicate that the upper reaches of the Colorado River continued generally along its present course in Marble Canyon and across the Kaibab Plateau through now long-gone “racetrack-shaped” valleys in the area of the Kanab, Uinkaret or Shivwits plateaus and terminated at an unknown destination, likely long-since eroded away during the formation of the modern Grand Staircase Escalante and Zion regions. Once the Gulf of California was opened, the upper reaches of the ancestral river were captured by the lower Colorado drainage somewhere around the Kaibab Plateau sometime around 5 million years ago, forming the course of what we today call the Colorado River.

More recently, Karlstrom and his colleagues (2014) have used apatite fission-track dating to investigate the formation history of the Grand Canyon. The results of their research indicate that the middle-west section of the Canyon, they name the Hurricane Fault Segment, was carved to half of its current depth 65-50 million years ago, by a paleo-canyon that flowed northward through now eroded Mesozoic Era (250-65 million years ago) strata. The middle-east section of the canyon, they term the Eastern Grand Canyon Segment, was carved about 25-15 million years ago, to about half of its current depth, by a paleo-river that extended approximately 100 kilometers from the modern Canyon close to the modern Virgin River, and terminating as either the Crooked Ridge or Little Colorado paleo-rivers. The two end segments, Marble Canyon to the east, and to the west an area they term the Westernmost Grand Canyon Segment, were both carved beginning about 6 million years ago. The current Grand Canyon was formed 5-6 million years ago by the integration of the two younger segments (Marble and Westernmost) with the two older segments (Hurricane Fault and Eastern). Since that time, the Grand Canyon has widened and deepened at the rate of about 100-200 meters per million years (Karlstrom et. al. 2014). This most recent investigation disproves both the deep-time and more recent monophasic carving of the Canyon, and suggests a more complex formation history, where multiple paleo-canyon were integrated into the current Canyon about 5 million years ago.

CLIMATE

The climate of Grand Canyon is diverse and controlled by elevation and landforms. In general, the North Rim is the coolest and most wet region, the River Corridor is the hottest and most arid, and the South Rim is somewhere in between (Table 3.1 and 3.2).

Table 3.1. Temperature data for Grand Canyon National Park. (http://www.nps.gov/grca/planyourvisit/weather-condition.htm, accessed 1/19/2014 9:50 PM EST).

South Rim Average Temps												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
High (F)	41	45	51	60	70	81	84	82	76	65	52	43
Low (F)	18	21	25	32	39	47	54	53	47	36	27	20
Inner Canyon Average Temperatures												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
High (F)	56	62	71	82	92	101	106	103	97	84	68	57
Low (F)	36	42	48	56	63	72	78	75	69	58	46	37
North Rim Average Temperatures												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
High (F)	37	39	44	53	62	73	77	75	69	59	46	40
Low (F)	16	18	21	29	34	40	46	45	39	31	24	20

Table 3.2. Precipitation data for Grand Canyon National Park .
– winter snowfall was converted by NPS to precipitation values at roughly a rate of 10 to 1, e.g. 10 inches of snow would be recorded as 1 inch of precipitation] (http://www.nps.gov/grca/planyourvisit/weather-condition.htm, accessed 1/19/2014 9:50 PM EST).

Average Precipitation in Inches													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
South Rim	1.32	1.55	1.38	0.93	0.66	0.42	1.81	2.25	1.56	1.1	0.94	1.64	15.56
Inner Canyon	0.68	0.75	0.79	0.47	0.36	0.3	0.84	1.4	0.97	0.65	0.43	0.87	8.51
North Rim	3.17	3.22	2.65	1.73	1.17	0.86	1.93	2.85	1.99	1.38	1.48	2.83	25.26

The South Rim has its lowest average temperatures in January (18°F low and 41°F high) and highest average temperatures in July (54°F low and 84°F high). The Inner Canyon has the overall warmest high and low temperatures, with the lowest temperatures occurring in January (36°F low and 56°F high) and the highest in August (78°F low and 106°F high). The overall lowest average temperatures in the Park occur on the North Rim, where January is the coldest month (16°F low and 37°F high) and July is the hottest month (46°F low and 77°F high).

The precipitation levels in the Canyon are also controlled by elevation and landform, with the North Rim receiving the highest total (25.26 inches), the Inner Canyon the lowest total (8.51 inches), and the South Rim roughly in between the other two regions (15.56 inches). Precipitation falling on the rims from December through February is principally snow, while precipitation in the months of October, November, March and April can be a mixture of snow or rain depending on the temperature, and precipitation throughout the rest of the year is rain. Precipitation in the Inner Canyon is predominately rain with some light snow possible during extreme cold snaps. The highest average winter precipitation accumulations occur on the South Rim in December (1.64 inches of precipitation or 16.4 inches of snow) and on the North Rim in February (3.22 inches of precipitation or 32.20 inches of snow). An examination of the precipitation data also reveals a secondary spike of precipitation in the summer during the months of July, August, and September. The biseasonal precipitation pattern is found throughout the Southwest (Sullivan and Ruter 2006) and the summer increase in rain is often referred to locally as the summer monsoon season. The weather pattern is created by a shift in wind patterns that brings moisture from the Gulf of Mexico and Gulf of

California to the parched and heated lands of northern Mexico and the southwest United States (Schmidt 1993). A low pressure trough is created over the Southwest, due to the heating up of the land over the summer months, this trough is then filled with moist air from the Pacific that changes the wind patterns and delivers the moist air first to northern Mexico and then to the Southwest, resulting in the summer rainstorms. In the Canyon, there is definite increase in precipitation peaking in August, with average totals on the South Rim at 2.25 inches, the Inner Canyon at 1.4 inches, and on the North Rim at 2.85 inches.

Overall the variation in temperature and precipitation throughout the Canyon is influenced by elevation and landform. The plants, animals, and even human habitation are all affected by the creations of very distinct climatic zones that impact where specific vegetation can grow. While prehistoric peoples could manipulate vegetation and animal habitats, temperature and precipitation are environmental factors that are beyond control, both prehistorically and today. However, even though they lacked the ability to control the climate, prehistoric peoples of the Canyon were able to employ methods, such as anthropogenic burning, to encourage the growth of economically important resources. As I will more fully discuss in later chapters, the ability of Pueblo Period native peoples to engineer ecosystems, in an already diverse environment, made the Canyon an ideal place for pioneering prehistoric peoples to experiment with assorted subsistence strategies.

MODERN AND PALEO ECOLOGIES

From a biogeographical perspective, the Canyon's verticality influences the distribution of many species. In certain instances, it serves as an isolation barrier to species and populations. The most common example is the Kaibab squirrel (*Sciurus aberti kaibabensis*), a dark gray, almost black, squirrel with a white tail and white tasseled ears. This beloved, fuzzy-eared animal is only found on the Kaibab Plateau on the North Rim of Grand Canyon and was separated from its brethren, the Albert squirrel (*Sciurus aberti*), and the common tassel-eared red tree squirrel found throughout the southwest, including on the South Rim of the Park, and developed into a separate species. In other cases it serves as a corridor for certain species, such as migratory birds, fish, and reptiles. The Grand Canyon is also a hideaway for some species, such as the Grand Canyon pink rattlesnake (*Crotalus oreganus abyssus*), and native plants like the McDougall's yellow tops (*Flaveria mcdougallii*) a member of the sunflower family. Finally for some species, the Canyon is inconsequential to their distribution and movement. For example, the desert mule deer (*Odocoileus hemionus*) and ravens (*Corvus corax*) can be found throughout the Canyon. These factors make the Grand Canyon's ecology one of the most diverse on the Colorado Plateau (Carothers and Brown 1994).

Biotic Communities

Biotic communities at Grand Canyon were first described by C. Hart Merriam, the father of the life zone concept (geographic areas with similar plant and animal communities). In 1899, Merriam proposed to carry out an extensive biological survey of a high mountain region, where he would be able to describe the succession of plant and animal life, from the summit to the base of the mountain. Merriam decided the San Francisco Mountains in the Arizona territory were a suitable area for his study "because of its southern position, isolation, great altitude, and proximity to an arid desert" (Merriam 1890:136). For two months, Merriam and his team conducted fieldwork on the

San Francisco Mountain peaks, the Painted Desert, and in the Grand Canyon. The extensive variability in biodiversity found in this topographically constrained area, and documented by Merriam and his team, led to his developing and publishing the concept of life zones. He used the results of this Arizona study to extrapolate life zones for the entire North American continent (Sterling 1974). Refinement of Merriam's original life zones continued throughout the twentieth century, resulting in the biotic communities recognized today (Cole 1990, Vankat 2013, Warren et. al. 1982). Most of the major biotic communities identified in Arizona are found at the Grand Canyon (Figure 3.5), including forests and woodlands, desert scrub, riparian woodlands, and barrens (Carothers and Brown 1994).

Forests

The Grand Canyon contains four conifer forest biotic communities: spruce/fir, mixed coniferous, ponderosa pine, and pinyon/juniper. The spruce/fir forest at Grand Canyon is only found on a portion of the North Rim at elevations above 8,700 feet. The trees found in this biotic community include blue spruce (*Picea engelmannii*), fir (*Abies lasiocarpa*), white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*), and Douglas fir (*Pseudotsuga menziesii*). The area is also referred to by Rasmussen (1941) as a mixed coniferous forest, but Warren and colleagues (1982) distinguish between spruce/fir forests and mixed coniferous forests.

The mixed coniferous forest is also found on the North Rim at a slightly lower altitude than the spruce/fir at an elevation of 8,250 feet to 8,700 feet. The trees associated with this forest include fir (Abies *concolor*), ponderosa pine (*Pinus ponderosa*), Aspen (*Populus trernuloides*), and Douglas fir (*Pseudotsuga menziesii*).

The ponderosa pine forest occurs on both the North and South rims on the Kaibab and Coconino plateaus and between the elevations of 6,500 feet and 8,500 feet. Here ponderosa pine (*Pinus ponderosa*) mixes with pinyon (*Pinus edulis*), juniper (*Juniperus osteosperma*), and big sagebrush (*Artemisia tridentate*) at the lower elevations and with white fir (*Abies concolor*) and aspen (*Populus trernuloides*) at the higher elevations.

The pinyon and juniper forests of the Grand Canyon also occur on both the North and South rims, at elevations below 7,000 feet. Common plants associated with the pinyon and juniper include big sagebrush, Mormon tea (*Ephedra virid*), snake weed (*Gutierrezia sarothrae*), and banana yucca (*Yucca baccata*).

Desert Scrub

The Grand Canyon is situated at the edge of three of the four major desert regions found in North America: Sonoran Desert, Mojave Desert, and the Great Basin Desert. Variation in elevation and climatic factors determine the floristic composition of the two desert scrub biotic zones (Beatley 1975). In particular, the frequency and intensity of freezing weather is the major factor that determines which desert biotic community is present. Two, desert scrub biotic zones encompass the Grand Canyon: warm desert scrub and cold desert scrub. The cold desert scrub experiences longer and more intensive bouts of freezing weather, while the warm desert scrub experiences much shorter and less intense stretches of freezing weather

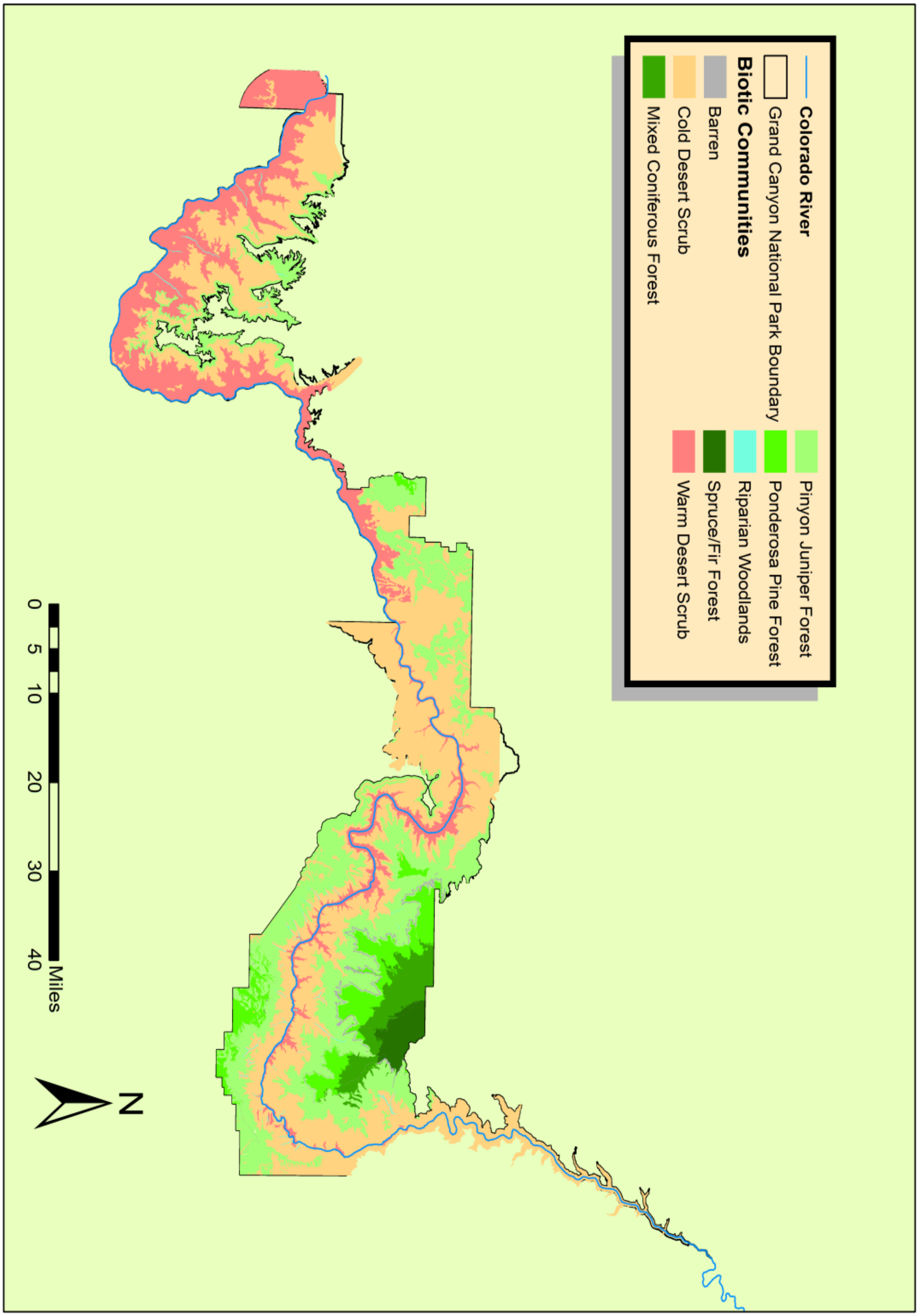

Figure 3.5. Biotic communities within Grand Canyon National Park.

The cold desert scrub biotic zone is composed of Great Basin Desert plant associations and is located principally upstream of the little Colorado River, in Marble Canyon, and along the Tonto and Shivwits plateaus. Representative vegetative species include big sagebrush, rabbit brush (*Chrysothamnus spp*.), Mormon tea, and a variety of perennial grasses such as blue grama (*Bouteloua gracilis*), Indian rice grass (*Oryzopsis hymenoides*), and needle grasses (*Stipa spp*.) (Warren et al. 1982).

The warm desert scrub biotic zone is composed of the Mohave and Sonoran Desert vegetation associations. It is found along the Colorado River from the confluence of the Little Colorado and Colorado rivers to the Grand Wash Cliffs. Representative species include turpentine broom (*Thamnosma montana*), bladder sage (*Salazaria Mexicana*), rabbitbrush, blackbrush (*Coleogyne ramosissima*), brittlebrush (*Encelia farinosa*), catclaw acacia (*Acacia greggii*), and ocotillo (*Fouquiera splendens*) (Warren et al. 1982).

Riparian Woodlands

Riparian woodlands are principally found within side canyons with perennial streams below the rim line throughout GRCA. Riparian woodlands are characterized by cottonwood (*Populus fremontii*) and willow (*Salix spp.)* vegetation associations; and in some environments, such as below Roaring Spring and Thunder River, uncommon species such as scarlet sumac (*Rhus glabra*), water birch (*Betula occidentalis*), red-osier dogwood (*Cornus stolonifera*), and Knowlton hop-horn bean (*Ostrya knowltoni*) (Warren et al. 1982). Clover and Jotter (1944) described the riparian vegetation along the Colorado River, but the construction of the Glen Canyon Dam has dramatically changed the composition of the riparian zone along the Colorado River, which is now dominated by exotic plants, such as salt cedar (*Tamarix chinenis*) and camelthorn (*Alhagi camelorum*) (Carothers et al. 1979).

Barrens

The barrens are minor transition zones, principally along the edge of the Canyon rim. As the name suggests there are no vegetative associations with this biotic community, as it is dominated by bare rock outcrops.

Vegetation

The Grand Canyon is located in a transition zone between the cold-climate vegetation communities of the Colorado Plateau and the warm-climate deserts of the Southwest and Great Basin. As previously discussed, the Canyon creates a corridor, whereby species from both regions are brought into close association (Cole 1990; Schmidt 1993). The large variety of landforms, climate zones, and elevations created a great diversity of vegetation associations in the Canyon. A total of 61 vegetation associations (Table 3.3 and Figure 3.6) were identified and mapped in the Park by Warren et al. (1982), a large number for such a limited geographic area. I will summarize the most important vegetation associations employed in this analysis below, but for a detailed discussion of the distribution, floristics, and physiognomy of all 61 vegetation associations, see Vankat 2013 and Warren et al. (1982).

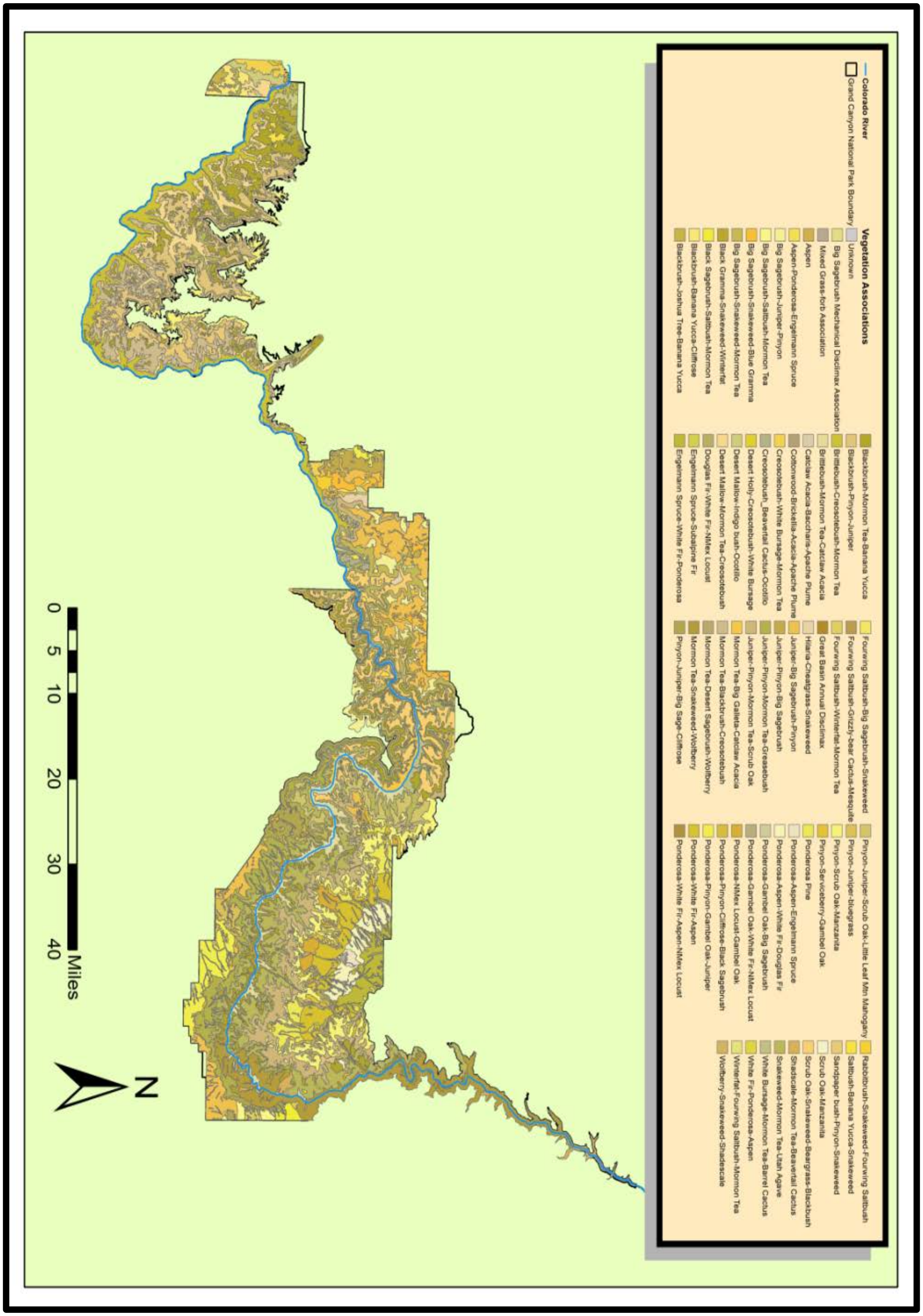

Figure 3.6. Vegetation associations identified and mapped by Warren et al. (1982).

Table 3.3. Vegetation associations (Warren et al. 1982) and corresponding archaeological site presence (GRCA GIS), wild resource production (Dunmire and Tierney 1997) and maize agricultural (Kuwanwisiwma and Ferguson (2009) potential.

Mapping Unit #	Vegetation Association Name	Archaeology Site Presence	Wild Resource Production	Maize Agriculture Potential
Forest and Woodland				
121 Boreal Forests and Woodland				
121.3111	Engelmann Spruce-Subalpine Fir*	X		
121.3171	Engelmann Spruce-White Fir-Ponderosa*	X	X	
121.3172	Aspen - Ponderosa - Engelman		X	
122 Cold Temperate Forests and Woodlands				
122.3121	Douglas Fir - White Fir - New Mexican Locust		X	X
122.3211	Ponderosa-Aspen-Engelmann Spruce*	X		
122.3212	Ponderosa Pine*	X	X	
122.3221	Ponderosa-Aspen-White Fir-Douglas Fir*	X	X	
122.3222	Aspen - Ponderosa - Engelman			
122.3231	Ponderosa-New Mexican Locust-Gambel Oak*	X	X	
122.3232	Ponderosa-Pinyon-Cliffrose-Black Sagebrush*	X	X	
122.3233	Ponderosa-Pinyon-Gambel Oak-Juniper*	X	X	X
122.3234	Ponderosa-Gambel Oak-Big Sagebrush*	X	X	X
122.3261	Ponderosa-Aspen-Engelmann Spruce*	X		
122.3271	Ponderosa-White Fir-Aspen*	X	X	
122.3272	Ponderosa-White Fir-Aspen-New Mexican Locust*	X	X	
122.3273	White Fir - Ponderosa - Aspen		X	
122.3274	Ponderosa - Gambel Oak - White Fire -New Mexican Locust		X	
122.4141	Pinyon-Juniper-Scrub Oak-Little Leaf Mtn Mahogany*	X	X	
122.41411	Juniper-Pinyon-Mormon Tea-Greasebush*	X	X	X
122.4142	Juniper-Pinyon-Mormon Tea-Scrub Oak*	X	X	X

122.4143	Juniper-Pinyon-Big Sagebrush*	X	X	X
122.4144	Juniper-Big Sagebrush-Pinyon*	X	X	X
122.4145	Pinyon-Juniper-Big Sage-Cliffrose*	X	X	X
122.4146	Pinyon-Scrub Oak-Manzanita*	X	X	X
122.4147	Blackbrush-Pinyon-Juniper*	X	X	X
122.4148	Pinyon-Serviceberry-Gambel Oak*	X	X	X
122.4149	Pinyon-Juniper-bluegrass*	X	X	X
122.7111	Aspen - Ponderosa		X	
Scrubland Formation				
133	Warm Temperate Scrubland			
133.3111	Quercus turbinella - *Astrostaphylos pungens*		X	
Grassland Formation				
142	Cold Temperate Grasslands			
142.2511	Hilaria-Cheatgrass-Snakeweed*	X	X	X
142.411	Mixed Grass-forb Association*	X	X	
143	Warm Temperate Grasslands			
143.1131	Black Gramma-Snakeweed-Winterfat*	X	X	X
Desertland Formation				
152	Cold Temperate Desertlands			
152.1111	Big Sagebrush-Snakeweed-Blue Gramma*	X	X	X
152.11121	Big Sagebrush-Juniper-Pinyon*	X	X	X
152.11211	Big Sagebrush-Snakeweed-Mormon Tea*	X	X	X
152.1142	Black Sagebursh - Saltbush -Mormon Tea		X	X
152.1311	Blackbrush-Mormon Tea-Banana Yucca*	X	X	X
152.14211	Rabbitbrush-Snakeweed-Fourwing Saltbush*	X		X
152.1531	Winterfat - Four-Wing Saltbush - Mormon Tea		X	X
152.16209	Scrub Oak-Snakeweed-Beargrass-Blackbush*	X	X	X
152.1721	Fourwing Saltbush-Big Sagebrush-Snakeweed*	X		X

152.1722	Saltbush-Banana Yucca-Snakeweed*	X	X	X
152.1723	Four-wing Saltbush - Winterfat - Mormon Tea		X	X
153	Warm Temperate Desertlands			
153.11011	Snakeweed-Mormon Tea-Utah Agave*	X	X	X
153.11012	White Bursage-Mormon Tea-Barrel Cactus*	X		
153.11014	Mormon Tea-Snakeweed-Wolfberry*	X	X	X
153.11015	Mormon Tea-Big Galleta-Catclaw Acacia*	X	X	
153.1111	Creosotebush_Beavertail Cactus-Ocotillo*	X		
153.11211	Creosotebush-White Bursage-Mormon Tea*	X	X	
153.12109	Blackbrush-Mormon Tea-Banana Yucca*	X	X	X
153.1212	Blackbrush-Joshua Tree-Banana Yucca*	X	X	X
153.12131	Blackbrush-Banana Yucca-Cliffrose*	X	X	X
153.1721	Desert Holly - Creosotebush -WhiteBursage			
153.1731	Fourwing Saltbush-Grizzly-bear Cactus-Mesquite*	X		X
153.1741	Shadscale-Mormon Tea-Beavertail Cactus*	X	X	X
153.18111	Desert Mallow-Mormon Tea-Creosotebush*	X	X	
153.1812	Desert Mallow - Indigo Bush - Ocotillo			
153.1911	Brittlebush-Creosotebush-Mormon Tea*	X	X	
153.19119	Brittlebush-Mormon Tea-Catclaw Acacia*	X	X	X
Wetland Forest Formation				
223	Warm Temperate Swamp and Riparian Forest			
223.2121	Cottonwood-Brickellia-Acacia-Apache Plume*	X	X	
Strand Formation				
253	Warm Temperate Strands			
253.4221	Catclaw Acacia-Baccharis-Apache Plume*	X	X	X

Forest and woodland vegetation associations are the most diverse (28 associations), and have the second largest distribution (518,941 acres), in the Park (Figure 3.7). The forest vegetation associations are found principally on the high plateaus above the Canyon's rim. However, there are several smaller plateaus above the Colorado River and just below the Rim, such as Powell Plateau, which are also forested. The forests on the Kaibab Plateau on the North Rim have the largest diversity in the number of species, due in part to a greater change in elevation. The differences in forest vegetation associations on the North Rim occur in four large bands that are then also subdivided into smaller bands by cross-cutting valleys. The soil differences created by these topographic changes have resulted in a diverse set of biota associations (Warren et al. 1982). The forested regions within the rest of the park, including the South Rim and all areas below the rim line, are all below 7,600 feet and are represented by a mixture of ponderosa pine and/or pinyon juniper woodlands.

The grassland vegetation communities are only found in four areas of the park, the North Rim, Toroweap Valley, above the Grand Wash Cliffs, and near Nankoweap. There are four mapping units identified for this vegetation association and they only cover 8,224 acres of land (Figure 3.8). The grasslands found on the North Rim, occur in valley bottoms and sinkholes in small slivers between the varying woodlands. These mountain meadow environments contain a large number of grass species, with sedges in some of the wettest sinkhole areas, which are bordered by a variety of herbs and mixed grasses in the drier areas (Warren et al. 1982). The grasslands found in the Toroweap Valley, south of the Grand Wash Cliffs and near Nankoweap, are classified as semidesert scrubland and predominately consist of small perennial bunch grasses and smaller shrubs.

The desertland vegetation associations, while not quite as diverse as the forest and woodland associations are still quite varied and represented by 21 mapping units that cover the largest area of any of the vegetation formations at 672,179 acres (Figure 3.9). The desertland associations can be divided into two biotic communities, cold desertscrub and warm desertscrub. The cold desertscrub communities are characterized by the types of plants found in the Great Basin Desert. These communities are found on the lower elevation plateaus on the Canyon rims (e.g., Kanab, Uinkaret, and Lower Basin) and along some of the higher elevations slopes and terraces in the inner canyon. The cold desertscrub is dominated on the plateaus by sagebrush, on inner canyon terraces by blackbush and saltbush is found in both locales. The cold desertscurb, is often found in conjunction with pinyon-juniper woodland associations, and share many of the same species. The warm desertscrub communities are found below the Canyon Rim in the Inner Canyon. The plants in these communities do not tolerate cold weather well and will be killed by any major freezes. The intolerance to cold limit their distribution in the Canyon to areas that do not tend to freeze, which are areas located below 4,000 feet in elevation. The plant species present are typical of both the Sonoran and Mohave deserts, though Warren et al. (1982) principally classified associations based on the Mohave desert categories due to the predominance of species from that desert.

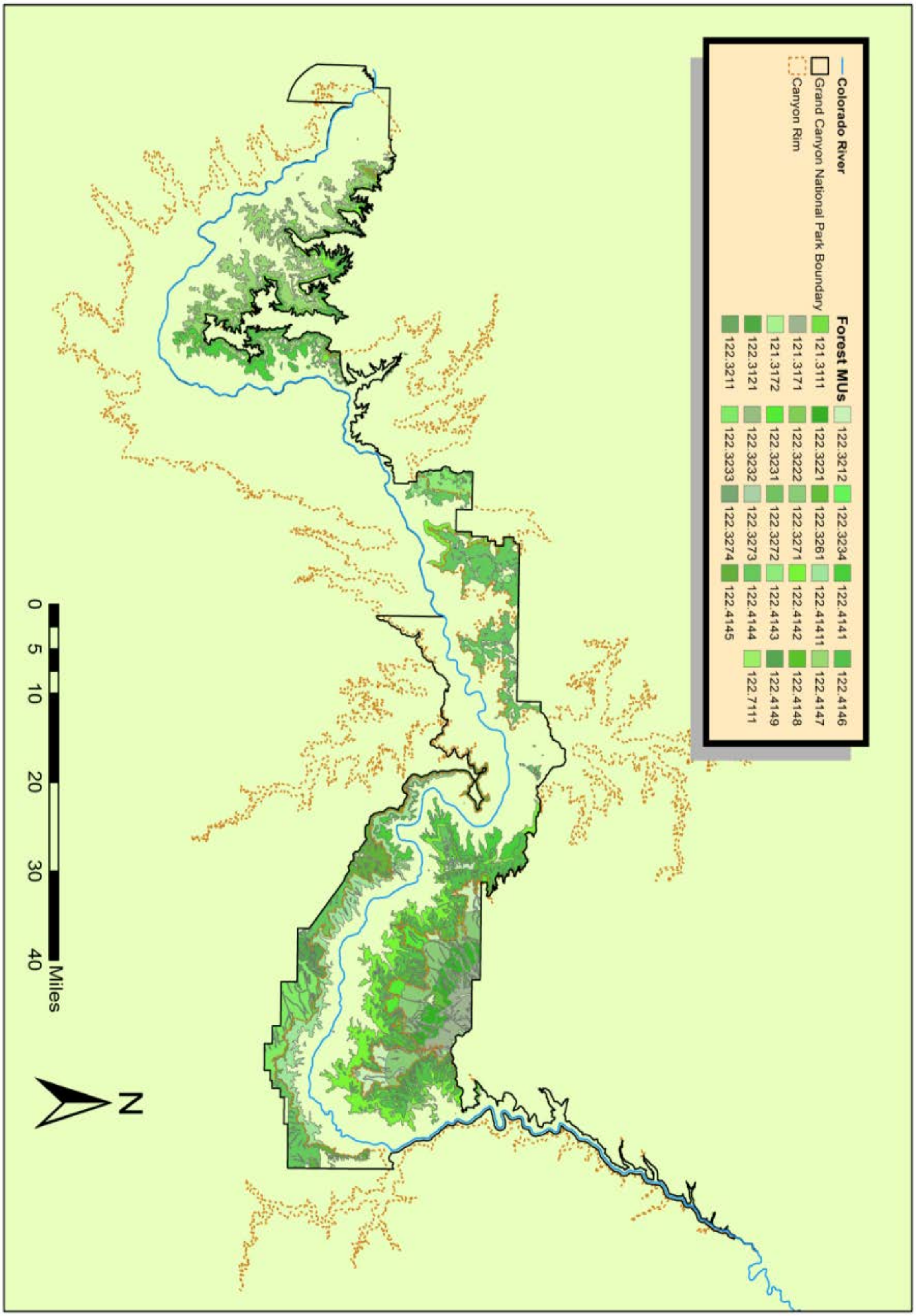

Figure 3.7. Forest and woodland vegetation associations.

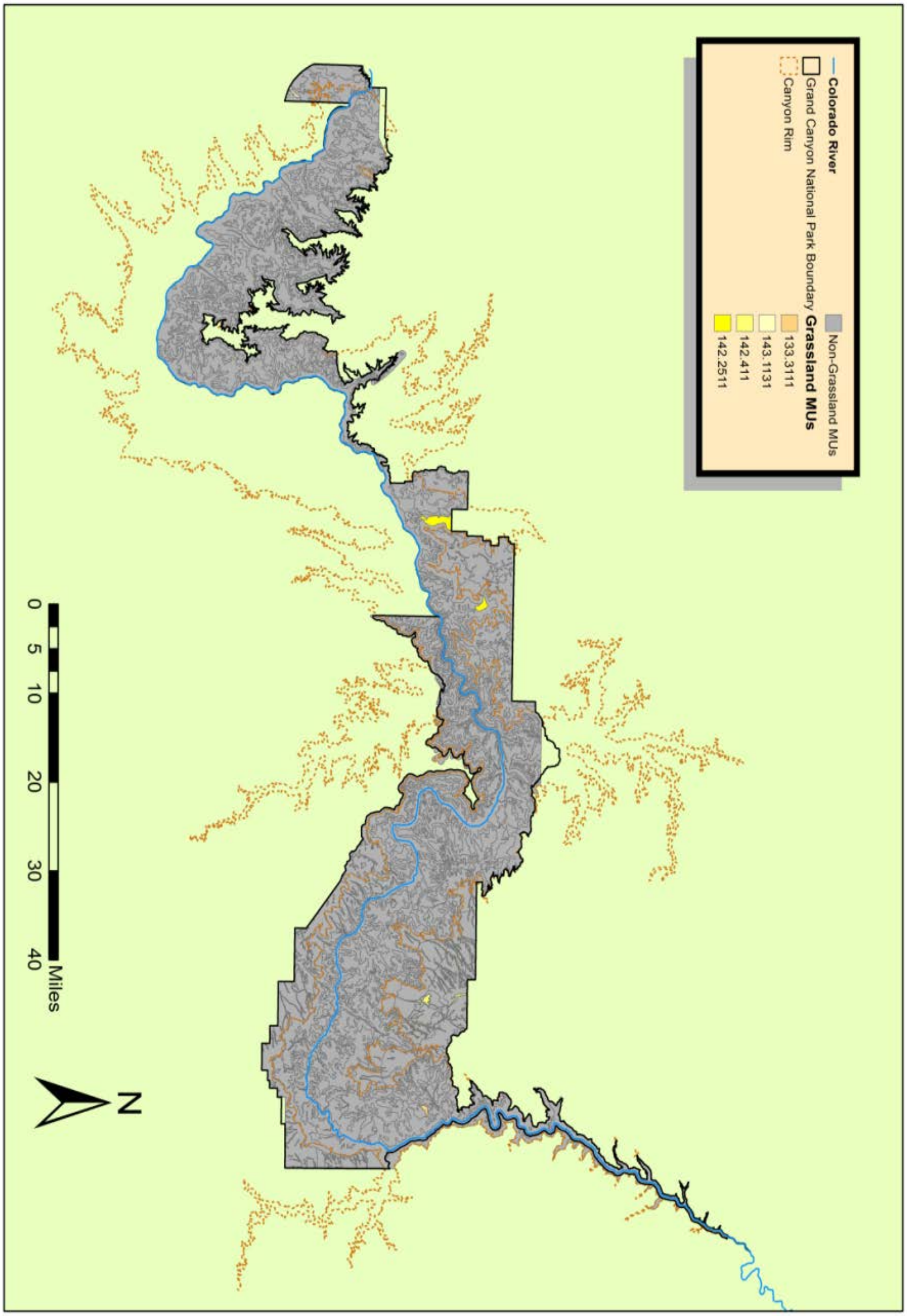

Figure 3.8 Grassland vegetation associations.

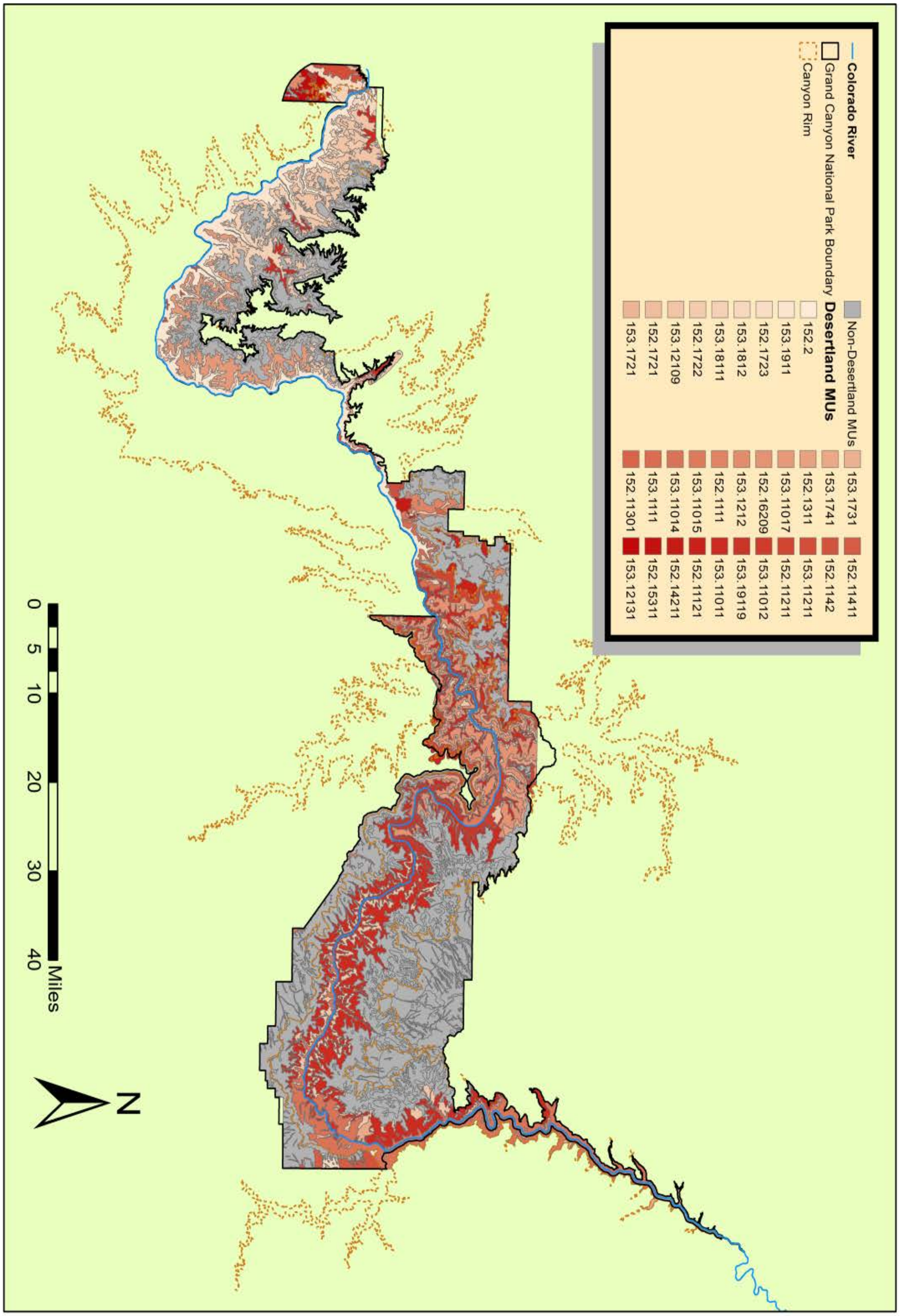

Figure 3.9 Desertland vegetation associations.

The wetland forest and strand vegetation associations cover the smallest land area in the Park, encompassing only 3,758 acres (Figure 3.10). These are predominately riparian communities, and though they are the most complex assemblage of plant species they were divided into only two mapping units. The alternative would have been to give each dry wash, spring, seep, pond, or stream its own mapping unit, as each of these natural features has unique vegetation associations based upon localized environmental conditions. Instead of such a fractured classification scheme all of these different associations were lumped by Warren et al. (1982) into two associations: one with perennial water sources (permanent springs and streams) and woodlands, termed the wetland forests, and one that is near intermittent or ephemeral water sources and no woodlands, termed strand vegetation communities.

Southwest Indigenous Plant Usage

Native peoples have exploited a wide variety of vegetation throughout the Southwest. In their book *Wild Plants and Native Peoples of the Four Corners* Dunmire and Tierney (1997) extensively describe the plants that were used both historically and prehistorically by indigenous peoples in the Colorado Plateau region. Table 3.4 lists the both the scientific and common names of the plants that were used as either food or beverage and that have been identified at prehistoric sites. Many of these sites occur at the Grand Canyon and, as I discuss below, are the vegetation associations that will be examined in relation to archaeological sites.

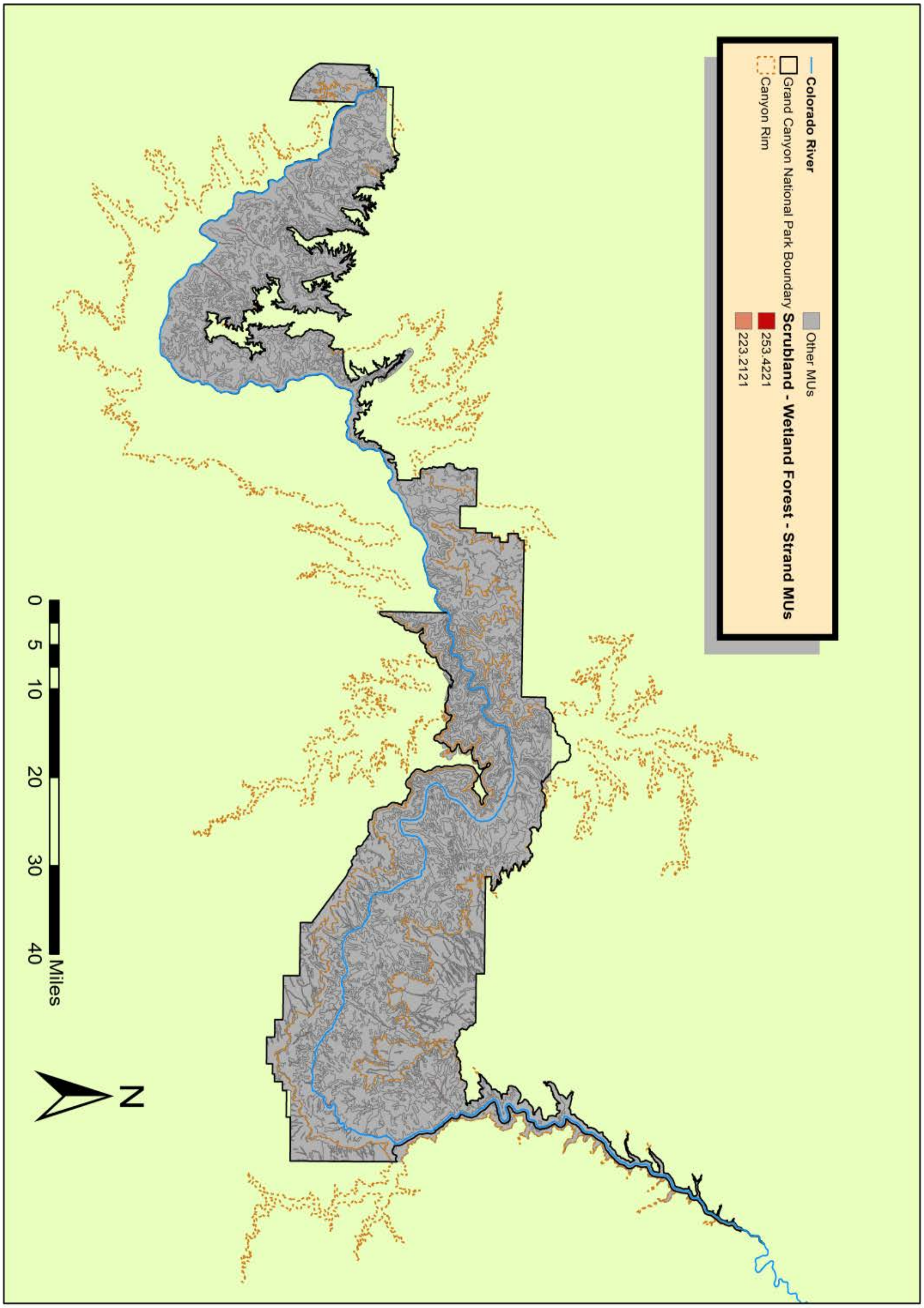

Figure 3.10 Wetland Forest, and Strand vegetation associations.

Table 3.4 Wild plants utilized by native peoples in the Four Corners area, including the Grand Canyon (Dunmire and Tierney 1997).

Scientific Name	Common Name
Ammaranthus spp.	amaranth
Amelanchier spp.	serviceberry
Anemopsis californica	yerba mansa
Artemisia tridentata	big sagebrush
Artiplex spp.	saltbrush
Atriplex canescens	fourwing saltbrush
Atriplex concertifolia	shadscale salbrush
Celtis reticulata	netleaf hackberry
Chenopodium spp.	goosefoot
Cleome serrulata	Rocky Mountain beeplant
Corispermum spp.	bugseed
Cryptantha spp	hidden flower
Cycloloma atriplicifolia	winged pigweed
Descurainia spp.	tansy mustard
Echinocereus spp	hedgehod cactus
Ephedra spp.	joint-fir
Eriogonum spp.	wild buckwheat
Scientific Name	**Common Name**
Helianthus spp.	sunflower
Juncus spp.	rush
Juniperus spp.	juniper
Lepidium spp.	peppergrass
Lycium pallidum	wolfberry
Mentzelia albicaulsi	witestem blazing star
Opuntia spp.	cholla &prickly pear cactus
Oryzopsis hymenoides	Indian ricegrass
Pectis angustifolia	lemoncillo
Physalis spp.	groundcherry
Pinus edulis	pinyon pine
Polanisia spp.	clammyweed
Poliomintha incana	hoary rosemary-mint
populus spp.	cottonwood
Portulaca retusa	nothcleaf purslane
Prunus virginiana	chokecherry
Quercus spp	oak

Table 3.4, cont.

Rhus trilobata	threeleaf sumac
Ribes spp.	gooseberry or currant
Sclerocactus whipplei	sclerocactus little barrel cactus
Sparganium spp.	bur-reed
Sphaeralcea spp.	globe-mallow
Sporobolus spp.	dropseed
Symphoricarpos spp.	snowberry
Tetradymia canescens	horsebrush
Vitis arizonica	canyon grape
Yucca baccata	banana yucca
Yucca spp.	yucca

Vegetation associations can also be utilized to examine areas that are suitable for maize agriculture. Kuwanwisiwma and Ferguson (2009) provide the common and Hopi names of three plants (saltbush, greasewood, and rabbitbrush) that Hopis conducting archaeological research in the Grand Canyon associated with locations that were areas of high agricultural potential. In areas with sandy soil the presence of saltbush or greasewood and any area containing rabbitbrush were areas with great farming potential. These are the plants that the Hopi would look for when deciding that an area was an appropriate place to plant their maize fields.

For this study I utilized Kuwanwisiwma and Ferguson's (2009) Hopi data concerning land with a high potential for successful maize agriculture, along with the wild plant consumption data provided by Dunmire and Tierney (1987), to reclassify the vegetation association layer into areas suitable for maize agriculture, wild plant production, or combination of both. As shown in Table 3.3, 50 out of 61 vegetation associations mapped in the Park contain wild plants that would have been exploited prehistorically. Conversely, vegetation associations that contain at least one of the plants identified by the Hopi as corresponding to prime maize farmland, occur in 33 out of 61 of the Grand Canyon's vegetation associations. Based on these data if Pueblo Period inhabitants of the Canyon were principally maize agriculturalists, the interpretation favored by those following the SARG Approach, I would expect sites to occur predominately in the 33 vegetation associations identified as containing saltbrush, greasewood, or rabbitbrush. However, if the prehistoric indigenous peoples primarily exploited wild resources, as proposed by those following the UBARP Approach, I would expect the sites to be much more widely dispersed throughout the Canyon in any of the 50 vegetation associations containing wild plant resources. In Chapter 6, I will investigate the correspondence of archaeological sites to the mapped vegetation associations to determine test these ideas.

Paleoecology

The most extensive research on Grand Canyon paleoecology has been conducted by Kenneth Cole of the United States Geological Survey (Cole 1982, 1990). Cole found that, just as major biotic communities are controlled by physical geography and climate today, in the past those same two factors (physiography and climate) also constrained the development of these life zones (1990). Cole (1990) notes that since there have been no major modifications to the Canyon’s topography during the late Pleistocene and Holocene then one must examine climate to understand the link between modern environmental conditions and those of the past, thus the climate during these prehistoric periods should be examined.

Based on his Grand Canyon paleoecological research, which involves examining ancient pack rat nests, Cole (1990) posits that during the Late Pleistocene the total mean annual precipitation would have been 8.7 centimeters higher than current recorded precipitation values (Table 3.2), which results in a 24% increase on the South Rim and a 41% increase for Phantom Ranch, Further, Cole argues that temperatures would have been 6.7°C lower than modern values throughout the Canyon. Later, during the early- to mid-Holocene, temperature and precipitation levels are harder to estimate because the rapidly changing climate during this time is not readily apparent in the pack rat midden record; however, in general, temperatures would have been about the same or at most one degree higher, while precipitation levels would have been slightly lower (Cole 1990). By the Pueblo Period, temperature and precipitation would have settled into similar ranges as what we see historically in the Southwest, before the recent onset of climate change. This is not to say that climatic conditions were unchanged throughout the past 1,400 years, quite the contrary; as Salzer and Kipfmueller (2005) demonstrate even though temperature and precipitation were within modern ranges there were fluctuations in the past as there still are today between cool/dry, cool/wet, warm/dry and warm/wet overall conditions.

Salzer and Kipfmueller (2005) conducted a study examining two long-term proxy records of climate, precipitation and temperature reconstructions, developed from tree-ring data collected on the southern Colorado Plateau, and spanning over 1,400 years of prehistory (including all of the Pueblo Period). By employing two independently calibrated and verified climate reconstructions, from ecologically contrasting tree-ring sites on the southern Colorado Plateau, they were able to reveal decadal-scale climatic trends during the past two millennia. The study identified 30 extreme wet periods and 35 extreme dry periods in a 1,425-year precipitation reconstruction, and 30 extreme cool periods and 26 extreme warm periods in a 2,262-year temperature reconstruction. These two reconstructions were then integrated to identify intervals that were extreme with regards to both climatic variables (cool/dry, cool/wet, warm/dry, warm/wet) in order to develop the most accurate temperature and precipitation reconstruction. Blending temperature and precipitation histories using tree-ring data from different elevations allows an evaluation of their physical interaction on multiple spatiotemporal scales. Salzer and Kipfmueller (2005:466) note "most responsive trees are found near distributional edges and ecotonal boundaries, where climatic factors are most limiting. Hence boundary areas, such as lower forest border and subalpine tree line, are ideal for developing tree-ring chronologies at both the cold and arid limits of the trees." The best trees on the southern Colorado Plateau to develop past precipitation data are the lower elevation pines such as ponderosa pine, pinyon pine, and Douglas-fir (*Pseudotsuga menziesii*), while the high elevation Bristlecone Pine (*Pinus aristata*) provides data on temperature. "Through a comparison of these two growth records, paleo-climatic insight unobtainable from either record alone is generated, allowing an integrated view of temperature and precipitation variations," (Salzer and Kipfmueller 2005:466). Table 3.5 below illustrates Salzer and Kipfmueller's (2005) dual climatic extremes (cool/dry, cool/wet, warm/dry, warm/wet) from AD 570 to 1994.

The climatic differences between the Late Pleistocene and Holocene did have an influence on the location of biotic communities. According to Cole (1990), the majority of Grand Canyon plant species moved 600-1000m upward in elevation during the Pleistocene-Holocene transition. However, this elevation shift can be more accurately perceived as a latitudinal shift that produces an apparent upward movement because of the correlation between the elevation and latitude. The latitudinal nature of the shift is demonstrated in the paleoecological record of the Grand Canyon by the dominance of northerly species during the Late Pleistocene and southerly species during the Holocene These shifts in biotic community composition would have had the most effect on Paleo-Indian and Archaic peoples who visited the Canyon from about 12,000 to 3,000 years ago. By the time of the Pueblo, Proto-Historic and Historic periods, the modern biotic zones and climate cycles would have been in place.

Table 3.5 Climatic intervals from AD 570 to 1994 (from Salzer and Kipfmueller 2005).

Cool/Dry	Cool/Wet	Warm/Dry	Warm/Wet
663-664	688-695	706-717	1378-1380
699-700	729-736	878-884	1427-1434
823-824	804-805	1090-1091	1688-1695
847-851	987-989	1146-1154	1718-1721
900-902	1195-1204	1390-1393	1743-1744
1094-1101	1330-1334	1435-1443	1760-1761
1215-1219	1512-1515	1586-1593	1978-1988
1360-1364	1640-1647	1736-1742	
1666-1672	1763-1771	1753-1757	
1818-1823	1835-1840	1777-1783	
	1911-1912	1946-1947	
		1953-1972	

The one region of the Canyon where the modern biotic communities vary considerably from the past is the Colorado River and its flood zones. Prior to the construction of the Glen Canyon Dam in 1963, the Colorado River was a silt-laden river that was warm in the summer and cold in the winter. The river fluctuated between little or no flow during the pre-monsoon summer months and in excess of 200,000 cubic feet per second during spring floods (Fairley 2003, Pederson et al. 2003). Now, the Colorado

River below the Dam and through the Grand Canyon National Park is released from the bottom of Lake Powell. The water is clear and cold, from 45°F - 50°F, throughout the year (Fairley 2003). The flow of the river is determined not by natural cycles and seasons but by the power demands in Arizona, California, Nevada, and Utah, and is typically from 35,000-5,000 cubic feet per second. The new flow regime has resulted in the development of a post-dam river ecology (Carothers et al. 1979) that is more stable than any other time in the Holocene. Clover and Jotter (1944) conducted a floristic survey of the Colorado River Corridor in 1938 and found that the heavy spring flooding on the river restricted most riparian plants to tributary drainages and springs. However, Carothers and his team found (1979) that the new flow routine created by the Glen Canyon Dam resulted in a much smaller to non-existent flood zone and a desert scrub/riparian vegetation association, developed along the pre-dam flood plain (Figure 3.11). These factors should be considered when interpreting the prehistoric land use of the Inner Canyon.

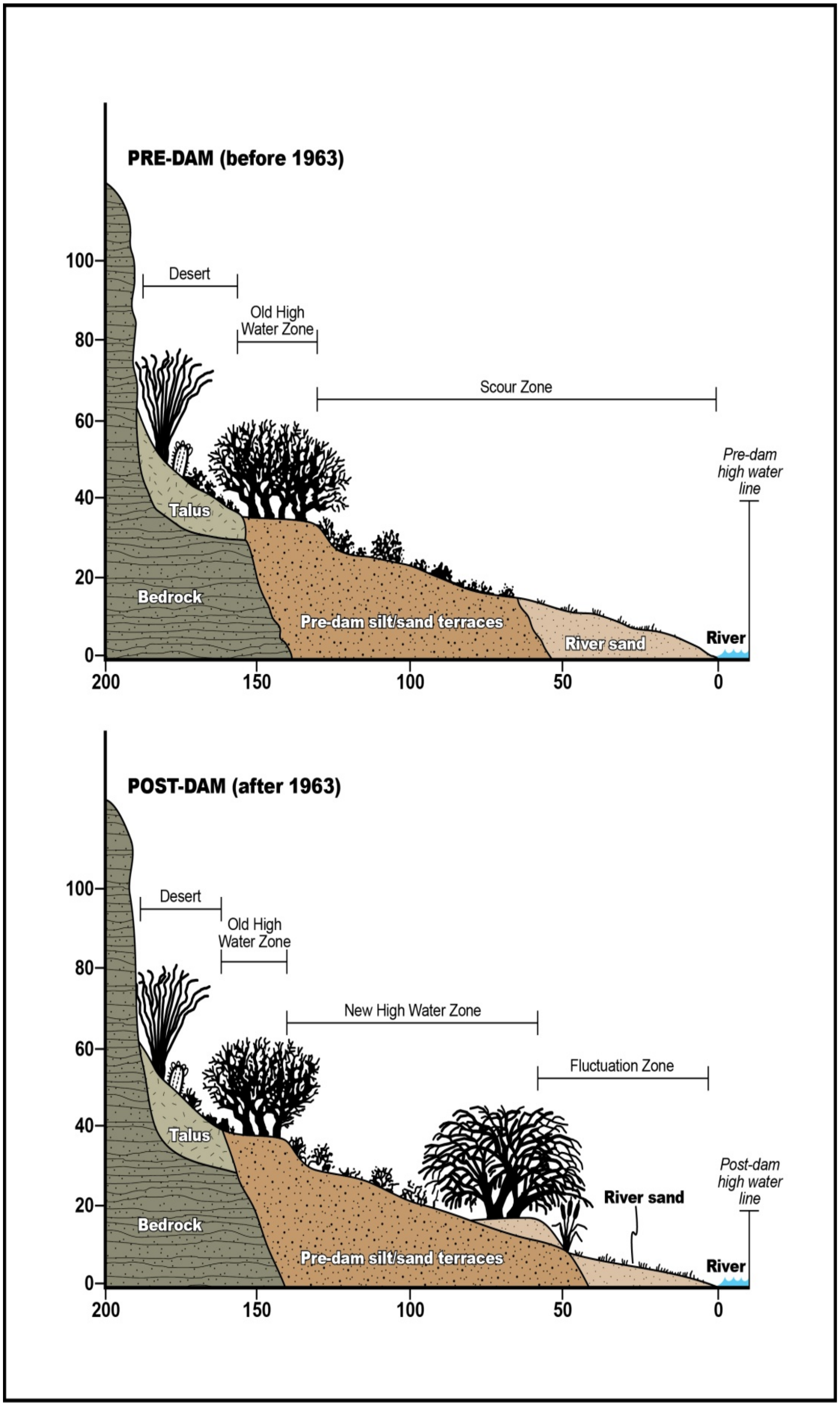

Figure 3.11 Colorado River floodplain vegetation zones Pre- and Post- Glen Canyon Dam (based on Carothers et. al. 1979).

Hydrologic System

The Grand Canyon hydrologic system consists of several components (Crossey 2006), including precipitation-fed streams and rivers, and springs fed from local and regional aquifers (Figure 3.12). The most visible element of the hydrologic system is the Colorado River, which runs through the Canyon and at various points is either the boundary or the centerline of the Park. The Colorado River originates in the Rocky Mountains in the state of Colorado and flows south and westward until ending in the Gulf of California. The river is fed by runoff from the Rocky Mountains and other highland areas within its watershed. As previously discussed, the twentieth-century damming of the river has changed its flow routine dramatically, which now is controlled by electricity and water demands of western states and not by natural forces. In addition to the Colorado, the second component of the hydrologic system is perennial surface streams, such as Havasu Creek and Bright Angel Creek. Twenty of these permanent surface water sources have been identified (Brown and Moran 1979) and most of them originate from springs and flow through the various side canyons. The third component of the hydrologic system is the springs and seeps that flow from the Paleozoic rock layers. NPS has mapped 298 seeps and springs, within the boundaries of Grand Canyon National Park, and they are all fed by aquifers recharged by surface precipitation located on the Colorado Plateau. High-discharge springs (e.g., Thunder River), emerge from the Muav and Redwall formations, via karstic aquifers, and lower-discharge springs (e.g., Santa Maria spring), emerge along faults and fissures in the Vishnu basement formation and along the Great Unconformity (Crossey 2006). How the hydrologic system impacted settlement from AD 700 – AD 1225 will be discussed in Chapter 6.

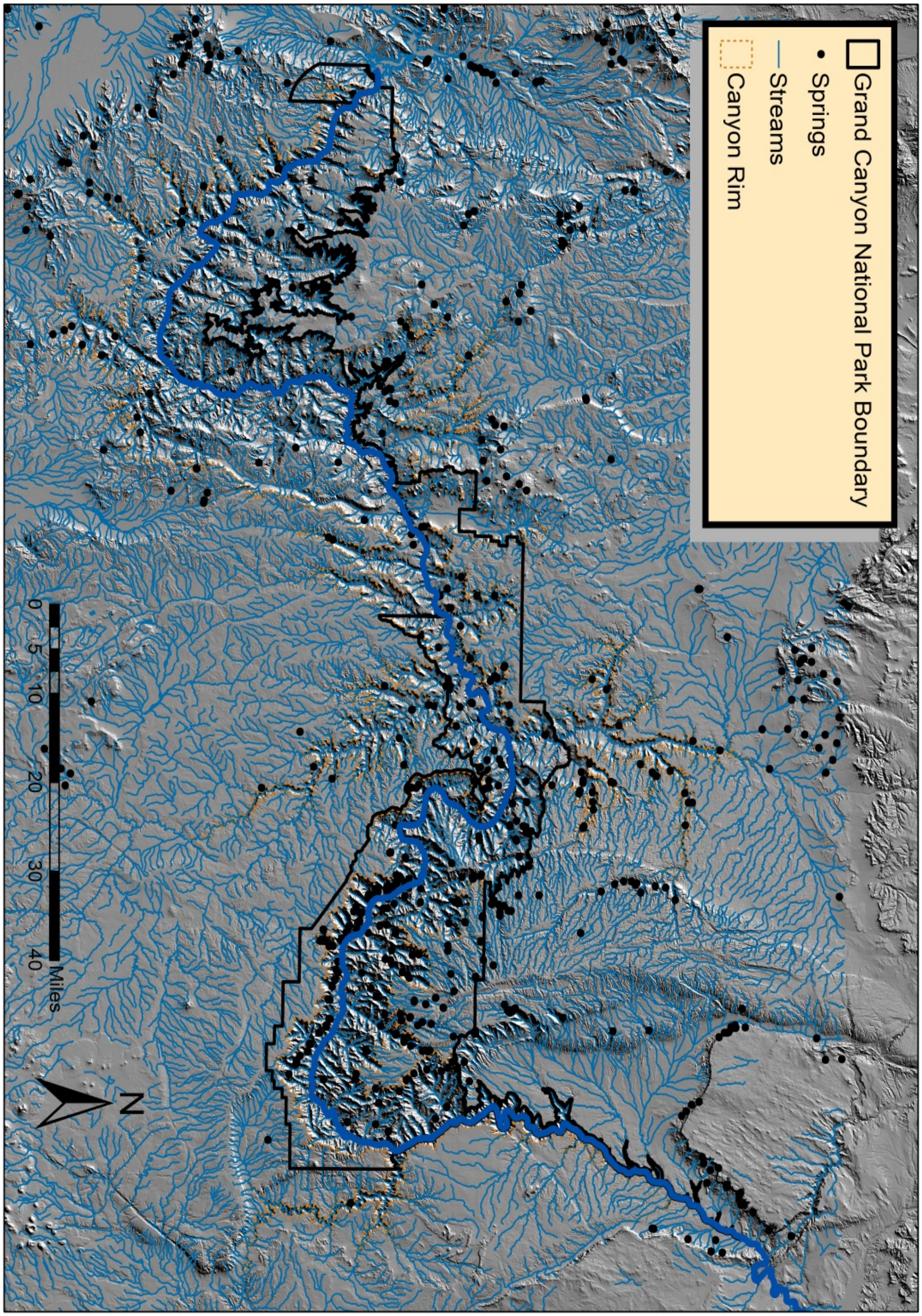

Figure 3.12 Grand Canyon Hydrologic System.

Soil Taxonomy

The soils of the Grand Canyon are complex and multi-faceted (Lindsay et al 2003). The arid climate and active geomorphic cycles of the region create difficult conditions for the formation of soils and, as with all facets of the natural environment in the Canyon, topography dramatically influences the distribution of soil types. The soils presented here (Figure 3.13), and used for my analyses, were mapped as part of a partnership between the United States Department of Agriculture, Natural Resources Conservation Service (NRCS), United States Department of the Interior, National Park Service (NPS), and the Arizona Agricultural Experiment Station (Lindsay et al. 2003). The data are based on a survey conducted in 2001, and the soil units were classified based on field work and laboratory testing of the soil material. In the field, soil scientists observe and record the steepness, length, and shape of the slopes, drainage patterns, vegetation patterns and geology. Throughout the area, a sample of soil units was excavated from the surface down to the unconsolidated material that produces soil (Lindsay et al. 2003). Because only a limited number of soil profiles can be excavated, the pattern between the surface features (slope, vegetation, etc.) and excavated soil profiles are recorded and used to extrapolate soil types across the region (Lindsay et al. 2003). In the laboratory, chemical and physical properties of the collected samples are measured, data on agricultural and range productivity are generated, and engineered tests are conducted, all of these analyses are conducted so that the soil scientists can make inferences about how the soils will behave under certain conditions (Lindsay et al. 2003).

The soil survey of the Grand Canyon was focused on obtaining data for the most intensively utilized areas, with some regards to accessibility. Therefore, the most intensive data were collected on the South Rim, North Rim and along the Bright Angel Corridor in the Inner Canyon. Limited access to the Inner Canyon, beyond the Bright Angel Corridor, resulted in the bulk of the Inner Canyon mapping units being based on remote sensing data along with existing geology and vegetation maps. A total of 177 mapping units were recorded in the region (Lindsay et al. 2003). In addition to soil taxonomy, the NRCS soil layers also contain information on suitability for development, military operations, disaster recovery, animal grazing and agriculture. For this investigation, range productivity was determined to be an important characteristic as a proxy for wild plant production for prehistoric settlement studies.

Range productivity values (Figure 3.14) calculated from the NRCS soil database are an estimate (in pounds per acre per year) of the amount of vegetation that can be expected to grow in a managed area during a normal year (Lindsay et al 2003). The estimate includes all vegetation (leaves, twigs, seeds, and fruits), whether palatable to grazing animals or not, but does not include increases in stem diameters for trees. Because many of the wild plants utilized by Native Peoples during this time, except for the pinyon nut, would be captured by this productivity range, I use it in my Chapter 6 analyses as a proxy for wild plant productivity. Although, I argue it is a sound substitute for wild plant productivity, I do not think it is a good alternative for maize agriculture potential. The maize grown by prehistoric native peoples requires a whole host of conditions (specific quantities of water, number of frost-free days, etc.) that are different then what it takes for the wild resources to thrive and produce. The NRCS database d have a crop yields calculation (for both irrigated and non-irrigated crops) but it cannot be used on the Grand Canyon

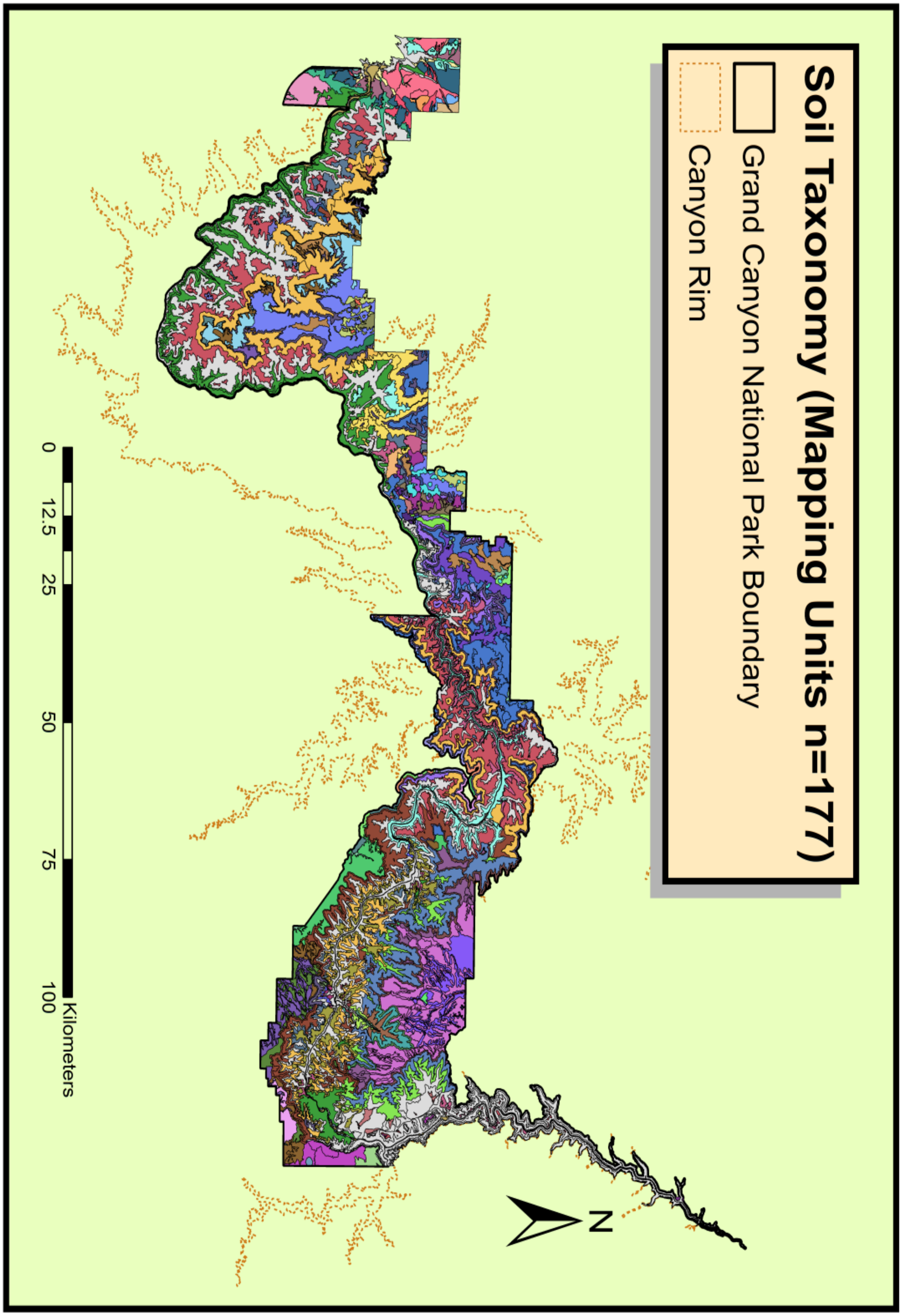

Figure 3.13 Grand Canyon soil taxonomy.

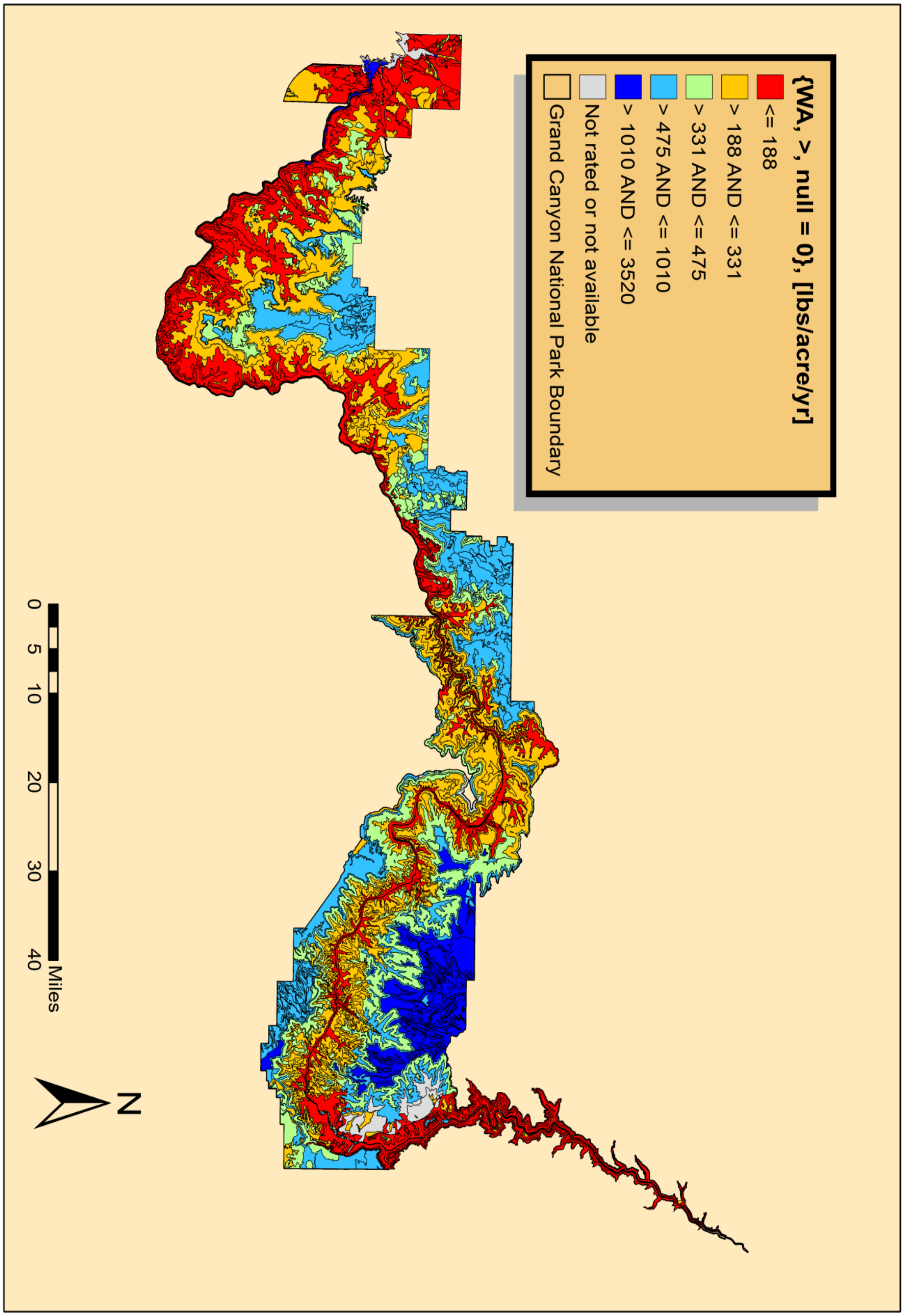

Figure 3.14. Range productivity in the Grand Canyon.

soils data, as the crop yield units were not recorded during the NRCS Grand Canyon Soil Survey.

GEOGRAPHIC ZONES

The climate and elevation of the Canyon, combined, have a dramatic effect on both the natural ecology (as discussed above) and on human ecology (the focus of this dissertation). In order to fully understand the impact of the Canyon's unique physical geography on indigenous settlement from AD 700 – 1200, Grand Canyon National Park must be divided into defined geographic zones or provinces. For this study, Grand Canyon National Park will be parsed into three larger regions: North Rim, South Rim, and Inner Canyon that are further divided into eight sub-regions: Kaibab Plateau, Kanab\Uinkaret Plateau, Coconino Plateau, Upper Basin, Upper Canyon, East Canyon, Gorge, and Lower Canyon (Figure 3.15).

North Rim

The North Rim is located at elevations from 8,000- 9,000 feet above sea level. Portions of four named plateaus are located within the Park boundaries (Uinkaret, Kanab, Kaibab, and Walhalla), another plateau (Shivwits) is an adjacent topographic feature located just outside the Park boundaries but will be referred to when discussing distributions of ecological units and archaeological sites.

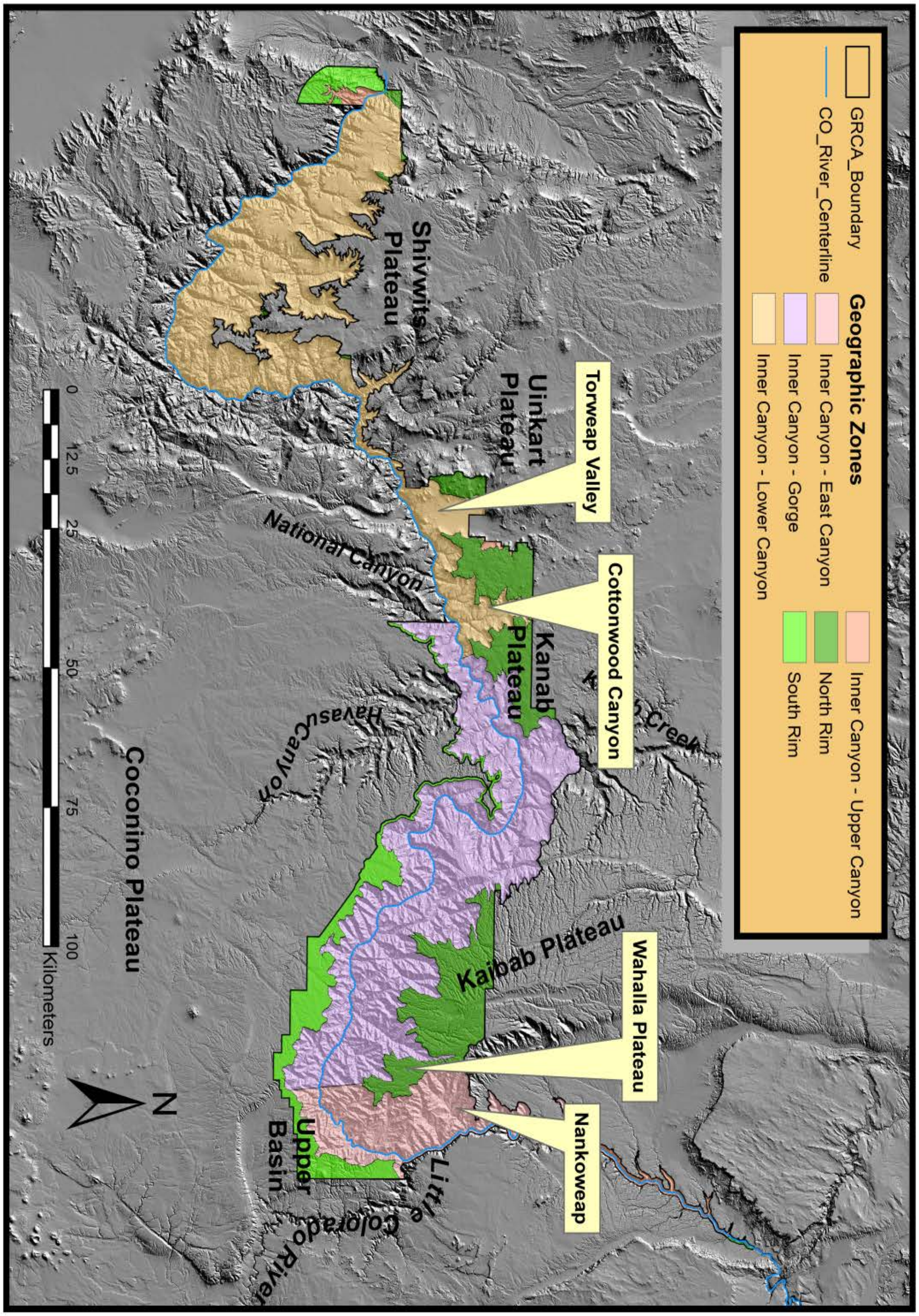

Figure 3.15. Grand Canyon Geographic Zones.

South Rim

The South Rim is located at elevations from 6,000 – 7,000 feet above sea level. Portions of the Coconino Plateau and the Upper Basin are the major topographic features that occur within the Park boundaries. Outside the Park, several landscape features (National Canyon, Havasu Canyon, and the Little Colorado River) will be referred to when discussing the results of the settlement analyses.

Inner Canyon

The Inner Canyon is located at elevations from 900 – 3,000 feet above sea level. The major feature of the Inner Canyon is the Colorado River, and the corridor it and its tributaries have carved through this corner of the Colorado Plateau. Because the Inner Canyon zone is varied in elevation, topography and vegetation along its 241-mile length, and because those variations have an influence on both the natural and cultural histories, this zone was divided into four sub-provinces: Upper Canyon, East Canyon, Gorge, and Lower Canyon. The Upper Canyon is the farthest north and east that the canyon extends, running from Lees Ferry and extending to River Mile 30, where the Fence Fault crosses the Canyon. This upper portion, also called Marble Canyon, is enclosed by steep limestone cliffs, leaving little area for human activity and preservation of archaeological sites. The second Inner Canyon sub-province, the East Canyon, extends from River Mile 30 to River Mile 78. The first five miles of this part of the Canyon are still enclosed by steep limestone walls but several small side-canyon debris fans provide some locations for preserved archaeological sites. Continuing downstream through the East Canyon zone, the canyon itself opens up and a variety of larger deltas are found and larger archaeological site complexes such as Nankoweap, Palisades and Unkar Delta are present. After Unkar Delta, the river corridor again begins to narrow and around River Mile 78 an area known as the Granite Gorge forms. This third sub-region of the Inner Canyon, called the Gorge, extends from River Mile 78 to River Mile 160; in this zone the Colorado is flowing through the oldest geologic formation, the Vishnu Schist (Fairley 2002). The Powell Plateau and other below "rimline" plateaus will be referred to during later discussions on land use in Chapters 6 and 7. The final Inner Canyon sub-zone, Lower Canyon, extends from River Mile 160 to River Mile 278 where the Park ends as the Colorado River enters Lake Mead. In the eastern half of the Lower Canyon two features (Toroweap Valley and Cottonwood Canyon) will occasionally be referenced during discussion of settlement analyses. All of these geographic provinces enable a discussion of the natural and cultural landscapes in a manner where the varying topography of the Canyon can be quickly referenced. For example, one should not be surprised that there are many more archaeological sites along the Colorado River in the East Canyon than in the Gorge, because the wider East Canyon contains numerous deltas and other places for human settlement (Fairley 2002, Schwartz 1989).

CHAPTER SUMMARY

The focus of this chapter is the natural history of the Grand Canyon, with an emphasis on the environmental factors utilized in the analyses presented in Chapter 6. In settlement pattern studies a discussion of the natural environment is important if we are to understand why and how people inhabited a particular locale. This chapter began with an examination of the modern natural environment and then proceeds to discuss the paleo-ecology of the region.

Grand Canyon National Park is a United Nations World Heritage site and one of the premier parks in the NPS. The Park is located in northern Arizona and cuts through the western-most edge of the Colorado Plateau. Within the boundaries of the Park almost 2-billion years of geology is laid bare in the exposed stratigraphy. Biologically it is a diverse environment where numerous small ecotones are created by the vertically compacted topography. The Canyon acts a barrier to some species and a corridor for others but overall the diversity creates a plethora of environments for both humans and other animals to exploit.

The formation of the Grand Canyon has been a hotly debated topic throughout the twentieth century. However, the recent work of Karlstrom and his colleagues (2014) provides a comprehensive chronology for the creation of the Canyon. In Karlstrom et al.'s model the Canyon was formed about 6-million years ago when two older paleo-canyons, one about 60-million years old (Hurricane Fault Segment) and the other about 25-million years old (Eastern Grand Canyon Segment), were joined to two new canyon, Marble Canyon to the east and Westernmost Canyon to the west. The Canyon continues to deepen at a rate of about 100-200 meters per million years.

The climate of the Grand Canyon is controlled by both elevation and landforms. The highest elevation North Rim has the coldest temperatures and is the wettest locale in the Park. The lower elevation Inner Canyon is the hottest and driest of the geographic regions, with the temperature increasing and precipitation decreasing as the Colorado River flows from the higher elevation Marble Canyon to the lowest elevation West Canyon at Lake Mead. The South Rim weather falls in between these two areas with both moderate temperatures and precipitation levels.

As previously stated, the Canyon's biotas are controlled by topography and vegetation and the gorge itself serves as both a barrier and a corridor to different species. Five biotic communities, including forests, woodlands, desert scrub, riparian woodland and barrens have been identified in the Park. Based on archaeological research throughout the Colorado Plateau it would not be surprising to identify sites in any of these biota.

The five biotic communities can be further parsed into 61 vegetation associations. Of those 61 vegetation associations 50 of them contain wild resources that have been identified in prehistoric contexts throughout the Four Corners region. In addition, 33 vegetation associations contain one of the three plants (saltbrush, greasewood, and rabbitbrush) that have been identified by Hopi researchers as areas that hold high agricultural potential. Thirty of those are also found in association with wild plants utilized for food by prehistoric peoples. Based on these data, I hypothesized that if the Canyon's Pueblo Period inhabitants were predominately maize agriculturalists I should find a higher than expected number of sites in areas containing the Hopi indicator species. If these prehistoric people predominately relied on wild resources I would expect the archaeological sites to be located more extensively in those vegetation communities.

The paleo-ecology of the Park has also been studied quite extensively. Cole (1990) has investigated packrat middens to reconstruct both prehistoric vegetation associations and climate changes. Additionally, Salzer and Kipfmuller have examined tree-ring data and used that information to model the paleo-climate by estimating past temperature and precipitation ranges.

Both soil GIS data were obtained but subsequent analyses indicate that the associations between soil taxonomy and archaeological sites did not demonstrate any relationship. Soils data were also reclassified into range productive, which calculates the ponds per acre per year of the wild plant resources that can be expected to be harvested from a particular locale. Because it is a good proxy for wild resource productivity it was correlated to archaeological sites (see results in Chapter 6).

Finally, I divided the Canyon into eight geographic regions including three larger regions: North Rim, South Rim, and Inner Canyon, which are further divided into eight sub-regions: Kaibab Plateau, Kanab\Uinkaret Plateau, Coconino Plateau, Upper Basin, Upper Canyon, East Canyon, Gorge, and Lower Canyon (Figure 3.15). The division of the Canyon into these units was important as it provides much needed information on the variation in topography that influenced Pueblo Period settlement.

Chapter 4: An Archaeological and Culture History of Grand Canyon

This dissertation focuses on using existing archaeological site files to investigate Grand Canyon settlement from AD 700 – 1225, and to explore how differences in ecological paradigm affect our interpretations of the Canyon's cultural past. In order to address these research goals one must first understand the history of archaeological research in the Park. This chapter will present a discussion on both the archaeological and prehistoric cultural history of Grand Canyon National Park. This discussion data will provide background information to inform the inferences about land use developed in Chapters 6 and 7.

HISTORY OF ARCHAEOLOGICAL RESEARCH AT GRANDCANYON

Prehistoric remains within the Grand Canyon have been documented for almost 150 years (Balsom 2005). The first remains were noted by John Wesley Powell, who began documenting the pueblo ruins he encountered, on the first successful trip down the Colorado River and through the Grand Canyon in 1869 (Fowler et al.1981). Since Powell's expedition, a variety of academic and resource management archaeologists have recorded more than 4,200 sites within Grand Canyon National Park (Balsom 2005). Over the intervening years, archaeology as a discipline has advanced both theoretically and methodologically. The archaeologists working within the Park have also shifted focus, from a mostly research motivation, to a hybrid approach, that emphasizes research in the service of resource management, over just pure academic research or only legally mandated compliance projects (Anderson and Neff 2011, Balsom 2005, Fairley 2003, Smiley and Vance 2011).

As the sesquicentennial of Powell's journey nears, a look back at the last 150 years of archaeological research is in order. The most useful approach for such a reexamination is to divide past research into three phases -Exploration Era, Post-World War II Era, and Heritage Management Era each of which parallels the development of archaeology in North America (Trigger 2006). Thinking about Grand Canyon archaeological research in these terms will highlight how the focus of the research has changed from merely identifying archaeological sites, to understanding prehistoric people's behavior, while also preserving the archaeological sites in perpetuity.

Exploration Era

The Exploration Era of archaeological research at the Grand Canyon reflects the activity of early explorer-scientists. During the beginning of this era, these individuals were often natural historians who were recording data about the geology and biology of region and, while describing those characteristics, would often make notations and comments on both the archaeological sites and on local indigenous populations. By the later part of the Exploration Era, early twentieth-century trained archaeologists began exploring the region, with the intent to record information on Grand Canyon archaeology. In the Grand Canyon, three individuals and one institution conducted extensive survey and limited excavations throughout what is modern-day Grand Canyon National Park: John Wesley Powell, Neil Judd, Edward T. Hall, and Gila Pueblo.

John Wesley Powell

John Wesley Powell was the first European to successfully navigate the Colorado River through the Grand Canyon. During both his first (1869), and second (1871-1872) descents down the Colorado, Powell and his men noted at least eight archaeological sites in their journals (Fairley 2003, Fowler et al. 1981, Powell 1875), and several Native American encampments (which would now be archaeological sites). Because no method for dating these sites existed, Powell and his men, in many cases, thought the ruins found along the river were recently abandoned habitations of the surrounding Pueblo peoples. In some cases, he even suggested they may have been created by refugees, seeking to escape Spanish and Navajo aggression in the sixteenth and seventeenth centuries. As of the mid-twentieth century, Euler (1969) was able to relocate and record the sites originally identified by Powell during the early explorations of the Colorado River corridor.

Neil Judd

The first archaeological investigations in Grand Canyon by trained archaeologists, were conducted by Neil Judd from the U.S. National Museum (Smithsonian Institution). While working for the Museum, Judd led an expedition from 1915 - 1920 to explore the archaeology north of the Colorado River (Spangler 2007). "My sights have been set on the little-known region north of the Grand Canyon – the region that had tempted me repeatedly" (Judd 1926:85). In 1918, he undertook a brief reconnaissance survey by horseback of the Kaibab Plateau including the Walhalla Plateau, or "Greenland" as he called it, and noted the wide variety of puebloan architectural styles found in the region, noting: "no two of them were exactly alike. Each was distinct within itself, and yet each possessed certain characteristics common to others" (Spangler 2007:4). However, he was quite clear in his lack of enthusiasm for these sites: "None of these ancient dwellings holds any particular interest for the casual passer-by. They are comparatively inconsequential structures, now represented by rambling piles of weathered limestone.

Yet, they furnish mute evidence that prehistoric man in his migrations tarried here long enough to construct at least temporary homes while he sought out more favorable locations elsewhere" (Judd:1926:85).

Near the end of his expedition in 1920, Judd surveyed portions of the Kanab and Paria plateaus, and Bright Angel Canyon. In Bright Angel Canyon, he documented a cliff dwelling and granaries in the upper part of the canyon; near Upper Ribbon Falls he documented several additional habitation and storage rooms. High water prevented him from following Bright Angel Creek to its confluence with the Colorado River, where the Bright Angel ruins are located, but he indicates the ruins exist. He likely made this assumption based on a 1917 Kaibab National Forest map, and Powell's published notes, both of which mention the Bright Angel Pueblo. In addition to comments about the varied architectural styles, Judd also noted the presence of corncobs in the ruins along Bright Angel Creek and in storage cists below the Walhalla Glades.

<u>Edward T. Hall</u>

In 1937, Edward T. Hall (1942) conducted an archaeological survey of the Walhalla Plateau for the National Park Service, which he later used as the basis of his Master's thesis at the University of Arizona. He surveyed an approximately six square mile area, bordered on the south by Cape Royal, on the north by the Canyon rim, on the southwest and west by a point three-and-half miles north of Cape Royal, and the highway from the Park Headquarters to Cape Royal on the east. He located 273 "ruins" during the survey, which ranged from single rectangular and circular rooms, to more complicated larger structures (Hall 1942:6). He posits that sites were reoccupied throughout the Pueblo Period, and based on his ceramic analyses, of over 10,800 sherds, he concluded

64% contained Pueblo I ceramics (AD 750 – 900), 92% contained Pueblo II ceramics (AD 950 – 1150) and 43% had early Pueblo III ceramics (AD 1150 – 1200). Hall also believed this area was utilized year-round by prehistoric Pueblo peoples practicing a maize agricultural lifeway. He argues that "Most of the sites occupied the ridge tops and were not far from the agricultural terraces" and "were not centered on large level places" (Hall 1942:10). The terraces he records near the structures followed natural contours and were up to 20 feet wide, 300 feet in length, and were placed up to 9 in a row. Hall, also documented small garden plots (areas cleared of rock), and rock dams, that he argued were used to divert rainwater into ditches and then to the terraces. In addition to these agricultural features, he also identified several granaries during his survey. Based on his research, Hall (1942) concludes that the agricultural evidence indicated investment and "remove[s] any doubt that the country was occupied year round" (Hall 1942:13). Finally he claims the Walhalla Plateau was abandoned sometime from AD 1150 – 1175 (early PIII), as residents moved to the South Rim to aggregate into larger sites like the Tusayan Ruin.

<u>Gila Pueblo</u>

In 1930, Gila Pueblo conducted a survey along the South Rim of the Grand Canyon, and located 255 sites (Gladwin 1946; Haury 1931). During this survey, they collected sherds, and described numerous one-room and two-room masonry structures, which according to Gladwin "occurred with monotonous regularity all along the South Rim and down the Coconino Plateau" (Gladwin 1946:1). The survey, documented everything from Basket Maker III to Pueblo III sites, but an overwhelming number dated to the Pueblo II time period. In trying to explain the abundance of Pueblo II sites, Gladwin notes "there was a complete lack of anything which could have served as underpinning for the large number of Pueblo II sites which were scattered all along the South Rim of the Canyon" (Gladwin 1946:1). In his report, Gladwin notes the presence of black-on-white decorated pottery (which he later typed as Black Mesa Black-on-white), and describes the utility ware pottery as smooth and almost polished, gray to brown in color, and often with a fugitive red color. His utility ware description is indicative of what today is called San Francisco Mountain Gray Ware and suggests that most of the sites he was finding belong to the taxon called the "Cohonina." One site located on the survey that did not seem to fit the pattern of the Kaibab Phase was the Tusayan Ruin. In 1930, under the direction of Haury (1931), a portion of the site was excavated, including "four dwelling rooms on the west side, five storage rooms on the north side, and two kivas" (Hastings 1932:24). One of the kivas was subsumed by the main room block and is located south of the four excavated dwelling rooms. The second kiva is located about 10 to 12 meters east of the storage rooms excavated on the north-side of the structure. The second kiva was built later than the first one as evidenced by the fact it is constructed on an earlier trash midden. Most of the decorated ceramics were described by Gladwin as being Black Mesa Black-on-white, with some other possible earlier form of Tusayan Black-on-white being present. While there was originally contention over Haury's (1931) tree-ring dates (Gladwin 1946), it is now generally thought the pueblo was occupied from AD 1185 - 1205 (Robinson and Cameron 1991).

Post World War II Era

The next phase of archaeological investigations at Grand Canyon is here termed the Post World War II Era. During this Era, interest in exploring the archaeology of the

Canyon to investigate prehistoric lifeway's continued. An interest in science and culture had expanded across the United States after World War II, as a result of the oncoming "Atomic Age", and the investigations by Grand Canyon archaeologists during this Era express this new-found scientific curiosity in the U.S. public's consciousness. The Post World War II Era was a time when continued exploration of the Park to identify sites is supplemented with excavations, conducted to answer specified hypotheses. During this time, the most notable contributions to Grand Canyon archaeology were by three individuals: Joe Ben Wheat, Walter W. Taylor, and Douglas W. Schwartz.

Joe Ben Wheat

Joe Ben Wheat got his introduction to Grand Canyon archaeology while he was a ranger and archaeologist at the Park between 1952 and 1953, as he finished his PhD in Anthropology at the University of Arizona. During that time, he excavated a small Cohonina ruin, located near the Tusayan Ruin. The site (GC505) contained a partial subsurface structure, with two attached storage rooms and another small structure (Wheat and Wheat 1954). The ceramics and other artifacts indicated that the site was definitely Cohonina, with over 72% of the assemblage consisting of San Francisco Mountain Gray Ware. This revelation confirmed that the Cohonina were more widespread along the South Rim than originally thought. Wheat later used the data from that excavation to pen a book on the prehistoric peoples in the northern Southwest for the Grand Canyon Natural History Association (Wheat 1963).

Walter W. Taylor

Walter W. Taylor conducted the first professional archaeological survey of the Colorado River corridor downstream from Lees Ferry in July of 1953 (Taylor 1958).

Taylor, who was a research associate at the Smithsonian Institution, joined a seven day reconnaissance trip from Lees Ferry to Lake Mead (Fairley 2003); the purpose of the trip was to provide an assessment of the area that was slated to be inundated by the proposed Bridge Canyon Dam. During this trip, he recorded several archaeological sites in South Canyon, Nankoweap, Unkar, Bright Angel, and Deer Creek. He was hesitant to make too bold of an assessment, based on such a short trip, but he did conclude that the inner corridor of the Canyon was likely sparsely occupied because of the confined topography and limited access to the rim.

Douglas W. Schwartz

Douglas W. Schwartz began his work in the Grand Canyon region in 1949, as an undergraduate, assisting John McGregor in excavating sites near Williams. During that field season, Schwartz became intrigued by the local Havasupai workers' claims that their tribe had connections to the prehistoric Cohonina. He decided to focus his graduate research, at Yale University, on this question of Cohonina and Havasupai continuity (Schwartz 2009). In 1953 and 1954, he conducted survey and excavations in Havasu Canyon for his dissertation and concluded that the Cohonina and the Havasupai were indeed directly linked (Schwartz 1955).

After completing his dissertation, Schwartz conducted several surveys in the Inner Canyon. His first Inner Canyon surveys were within the Shimano (1960) and Nankoweap (1963) drainages, and later in 1965 he conducted a survey along the Colorado, beginning at Nankoweap and extending downstream several miles (1965), in what was the first intensive archaeological survey along the Colorado River in Grand Canyon (Fairley 2003). In 1966, Schwartz submitted a grant proposal to the National

Science Foundation to excavate sites in the river corridor. In her summary of River Corridor archaeology in the Grand Canyon, Fairley notes "Schwartz's NSF proposal was the first attempt by a Grand Canyon archaeologist to develop and test an explicit theoretical idea: that Puebloan farmers had migrated into the Grand Canyon in response to favorable climatic conditions and had subsequently adjusted their settlement strategies in response to environmental variations over the next two centuries" (Fairley 2003:47). Between 1967 and 1969, Schwartz and students from the University of Kentucky, in Lexington, Kentucky, where he was employed as an Anthropology professor, spent the summers excavating sites on Unkar Delta (1967-68) at the Bright Angel Ruin and on the Walhalla Plateau in 1969. These excavation results were presented in three books published by the School for American Research (Schwartz et al. 1979, 1980, 1981), and were the last major excavations in the river corridor until 2007 when the National Park Service and Museum of North Arizona undertook a three year project to mitigate adverse effects caused by the operation of the Glen Canyon Dam (Anderson and Neff 2011).

Schwartz's initial investigations in Havasu Canyon were the beginning of a lifelong research project, and even though his last Canyon excavations were completed in 1969 (Fairley 2003, Schwartz et. al. 1981), as he became preoccupied with growing the School for American Research, he continues to synthesize his data and publish his reflections on Grand Canyon prehistory (Schwartz 1989, 2008). His contributions to Grand Canyon archaeology were immense, and alongside the work of Robert C. Euler is still the basis for many of the current models of Grand Canyon prehistory. What is so interesting about Schwartz's work is that it was all theoretically and academically driven, a rarity on federal lands where typically legislative mandates drive the research agenda.

Schwartz was able to conduct research at a time when the Park was interested in gathering as much information as possible about the resources under its control, but before the historic preservation legislation limited excavation to only sites being impacted by federal undertakings. When he chose to excavate a site, it was because of its potential to answer his research question, and not because it was being impacted by some Federal Government undertaking. It is unlikely archaeologists working within the boundaries of the Park will have the same opportunity again.

Heritage Management Era

The final era of archaeological investigations can be classified as the Heritage Management Era. While some of the projects, particularly those conducted by Schwartz, overlapped projects undertaken by NPS archaeologists, such as Robert C. Euler, the focus of the archaeology was somewhat different. Schwartz's research was motivated by answering academically oriented research questions that he had developed during his long association with the Canyon. On the other hand, Robert C. Euler, as will be highlighted more fully below, while still very concerned about academic research questions, he was also interested in applied archaeological research and applying that paradigm to the management of the Park's cultural resources. The application of archaeology in the service of resource management was about to begin. Because the majority of archaeology conducted in Grand Canyon National Park was undertaken during this Era, it is impossible, in this treatment, to identify and discuss all of the individuals who made contributions. Therefore, I will focus my discussion on Robert C. Euler, the National Historic Preservation Act, Indigenous Consultation, and the Upper Basin Archaeological Research Project, as these all relate to this study.

Robert C. Euler

Robert C. Euler began his research in the Grand Canyon in 1952, when he started collecting data for the Hualapai tribe, who requested help from the Museum of Northern Arizona in documenting their land claim to the federal government. The Museum's director, Harold Colton, directed Euler, then a young museum staffer, to conduct the work. As part of this research, Euler excavated 10 ancestral Hualapai sites on land that is now part of the Hualapai Reservation. He would later use these data to finish his PhD dissertation at the University of New Mexico. Based on his initial work and continued research in the Park, Euler came to quite a different conclusion than Schwartz, and believed that the Cohonina were not in fact linked to the Pai groups (Hualapai or Havasupai), and had instead abandoned the area around AD 1150, before later Cerbat groups entered the area, around AD 1250, and became the various Pai groups (Euler 1958).

In the late 1950s, Euler was hired by the Arizona Power Authority (APA), to assess the archaeological potential of Marble Canyon and the lower Grand Canyon, in anticipation of the development of the Marble and Bridge Canyon dams, (both planned but never built). Throughout the early 1960s, Euler undertook three river trips (1960, 1963, 1965), supported by the APA, which resulted in the publication of numerous articles in both research journals and the popular press (Euler 1966, 1967, Olson 1966). In 1966 Euler received a grant from the National Science Foundation to conduct a helicopter survey of the Canyon to record archaeological sites. A total of 60 sites were recorded during that survey, with most of them occurring in the backcountry areas of the Park. In 1969 he received a grant from the National Geographic Society to conduct archaeological excavations in Stanton's Cave (Euler 1984). The cave had been vandalized a couple of years earlier and Euler's grant helped to recover material from the disturbed site, including 165 split-twig figurines and the remains of a variety of extinct Pleistocene fauna (Euler 1984).

In 1974, Euler was hired as Grand Canyon National Park's first staff anthropologist; his job was to act as official liaison with the neighboring Navajo and Havasupai tribes. In 1975, Euler participated in an annual NPS resource management Colorado River rafting trip, so that archaeological sites could be added to the list of resources monitored by the Park; by 1982 NPS resource management rafting trips routinely included archaeological site monitoring (Fairley 2003). In 1984, he received support from NPS to conduct test excavations and stabilization of several stratified rock shelters, the first such excavations in the Canyon, since his excavations at Stanton's Cave in 1969. Euler had tried to obtain funding for this project for over a decade, and was finally successful when he and his research assistant Anne Trinkle Jones tied the funding request to the NPS management requirement that they minimize impact from river-running visitors (Jones et al. 1984).

Euler, like Schwartz, was working in Grand Canyon National Park at a time when so little was known about the general culture history of Grand Canyon National Park that every discovery was new, exciting, and a major contribution to our understanding of the past. Whereas Schwartz was theoretically focused, Euler, as someone working in an applied archaeological context, balanced theoretically based research with the practical and legislatively mandated needs of the Park. His contributions to Grand Canyon archaeology demonstrate that is possible to successfully walk the fine line between an applied perspective and a pure theoretical research agenda.

National Historic Preservation Act of 1966

The National Historic Preservation Act of 1966 (NHPA1966) had a profound impact on the archaeology of Grand Canyon. This act (Public Law 89-665; 16 U.S.C. 470 et seq.), and the supplemental implementing regulations 36CFR800, required that federal agencies apply the NHPA of 1966 to cultural resources on public lands. Complying with this federal law resulted in an increase in the number of archaeological investigations at the Park, as any undertaking determined to have an effect on archaeological and other cultural resources was required to mitigate those impacts through excavation or some other means. Archaeological survey also increased during this time, as identifying cultural resources is the first step in determining whether or not a project will have an adverse effect on a resource. These NHPA1966 surveys have been conducted not only by NPS (Balsom 2003, Jones 1986) but also by a variety of public institutions (e.g., Museum of Northern Arizona, Northern Arizona University, and Southern Utah State College) but also by for-profit companies (e.g., SWCA and SRI). Research continues under these regulations, and the impact of NHPA 1966 on the archaeology of the Grand Canyon will only continue to grow as additional research is conducted as part of the compliance process outlined in the legislation. For example, the recent excavation of nine archaeological sites along the Colorado River, the first Inner Canyon excavations since Schwartz's Unkar Delta Excavations in 1969, were a direct result of the Grand Canyon National Park and Bureau of Reclamation complying with Section 106 of the NHPA 1966.

One offshoot of the NHPA 1966 was the legal mandate that the Park also consult with Native Americans as part of the compliance process (36 CFR 800.2(c)(2). The Grand Canyon is claimed as a sacred place by over 22 Native American groups and handling relations with all of these tribes is now done by a full time staff member at the Park, who understands discussion with indigenous peoples is conducted as government-to-government consultations (Fairley 2003). These groups not only consult on archaeological issue but also on a host of other issues related to the Religious Freedom Restoration Act of 1993 (Public Law 103-141, 42 U.S.C. 2000bb et seq.) Native American Graves Protection and Repatriation Act (Public Law 101-601; 25 U.S.C. 3001-3013), Archaeological Resource Protection Act of 1979 (Public Law 96-95; 16 U.S. C. 470aa-470mm) and the identification of Traditional Cultural Places (TCPs). The effects of these laws on the interpretations of the Pueblo Period, indigenous settlements are minimal. In fact, a recent publication by Kuwanwisiwma and Ferguson (2009) illustrates that the indigenous views of the Pueblo Period are quite similar to those of Schwartz and Euler, believing their ancestors, like them, were settled agriculturalists that extended their lifeways back in time. All excavations conducted these days are done so only with Native American consultation and concurrence.

<u>Upper Basin Archaeological Research Project (UBARP)</u>

One of the most insightful projects in modern times is the Upper Basin Archaeological Research Project (UBARP), which is led by Alan Sullivan of the University of Cincinnati, Department of Anthropology. As I have noted in Chapter 1, Sullivan and his students are challenging the deeply-rooted obligate ecological paradigm and proposing a new facultative framework to explore our understanding of the Grand

Canyon Pueblo Period (Sullivan 2015). This project had its origins in an Arizona Department of Transportation project that Sullivan conducted through the Arizona State Museum (Sullivan 1986). For over 25 years, UBARP has conducted a series of survey and excavation projects on the South Rim of the Canyon in an area known as the Upper Basin. The focus of this research has been to understand the complex socioecological relationships between humans and their environment at the Canyon (Sullivan 2015, Sullivan et al. 2014). The results of this research project have demonstrated that Pueblo Period peoples in the Upper Basin were not intensive agriculturalists but were instead ruderal horticulturalists who relied heavily on the production of wild resources, such as pinyon nuts and grasses (Sullivan and Forste 2014), in a settlement system that involved low-level seasonal movement between the various topographic zones throughout the Canyon (Sullivan et. al. 2002).

CULTURE HISTORY

The Grand Canyon has been inhabited by humans for at least 8,000 years (Fairley 2003). During that time, archaeologists have identified six periods of human habitation: Paleo-Indian, Archaic, Pre-Formative, Formative, Protohistoric, and Historic (Table 4.1). Throughout those 8,000 years, occupation fluctuated from mobile-bands of hunters-and-gathers, to semi-sedentary horticulturalists and agriculturalists, and back to mobile hunter and gathering horticulturalists. The Canyon is of great importance to many Native Peoples even today and their ties to this grand landscape are through these peoples of the past.

Table 4.1 Chronology of Grand Canyon Prehistory.

Fairley (2003) Period	Dates	Pecos Period	Dates
Paleo-Indian	> 8,000 BC		
Archaic	~ 8,000-1,000 BC	Basketmaker I	~8,000 BC - AD1
(Early)	~ 8,000-5,000 BC		
(Middle)	~ 5,000-3,000 BC		
(Late)	~ 3,000-1,000 BC		
Preformative	1,000 BC - AD 400	Basketmaker II	AD 1- 400
Formative	AD 400-1250		
(Early)	AD 400-1000	Basketmaker III	AD 400- 700
		Pueblo I	AD 700-900
(Late)	AD 1000-1250	Pueblo II	AD 900-1100
		Pueblo III	AD 1100-1300
Protohistoric	AD 1250-1776		
Historic	AD 1776-1950		

Paleoindian Period 10,000 -8,000 BC

The settlement of the Americas is a contentious issue, with the exact date and route of indigenous migration into North and South America subject to much debate (Adovasio 2003, Dillehay 2001). While the exact timing is vague, archaeologists generally agree that by 14,000 years ago Native People, identified by their stone tools as part of the Clovis Tradition, were hunting and gathering throughout the Southwest (Boldurian and Cotter 1999, Cordell and McBrinn 2012), including within the boundaries of modern Arizona, near the Grand Canyon (Huckell 1982, Mabry 1998).

The current evidence of these peoples in Grand Canyon National Park is sparse, likely due to a variety of factors including sampling biases, the extreme erosive nature of the Canyon, and because of the lack of targeted research to locate sites dating to this time period. The evidence for a Paleoindian occupation is confined to the eastern half of the

Park and consists of a partial Clovis projectile point and a Folsom point. The partial Clovis point was discovered near present-day Desert View (Fairley 2003) and the Folsom point was discovered in the vicinity of Nankoweap Canyon. Based on other Paleoindian settlement data, early Paleo-sites should occur within the Park on upper terraces of the Colorado River (particularly those with deep Pleistocene deposits) or in caves and rock shelters located throughout the Canyon.

Archaic Period 8,000 – 1,000 BC

The Archaic Period is one of the longest occupation periods of the Canyon's prehistory and lasted from 8000 – 1000 B.C. During this period, the indigenous peoples were hunters and gatherers, who lived in small dispersed encampments throughout the region (Fairley 2003). Overall the Archaic period is not very well studied in the Canyon, with only about 60 Archaic sites recorded in the Park's database. Most of our inferences about the Grand Canyon Archaic come from examining data from nearby and better studied regions (Fairley 2003). The archaeological signature of these groups consists of projectile points, rock art, and split-twig-figurines. The most abundant artifacts associated with Archaic sites are lithic artifacts, such as flakes and spear points. Table 4.2 lists the projectile point types and associated data ranges for the projectile points found in the Park. It is apparent from these data that the Archaic Period contains the largest variation of lithic tools of any of the time period identified in Grand Canyon National Park. The high degree of variation in Archaic stone tools is a product of both a very long temporal span (~7,000 years) and changing subsistence/settlement strategies. As in other parts of North America, settlement during the Archaic Periods at the Canyon was likely modified as changing subsistence strategies and increased population began to limit mobility (Crothers 2004).

The Late Archaic (3,000 – 1,000 BC) is the best known aceramic period in the Grand Canyon, because of the discovery of split-twig figurines in numerous caves throughout the Park (Emslie et al. 1987, 1995, Euler 1984, Famer and DeSaussure 1955, Schroder 1977, Schwartz et al. 1958). These figurines are often made from a single willow or other pliable twig that is bent into animal shapes. The figurines are thought to represent ritual objects related to cultural practices associated with hunting ceremonies (Euler and Olson 1965). Also, there are several styles of rock art that may date to the Late Archaic (Schaasfma 1990).

Pre-Formative 1,000 BC – AD 400

The Pre-Formative Period lasted from 1000 B.C. – A.D. 400, and is described by Fairley (2003) as the time when cultivated plants were first utilized on the Colorado Plateau, but before ceramics or semi-sedentary settlement became the primary subsistence-settlement strategy. Jones and Euler (1979) believed there was no occupation of the Canyon during this time period. However, that hypothesis can now be discarded because the recent excavation of a buried hearth along the Colorado River has produced material radiocarbon dated to this period (Fairley 2003). One controversial study (Davis et al. 2000) argues for introduction of maize agriculture around 1300 BC, but the evidence is problematic due to likely sample contamination and so this early date is not generally accepted as clear evidence of cultigens in the Canyon before the Formative Period.

Table 4.2. Projectile point types identified on Grand Canyon sites with associated date ranges from both Lyndon (2005) and Justice (2002).

Projectile Point Types	Chronology (Lyndon 2005)	Chronology (Justice 2002)
Paleoindian		
Clovis	11,500-10,900	12,000-9,000
Folsom		9,000-8,000
Early Archaic		
Jay	11,000-8,000	9,000-6,000
Bajada	8,000-5,000	6,000-3,300
Northern Side-notched	7,500-6,400	6,000/5,000-3,000
Pinto/San Jose	5,200-3,200	6,000/5,000-3,000
Humboldt		6,000-AD600
Hawken		
Rocker Side-notched		4,500-2,000
Southern Side-notched	6,400 - 4,400	4,500-2,000
Unknown Late Archaic		
San Rafael Side-notched	4,400-3,600	6,000-3,000
Gypsum	4,500-1,450	2,000-800
Unknown Elko		3500-1300
Elko Eared	3,740-3,300	3,500-1,300
Elko Side-notched	8,000-6,200; 5,000-3,400	3,300-1,300
Elko Corner-notched	1,750-950	3,300-1300
Chiricahua	4,800-2,500	5,500-3,800
Armijo	3,800-2,800	6,500-3,500
Preformative		
WBMII – Western Basketmaker II	2,750-1,650	2000-1200
Cienega	2,750-1,400	2100-1100
Formative		
Rosegate	AD300-AD900	1500-700
Triangular	AD850-AD1150	
Kahorshow Serrated	AD950-AD1150	
Nawthis Side-notched	AD800-AD1200	
Parowan Basal-notched	AD850-1150	
Sitgreaves Serrated	AD1000-1200	
Desert Side-notched	AD1300-1600	
Buck Taylor-notched	AD1300-1600	
Cohonina	AD200-1150	
Coconino	AD700-historic	
Rose Springs	AD300-900	

Formative Period AD 400 -1250

The Formative Period overlaps in time with what is traditionally termed the Pueblo Period in Southwest archaeology and is the most well-studied time period of Grand Canyon prehistory. The information presented in the discussion below is based on data from the Canyon and surrounding areas, and follows the historic interpretations of this time period by those that developed the cultural ecological SARG Approach (defined in Chapters 1 and 2). As this dissertation focuses on rethinking indigenous settlement in the Grand Canyon from AD 700 – AD 1225 it should be expected that inferences presented in future chapters may differ from the more general perspective presented in the culture history summary (below).

Traditional interpretations of the Formative Period at Grand Canyon, indicate the area was inhabited by three archaeological groups, -the Cohonina and both the Kayenta (South Rim) and Virgin (North Rim) Ancestral Puebloan groups. The SARG Approach model indicates that the Cohonina, believed to be descended from the Cerbat peoples (McGregor 1967, Schwartz 2008), moved into the area from the west around A.D. 700 from an area centered on Mount Floyd, in northwest Arizona. The ancestral puebloan groups moved into the area soon after (Kayenta in the east and central portions of the Canyon and the Virgin branch on the western portion of the North Rim). These three groups seemed to have lived together peacefully and interacted with each other on numerous occasions (Fairley 2003). Below, I more fully discuss each of these three groups based on both Grand Canyon and wider regional literature.

Cohonina

The Cohonina culture area is centered on Mount Floyd, in an area west of the San Francisco Peaks, north of the Mogollon Rim, east of the Aubrey Cliffs, and south of the Colorado River in the Grand Canyon. The Cohonina, although well known to archaeologists working in the Flagstaff/Grand Canyon area, are not well known by other Southwest archaeologists (Cartledge 1979, Schroder 2002). The lack of publicity likely results from a variety of factors, including their limited spatial distribution and temporal span. The Cohonina, were defined as a distinct group from their puebloan neighbors by Colton and Hargrave (1937) based on ceramic traditions. The characteristics that differentiated the Cohonina from the puebloan groups were expanded by McGregor (1951, 1967) based on excavations in the Red Butte, Red Lake, and Mt Floyd areas. McGregor (1951, 1956) identified six differences between the Cohonina and the puebloan groups, which he identified as the Anasazi, including economy, villages, dwellings, ground stone industry, chipped stone industry, and ceremonial structures. McGregor indicated that the Cohonina were mobile horticulturists that exploited a variety of wild resources with a limited lithic and ground stone assemblage. They occupied non-permanent villages, in a variety of constructions, including small masonry structures with wood roofs and walls, temporary shade erections, with no inside hearths and lack of any identifiable ceremonial structures. He contrasted the Cohonina with the ancestral Puebloans (Anasazi) who he argues were permanently settled agriculturalists with little exploitation of wild resources. The ancestral puebloans lived in definite planned villages, with a unit-type pueblo plan, and both pithouses and surface masonry structures, containing multiple rooms and often a distinctive ceremonial structure (kiva). Many of these ideas are still accepted today, though our understanding of the Cohonina has expanded immensely since then (Schroder 2002).

The Cohonina produced San Francisco Mountain Gray Ware pottery, using the coil, paddle and anvil technique. The most common utility type is Deadmans Gray or a hematite covered version called Deadmans Fugitive Red (McGregor 1951, 1956). The Cohonina practiced a biseasonal settlement strategy, summering and wintering in different locales (Samples 1992, Sullivan et. al. 2002) to exploit a variety of wild resources, combined with low-level maize agriculture (Sullivan 1995, Sullivan et. al 2002). Cohonina architecture varies between sites in form, function, spatial patterning, and construction material. Structures in an individual community are similar in construction and form, but variation between communities exists. In the Grand Canyon, architectural styles include long rectangular masonry rooms, alcove and patio houses, single room structures, shade or ramadas and forts (Schroder 2002). Floors are typically compacted clay, and may contain subsurface storage and trash pits, but rarely hearths. The walls were usually made of unshaped limestone blocks held together by mud daub and in some cases excavated into the bedrock. Roofs were held up by support posts and beams and covered with spit branches and often a layer of bark and pine needles (Schroder 2002).

Work by Forest Service archaeologists (Fairley 1979, Hanson 1996), hypothesizes that the Cohonina originated from late Basketmaker Period populations from the Virgin culture area, who migrated across the Grand Canyon, or from local Late Archaic groups. There is considerable debate as to where the Cohonina went when they disappear from the local archaeological record around AD 1150. Euler believes they were subsumed by increasing numbers of Kayenta peoples and then abandoned the area sometime around AD1200 (Euler 1958, Fairley 2003). Schwartz, however, disagrees and postulates that the Cohonina never abandoned the Grand Canyon, and instead retreated into Havasu Canyon and later developed into the modern Havasupai tribe (Schwartz 1989).

Virgin

The Virgin Branch is the farthest west, and least understood, of all of the ancestral puebloan (Anasazi) groups (Cordell and McBrinn 2012, Harry et al. 2013, Lyneis 1995). They occupied a territory extending from north of the Colorado River in the Grand Canyon, through northwestern Arizona, and into southwestern Utah and southeastern Nevada. The Virgin Branch is divided into two regional sub-groups based on the geography of the Virgin River. Lower elevation sub-group sites, are located in southeastern Nevada, while the upper sub-group, and are located at higher elevations in southwestern Utah and northwestern Arizona, including the Grand Canyon north of the Colorado River.

The occupation of the Virgin heartland began at least by AD 1, and lasted until about AD 1200, though some research indicates that settlement may have commenced as early as Basketmaker II (300BC - 400 AD) or Basketmaker III (AD 400 - AD 800) times (Lyneis 1995). Though no chronometric dates have been recorded on Basketmaker sites, in the Virgin area prior to AD 1, Lyneis (1995) asserts that a difference in artifact assemblages can be utilized to determine chronology. Typically, Basketmaker II sites contain smaller dart-points and the first instances of gray ware pottery in the region. The presence of several sites with these features, stored maize (Janetski and Wilde 1989, Larson 1978, Schroder 1955) and tree-ring dates of 81 BC, 3 BC, and AD 5, at the South

Fork site, suggests that occupation by pueblo peoples likely occurs by Basketmaker II times in the Virgin area. Later, changes in decorated ceramic designs and artifact assemblages have been used to classify sites into Pueblo I and Pueblo II times. It is important to note that the lack of a good dendrochronology sequence in the Virgin area means that Virgin ceramic series are not as tightly dated as ceramics in other pueblo regions (Lyneis 1995).

Virgin groups practiced a mixed subsistence economy, conducting agriculture but also exploiting wild resources. Still the importance of domestic plants and wild plants is the source of debate amongst archaeologists who study the Virgin Branch groups (Larson and Michaelsen 1990, Lyneis 1995, McFadden 1996). In lower-elevation regions, such as the Saint George Basin, evidence seems to indicate an agricultural subsistence system that was dependent almost exclusively on maize (Dalley and McFadden 1988, McFadden 1996). In contrast, data from the higher elevations areas seems to indicate a heavy use of wild plants (Lyneis 1995).

The variability in Virgin group subsistence strategies, has resulted in diverse site types, settlement settings, and architectural forms. McFadden (1996) posits that the Virgin Anasazi can be differentiated from other surrounding groups based on four criteria: (1) accretional rather than unit construction of storage room blocks, (2) sequentially occupied room blocks separated from storage room blocks, (3) super-positioning of room blocks separated by abandonment, and (4) clustered sequentially occupied sites on the same landform in the same micro-environment. This Virgin pattern, results in densely occupied areas that contain numerous sites, with a large number of rooms and sites that have been occupied numerous times. The complexity of the Virgin settlement pattern, combined with a chronologically poor ceramic series makes regional analyses of the entire Virgin cultural area difficult and lacking in detail(Lyneis 1995).

Kayenta

The Kayenta, are the best understood Formative Period ancestral puebloan cultures in the northern Southwest (Geib 2011, Powell and Gumerman 1987, Powell and Smiley 2002, Smiley 2002), and one of the most studied groups in the Grand Canyon (Fairley 2003). Data on the Kayenta Anasazi area come from a variety of large scale contract programs including both the Glen Canyon Dam project (Jennings 1966) and the Black Mesa project (Dean 1996, Gumerman 1988). Both of these projects resulted in the development of a high-quality data including precise chronological data, extensive settlement data, and robust paleo-environmental data.

The artifact assemblages of Kayenta Anasazi are dominated by ceramics, fired in a reducing atmosphere, and constructed by coiling and scraping (Hays-Gilpin and van Hartesveldt 1998). Kayenta ceramic assemblages contain a preponderance of Tusayan Gray utility wares (Ambler 1985), and smaller amounts of decorated wares, such as painted black-on-white and black-on-red wares (e.g., Tusayan White Ware, Tsegi Orange Ware, and San Juan Red Ware). Lithic artifact collections are primarily debitage and the lithic tools consist of small arrow points, while the ground stone assemblage mainly consists of manos and metates (Geib 2011).

Data from the Glen Canyon and Black Mesa areas, indicate that the Kayenta settlement pattern changes through time, based on changing social and environmental conditions occurring in the Southwest (Cordell and McBrinn 2012). During the

Basketmaker phases, people lived in small pithouses similar to what has documented in other regions of the Southwest during this time. Pueblo I Period (AD 750 –975) northern Kayenta settlements are similar in size and structure to what has been documented for Anasazi on other parts of the Colorado Plateau (Cordell and McBrin 2012, Powell and Smiley 2002). Pithouses are the most common architectural form, but an increasing number of surface rooms are being constructed using a jacal or jacal-masonry style. The surface rooms were often constructed in an Arc or L-shape, and used primarily for storage. In other regions of the southwest, such as Mesa Verde, Pueblo I settlements are often quite large, and while there are cases of large Pueblo I sites in the Kayenta area, for example the Alkali Ridge Site 13 in Utah (Brew 1946) this is the exception and not the rule in the Kayenta region (Cordell and McBrinn 2012). In the Grand Canyon evidence for Pueblo I sites is limited. Two excavations along the River at sites B:10:4 and C:13:10 yielded dates (radiocarbon and ceramic cross-dating) indicating a Pueblo I occupation but later Pueblo II occupations obliterated all but a couple of hearths at these sites. The paucity of excavation data on Grand Canyon Pueblo I sites makes it difficult to surmise if settlement is similar to the wider Kayenta region during this time.

Pueblo II (AD 975 – 1150) was when the Kayenta groups expanded to the largest extent across the western Colorado Plateau, including into the Grand Canyon. In the large Kayenta region architectural forms shift from pithouses to unit pueblos that consist of a block of rooms facing a central plaza area. Typically, the Pueblo II sites would also contain a kiva and a trash mound. In the Grand Canyon, there are not many sites with kivas nor have many sites with room blocks, trash mounds and central plazas been documented. Instead, the Kayenta pattern seems to principally consist of smaller one and two room structures scattered throughout the central portion of the Park. During the latter part of the Pueblo II Period several site layouts, including the Tusayan Ruin and Walhalla Ruin, both are indicative of a typical Kayenta Pueblo II layout. Visitors to the Park can visit the Tusayan Ruin which has been reconstructed in a late Pueblo II Kayenta settlement arrangement, complete with a L-shaped room block, kiva, trash mound and central plaza. The Kayenta area is different from the Chaco and Mesa Verde regions, in the sense that aggregation of pueblos does not occur in the Kayenta region as it does in those other areas during the Pueblo II era. Aggregation does not occur in the Kayenta region until late into the Pueblo III period, in some cases as late as AD 1250, only 50 years before the abandonment of the area by the Kayenta peoples (Cordell and McBrinn 2012). This is an important observation for Grand Canyon Pueblo Period studies since the area would have been abandoned before aggregation became the norm amongst the Kayenta groups; one reason that there are only a couple of large aggregated pueblos recorded in the Park.

The Pueblo III (AD1150-AD1300) Kayenta settlement pattern shifted from a widespread homologous arrangement to a more variable system. Some settlements consist of clusters of pithouses, others contain unit pueblos, and a new pattern, entailing a set of masonry surface rooms arranged in a square and facing an internal courtyard, appears. No matter what the architectural form, the communities consisted of cluster of rooms divided between living rooms, storage rooms, and granaries. Kivas were usually circular, masonry lined and in some cases key-hole shaped. By AD 1300 the Kayenta area had been abandoned. Since the Kayenta settlement pattern continues in the middle Little Colorado River drainage and other ancestral Hopi regions, it is likely those regions are where the Kayenta people migrated. In the Grand Canyon, most of the area was abandoned from AD 1200 -1250, and these later larger settlements do not occur, though we do find some decorated wares (e.g., Flagstaff black-on-white, Tusayan Polychrome) that date to this time period but those sites continue the Pueblo II settlement pattern.

Post Pueblo Period (AD1300 – present)

After the abandonment of the Canyon by the Cohonina, Kayenta, and Virgin groups other indigenous peoples exploited the area but the extent of occupation would not reach the same size until late into the European settlement of the area (Fairley 2003, Schwartz 1989). Post-puebloan occupation of the Canyon has been documented for the prehistoric Prescott groups, ancestral and modern Paiute, Pai, Hopi, and Navajo native peoples and later by Europeans (Fairley 2003).

GRAND CANYON SETTLEMENT SUBSISTENCE MODELS (AD 700 – 1225)

Because the focus of this dissertation is on Grand Canyon indigenous settlement patterns from AD 700 – 1225, including, how differences in ecological paradigms affect our understanding of origins of the archaeological landscapes, a brief discussion on previously proposed settlement models is warranted. Below I discuss the four land use / settlement models proposed for the Pueblo Period at the Grand Canyon (Sullivan et al. 2002).

Biseasonal Model

The Biseasonal Model was first proposed by Schwartz et al. (1980) after carrying out extensive survey and excavations on the North Rim and along the Colorado River at Unkar Delta. His model posits that Grand Canyon pueblo peoples were agriculturalists that seasonally migrated between Unkar Delta and other Inner Canyon sites, where they lived and farmed most of the year to summer field houses on the North Rim (Schwartz 2008). Although these people likely shifted their long-term settlements based on cyclic weather patterns (e.g., monsoon rains), during most of the year they settled and grew corn, beans, and squash, at permanent settlements in the Inner Canyon, such as those found on Unkar Delta and seasonally the migrated to the North Rim during hot and dry periods for a short farming season. Schwartz argues that the weather patterns at the Canyon, where warm air rises from the Inner Canyon and creates a low blanket of warm air along the edges of the rim, allowed the Pueblo Period peoples to farm the North Rim. In good years, Schwartz (2008) argues pueblo peoples may have been able to harvest three set of crops a year: (1) a summer crop on the North Rim, and both (2) a late spring and (3) early fall set of crops from the Inner Canyon (Schwartz 2008).

Havasupai Model

The Havasupai Model is based on the historic settlement patterns of the Havasupai Tribe, the only tribe settled in the Canyon today (Weber and Seaman 1985). The model postulates a lowland/upland seasonal migration scenario. In this model, the Havasupai spent summers in the bottom of the Canyon, where they farmed and gathered wild desert and scrubland plants (McCoy 1990). Then in the fall and winter, the Havasupai migrated to the uplands on the South Rim, and exploited wild resources such as pinyon nuts and native grasses, like amaranth (McCoy 1990, Weber and Seaman 1985).

Powell Plateau Model

The Powell Plateau Model was developed by Richard Effland and colleagues (1981), and is based on a survey of the Powell Plateau, which is an Inner Canyon plateau located just west of the Kaibab Plateau at a lower elevation. The Powell Plateau model speculates that Pueblo Period indigenous peoples moved seasonally between garden houses and masonry-structures in a single geographic region of the Canyon (North Rim, South Rim, or Inner Canyon). These indigenous peoples then relied on extensive social networks to trade for resources that could not be obtained in their region (Effland et al. 1981).

Cross Canyon Model

The Cross Canyon model was developed by Sullivan et al. (2002) as a response to the limitations in earlier Grand Canyon settlement models that focused on limited interaction among the three distinct Canyon ecozones. The Cross Canyon model posits hunting and gathering of pinyon nuts and other wild resource on the South Rim in the fall and winter; gathering of agave and other wild plant resources along with hunting and fishing in the Inner Canyon during the spring; and farming in the Inner Canyon bottom and North Rim during the summer (Sullivan et al. 2002).

Discussion

All of these models provide valuable insight to my research into settlement during the Pueblo Period at Grand Canyon. The contrast between the Cross-Canyon model, which follows the UBARP Approach, and the other three models, which follow a SARG Approach, kindled my interest into how differences in ecological paradigms can affect our inferences about prehistoric settlement. All of the models recognize that it is likely that the wide variety of habitats in the Canyon would have been exploited by Pueblo Period peoples, and that in-order to utilize these various ecozones the people would have had to maintain a degree of mobility. How the Pueblo Period peoples used the variable environments in the Canyon, is where all of these models differ. The SARG Approach models all presume a heavy reliance on maize agriculture and are principally based on the geographic regions where the research occurred and little effort is made to incorporate data from the western part of the Canyon or from the Virgin Anasazi. For example, the Biseasonal Model provides a well-thought out and supported model of a settlement system that linked Unkar Delta to the Walhalla Plateau. However, it completely ignores what was happening on the South Rim and how that region would have been utilized by the people settled on Unkar Delta. Similarly, the Powell Plateau model focuses on the Powell Plateau, and although the researchers tried to expand the model to the entire Canyon, the data provided to back up the assertions were not robust enough for the task. The Cross-Canyon Model does incorporate all three major geographic regions of the Canyon but it is primarily based on data from the Upper Basin and published data from Schwartz's investigations, and it too ignores the Virgin group.

There are two deficiencies that all of the models share: (1) central Canyon focus and (2) little attention paid to group differences. All of the models focus on the archaeology of the central Canyon region (the section where NPS has the most development). This fact is understandable because that is where most of the investigations have occurred, but all of the models fail to investigate and make inferences about settlement in the far western and far eastern sections of the Canyon. Second, while many of the studies do recognize that there is a difference between the Kayenta and the Cohonina groups, the subsistence strategies presented for each of the models treats Pueblo People as a single entity and no one mentions the Virgin group, at all.

The new settlement models developed for this investigation will address both of these weaknesses. As will be discussed in Chapters 5 and 6, variation between Pueblo Period groups in their settlement strategies will be identified. Second, my analysis and new models will also include data from the entire Park. While the data from some sections of the Canyon are limited, they still provide insight into prehistoric Pueblo Period settlement. Finally, the variations between the models developed based on the SARG Approach and the UBARP Approach will allow me to explore the how differences in ecological paradigm can affect our inferences about the origins of the archaeological landscape.

CHAPTER SUMMARY

The focus of this dissertation on rethinking Pueblo Period settlement at the Grand Canyon entails utilizing the existing data recorded in the Park's archaeological site files. This chapter presents a chronology on the collection of archaeological data in Grand Canyon National Park, a summary of the prehistoric culture history of the region, and an examination of previous settlement models proposed for the Canyon's prehistoric inhabitants.

The discussion of previous archaeological research at the Park is broken into three eras – Exploration, Post World War II, and Heritage Management.   Archaeology sites recorded during the Exploration Era were not formally recorded but rather noted in journals and other trip reports by the early explorer-scientists, who were mainly natural historians that recorded information about archaeological sites and the Native Peoples of the Canyon as part of larger studies of the region. In this Chapter, I discuss how John Wesley Powell began the recordation of archaeological sites, which he attributed to the tribes currently living in the area during his initial voyages through the Canyon in 1869 and 1871-72. Later, during the twentieth-century both Neil Judd and Edward Hall conducted archaeological survey in the North Rim and portions of the Inner Canyon, while the Gila Pueblo conducted survey on the South Rim near Desert View and excavated the Tusayan Ruin, which is located in the same area.

The Post World War II Era saw an increasing interest in the archaeology of the Grand Canyon. Joe Ben Wheat, a seasonal ranger in the early 1950s who worked at the Park while completing his dissertation at the University of Arizona, conducted an excavation on a small Cohonina site near the Tusayan Ruin. Walter Taylor conducted the first professional archaeological survey of the Colorado River corridor. While his investigation was only reconnaissance in nature he did argue the Inner Canyon was likely sparsely settled due to the confined topography. The most extensive work during this Era was done by Douglas Schwartz, whose affiliation with Grand Canyon archaeology started when he conducted his dissertation research on whether or not there was continuity between the prehistoric Cohonina and the modern Havasupai. He completed three major survey and excavation projects on the North Rim and Inner Canyon, which "wrote the book" (literally 4 publications) on the archaeology of Grand Canyon. His excavations at Unkar Delta were the major source of information on Inner Canyon archaeology, until the Park just recently (2007) conducted excavations as part of a compliance project related to impacts from the Glen Canyon Dam. Schwartz's Unkar data demonstrated that Taylor was wrong about the Colorado River being sparsely populated. In fact, the Unkar excavations and later survey and excavation on the Walhalla Plateau on the North Rim, indicated that the prehistoric inhabitants of the Canyon practiced a complex settlement strategy that involved seasonal movements among the Canyon's various ecozones.

The Heritage Management Era is most readily described as the time period when archaeology in Grand Canyon National Park shifts to an applied research focus. During this Era, which continues today, archaeological research in the Park is conducted as much to protect the resource, as required by U.S. Federal Law, as it is to learn about the past. Robert C. Euler, a contemporary of Schwartz, was the Park's first anthropologist, who set up the first archaeological site file and database (the central data source for this dissertation), and developed the cultural resources program at Grand Canyon. His research focused on recording sites and protecting those that were being damaged by visitors. He conducted a helicopter survey of the Park, which him allowed him to quickly and efficiently identify larger archaeological sites from the air, often in areas that were practically inaccessible. Euler also conducted archaeological and paleontological excavation in Stanton's Cave, a site that had been vandalized by river runners. The site contained 165 split-twig figurines, one of the most recognizable artifacts from the Canyon's Archaic Period, along with numerous Pleistocene fauna. He also successfully tied funding for the Cultural Resources Program to helping the Park fulfill its management responsibilities related to whitewater rafting trips. The passing of the National Historic Preservation Act in 1966 provided the legislative mandate that Euler used to obtain this funding, though it took him over a decade to convince NPS administrators to fund his research. All of the archaeology conducted by the Park today is to comply with various portions of NHPA 1966, including and increasing consultation with native peoples, who claim affiliation with the Grand Canyon. The final project I discuss for the Heritage Management Era is the Upper Basin Archaeological Research Project (UBARP). For the past 25 years, UBARP has conducted a series of survey and excavation projects in the eastern part of the Park overlapping Kaibab National Forest. The results of these projects started a reassessment of the Canyon's Pueblo Period peoples, which this dissertation continues. In short, the UBARP studies demonstrated that the prehistoric pueblo peoples were not the intensive maize agriculturalist that have been presumed but instead were ruderal horticulturalists that relied heavily on production of wild resources and limited maize farming.

The second part of this Chapter presents a brief culture history of prehistoric indigenous occupation of the Park. Humans have inhabited the Canyon for over 8,000 years, during six different periods: Paleoindian, Archaic, Pre-Formative, Formative, Protohistoric, and Historic. The discussion in this chapter emphasizes the Formative Period, also called the Pueblo Period, which is the focus of this dissertation. During the Pueblo Period, archaeologists have identified three distinct groups, the Cohonina and both the Kayenta (South Rim) and Virgin (North Rim) Ancestral Puebloan groups. While in this chapter I present a more traditional SARG Approach view of the Pueblo Period, the data presented in Chapters 5, 6, and 7 all rewrite portions of this long-accepted history.

The Chapter ends with a discussion of the four previously proposed settlement models for the Grand Canyon peoples who inhabited the area from AD 700 -1225. Three of the models, Biseasonal, Havasupai, and Powell Plateau, all follow the SARG Approach and are grounded in a cultural ecological paradigm. They all a reliance on maize agriculture and settling in places where maize could be readily grown. The Cross

Canyon model follows the UBARP Approach and is grounded in an agentive ecological paradigm that argues people moved through the Grand Canyon to control production of wild resources, principally by fire, on the South Rim during the fall, winter, and early spring and then low-level planting of maize mixed with wild plant production on the North Rim and Inner Canyon during the late spring and summer. All of these models will be critiqued in future Chapters as I develop newer models of the Canyon's Pueblo Period occupation.

Chapter 5: A Geoinformatics Approach for Investigating Grand Canyon Settlement (AD 700 -1225)

Data and methods are central to any scientific investigation. Where did the data originate? How reliable are the data? How and why were the data manipulated? These are essential questions, and the focus of this chapter. The emphasis of this dissertation is on using existing NPS archaeological site files to investigate Grand Canyon settlement from AD 700 - 1225. To conduct the analyses that underlie the new settlement models presented in Chapter 7, I have amalgamated data from a variety of sources including Grand Canyon National Park, the Upper Basin Archaeological Research Project, and my own field and lab research.

BACKGROUND

I did not collect the site locational data recorded within the Grand Canyon National Park databases; however, I did ground-truth approximately 100 sites. During the ground-truthing, I checked to ensure the location was plotted correctly and that the archaeological feature and artifact identifications made on site forms were accurate. I have participated in the recording of archaeological data with the Upper Basin Archaeological Research Project in the eastern half of the Grand Canyon since 1994 and, since 2004, have developed the first program to collect geophysical data at archaeological sites on the North Rim, South Rim and Inner Canyon along the Colorado River. Again, I have not visited every site in the UBARP database, but I have been to approximately 90% of the sites and helped recorded artifact data for about 60% of the sites. In addition to fieldwork, the research conducted for this dissertation involved extensive lab work, as I will describe more fully below. I spent many months modifying and correcting the NPS databases before beginning the analyses. In addition to data corrections, I also assigned all the sites utilized in this research ceramic ware-groups and time periods by manipulating the data with techniques such as mean ceramic dating. Once the data had been corrected and reclassified, my analyses consisted of examining the data in terms of both socio-environmental correlations and overall settlement structure (Chapter 6). While there may be some errors in the location, identification, and artifact identification recorded in the databases, I am comfortable that, based on my fieldwork verifications and data cleanup measures, the errors are minimal and do not affect the overall interpretations I make in this dissertation.

GEOINFORMATICS

Geoinformatics is a method of inquiry and explanation that is interdisciplinary and employs the information sciences infrastructure to investigate complex geographic questions. Geoinformatics encompasses many of the traditional methods and technologies associated with geospatial analyses including surveying, mapping, photogrammetry, geographic information systems (GIS), global positioning systems (GPS), remote sensing (RS), and light detection and ranging (LiDAR) (Newhard et al. 2013, Reid 2011, Sahoo 2010). However, a geoinformatics approach extends the research focus to consuming “big data” (Birkin 2013) to answer questions about spatial organization. While most of these geospatial methods have been utilized in archaeology for decades, the application of them to large data sets has been limited (Arias 2013). Increasingly, geoinformatics is being applied to archaeological investigations (Newhard et. al 2013, Reid 2008) and this chapter outlines how a geoinformatics approach is applied to the focus of this dissertation, indigenous settlement in the Grand Canyon from AD 700 - 1225.

What sets geoinformatics research apart from traditional GIS analyses is that it involves several different geospatial technologies and large data sets (Arias 2013). Archaeologists following a geoinformatics method of inquiry will engage with several possible geospatial technologies (GPS, GIS, and RS), methodologies (wayfinding, weighted overlay, image classification), and data sources (elevation, soils, archaeology), often including legacy site file data. How archaeologists consume legacy data is a difficult question (Allison 2008, Arias 2013)and as discussed below, a variety of methods on how best to utilize these data have been put forth (Allison 2008, Comstock 2012, Ellis 2008, Witcher 2008). In his analysis of Mediterranean landscape surveys, Witcher (2008) notes that is often necessary to combine data from multiple projects in order to answer questions, but as Allison (2008) and her colleagues (Allison et al. 2008) demonstrate, if using multiple data sources, standardization of legacy data is often necessary. Sometimes compromises to methodology and sampling strategies must be made, so that a robust data set can be constructed to answer one's research question. These compromises may include a more liberal or conservative application of typical methodologies to ensure that an adequate sample size is obtained for analysis. For example, as will be further discussed below, typically to include a ceramic ware as being present at a site, an investigator may require a minimum number of sherds to be recorded, but when dealing with survey-level legacy data, oftentimes count data are not available, as only presence or absence of a ceramic ware is recorded. An analysis methodology requiring a minimum number of sherds could limit the sample size so severely that any analysis is meaningless. The basis of this dissertation is archaeological site locations that have been recorded by the NPS for at least the past 60 years, and while the data have all be entered into digital formats, the data still are only as good as the initial data recorded on paper. For that reason, certain methodological assumptions (described below) were required.

Global Positioning Systems

Global positioning systems (GPS) were first developed by the United States Department of Defense in the 1960s and 1970s as an improved navigation system for the armed forces. It took almost twenty years (until the mid-1990s) for the system to be fully functioning (Kennedy 2009). The system is not only used by archaeologists and other scientists but by consumers throughout the world in everything from sportsman's GPS units, to phones, watches, and vehicles.

GPS is considered a U.S. owned utility that provides users with positioning, navigation, and timing capabilities, and is divided into three segments: space, control, and user (www.gps.gov). The space segment consists of a constellation of 24 satellites that orbit the Earth at an altitude of approximately 20,200 kilometers. The satellites are positioned in six equally-spaced planes, with each plane containing four slots that are occupied by baseline satellites. This 24-slot arrangement ensures that users are able to access data from at least four satellites anywhere on Earth (GPS.com). The control segment is made up of a global network of ground facilities that track, monitor, and control the satellites. Currently, the U.S. control segment consists of 12 command and control antennas and 16 monitoring sites located across the globe (GPS.com). The GPS user segment consists of receiver equipment that collects transmitted data from the satellites and uses them to calculate the geographic position of the user. GPS is used routinely by archaeologists to record the locations of sites or features on the landscape

(Sullivan et al. 2007). The increased accuracy has allowed archeologists to conduct more robust and accurate spatial analyses (Sullivan et al. 2012).

Geographic Information Systems

Geographic Information Systems (GIS) are utilized in archaeology at multiple scales and for a wide range of activities (Kvamme 1995). In her recent dissertation, Veronica Arias (2013) examines how and why GIS has been used in archaeology over the past 25 years. She argues that GIS is one of the most important methodological advancements in archaeology in the past two-and-a-half decades, and notes that just like the quantitative revolution of the 1970s and 1980s, GIS has the potential to fundamentally change the practice of archaeology.

While an agreed-upon definition of GIS is elusive, a satisfactory description is provided by Steinberg and Steinberg (2006): "GIS is a spatially based technology that enables the capture, management, analysis and display of geographically referenced information." According to the Steinbergs, "a GIS system requires specific hardware, software, data with a spatial component, and a knowledgeable user who can construct and process geographic data" (Steinberg and Steinberg 2006:8).

The two most common usages of GIS in archaeology are for resource management and site location modeling (Conolly and Lake 2006, Kvamme 1999). Resource managers often use GIS as a database technology to manage both the locational and textual data about the sites that have been recorded in their management area (Mink et al. 2006). Other archaeologists utilize GIS for cartographic modeling analyses (Judge and Sebastian 1988, Kvamme 2006). The aim of the models is to predict the location of areas that have either a high or low probability of containing archaeological sites

(Westcott and Brandon 2000). While these models are principally developed to help resource managers comply with their regulatory responsibilities, they can also be a useful first step in understanding past human behavior (Mink et al. 2006). The statistical analyses, conducted as part of the modeling process, can elucidate relationships between archaeological sites and environmental variables that provide data points that can then be employed to make inferences about human behaviors reflected in the archaeological record.

Remote Sensing

One geospatial technology gaining a renewed application in archaeology is aerial or satellite remote sensing (Johnson 2006, Parcak 2009). Satellite technology was initially adopted in archaeology during the 1970s, as the US government began launching a series of earth monitoring satellites, such as LANDSAT (Lyons and Avery 1977). However, the interest in using satellite data for archaeological research stalled during the 1980s, as the resolution of the satellite data was too coarse to make meaningful investigations of the archaeological record and the cost of obtaining the data and software were too cost prohibitive for most projects. In the late 1990s, as satellite technology advanced, and high-quality fine-resolution data became more widely available through commercial data-vendors, a renewed interest in the method has emerged. Satellite remote sensing is principally applied in archaeology to discover the location of unknown archaeological sites, and to map features within known archaeological sites. These applications are performed either through visualization (viewing archaeological phenomena by sight) or multi-spectral analyses (measuring light reflection from archaeological sites).

Geophysical Survey

Subsurface remote sensing in archaeology is often called geophysical prospection or archaeo-geophysical survey (Clark 2006, Johnson 2006, Witten 2006). Geophysical remote sensing technology was first applied to archaeological research in North America at Williamsburg, Virginia in 1921 (Gaffney and Gater 2003). While sporadically applied during the mid-twentieth century, it was during the 1970s that geophysical surveys in North American archaeology intensified, as commercial equipment became more readily available and compliance archaeology expanded, a trend that continues today (Bevan 1975, Bevan and Kenyon 1975, Johnson 2006, Sullivan et. al. 2012, Witten 2006). The increasing availability of commercial equipment amplified the quality and quantity of data collected, and the more intensive usage by archaeologists resulted in theoretical (Kvamme 2008) and methodological advancements (Clark 2001) in archaeological geophysics.

Archaeological geophysical surveys consist of a set of noninvasive techniques that measure variations in Earth's physical properties (Gaffney and Gater 2003). The techniques can be broadly classified into two groups: active and passive. Active geophysical techniques, introduce a form of energy, such as electricity (electrical resistance) or electromagnetism (ground penetrating radar), into the ground and measures variation in the movement of the energy through a matrix (Witten 2006). Passive techniques measure variation in natural phenomena, such as magnetic flux density (fluxgate magnetometery). These techniques are used by a variety of geoscientists to map large scale variations across the landscape (Milsom and Eriksen 2011); conversely archaeologists employ them to map very fine disparities in anthropogenic soils or to find small objects (Gaffney and Gater 2004, Witten 2006). The focus on collecting fine resolution data by archaeologists requires a more intensive data collection strategy than is utilized by most geoscientists. Many archaeologists have made the unfortunate mistake of enlisting geosciences colleagues to perform geophysical surveys only to be disappointed with the results because the surveys were poorly designed to locate archaeological phenomena that are often expressed at finer scales than geological or pedological phenomena (Conyers 2004).

Geoinformatics: A New Science Paradigm

The term geoinformatics is sometimes mistakenly applied interchangeably with the terms Geomatics, geospatial technologies, or GIScience; each of these terms, while similar, has distinct meaning in geographic inquiry. Geomatics refers to the process of gathering, storing, and processing spatially referenced or geographic information (Gomarasca 2009). This data gathering process employs a variety of geospatial technologies and occurs either in the field with surveying and mapping, or by processing digital data in the lab. Geospatial technologies are information systems, or other technological products, designed to measure, record and analyze spatial data, and include GIS, GPS, and geophysical survey methods.

Geoinformatics encompasses all of these processes, methods, and techniques, and applies them to multiple large data sets "big data," often requiring data mining, and copious amounts of information processing power, exploratory analyses, and novel approaches, such a geosimulations (Birkin 2013). Birkin argues that geoinformatics is the geosciences entry into the new fourth paradigm of science inquiry. He notes "while earlier paradigms are characterized by experimentation and reasoning, the latest approaches are strongly driven by the availability of data at an unprecedented scale, and by the computational resources to extract maximum value" (Birkin 2013:1). Bioinformatics is the most notable example in the application of the new "big data" science paradigm. The fully mapped human genome, itself, was an intensive task but genetic data are now routinely mined to make discoveries, big and small, on the complex interactions that occur within the human body (Shah and Kusiak 2007). A perusal of most scientific journals, including the flagship publications of Nature, Science, and PNAS will uncover numerous big-data driven investigations. The task for those of us who follow this new science paradigm is to "deploy the methods, resources and imagination to discover the meaning in these rich streams of raw data" (Birkin 2013:1).

Archaeology is just beginning to enter this fourth science paradigm, and while we do not have anything rivaling the human genome project, there are several efforts currently underway whose goal is to compile both academic and compliance archaeological data (e.g., tDAR, DINNA, ADL). These data compilation projects are attempting to migrate the gray literature created by those doing compliance or government sponsored research and research submitted by academics into one online database. Their goal is noble, as the vast majority of archaeological data collected today is gathered as part of these compliance investigations, but unfortunately the data are often not easily accessible. Hopefully, these attempts will succeed so that large regional and pan-regional investigations can be undertaken.

In regards to research usages of big data in archaeology, most attempts have been proof of concept, data set construction, or generic data syntheses. I would posit it is time to leverage these large-scale databases to answer questions about the archaeological record. Too often large regional archaeological analyses have focused too intently on improving methodologies, and when they are not careful they let the technology drive the research questions rather than vice-versa. This dissertation is one example of employing regional data, mined from a variety of sources, and employing a variety of geospatial analytical techniques to answer an anthropological question about prehistoric settlement in the Grand Canyon from AD 700 – 1225.

AN INTRODUCTION TO THE GRCA DATABASE AND GIS (ATTRIBUTE AND SPATIAL DATA)

Data on the archaeological record of the Grand Canyon have been collected for almost 150 years (Chapter 4 of this dissertation). The data collected by Powell, during his river corridor surveys are available in a variety of official records and personal accounts (Darrah 1947, Powell 1875), but the earliest data from survey along the rims are spotty. For the North Rim, Judd's information can be located but his assessment of the local archaeology as being relatively inconsequential renders most of his data uninformative. Hall's data, on the other hand, are quite informative, and his analyses on settlement can help inform modern interpretations. On the South Rim, there is a short report on Haury's excavation on the Tusayan Ruin (Haury 1931), but the data on 200 plus sites found during the Gila Pueblo survey of the area have been lost.

During the 1960s, under the guidance of the Park's first anthropologist, Robert C. Euler, data on archaeological sites were compiled on paper site cards that were later entered into the Southwest Archaeological Research Group (SARG) relational database in the 1980s (Euler personal communication). Beginning in the 1990s, the Grand Canyon National Park, started creating a GIS that would link the attribute data recorded on the site cards and stored in the relational database, to spatial locations. It was also during the 1990s that the Archaeological Site Management Information System (ASMIS), an NPS-wide, standardized relational database, was pushed out to all NPS units, including Grand Canyon. Initially in the Park GIS, archaeological sites were digitized as site centroids but more recently polygon site boundaries have been digitized for a subset of the Grand Canyon dataset. Although polygon representations of sites in GIS analyses have advantages (Mink et al. 2006), the number of GRCA sites whose boundaries have been digitized as polygons is too few to utilize them for this investigation; thus all analyses in this dissertation will be conducted using site centroids to represent archaeological site locations.

Grand Canyon Pueblo Period Archaeological Database

This study relies on five primary archaeological databases: Grand Canyon National Park's site (centroid) datum GIS layer, the Grand Canyon National Park archaeology attribute database (modified ASMIS), the Grand Canyon Archaeological Synthesis (GCAS) database, the Upper Basin Archaeological Research Project (UBARP) mapping unit (MU) GIS layer, UBARP Artifact Enumeration Unit centroid GIS layer, and numerous environmental GIS geodatabases (described in more depth when employed below) provided by GRCA to me. Working with legacy data and regional environmental databases has its own special set of problems (see earlier Legacy Data discussion). It is important to note that none of these databases were used "off-the-shelf" without some type of major modification by me specifically for this study. In addition to the field time I spent ground-truthing the Park's data and assisting in the collection of the UBARP data, I also spent many months in the lab correcting, reclassifying, and manipulating the datasets before the analyses for this dissertation could be initiated. A brief discussion of the data used in this investigation follows.

In the late 1990s and early 2000s, Grand Canyon National Park (GRCA) began developing a GIS for archaeological site locations reported in the Park. The data were originally plotted using historic maps, and later by downloading global positions system (GPS) data (some corrected, some not) into ESRI's shapefile format. In 2012, a cooperative "geo-rectification project" between the Park and the Northern Arizona University (NAU) Geography Department resulted in a GIS with vastly improved locational positions for the archaeological sites (Ellen Brennan, personal communication, 1/29/2014). The GIS has been crucial for Grand Canyon archaeologists to conduct their resource management responsibilities, which include evaluating park projects' effects on cultural resources, planning efforts like environmental impact studies and environmental assessment development, planning response to fires and a host of other federally mandated responsibilities (Ellen Brennan, personal communication, and 1/29/2014). The GIS layer employed in this study is the Site Datum feature layer from the Cultural Resources geodatabase, a product of the NAU and GRCA geo-rectification project. This GIS layer provides a point location, for the centroid of each site datum, and the attribute data contains eight attribute fields (Table 5.1). The attribute data entered into the Site Datum GIS layer, are limited and only useful for conducting rudimentary spatial analyses. In order to conduct more intensive investigations of the Pueblo Period archaeological record of GRCA, additional attributes needed to be linked to the GIS data layer. These additional data layers were acquired from three tables in the GCAS database and cross-checked with data from the GRCA archaeology database and paper site files (described below).

Table 5.1. Attribute data for the GRCA Site Datum GIS layer

Field Name	Description
Shape	Feature Geometry (point)
GISID	ID # Generated by NAU for this centroid
ASMIS_ID	ID# for the archaeological site in ASMIS
State_NUM	State Trinomial Site Number
UTM_EASTING	Eastward (X) UTM Coordinate
UTM_NORTHING	Northward (Y) UTM Coordinate
CR_NOTES	Annotated Notes Field from GRCA dbase
SOURCE	Source of locational info (GPS, MAP)

The GCAS and GRCA archaeology databases, although similar, were created for different purposes, and therefore contain complementary but dissimilar data. The GRCA archaeology database was originally created in the 1980s, updated between 2004 and 2008, and contains a wide variety of information about the archaeological resources in GRCA. The GRCA database was developed to meet two needs: (1) supply the required data fields to the NPS ASMIS and (2) hold information above and beyond what is in ASMIS (e.g., C14 dates, pollen data, etc.) for GRCA to use for other management and research data analyses (Balsom 2003, Ellen Brennan, personal communication 1/29/2014). The GRCA database combines data from numerous NPS sources including paper site records, the River Corridor Monitoring Program database, and ASMIS (Horn 2008). It is an SQL database, maintained on the Park's server and intranet, and is a complex relational database with numerous parent and child tables (Figure 5.1). These data have been entered by a large number of individuals, as funds and projects have allowed, and while the data are useable for cursory analyses for conference presentations (Mink 2009), the information is often incomplete and not very useful for large-scale analyses (like the ones presented in this dissertation). In particular, there are no data recorded on a site's artifact assemblage, which it makes it impossible for a researcher to independently assign sites to temporal periods or cultural groups. The inability of an investigator to independently (re-)classify data necessitates that the researcher utilize the temporal and cultural data listed in the database, which was often determined by the field crew based on intuition.

The GCAS database is a much more refined and complete database. It was created by the Museum of Northern Arizona (MNA), for GRCA, as a deliverable for the Grand Canyon Archaeological Synthesis project. The GCAS project was a cooperative research venture, between MNA and GRCA, to develop a synthesis of Grand Canyon archaeology (Smiley and Vance 2011), and to be used by later researchers to conduct in-depth analyses, such as this dissertation. The database contains three tables, one each for ceramics, lithics, and general site attributes (Table 5.2). The data in these tables were compiled in 2010, when MNA associates examined approximately 4,200 scanned PDF site files (1,400 of the masonry structure site forms were scanned into PDFs by me in 2008, prior to GCAS project) and entered frequency data for each of the ceramic types, lithic raw materials and tool types, and archaeological site features (each table will be

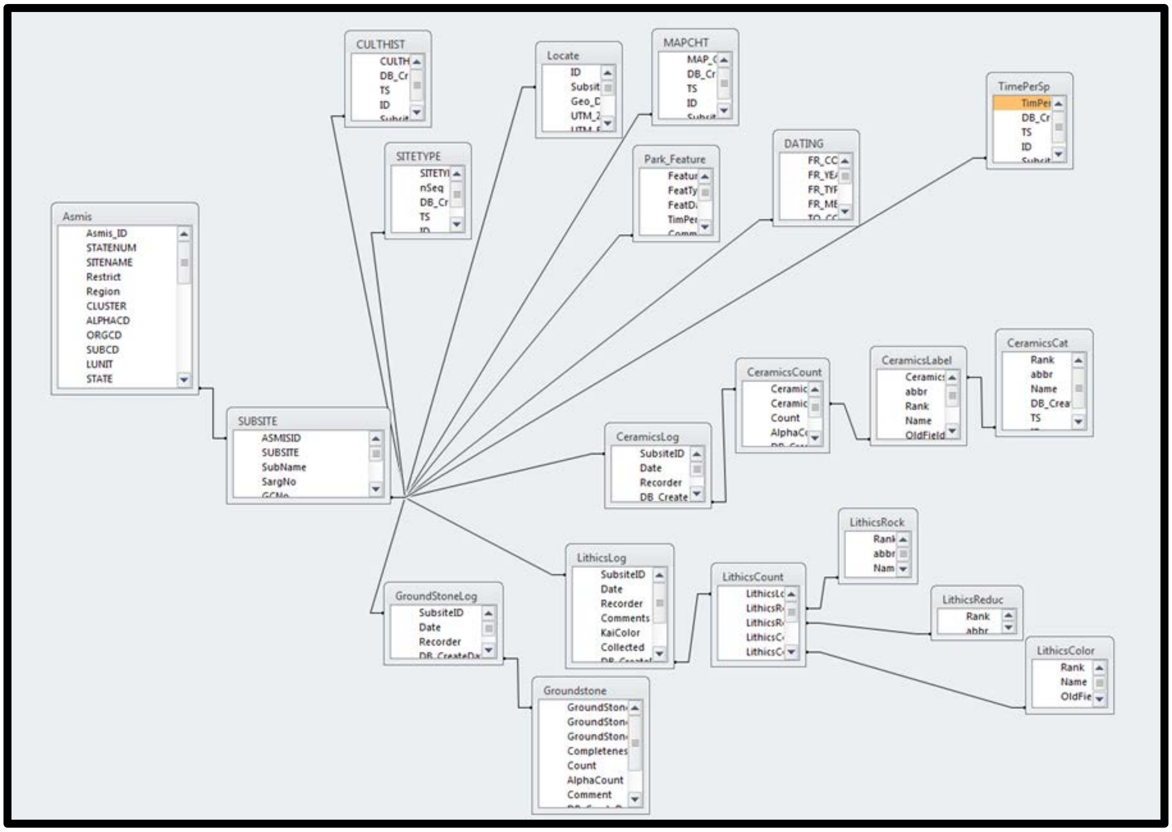

Figure 5.1. GRCA Archaeology table relationships.

described more fully in the appropriate sections below). The data from the GCAS database were invaluable for this research project, even though they were supplemented with data from the GRCA database (e.g., site area), the GIS Site Datum layer (site descriptions), and original data created by me for site type, cultural affiliation, and chronology. The existence of this database did allow me to concentrate on data cleanup, reclassification, and analyses rather than data entry of artifact frequencies for over 4,200 sites.

Table 5.2. GCAS data tables and their attribute fields.

Final Site Table	Ceramics Table	Lithics Table
STATE_NUM	STATE_NUM	STATE_NUM
Structures	Collex_Mthd	CollexMthd
MasonryRms	Un_Tus_GWr	Coder
Middens	Lino_Fug_Red	UnkMaterial
Enclosures	Lino_Gray	KaibabCht
BedRkRooms	Kana_a_Gray	RedWallCht
SecFloorRooms	CocoMedGray	RedButteCht
LowWallRooms	TusCorr	Chalcedony
Depressions	Moen_Corr	Quartzite
MainStrShape	Kiet_Siel_Gray	BlackRhy
MainStrRmCt	Lino_Tradition	Jasper
RkShlArch	Tus_Plain	PetWood
RkShlNoArch	OLeary_Tooled	UnkObsidian
Petroglyphs	Obelisk_Gray	GovtMtnObs
PetroPanels	Honani_Tooled	PartCrObs
Pictographs	Un_Tus_WWr	PreslyWaObs
PictoPanels	Kana_a_BW	BlkTnkRsWIOBS
Roasting_Pits	Wepo_BW	UnkPaleo
ExtSlabHearth	Black_Mesa_BW	Clovis
LinearAgFea	Sosi_BW	Folsom
NonlinearFea	Dogoszhi_BW	UnkEarlyArch
Burials	Flagstaff_BW	Jay
CeramicTtl	Tusayan_BW	Bajada
CeramicReptd	Kayenta_BW	UnkMidArch
DebitageTtl	Shato_BW	NorSiteNot
DebitageReptd	Un_SJ_RWr	PintoSJ
ProjPts	Buff_BR	Humboldt
StoneTools	Abajo_BR	Hawken
Cores	Deadmans_BR	RockerSideNot
GS	Medicine_BR	UnkLateArchaic
BedRkGrinding	Tus_BR	GatecliffStem
Sandals	Cameron_Poly	SanRafaelSideNot
Weaponry	Citadel_Poly	Gypsum
SplitTwigFig	Tus_Poly	UnkElko
Baskets	Tsegi_Poly	ElkoEared
OtherPerishables	Un_SF_Mt_GWr	ElkoSideNot
Shell	Floyd_Gray	ElkoCorNot
Ornaments	Deadmans_Gray	Chiricahua
Turquoise	Deadmans_Fug_Red	Armijo

Tabe 5.2, cont.

Problem	Floyd_BG	UnkPreformative	
Comment	Deadmans_BG	WBMII	
CoderName	Kirkland_Gray	Cienega	
	Un_Tizon_BWr	UnkFormative	
	Tizon_Brown	Rosegate	
	Tizon_Wiped	Triangular	
	Cerbat_Brown	KahorshoSer	
	Un_Prsct_Ver_GWr	NawthisSideNot	
	Prsct_Verde_Gray	ParowanBasalNot	
	Prsct_Verde_BG	SitegreavesSer	
	Aquarius_Orange	DesertSideNot	
	Aquarius_Brown	BuckTaylorNot	
	Angell_Brown	Cohonina	
	Sunset_Brown	Coconino	
	Sunset_Red	RoseSpgs	
	Sunset_Smudged	Eastgate	
	Verde_Brown	BullCr	
	Un_Tus_Virg_GWr	TrumbullStem	
	North_Cr_Gray	BiFaceBiFrag	
	North_Cr_BG	ProjPtFrags	
	North_Cr_Corr	UnkPointType	
	Un_Tus_Virg_WWr	Comment	
	Mesquite_BG	NewTypePt	
	Washington_BG		
	St_George_BG		
	Hilldale_BG		
	Glendale_BG		
	Un_Walhalla_Wr		
	Walhalla_Plain		
	Walhalla_Corr		
Walhalla_BW	Un_Logandale_Wr	Moapa_WWr	Jeddito_Plain
Boulder_BG	Logandale_Gray	Un_Shinarump_GWr	Jeddito_Corr
Boysag_BG	Logandale_Corr	Shinarump_Plain	Hopi_Yellow_Wr
Trumbull_BG	Un_Shivwits_GWr	Shinarump_Corr	Navajo_Util_Poly
Moapa_Brown	Shivwitz_Plain	Shinarump_Brown	Sikyatki_Poly
Moapa_Gray	Shivwitz_Corr	Un_Shinarump_WWr	Un_L_Colo_WWr
Moapa_BG	Un_Jeddito_Wr	Virgin_BW	Walnut_BW
Moapa_Corr	Jeddito_BY	Toquerville_BW	Lowr_Colo_Buff
Slide_Mtn_BG	Awatovi_BY	Un_Shinarump_RWr	Parker_RB
Poverty_Mtn_BG	Holbrook_BW_B	Holbrook_BW	Parker_Stucco
Holbrook_BW_A	Other	Present	CoderName

Data Preparation

The data from the aforementioned five datasets, and PDF versions of the GRCA site files, were compiled into one comprehensive dataset that was utilized for this study. As with any project employing multiple legacy databases, the number of sites utilized for each analysis may vary. Every effort was made to match the data sets as much as possible and to maximize the number of sites utilized in each analysis but in some cases the data just do not exist (e.g., the total amount of lithic debitage or number of pottery sherds at a site may not have been recorded). An ESRI ArcGIS file geodatabase was developed to house both the spatial and attribute data for this analysis. Some of the non-spatial analyses were performed in other software programs, most notably, Microsoft Excel, IBM SPSS, and R, but the results were then imported into the geodatabase for additional spatial analyses.

The first task was to cull the GIS Site Datum layer, so that it only included data germane to this investigation. The GIS file initially had 4,243 recorded archaeological sites (Figure 5.2) but numerous sites were located outside of the current GRCA boundary. As the most visible and oldest U.S. Federal Government management area in the region, sites were often reported and recorded by Grand Canyon National Park personnel prior to the other nearby land agencies being created, or before they had full-time cultural resource managers on staff. Because there is a possibility that some of the site locations may be slightly mis-plotted, and the fact the Park's GIS boundary layer was digitized from United State Geological Survey 7.5-minute quadrangles, where both the plotting of the boundary and underlying topographic maps introduce various levels of error, sites for this dissertation were selected if they were within 150-meters of the GRCA boundary polygon. After the first cull, the resulting 4,103 sites (Figure 5.3) were then linked to the GRCA archaeology and GCAS databases to further eliminate sites not germane to this study.

Site Type

Once the sites were culled based on location, the next step was to eliminate sites that are inappropriate for this analysis based on attribute data. The "CR_Notes" field in the Site Datum layer is a *de facto* site type layer created by the NPS and MNA during the recent geo-rectification project. This field is a combination of the site type and summary descriptions fields in the GRCA archaeology database. While the "CR_Notes" field is useful for NPS resource managers, it is not a suitable site typology for in-depth analyses on settlement of the Canyon because of two issues.   First, a lack of terminological consistency in site type, for example, a site with a masonry structure can be coded in the Site Datum layer as one of the following: habitation, field house, masonry pueblo, masonry structure, structure, and a host of terms like 1-room structure, 1 room structure with lithics, multi-room pueblo with terraces, and multi-structure habitation with artifact

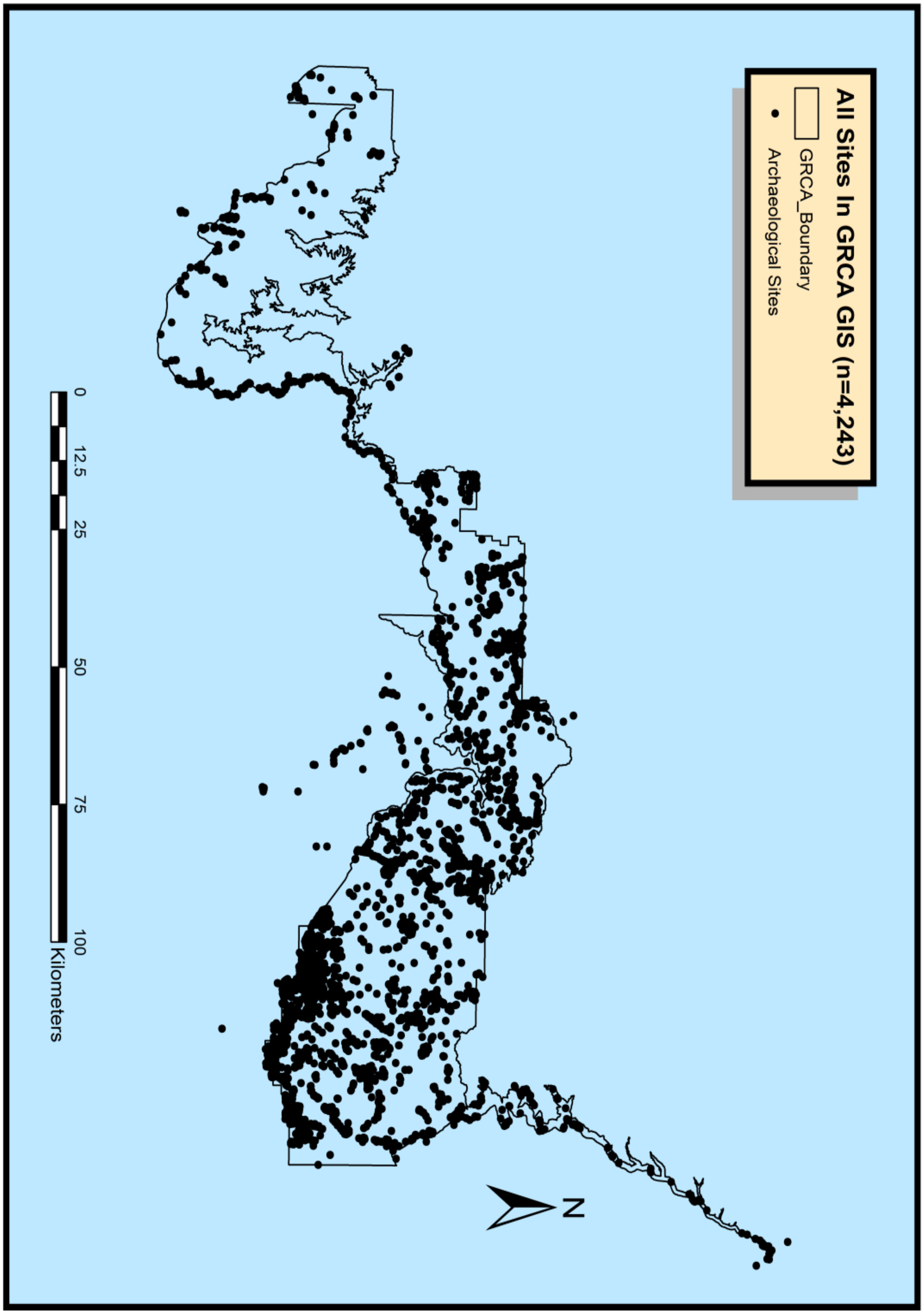

Figure 5.2. All the archaeological sites plotted in the GRCA Site Datum GIS layer (n = 4,243).

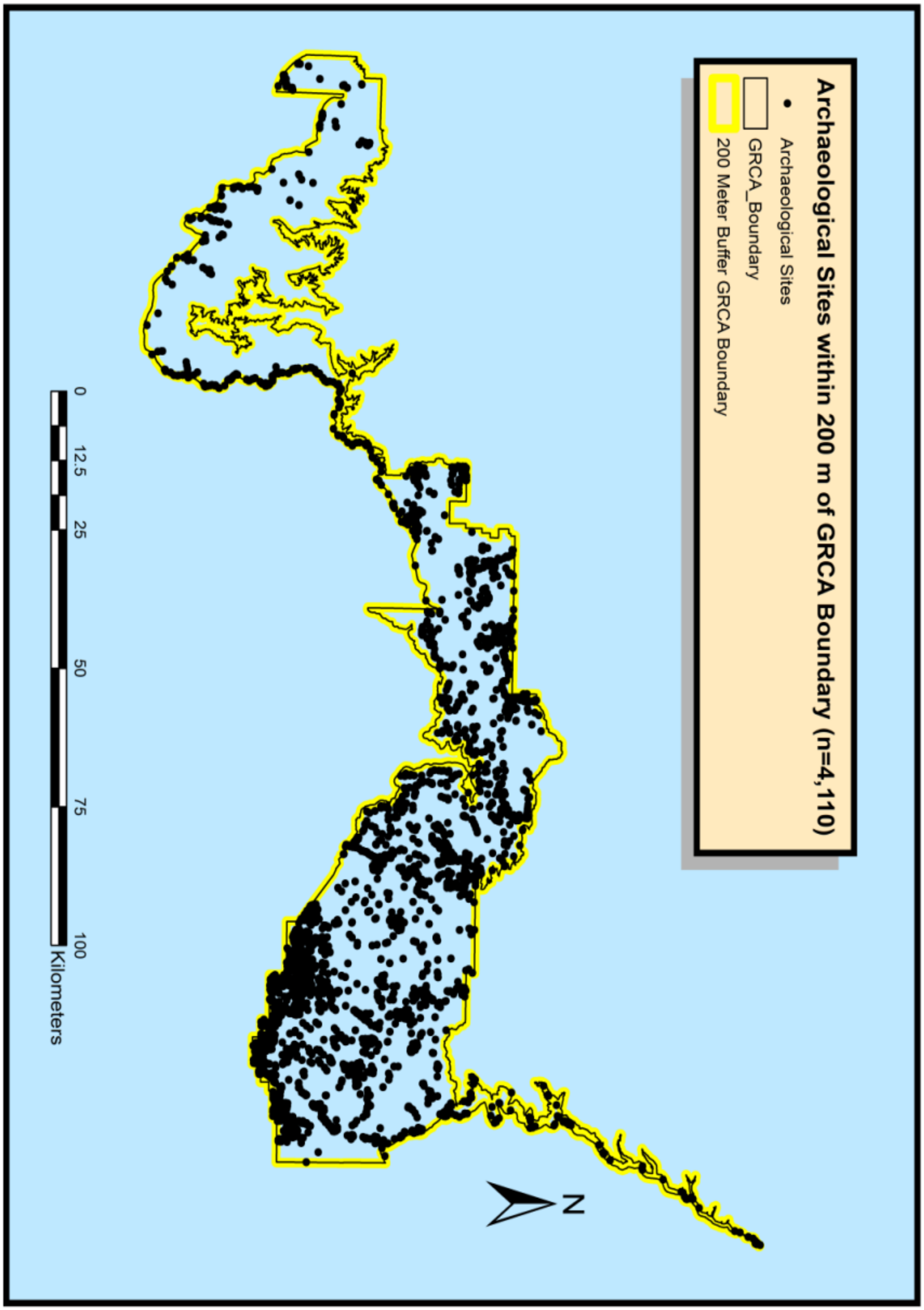

Figure 5.3. Archaeological sites within 200-meters of the GRCA boundary layer (n = 4110).

scatter and terraces, etc. Second, many of the types have an interpretive undertone (e.g., field house or storage structure)., masonry structure, structure, and a host of terms like 1-room structure, 1 room structure with lithics, multi-room pueblo with terraces, and multi-structure habitation with artifact scatter and terraces, etc. Second, many of the types have an interpretive undertone (e.g., field house or storage structure).   For those reasons, I developed a site typology that is consistent and free of functional interpretation, by modifying the Mapping Unit system developed by the Upper Basin Archaeological Research Project (Sullivan et. al 2002) and combining it with useful elements of the GRCA site type. The two other databases and the PDF site forms were then consulted to assign each site to a new site type. The new site typology contains 33 site types (Table 5.3).

Site Type 1 and its eight sub-types represent structure sites. These sites all had some form of architecture recorded on the site form. The subsets were created by ascertaining (1) how many masonry structures and rooms were present, (2) if the structure was an unusual case (e.g., pithouses or rockshelters with numerous rooms), or (3) historic structures (both European American or indigenous (principally Navajo but also some Pai and Hopi structures

Rockshelters (2.0) were divided into three sub-categories based on (1) presence (2.1) or (2) absence of masonry walls (2.2) and (3) if the site has an associated granary (2.3). The sites that were coded as 2.0 (rockshelter without masonry) are rockshelters that contain archaeological deposits but no masonry walls or structures. Granaries (2.3) are rockshelters or overhangs containing an enclosed masonry room that is too small for habitation and likely utilized to store wild or domesticated plant remains (Schwartz et al.

1980). If the shelter contained the remains of masonry walls but not an enclosed structure it was coded as a rockshelter with masonry walls (2.3). Both the granary and rockshelter with masonry walls are differentiated from the structure sub-category, rockshelter with multiple rooms, by size and their unsuitability for habitation. A site coded as a cave (3.0), a separate category from rockshelter, consists of limestone dissolution caverns with archaeological materials.

Table 5.3 Site Types employed in this dissertation.

Code	Description	Frequency
1	Masonry Structure	15
1.1	Masonry Structure 1 Room	375
1.2	Masonry Structure Multiple Rooms	199
1.3	Multiple Masonry Structures All Single Rooms	204
1.4	Multiple Masonry Structures at least 1 with Multiple Rooms	209
1.5	Rockshelter with Multiple Rooms	4
1.6	Rock Alignment with Artifacts (no-agricultural)	19
1.7	Possible Pithouse (depression with artifact scatter)	24
2	Rockshelter without masonry	209
2.1	Rockshelter with masonry	196
2.2	Rockshelter-Granary	54
3	Cave	7
4	Agriculture Features	25
5	Artifact Scatter	639
5.1	Lithic scatter	191
5.2	Sherd and lithic scatter	93
6	FCR	216
6.1	Mescal Pit	166
8	Cache	4
12	Rock Art (Both Pictographs and Petroglyphs or Unknown)	24
12.1	Petroglyph	24
12.2	Pictograph	43

The artifact scatter site type is divided into four sub types, with the base site type (5.0) indicating artifact scatters with an unknown composition. Site Type 5.1 represents lithic scatters, or artifact scatters only containing flaked stone or ground stone artifacts. Site Type 5.2 indicates sites with both lithic artifacts and pottery sherds comprising the assemblage; and Site Type 5.3 refer to scatters of historic artifacts.

Site Type 6 refers to locales that contain fire-cracked rock (FCR). The base types, 6.0, are piles or scatters of fire-cracked rock. Sub Type 6.1 refer to mescal roasting pits, which are comprised of large doughnut shaped piles of fire-cracked rock, used to roast agave plants.

The final set of site types are those associated with rock art. Sites categorized as 12.0 either contained both pictographs and petroglyphs or the type of art present was not recorded. The two rock art sub-types represent sites that contain only petroglyphs (12.1) or pictographs (12.2).

The other nine site types - burial (7.0), cache (8.0), cairn (9.0), dendroglyphs (10.0), historic/modern extractive sites (11.0) lithic quarries (11.1), mines (11.2), historic features (13.0), and undetermined/unknown site types (14.0) - were all deleted as they represent site types not associated to Pueblo Period archaeological sites. In addition, several sub-site-types were deleted because of the lack of correlation to the Formative Period, including site type 1.8 (historic structures) and 5.3 (historic artifact scatters). The deletion of these site types and several sites that had no site forms or information beyond the GIS plot resulted in a master site dataset containing 2,936 sites (Figure 5.4).

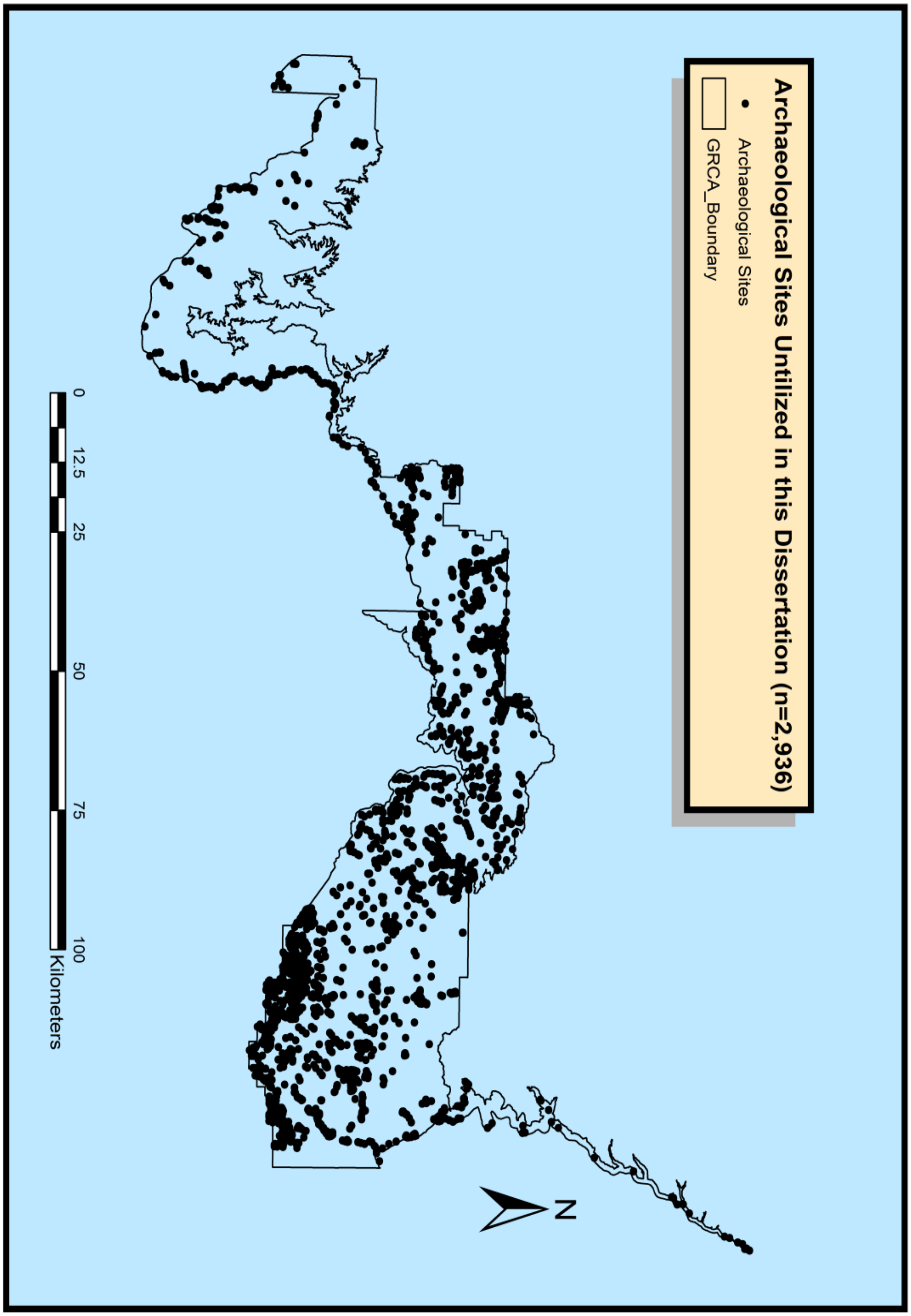

Figure 5.4. Archaeological sites utilized for this study (n = 2,936).

TEMPORAL AND CULTURAL PARSING

In order to fully understand Grand Canyon land use during the Pueblo Period, methods for classifying sites into both group associations and temporal periods had to be developed. Luckily, the archaeological record of the Grand Canyon is replete with pottery sherds of archaeologically defined groups, spanning 1,175 years (AD 675 – 1850). As will be elaborated more fully below, utilitarian gray wares were used to establish group associations, and decorated ceramics were utilized to place sites into a chronology.

Three ceramic ware groups are associated with Pueblo Period sites in the Grand Canyon. The three ware-groups, and the traditional archaeological groups they are associated with, are San Francisco Mountain Gray Ware (SFMGW) associated with the Cohonina, Tusayan Gray Ware (TGW) associated with the Kayenta Anasazi, and an assemblage of gray wares I have termed Virgin Gray Wares (VGW) associated with the Virgin Anasazi. Colton initially described SFMGW and TGW (1939, 1955) and VGW (1952); since then all of these wares have been further refined (Harry et al. 2013, Lyneis and Hays-Gilpin 2008).

Cohonina Ceramics

Cohonina ceramics are exclusively San Francisco Mountain Gray Wares (SFGW) and are composed of six types (Table 5.4) manufactured from AD 700-1200. The wares are predominately utilitarian wares, constructed with a ring-built technique (slab base is built up with thick coils) and thinned using a paddle and anvil. In the eastern Grand Canyon, studies have concluded SFMGW is formed from Mesoproterozoic sedimentary clays collected from the bottom of the Canyon (Carter 2008, Carter et al. 2011), and tempered with fine quartz and feldspar with mica and biotite also present (Carter and Sullivan 2007). Vessels are typically fired in a reducing atmosphere though some may have been fired in an oxidizing atmosphere. Vessel forms include shallow bowls and jars with handles attached directly to the rim, appearing gray or brown in color but sometimes with a slight (fugitive) red slip. The vessels are typically not painted, but in some cases, organic black paint will appear in on the interior of bowls in designs that match Tusayan White Wares (TWW) – Floyd Black-on-Gray and Deadmans Black-on-Gray. There is not a specific white ware that is exclusive to the SFMGW, and in fact most decorated wares found in association with SFMGW are TWW.

Table 5.4. Cohonina ceramics and associated date ranges.

Name	Colton Begin	Colton End	Oppelt Begin	Oppelt End	Mink Begin	Mink End
Floyd gray	700	900	700	900	700	900
Deadmans gray	pre-700	1150	775	1200	775	1200
Deadmans Fugitive Red	pre-700	1050	775	1200	775	1200
Floyd Black-on-gray	700	900	775	940	775	940
Deadmans Black-on-gray	900	1100	900	1115	900	1115
Kirkland gray					750	1200

Kayenta Ceramics

Kayenta ceramics are composed of a variety of utilitarian and decorated wares (Table 5.5) including Tusayan Gray Ware (TGW), Tusayan White Ware (TWW), San Juan Red Ware (SJRW), and Tsegi Orange Ware (TOW). Tusayan Gray Ware is composed of 12 types (Table 5.5) and is predominately a utilitarian ware. It is constructed by coiling and roughly scraping and then fired in a reducing atmosphere. In the eastern Grand Canyon recent studies have confirmed that TGW ceramics are formed from local sedimentary clays likely derived from the Kaibab formation (Carter et al. 2011, Carter and Sullivan 2007) and tempered principally with quartz (medium to coarse grained) and occasionally with feldspar. Vessel forms include jars, bowls, pitchers, and dippers, with jars and bowls predominating (Colton 1955).

Tusayan White Ware is composed of 9 types (Table 5.5) manufactured from AD 700 – 1300. Primary construction for TWW is similar to TGW (coiled and roughly scraped) but they were finished by polishing and applying a thin, usually white slip. The vessels were then painted with a variety of geometric designs in a black colored, carbon-based paint. Vessel forms for TWW include bowls, jars, dippers, and mugs (Colton 1939, 1955).

San Juan Red Ware (SJRW) is an orange pottery ware composed of 2 types (Table 5.5) and manufactured from AD 750 – 1100 (Colton 1956). According to Colton (1956) the development of orange wares went through six well defined steps: (1) development of a red paint for decorative designs ~ AD 600 (near the time pottery became widely adopted in the Southwest), (2) appearance of black manganese oxide paint that would not burn off vessels ~ AD 800, (3) introduction of a slip that made orange pottery red ~ AD 1050, (4) use of crushed pottery sherds for temper, again ~ AD 1050, (5) production of a three color polychrome by omitting the slip from certain areas of the vessel between ~ AD 1050 – 1100, and (6) production of a four-colored polychrome using white paint along with orange, black, or red paints beginning ~ AD 1200 – 1250. San Juan Red Ware occurs during the beginning of the orange ware development process and is distinguished from Tsegi Orange Wares (described below) based on clay, temper and lack of a slip. SJRW vessels rarely have a slip, are tempered with sand or crushed rock, and made from sedimentary clays that when fired turn a red or brown color. The vessel walls are smoothed, and painted with black or red paint, in one of several geometric design patterns. Vessel forms of SJW include bowls (without horizontal handles), dippers, seed jars, and pitchers.

Tsegi Orange Ware (TOW) is composed of 7 types (Table 5.5) and was manufactured from AD 1050 – 1300 (Colton 1956:2). TOW wares differ from San Juan Red Wares by the inclusion of an orange slip, sherd temper, and clay that fired orange. Vessel forms of TOW include bowls, jars, seed-jars, and dippers, with the bowls often having a single horizontal handle and depressed based. Decorations on TOW are painted on with black, red or white paint and confined to (1) the interior surface of bowls (black geometric patterns), (2) as a solid red band encircling the exterior surface of bowls with a red slip, or (3) as white outline for black design.

Table 5.5 Kayenta ceramics and associated date ranges.

Name	Colton Begin	Colton End	Oppelt Begin	Opplet End	Mink Begin	Mink End
Tusayan Gray Ware						
Lino Fugitive Red	600	700	572	800	572	800
Lino Gray	500	750	500	900	500	900
Kana a Gray	700	900	760	1100	760	1100
Coconino/Medicine Gray	800	950	890	1060	890	1060
Tusayan Corrugated	950	1275	1030	1300	1030	1300
Moenkopi Corrugated	1050	1275	1075	1285	1075	1285
Kiet Siel Gray	1274	1300	1200	1300	1200	1300
Lino Tradition			500	900	500	900
Tusayan Plain	500	1300	600	1300	600	1300
O'Leary Tooled	850	900	850	900	850	900
Obelisk Gray			620	750	620	750

Table 5.5, cont.

Honani Tooled	900	900	900	900	900	900
Tusayan White Ware						
Kana-a Black-on-white	700	950	725	1000	725	1000
Wepo Black-on-white			930	1050	930	1050
Black Mesa Black-on-white	900	1100	1058	1140	1058	1140
Sosi Black-on-white	1070	1150	1057	1200	1057	1200
Dogoshzi Black-on-white	1070	1150	1040	1220	1040	1220
Flagstaff Black-on-white	1125	1200	1085	1275	1085	1275
Tusayan Black-on-white	1225	1300	1125	1300	1125	1300
Kayenta Black-on-white	1250	1300	1260	1300	1260	1300
Shato Black-on-white	1050	1150	1080	1130	1080	1130
San Juan Red Ware						
Bluff Black-on-red			780	940	780	940
Deadmans Black-on-red	750	1050	880	1100	880	1100
Tsegi Orange Ware						
Medicine Black-on-red	1050	1100	1075	1125	1075	1125
Tusayan Black-on-red	1050	1150	1000	1290	1000	1290
Cameron Polychrome	1050	1100	1100	1290	1100	1290
Citadel Polychrome	1125	1175	1115	1200	1115	1200
Tusayan Polychrome	1150	1300	1125	1290	1125	1290
Tsegi Polychrome	1225	1300	1225	1300	1225	1300
Kayenta Polychrome	1250	1300	1250	1300	1250	1300

Virgin Ceramics

Virgin ceramics are composed of a variety of utilitarian and decorated wares (Table 5.6), found in an area of Arizona, Nevada, and Utah, ascribed to the Virgin Branch of the Anasazi. While the Virgin ceramic grouping contains the largest number of ceramic types, this grouping is also the least understood of the pottery sequences at the Grand Canyon (Hays-Gilpin and Lyneis 2007). This limited knowledge resulted in the combination of some wares that may represent different traditions but until further research is conducted throughout the region the most conservative approach is to combine all of the wares into the larger grouping, called the Virgin Ware Group (VWG).

The VWG consist of a variety of both gray and decorated wares (Table 5.6) including Tusayan Gray Ware Virgin Series (TGWV), Tusayan White Ware Virgin Series (TWWV), Walhalla Gray Ware (WGW), Walhalla White Ware (WWW), Moapa Gray Ware (MGW), Moapa White Ware (MWW), Shinarump Gray Ware (SRGW), Shinarump White Ware (SWW), Shinarump Red Ware (SRR), Logandale Gray Ware (LGW), and Shivwits Gray Ware (SVGW).

Table 5.6 Virgin Series ceramics and associated date ranges.

Name	Oppelt Begin	Oppelt End	Lyneis Begin	Lyneis End	Smiley Begin	Smiley End	Mink Begin	Mink End
Tusayan Virgin Gray Ware								
North Creek Gray			900	1150			900	1150
North Creek BG			900	1150			900	1150
North Creek Corrugated			1050	1150			1050	1150
Tusayan Virgin White Ware								
Mesquite Black-on-gray	525	775	400	700			400	700
Washington Black-on-gray			700	900			700	900
St. George Black-on-gray			1000	1225			1000	1225
Hilldale Black-on-gray	1100	1225	1050	1225			1050	1225
Glendale Black-on-gray	1125	1250	1050	1225			1050	1225
Walhalla Gray Ware								
Walhalla Plain	950	1150					950	1150
Walhalla Corrugated	950	1150					950	1150
Walhalla White Ware							950	1150
Walhalla Black-on-white	950	1150					950	1150
Moapa Gray Ware								
Boulder Gray			400	1075	500	700	400	1075

Table 5.6, cont.

Boulder Black-on-gray			400	900	500	700	400	900
Boysag Black-on-gray	725	900	700	1050			700	1050
Trumbull Black-on-gray			1000	1225	1100	1200	1000	1225
Moapa Brown			400	?	1100	1200	400	1200
Moapa Gray					1100	1200	1100	1200
Moapa Black-on-gray			1050	1225	1100	1200	1050	1225
Moapa Corrugated			1075	1150	1100	1200	1075	1150
Slide Mountain Black-on-gray	1100	1125	1150	1225			1150	1225
Poverty Mountain Black-on-gray	1125	1250	1150	1225			1150	1225
Moapa White Ware								
Moapa White Ware							N/A	N/A
Shinarump Gray Ware								
Shinarump Plain			1050	1225	1100	1200	1050	1225
Shinarump Corrugated			1050	1225	1100	1200	1050	1225
Shinarump Brown					1100	1200	1100	1200
Shinarump White Ware								
Wahweap Black-on-white							N/A	N/A
Wygaret Black-on-white							N/A	N/A
Vermilion Black-on-white			1050	1225			1050	1225
Cottonwood Black-on-white			1050	1225			1050	1225
Virgin Black-on-white							N/A	N/A
Toquerville Black-on-white			1050	1225			1050	1225
Shinarump Red Ware								
Middleton Black-on-red	1050	1130					1050	1130
Middleton Red	900	1130					900	1130
Middleton Polychrome							N/A	N/A

Table 5.6, cont.

Logandale Gray Ware				
Logandale Gray Ware	800	1050	800	1050
Logandale Corrugated			N/A	N/A
Longdale White Ware				
Logandale Black-on-white			N/A	N/A
Shivwits Gray Ware				
Shivwits Plain	900	1150	900	1150
Shivwits Corrugated	700	1075	700	1075

Ware Groups

The term "ware" typically refers to a group of pottery types that demonstrate a characteristic method of manufacture, including firing atmosphere, construction, temper, surface treatments and paint constituents (Colton 1953). Distinguishable types within a ware are identified based on slight changes to one these conditions, typically surface treatments and decoration. The question of whether pots equal people has been argued incessantly in Southwest archaeology since Colton (1939, 1953) proposed the idea by combining Gladwin's (1934) cultural classification of Southwest cultural units with the ceramic wares identified at archaeological sites in the area. Some have argued vehemently against the idea that differences in pottery represent different ethnic identities (Anderson 1975; Smith 1985) but others posit that combining ceramic assemblages with other archaeological traits does allow for a parsing of sites into groups that share cultural behaviors (Geib et al. 2001). For this investigation, assigning prehistoric sites into categories with shared cultural traits, particularly those sites with architecture, was essential to examining variation in land use from AD 700 - 1225.

A common practice, while recording sites in the field, is to anecdotally assign sites to cultural groups by estimating the preponderate gray or utility ware. For example, sites with a perceived majority of TGW sherds would be labelled Kayenta sites or sites where the bulk of the ceramics are SFMGW are branded Cohonina sites. While this methodology is appropriate for rough assessments in the field a more rigorous approach is required for more in-depth studies. Following the methodology originally developed by Liss (1992), and refined by Mink (1999) and Uphus (2003), sites for this analysis were assigned to a primary ware group if they contained more than 66-percent of one gray ware. The four primary ware groups and ten secondary mixed groups along with the total number of sites assigned to each category are listed in Table 5.7. The primary ware in the region is TGW, which contains more than double the number of sites categorized as SFMGW or VGW. San Francisco Mountain Gray Ware and the VGW groups contain the second and third highest frequency of sites, respectively.

Table 5.7. Primary utilitarian wares found in Grand Canyon National Park.

Primary Ware		
Code (group)	**Frequency**	**Description**
SFMGW (Cohonina)	258	Majority SFMGW
TGW (Kayenta)	586	Majority TGW
VGW (Virgin)	241	Majority VGW
PGW (Prescott)	24	Majority PGW

Secondary (mixed) Ware Groups		
Code	**Frequency**	**Description**
mck	102	Mixed SFMGW & TGW
mckp	8	Mixed SFMGW & TGW & PGW
mckv	46	Mixed SFMGW &TGW & VGW
mckvp	7	Mixed SFMGW & TGW & VGW & PWG
mcp	4	Mixed SFMG & PGW
mcv	1	Mixed SFMG & VGW
mcvp	4	Mixed SFMG & VGW & PGW
mkv	41	Mixed TGW & VGW
mvp	3	Mixed VGW & PGW

The Prescott Gray Ware (PGW) is associated with the Prescott, also called Yavapai, archaeologically identified culture. The total number of PGW sites is small (n=19) in comparison to the other three Primary Ware Groups but there are more sites than anticipated based on the absence of the Prescott in most discussions of Grand Canyon prehistory.

The Secondary (mixed) ware groups are dominated by the TGW and SFMGW assemblages. The mixed TGW/SFMGW group contains almost as many sites as all other mixed ware groups combined. The second largest number of mixed ware sites was surprising, as it contains sites with mixed Cohonina, Kayenta, and Virgin assemblages. Earlier discussions of settlement at GRCA discuss sites with either TGW and VGW assemblages or TGW and SFMGW assemblages but never a mixture of SFMGW and VGW. To be fair, only one site has a SFMGW and VGW assemblage but the fact that there are 46 sites with TGW, VGW, and SFMGW mixed assemblages is an interesting point for future discussion. Again, in the mixed Ware Groups the presence of a surprising number of PGW sites (n = 26) is notable and will be discussed more fully below.

Chronology

In addition to enabling sites to be classified by ware groups, the ceramic record at GRCA is robust enough to allow for chronological control. As Ambler notes (1985:28), "in order to make any meaningful statements concerning culture change or the processes thereof, it is axiomatic that we need to have the prehistoric chronology clearly defined." Numerous studies have examined the ceramic chronology of the Southwest (Breternitz 1966), Kayenta Region (Ambler 1985; Christenson 1994), Virgin Region (Hays-Gilpin and Lyneis 2007), more locally at Wupatki (Downum and Sullivan 1990) and the greater Flagstaff area (Downum 1988) and at the Grand Canyon, specifically (Samples 1994 and Downum and Vance in press). In these studies, ceramic date ranges have been established by association with dendrochronologically datable wood and charcoal specimens (Geib 2011). The TGW group has one of the most accurate prehistoric chronologies in the world (Christenson 1994, Geib 2011) and the SFMGW group while not as precise as the TGW group is still very well dated (Samples 1994). The VGW group dates are much more suspect, with most of the date ranges provided for VGW ceramic types are very broad and often based on TGW counterparts, with only a few of the dates confirmed by tight dendrochronology. The fact, that VGW ceramic dates are not as precise as either TGW or SFMGW, does not mean that the VGW sites are not datable, but the imprecision of the VGW ceramic dates does indicate that caution should be shown for interpreting the VGW dates as maximum ranges.

In an effort to determine the most appropriate method for developing a ceramic chronology for this analysis, three different techniques were assessed for assigning sites to a time period: Ceramic Group Dating, Mean Ceramic Dating, and Mean Ceramic Date Grouping. But first a note of caution about utilizing legacy data for chronological assignments is in order. Typically, when ceramics are employed to assign a site to a time period, heavy emphasis is placed on sample size or the minimum number of sherds required for a ware to be used in assigning a time period (e.g., Uphus [2003] utilized a minimum count of 3 sherds). However, when using legacy site form data, limiting ceramic sample size only serves to significantly decrease the population of sites used in further analyses, thereby making it difficult to develop any meaningful inferences about larger settlement dynamics. Further, as both Carlson (1983) and Christenson (1994) note there is no significant correlation between the accuracy of mean ceramic dates and the number and types of sherds. As will be discussed more fully below, mean ceramic dating and a derivative mean ceramic date grouping, were the most useful techniques for assigning a date or temporal period to a site for this analysis. Therefore, for this investigation a minimum of one ware type and one sherd was the baseline, even though many sites had far more ceramics than the minimum (Table 5.8).

Table 5.8. Descriptive statistics regarding abundance of sherds.

#Sherds	All Sites (n=2,936)	Site with Ceramics (n=1,438)
Min	0	1
Max	18,904	18,904
Sum	72,924	72,924
Mean	24	50
SD	372	530

Ceramic Group Dating

Ceramic Group Dating was one of the first methods employed to date sites in the Southwest. This approach was pioneered by the father of southwest ceramic systematics Harold S. Colton (1939), and refined by John Wilson (1969). The method is quite simple both decorated and utility/gray ware sherds are used to place sites into ceramic groups that represent restricted temporal intervals or time periods. The ceramic groupings tested for this investigation originated with a study of the Wupatki settlement system by Downum and Sullivan (1990) and updated more recently for the Grand Canyon by Downum and Vance (in press) to include Virgin group pottery. To create the ceramic group dating time periods (Table 5.9) for this investigation, Downum and Vance's groupings were modified to eliminate pottery types not present in the GCAS databases and to add a Tsegi Polychrome to Group 6.

Table 5.9. Ceramic Group Dating associated pottery types, temporal periods, and frequency of sites (modified from Downum and Vance in press).

Group	Ceramics in the Group	Number Sites
Group 1 AD 550 - 825	Mesquite Black-on-gray or Boulder Black-on-gray AND Lino Gray, Deadmans Gray, Deadmans Fugitive Red	1
Group 2 AD 825 – 1025	Kana-a Black-on-white, Deadmans Black-on-red, or Floyd Black-on-gray AND Kana-a Gray, Deadmans Gray, Deadmans Fugitive Red	134
Group 3 AD 1025 – 1065	Black Mesa Black-on-white, Wepo Black-on-white, Deadmans Black-on-red, Medicine Black-on-red, or Deadmans Black-on-gray AND Kana-a Gray, Coconino Gray, Medicine Gray, Deadmans Gray, or Deadmans Fugitive Red	231
Group 4 AD 1065 – 1140	Black Mesa Black-on-white, Tusayan Black-on-red, Medicine Black-on-red, Middleton Black-on-red, Deadmans Black-on-gray, Cameron Polychrome, Sosi Black-on-white, Dogoszhi Black-on-white, North Creek Black-on-gray, Moapa Black-on-gray, Hilldale Black-on-gray, Slide Mountain Black-on-gray, or Vermillion Black-on-gray AND Tusayan Corrugated, Deadmans Gray, Deadmans Fugitive Red	416
Group 5 AD 1140 – 1220	Flagstaff Black-on-white, Dogoszhi Black-on-white, Sosi Black-on-white, Citadel Polychrome, Tusayan Polychrome, North Creek Black-on-gray, Moapa Black-on-gray, Hilldale Black-on-gray, Slide Mountain Black-on-gray, Glendale Black-on-gray, Poverty Mountain Black-on-gray, or Middleton Black-on-red AND Moenkopi Corrugated, North Creek Gray, Longdale Corrugated, or Shinarump Corrugated	365
Group 6 AD 1220 – 1300	Tusayan Black-on-white, Kayenta Black-on-white, Kiet Siel Polychrome or Kayenta Polychrome AND Moenkopi Corrugated, Kiet Siel Gray, Sunset Red, Logandale Corrugated, or Shinarump Corrugated, Tsegi Polychrome	16
Group 7 Post AD 1300	Jeddito Black-on-yellow, Awatovi-Balck-on-yellow, or Sikyatki Polychrome AND Jeddito Plain	12

An examination of the Grand Canyon site time periods based on the Ceramic Group Dating method illustrates that a steady influx of population (measured here by site frequency) began in Time Period 2 (AD 825-1025) and then approximately doubled during the next two time periods (Time Period 3: AD 1025-1065) and (Time Period 4: AD 1065-1140). During Time Period 5 (AD 1140-1220) the number of sites began a slow decline before precipitously dropping during Time Periods 6 and 7.

While the production spans developed with the Ceramic Group Dating method could be utilized for examining large-scale land use patterns through time, they are deficient in their ability to provide a more accurate date for a site, which is important if one is trying to determine whether the variation in the archaeological record was either changing through time, or caused by different groups/cultures during a contemporaneous period. The broad date ranges (mean of 179 years) for the Ceramic Group Dating method disqualifies it for use in the analysis for this dissertation, and thus a different method was required.

Mean Ceramic Date

Mean ceramic dating was initially developed by Stanley South (1972) for archaeological sites in the eastern United States that contained historic ceramics. The method is based on four assumptions: (1) ceramic types have a unimodal frequency, (2) ceramic type frequency curves overlap, therefore at one time there are multiple types in use, (3) the date of a ceramic type is based on a mid-point calculated from the first and last date of manufacture, and (4) the mean ceramic date of a ceramic assemblage can be calculated by taking the mean of the type date weighted by their frequency (South 1972:83). The technique was first used in Southwest archaeology by Upham (1978) at the Nuvakwewtaqa site (Chaves Pass Ruin) and was employed on several other sites in the 1980s (Cline and Cline 1983, Linthicum 1980, Mills 1988), but it was never widely adopted by Southwest archaeologists at that time. Christenson (1994) postulates the sparse adoption was likely due to the rarity of an independent check on the resulting dates and the “black box” nature of the method. However, the adoption of the technique is increasing in Southwest archaeology (Geib 20ll, Peeples 2011) based on the positive finding of Christenson’s (1994) test of the method. He found that when comparing his mean ceramic data calculations for a series of Kayenta Anasazi sites to tree-ring dates from those sites he was able to “provide consistent, accurate, and replicable comparison of ceramic period occupations,” (Christenson 1994:312). Moreover, Christenson posits that mean ceramic dating is a chronometric technique that assigns a ceramic assemblage to a dendrochronologically calibrated temporal scale. Just like radiocarbon and archaeogeomatic dates have an associate statistical error, so to do mean ceramic dates, but unlike these other two methods mean ceramic dating is a chronometric date based on cultural process. Finally, he argues “while developing the theoretical underpinnings of mean ceramic date and refining various aspects of its application, we can still take advantage of the opportunity to narrow the temporal scale of our analyses of prehistoric ceramic period sites and to address and expanded list of questions of cultural stability and change” (Christenson 1994:312). The ability to assign an approximate occupation date to each site with the ceramics in this study seemed to indicate that mean ceramic dating would be a good method for assigning chronology

An R Script developed by Peeples (2011b) was utilized to calculate the mean ceramic date for each Grand Canyon site in this investigation. The R Script is designed to work on the open source R statistical package. Two data tables are required to calculate the mean ceramic date, one list each of the ceramic types and their beginning and end dates (Table 5.10) and the other date table is a list of sites and the frequency of each of those ceramic types. The R Script then calculates the mean ceramic date (following South's 1977 formula) by multiplying the number of sherds of a given type by the mid-point date range of that type (from the ceramics type table), summing the values for all of the types, and then dividing by the total ceramic count (Peeples 2011, South 1977).

Table 5.10. Ceramic types and beginning and end dates for each ware utilized in the Mean Ceramic Date calculations. (Dates were derived from Colton 1953, 1955, 1956, Hays-Gilpin and Hartesveldt 1998, Lucius and Breternitz 1992, Lyneis 1995, Oppelt 2002).

Field/Ceramic Type	BeginDate	EndDate
Tusayan Gray Ware		
Lino Fugitive Red	572	800
Lino Gray	500	900
Kana a Gray	760	1100
Coconino/Medicine Gray	890	1060
Tusayan Corrugated	1030	1300
Moenkopi Corrugated	1075	1285
Kiet Siel Gray	1200	1300
Lino Tradition	500	900
Tusayan Plain	600	1300
O'Leary Tooled	850	900
Obelisk Gray	620	750
Honani Tooled	900	900
Tusayan White Ware		
Kana-a Black-on-white	725	1000
Wepo Black-on-white	930	1050
Black Mesa Black-on-white	1058	1140
Sosi Black-on-white	1057	1200
Dogoshzi Black-on-white	1040	1220
Flagstaff Black-on-white	1085	1275

Table 5.10, cont.

Tusayan Black-on-white	1125	1300
Kayenta Black-on-white	1260	1300
Shato Black-on-white	1080	1130
San Juan Red Ware		
Bluff Black-on-red	780	940
Abajo Black-on-red	700	900
Deadmans Black-on-red	880	1100
Tsegi Orange Ware		
Medicine Black-on-red	1075	1125
Tusayan Black-on-red	1000	1290
Cameron Polychrome	1100	1290
Citadel Polychrome	1115	1200
Tusayan Polychrome	1125	1290
Tsegi Polychrome	1225	1300
Kayenta Polychrome	1250	1300
SF Mountain Gray Ware		
Floyd Gray	700	900
Deadmans Gray	775	1200
Deadmans Fugitive Red	775	1200
Floyd Black-on-gray	775	940
Deadmans Black-on-gray	900	1115
Kirkland Gray	750	1200
Tizon Brown Ware		
Tizon Brown	700	1890
Tizon Wiped	700	1900
Cerbat Brown	700	1890
Prescott Gray Ware		
Prescott Gray	1025	1200
Prescott Black-on-gray	1050	1200
Aquarius Orange	1000	1100
Aquarius Brown	900	1890
Alameda Brown Ware		
Rio de Flag Brown	775	1065
Angell Brown	1075	1150
Winona Brown	1075	1200
Sunset Brown	1065	1200

Table 5.10, cont.

Sunset Red	1065	1200
Sunset Smudged	1065	1200
Turkey Hill Red	1090	1200
Verde Brown	1100	1300
Tusayan Virgin Gray Ware		
North Creek Gray	900	1150
North Creek BG	900	1150
North Creek Corrugated	1050	1150
Tusayan Virgin White Ware		
Mesquite Black-on-gray	400	700
Washington Black-on-gray	700	900
St. George Black-on-gray	1000	1225
Hilldale Black-on-gray	1050	1225
Glendale Black-on-gray	1050	1225
Unidentified Walhalla Ware		
Walhalla Plain	950	1150
Walhalla Corrugated	950	1150
Wallhalla White Ware		
Walhalla Black-on-white	950	1150
Moapa Gray Ware		
Boulder Gray	400	1075
Boulder Black-on-gray	400	900
Boysag Black-on-gray	700	1050
Trumbull Black-on-gray	1000	1225
Moapa Brown	400	1200
Moapa Gray	400	1150
Moapa Black-on-gray	1050	1225
Moapa Corrugated	1075	1150
Slide Mountain Black-on-gray	1150	1225
Poverty Mountain Black-on-gray	1150	1225
Moapa White Ware	400	1150
Shinarump Gray Ware		
Shinarump Plain	1050	1225
Shinarump Corrugated	1050	1225
Shinarump Brown	1050	1225

Table 5.10, cont.

Unidentified Shinarump White Ware		
Wahweap Black-on-white	1505	1225
Wygaret Black-on-white	1050	1225
Vermilion Black-on-white	1050	1225
Cottonwood Black-on-white	1050	1225
Virgin Black-on-white	1050	1225
Toquerville Black-on-white	1050	1225
Shinarump Red Ware		
Middleton Black-on-red	1050	1130
Middleton Red	900	1130
Middleton Polychrome	1100	1290
Logandale Ware		
Logandale Gray Ware	800	1050
Logandale Corrugated	1050	1150
Logandale Black-on-white	800	1050
Shivwits Gray Ware		
Shivwits Plain	900	1150
Shivwits Corrugated	700	1075
Jeddito Ware		
Jeddito Black-on-yellow	1350	1450
Awatovi Black-on-yellow	1300	1350
Jeddito Plain	1300	1950
Jeddito Corrugated	1300	1400
“Hopi Yellow Ware”	1250	1950
Navajo utility/polychrome	1750	1950
Sikyatki Polychrome	1400	1625
Little Colorado White Ware		
Holbrook Black-on-white Variety A	1050	1150
Holbrook Black-on-white Variety B	1050	1150
Holbrook Black-on-white (unk)	1050	1150
Walnut Black-on-white	1100	1250
Leupp Black-on-white	1200	1250
Padre Black-on-white	1100	1250
Chevelon Black-on-white	1070	1125

Table 5.10, cont.

Homolovi Plain	1300	1400
Homolovi Corrugated	1300	1400
Lower Colorado Buffware	800	1900
Parker Red-on-black	900	1900
Parker Stucco	1000	1840

A total of 1,143 sites were assigned a mean ceramic date using Peeple's R Script. The earliest date assigned was AD 677 and the latest assigned date was AD 1850. The mean date assigned was AD 1042 with a standard deviation of 124 years. As Figure 5.5 illustrates there is definite increase in the number of sites dating from AD 700 - 1225.

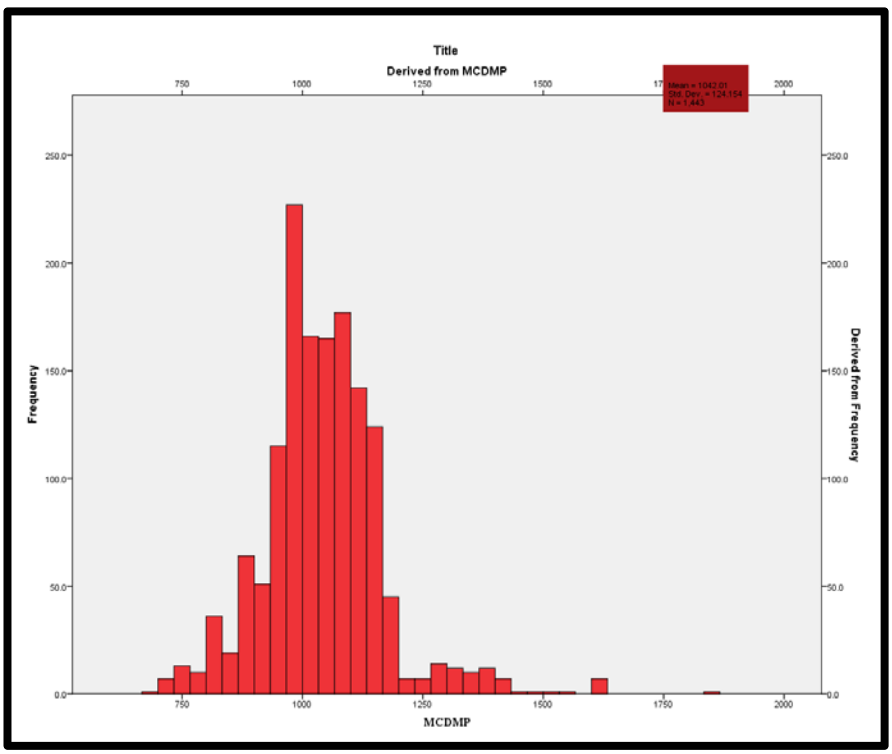

Figure 5.5. Mean ceramic date frequencies.

Mean Ceramic Group Dating

Obtaining the mean ceramic date for each site is very useful either when discussing an individual site, or when placing that one site into a larger temporal context when discussing broad regional patterns. However, it is difficult to use the mean ceramic date to explore the relationships among more than just a couple of sites that overlap in time unless they are grouped together. Because this investigation is focused on examining the relationship among all of these overlapping sites, Mean Ceramic Dating, by itself was not adequate and another method of assigning sites to a time period for this dissertation analysis was needed. A third method for calculating time periods -Mean Ceramic Group Dating- was developed. This methodology creates time periods by simply grouping sites based on the standard deviation of the mean ceramic dates for all of the sites. Because this study is only focused on Pueblo Period sites the mean and standard deviation were only calculated for sites that dated before AD 1301. A total of 1,143 sites met this criterion of having a mean ceramic date earlier than AD 1301, with a mean date of AD 1028 and a standard deviation of 50 years. Using the 50 year standard deviation as a break line, seven mean ceramic date groupings (time periods) were developed (Table 5.11) each separated by 100 years (with the exception of Time Period 1 which has a range of 125 years since only one site dates between AD 675-700).

An examination of the distribution of sites in the mean ceramic group dating time periods (Figure 5.6) illustrates a similar but more bell shaped curve of site distribution than using mean ceramic dating alone. The pattern shows a steady increase in the number of sites that peaks during Time Period 4 (AD 1001-1100) before abruptly dropping off from AD 1201-1300 (Time Period 6). The mean ceramic group date (henceforth referred to as time period) will be the principal chronological date assigned to each site for further analyses presented in this study.

Table 5.11. Mean Ceramic Groups (Time Periods).

Time Period	Begin AD	End AD	# Sites
1	675	800	31
2	801	900	119
3	901	1000	398
4	1001	1100	514
5	1101	1200	300
6	1201	1300	29
7	1301	1850	52
		Total	1443

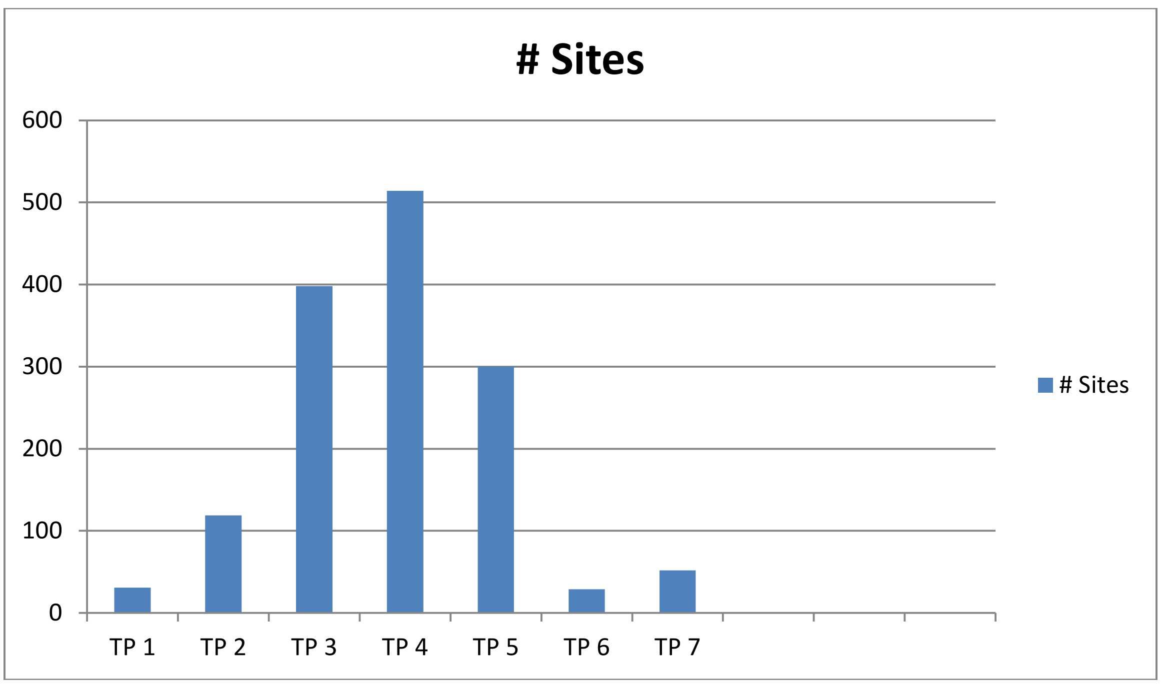

Figure 5.6. Frequency of sites in each of the Time Periods (mean ceramic groups).

In the next chapter, the distribution of sites and correlations with other archaeological sites and the natural environment will be discussed by employing the affiliation and chronological data that were calculated in the aforementioned discussion. These data on when a site was occupied and by whom, will allow for a more robust discussion on how settlement changes through time at the Canyon.

GIS ANALYSES METHODOLOGY

The analyses can be divided into two general categories: (1) large-scale correlations between site locations and environmental variables, and (2) small-scale comparisons of settlement organization. The large-scale correlations that I refer to as socio-environmental relationships consist of analyses that correlate site locations to environmental variables. The small-scale comparison of site structure, which I term settlement organization, will center on examining the variation in components present at or near each archaeological site. When these analyses are examined together they provide information on changing land use practices and archaeological landscapes across space and time at the Grand Canyon.

Socio-Environmental Analyses

In order to examine the role of the environment in land use practices at the Grand Canyon from AD 700 - 1225, an investigation into the socio-environmental relationships was undertaken. In the socio-environmental analyses the distribution of archaeological sites was correlated to environmental phenomena, which is a good first step in any analysis of settlement patterns and land use (see papers in Billman and Feinman 1999). For this study, the environmental data employed include: biotic communities, vegetation associations, range productivity, and hydrology.

In the case of biotic communities, vegetation association, and range productivity the percentage of sites occurring within a particular zone (biotic community, vegetation association, soil type) will be compared to the percent of the overall Park covered by the environmental zone. The working assumption for this type of analysis is that, all things being equal, if sites are randomly distributed across the landscape then the percentage of sites in an environmental zone should be equal to the percentage of the study area covered by that environmental factor. However, if the site distribution is influenced by human behavioral choices, then one would expect the proportion of sites in a given environmental zone to vary, based on whether there was a preference for an environmental zone. For this investigation, if there are a higher percentage of sites associated with an environmental zone than what would be expected based on a random distribution, the relationship will be discussed as a positive association, indicating a preference for that zone. Conversely, if there is a lower percentage of sites then expected based on a random distribution, the relationship will be considered a negative association, indicating avoidance of the zone. Further discussion, particularly in Chapter 7, will develop inferences about why a group may prefer or avoid a particular environmental zone. In the case of hydrology, the Euclidian (straight-line) distance to both the hydrologic resources (surface streams and springs) and canyon access (rimline and trails) will be calculated. Examining the mean distance and comparing it by ware group and time period will be conducted to make inferences about Grand Canyon land use from AD 700 – 1225.

Relationships between soils data and archaeological sites, first, by ware group and second, by time period, were derived by corresponding site to soil taxonomy (as defined by Natural Resource Conservation Service -NRCS) . After the analyses were completed, no apparent preference or avoidance was noted, e.g., the sites were distributed randomly in regards to soil taxonomy. However, the soils data contains a wealth of other information on both the physical and chemical properties of the soil but also on engineering specifications and productivity for forests, grazing and agriculture. These production categories, in particular crop output values have been employed by Tim Kohler and his colleagues as a method for estimating crop productivity in the Mesa Verde area (Kohler et al. 2012, van West 1994). The NRCS soils database does contain a crop yields calculation (for both irrigated and non-irrigated crops) but it cannot be used on the Grand Canyon soils data, as the crop yield units were not recorded for this survey, likely because most of the area was deemed unsuitable for agriculture. However, there is a function to calculate range productivity that I posit can be used as a proxy for wild-plant productivity. Range productivity values are calculated from the NRCS soil database as an estimate (in pounds per acre per year) of the amount of vegetation that can be expected to grow annually in a managed area, during a normal (average precipitation and temperatures) growing year (Lindsay et. al 2003). The estimate includes all vegetation (leaves, twigs, seeds, and fruits), whether palatable to grazing animals or not, but it does not include increases in stem diameters for trees and shrubs. Because many of the wild plants utilized by native peoples during this time, except for the pinyon nut, would be captured by this productivity range, I argue that it is an appropriate proxy for wild plant productivity. In contrast, I do not think it is a good proxy for maize agriculture. Because, the maize grown by native peoples at this time requires a host of specific conditions (specific quantities of water, number of frost free days, etc.) that are vastly different then what is required for wild resources to thrive and produce.

Settlement Organization Analyses

In order to understand land use at a local level, several smaller scale analyses will be performed to explore variation in settlement organization among ware groups and diachronically. The analyses will consist of examining descriptive statistics that pertain to the variability in the frequency of site types, masonry structure and room occurrences, artifact density, and population estimates.

Examining the relationship between ware group and site-type frequency provides insight into what types of activities (e.g., habitation, economic, ritual, etc.) were undertaken by the various groups at the Canyon. For this discussion, site types associated with habitation are those coded as containing a structure (1.0-1.7) and non-granary rockshelters (2.0-2.1); economic site types related to subsistence include granaries (2.2), agricultural features (4.0), and sites related to resource processing (6.0-6.1); ritual sites are those associated with rock art (12.0-12.2); and finally, artifact scatters (5.0-5.2) will be placed in a separate artifact-scatter category. Artifact scatters are assigned a distinctive category because they can provide evidence for both habitation (if they are associated with buried pithouses) and economic activities.

The number of structures and rooms will be examined to determine intensity of occupation and population estimates. Gilman (1987) noted that architectural forms can be a powerful tool for understanding culture change. Previous studies have shown that links between the built environment and social organization can be unraveled by examining the size, number, and function of rooms (Lawrence and Low 1990). The survey-level data used in this analysis are limited to number of structures and frequency of rooms, but these data along with information on associated features, such as agriculture features, rock art, and artifact density, does provide information about the variation in settlement organization through space and time at the Grand Canyon from AD 700 - 1225.

Another important element in understanding settlement organization is population size (Hassan 1974). Numerous methods have been proposed for calculating populations, all based on examining ethnographic data on the use of space. For this study I evaluated seven methods for developing population estimates, including (1) Casselbery (1974) who determined that in a multi-family dwellings the populations can be estimated as 1/6 the total floor are measure in square meters, (2) Clarke (1971) whose study found that the population of a pueblo can be calculated as 1/3 of the total floor area measured in square meters, (3) Cook (1972) who states "for measuring space a fair rule of thumb is to count 25 square feet for each of the first six persons and then 100 square feet for each additional individual," (4) Dohm (1990),who examined data from 25 historic pueblos and recorded area measurements and room count data and then used those figures to calculate mean roofed area at ~74 meters per family and ~16 meters per person, or 2.53 rooms per family and 0.6 rooms per person, (5) Hill (1970) estimates an average of about 1.7 people per room with a 22% abandonment rate, (6) Longacre (1975) estimates about 1.7 people per room with a 25% abandonment rate, and (7) Naroll (1962), conducted a cross-cultural study on a variety of houses, and determined 1/10 of the floor area in square meters represented the population size. There are numerous critiques of these methods (see Powell 1988 for a summary); nevertheless if one takes Robert Euler's approach

(1988) and considers the population estimates “not as reflective of absolute figures, but designated to indicate relative population fluctuations and trends of movements of people” (Euler 1988:222), then calculating population figures is a useful exercise for exploring past land use practices. The lack of data on structure or room area, in the Grand Canyon data set, limits the approach that can be utilized to estimate population for this investigation to the methods presented by Dohm, Hill or Longacre. While both the Hill and Longacre studies cover prehistoric pueblos (Broken K and Grasshopper, respectively), both of those sites date later and are large (> 100 rooms), aggregated prehistoric sites, whose population density per room was likely higher than what one would expect at the smaller settlements scattered through Grand Canyon from AD 700 - 1225. Conversely, Dohm’s work, while also problematic because it is based on larger historic sites, does have a larger sample size that includes a reasonable mean of 1.66 people per room estimate.   Based on that larger sample size, the 1.66 people per room figure will be used in this analysis.

The final two variables that will be examined as part of the settlement organization analysis are artifact density and associated features. The examination of associated features, such as agricultural terraces, resources processing areas, or rock art will provide information on the types of activities conducted at the site (Adams and Adams 2007). The artifact density data will be used to determine intensity of occupation (Jones 2010, Kintigh 1990).

CHAPTER SUMMARY

The focus of this chapter is on the data that will be utilized in the analyses for this dissertation. The chapter begins with a discussion of how the dataset is legacy data maintained by Grand Canyon National Park, and while I have not been to all of these sites I have ground-truthed a number of the site locations and recorded attribute data. I am also utilizing data from the Upper Basin Archaeological Research Project, which I have participated in since 1994 and helping to collect a large amount of the data in that database. As I will describe further below I also merged and manipulated the data from all of the sources to develop a unique data set to perform the analyses of this study.

This dissertation employs a geoinformatics methodology to examine land use form AD 675 – 1225 at the Grand Canyon. Geoinformatics is a method of inquiry and explanation that is interdisciplinary and utilizes the information sciences infrastructure to investigate complex geographic questions. It encompasses many of the traditional methods and technologies associated with geospatial analyses including surveying, mapping, photogrammetry, geographic information systems (GIS), global positioning systems (GPS) remote sensing (RS) and light detection and ranging (LiDAR) (Newhard et. al. 2013, Reid 2011, Sahoo 2010) but a geoinformatics methodology extends the research focus to consuming "big data" (Birkin 2013). While most of these geospatial techniques have been utilized in archaeology for decades, the application of them to big data has been limited (Arias 2013). This dissertation utilizes large regional databases to answer questions about prehistoric Grand Canyon land use.

This study relies on five primary archaeological databases: Grand Canyon National Park's site (centroid) datum GIS layer, the Grand Canyon National Park archaeology attribute database (modified ASMIS), the Grand Canyon Archaeological Synthesis (GCAS) database, the Upper Basin Archaeological Research Project (UBARP) mapping unit (MU) GIS layer, UBARP Artifact Enumeration Unit centroid GIS layer, and numerous environmental GIS geodatabases. It is important to note that none of these databases were used “off-the-shelf” without some type of major modification by me. In addition to the field time I spent ground-truthing the Park data, and assisting in the collection of the UBARP data, I also spent many months correcting, reclassifying, and manipulating the datasets before the analyses for this dissertation could be initiated.

The data from the aforementioned five datasets and PDF versions of the GRCA site files were compiled into one comprehensive dataset in this dissertation. An ESRI ArcGIS file geodatabase was developed to house both the spatial and attribute data for this analysis. Some of the non-spatial analyses were performed in other software programs, most notably, Microsoft Excel, IBM SPSS, and R but the results were then imported into the geodatabase for additional spatial analyses.

The first task was to cull the GIS Site Datum layer, so that it only included data germane to this investigation. The file initially had 4,243 recorded archaeological sites but by eliminating historic sites and sites reported outside of the Park boundaries a data set including 2,936 sites was developed. These data were classified into 33 site types (Table 5.3) by modifying the existing UBARP and GRCA site typologies.

In order to more fully understand the variation in land use across space and through time, at the Canyon, all of the sites were also grouped based on primary ware and by the time the site was occupied. Three ceramic ware groups are associated with Pueblo Period sites in the Grand Canyon. The three ware-groups and the traditional archaeological groups they are associated with are San Francisco Mountain Gray Ware (SFMGW) associated with the Cohonina, Tusayan Gray Ware (TGW) associated with the Kayenta Anasazi, and an assemblage of gray wares I have termed Virgin Gray Wares

(VGW) associated with the Virgin Anasazi group. Sites in this analysis were assigned a primary ware group if their ceramic assemblage contained more than 66-percent of one of the three principal gray wares. Ten secondary ware groups consisting of mixed variations of ceramics were assigned to the rest of the groups (Table 5.7).

In addition to classifying sites by wares I also classified sites into time periods based on both the decorated and utilitarian ceramics. Three different methods (Ceramic Group Dating, Mean Ceramic Dating, Mean Ceramic Group Dating) were tested to determine which would provide the most robust set of dates for this analysis of prehistoric settlement at the Grand Canyon from AD 700 - 1225. Ultimately, the Mean Ceramic Group Dating methodology proved to be the best technique for assigning sites to a time period for this analysis. This chronological methodology provided date ranges that were small enough to be meaningful, while large enough to allow a merging of sites into larger units of analysis. Both the ware group and time period site classifications will be utilized in the analyses presented in Chapter 6 of this dissertation.

This Chapter finishes with a discussion on the methodologies utilized to examine the data in Chapter 6. Two general types on analyses were undertaken, (1) large scale correlations between archaeological site locations and modern environmental variables, (2) small-scale evaluations of settlement organization. The analyses were implemented first by archaeological group without regard to Time Periods and second by time period regardless of the primary utilitarian ware present at a site. Together these analyses provide information on settlement patterns and changing land use practices.

Chapter 6: Pueblo Period Landscapes in the Grand Canyon

In order to elucidate indigenous settlement patterns at the Grand Canyon from AD 700 -1225, the relationships among archaeological sites and other archaeological sites and between the natural environment and archaeological sites will be investigated in this chapter. The focus of this chapter then is to present data on these relationships (site to site and site to environment) so that interpretations about Grand Canyon prehistoric settlement can be developed. In discussing the patterns identified by these analyses both the cultural ecological and niche construction paradigms will be employed to determine which one provides the most robust inferences about Grand Canyon's prehistoric settlement during the Pueblo Period.

ANALYSES DESCRIPTIONS

The analyses in this chapter will be presented in two parts: (1) a comparison of land use by ware groups, regardless of time, and (2) a diachronic examination of land use. As previously discussed in Chapter 5, sites were assigned both ware groups and temporal periods by examining the ceramic assemblage of each site. Utilitarian ware groups that were present in the Grand Canyon from AD 700 - 1225 include: Tusayan Gray Ware (TGW) majority, San Francisco Mountain Gray Ware (SFMGW) majority, Virgin Gray Ware (VGW) majority, and three mixed ware groups (SFMGW + TGW, TGW + VGW, and SFMGW + TGW + VGW), where no particular gray ware dominated. Sites were placed into one of the major ware groups (SFMGW, TGW, or VGW) if over 66% of the recorded utilitarian sherds at a site were recorded as one of those ware groups. Sites were placed into one of the mixed ware group categories if no particular utilitarian wares dominated the assemblage. Sites were also placed into one of seven temporal period categories by employing a mean ceramic group dating methodology. Using this dating method, sites were grouped together based on the mean (AD 1028) and standard deviation (+/- 50years), of all of the Pueblo Period sites (i.e., a recorded mean ceramic date between AD 700 and AD 1225). Discussions of the variability in settlement patterns are explored first by ware group, without regard to time, and then synchronically within a particular temporal period. This approach provides greater insight into shifting trends in human behavior related to land use and subsistence strategies.

SETTLEMENT VARIATION ACROSS SPACE: WARE GROUP VARIABILITY

The first step in my analysis was to examine both the socio-environmental relationships and settlement organization of sites classified by ware-group, regardless of time period, in order to determine if there are any broad patterns of variability among groups. In addition, it was hoped that examining the data by ware-group would provide a base pattern, so that later analysis by time period could note any abnormal variation in land use by a ware-group.

A total of 258 sites are dominated by SFMGW ceramics (Figure 6.1). The vast majority of these sites are located on the south side of the Colorado River in two clusters. The tightest cluster is located on the Coconino Plateau in the South Rim geographic province. The second cluster is more dispersed and located in the Inner Canyon - Gorge province around the mouth of Havasu Creek. It is interesting to note that these are areas that would have been readily accessible by any Cohonina migrating from their core area, near the San Francisco Peaks.

A total of 586 sites have more than 66% of their assemblage dominated by TGW ceramics (Figure 6.2). These sites are the most widely distributed ware group in the Canyon and several patterns of TGW sites can be discerned. First, sites occur in several dense clusters in the eastern half of the Canyon within the South Rim, North Rim, and Inner Canyon - Gorge provinces but do not occur in the western half of the Canyon. The sites on the North Rim are almost exclusively located on the Kaibab Plateau and not on the Kanab or Uinkaret plateaus, which only contains 3 sites whose ceramic assemblage is dominated by TGW.

The TGW sites on the Kaibab Plateau, of the North Rim, are all situated closer to the canyon rimline and not in the higher elevations on the northernmost part of the Plateau. There are also several clusters of TGW sites located in the Inner Canyon, in both the Gorge and East Canyon provinces. The TGW sites found in the Gorge are located either right below the rim, on lower plateaus (e.g., Powell Plateau), or along trails leading into/out of the Canyon. In the East Canyon, the TGW sites are located principally along the Colorado River, with some sites located along trails that lead in and out of the Canyon. It makes sense that the sites in the East Canyon are located along the Colorado since this portion of the River is known to contain open deltas that could be settled and built upon (Fairley 2003, Jones 1986, Schwartz 2008). The South Rim TGW sites are scattered throughout the South Rim province with the densest clusters recorded in the east in the Upper Basin area near Desert View. It is interesting to note that few TGW sites are located near Havasu Canyon (where SFMGW sites cluster) or near the VGW clusters on the Kanab and Uinkaret plateaus. The different site location patterning suggests that just like there are differences in ceramics between these ware groups there is also a variation in preference for site location, which could indicate a difference in settlement.

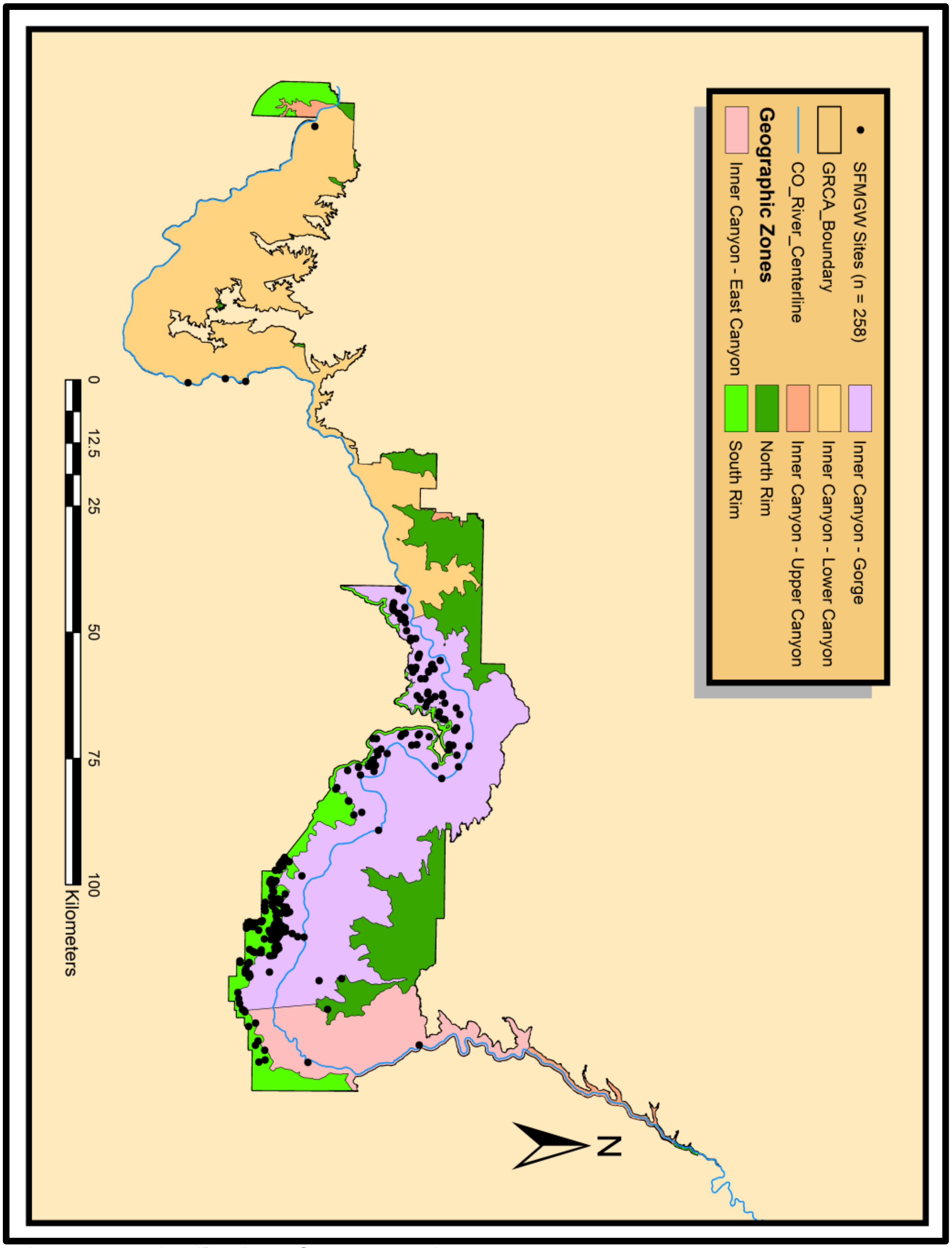

Figure 6.1. Distribution of SFMGW sites (n=258).

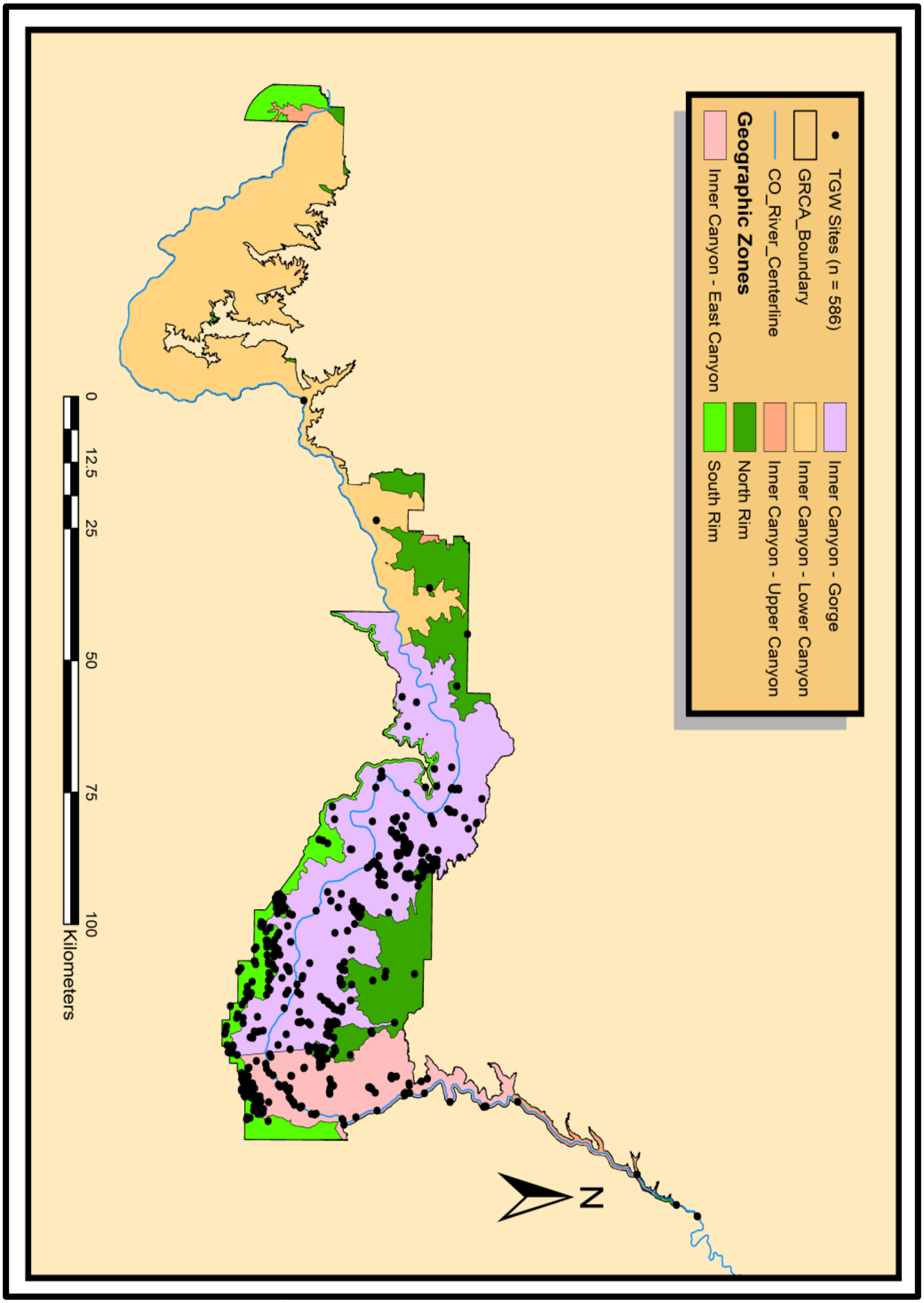

Figure 6.2 Distribution of TGW sites (n=586).

A total of 241 sites have a preponderance of VGW ceramics (Figure 6.3). These sites are positioned in the western half of the Canyon on the North Rim and in the Inner Canyon - Lower Canyon provinces. There are also several VGW sites located in the Inner Canyon -Gorge and East Canyon provinces. The sites in the east (East Canyon) and central (Gorge) sections of the Inner Canyon are located along trails and along the Colorado River. In the Lower Canyon province, there are two concentrations of sites, one along the river below the Shivwits Plateau and one in the Toroweap Valley below the eastern edge of the Uinkaret Plateau. While there are several VGW sites (n=12) located on the Kaibab Plateau portion of the North Rim province, the bulk of the VGW North Rim sites are located on the Kanab Plateau. There are also both eastern and western clusters of VGW sites on the North Rim, which are separated by Cottonwood Canyon, a part of the Lower Canyon province that also contains a cluster of sites.

A total of 216 sites have a mixed ceramic series, which as discussed in Chapter 5, indicates that ceramics were recorded but no ware was dominant (Figure 6.4). The lack of a prevailing ceramic ware could be due to a variety of factors including: exchange of goods between groups, intermarriage and exchange of traditions between the groups, or multi-component occupation, where one groups re-uses an area that hand been previously occupied by another group at an earlier time. The largest number of mixed sites are those with a blend of SFMGW and TGW ceramics (n=102). The sites with a mixed SFMGW/TGW assemblage are primarily located in the South Rim province but several sites are scattered throughout the Gorge and East Canyon provinces.

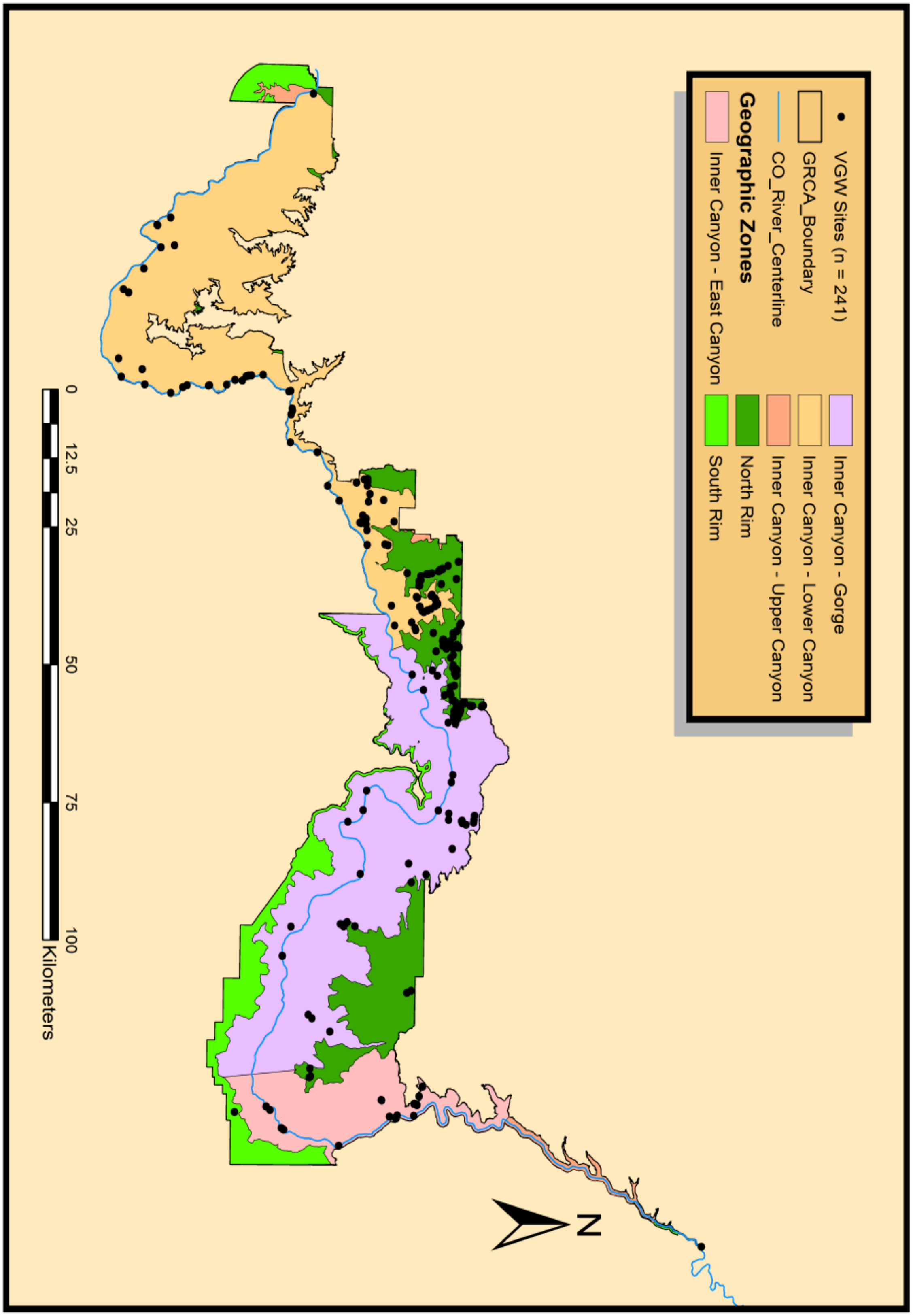

Figure 6.3. Distribution of VGW sites (n=241).

The majority of the sites are located in the South Rim Village area, which is where one SFMGW cluster occurs and also where a fair number of TGW sites are located. The second highest number of mixed ware sites (n=46) recorded contain a combination of all three major gray ware traditions (SFMGW /TGW /VGW). These triple-mixed-ware sites are located in the Gorge and North Rim provinces. In the Gorge province, the SFMGW/TGW/VGW mixed sites are scattered evenly throughout the zone but on the North Rim the SFMGW/TGW/VGW sites are principally clustered on the Walhalla Plateau with a smaller group on the edge of the Rainbow Plateau (the small North Rim plateau located south-and-east of the Walhalla Plateau). The SFMGW/TGW/VGW site patterning does not match any of the individual pattering by single ware group. This more random distribution seems to be evidence that these sites are likely multicomponent occupations. Finally, the sites with a mixed TGW and VGW assemblage (n=41) occur in almost equal proportions on the North Rim, Gorge, and East Canyon provinces. Again this more random distribution does not match the individual TGW or VGW patterns, which strongly suggests that these sites are sites occupied by the various groups at differing times. Due to the uncertain cause of the mixed ceramic assemblages, (e.g., multi-occupations or multi-group interactions) mixed sites will not be discussed in any further analyses.

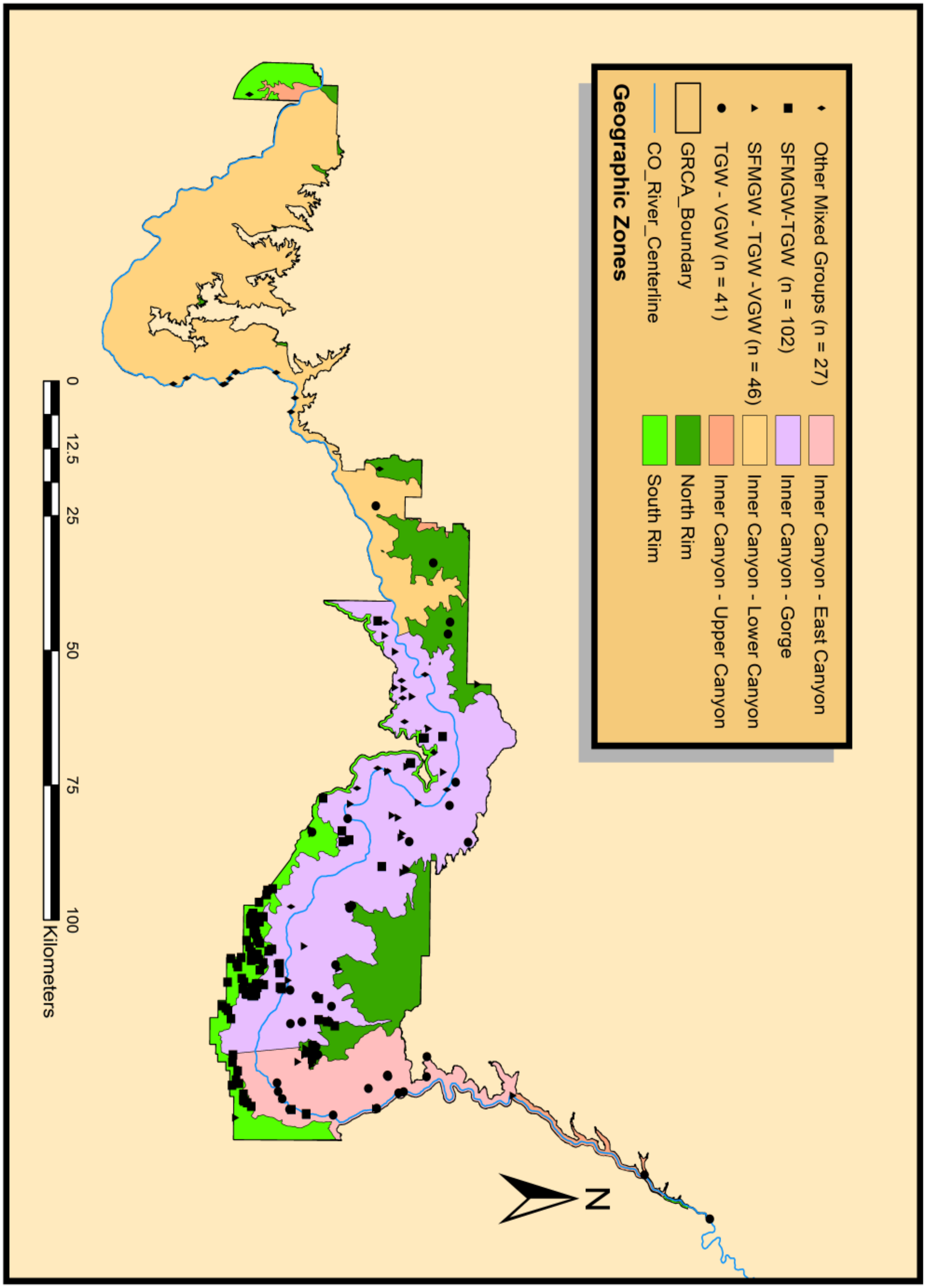

Figure 6.4 Distribution of mixed ware sites (n=216).

As Table 6.1 and Figure 6.5 illustrate, the distribution of sites by ware group across the Canyon's physical geographic regions is quite varied. Sites dominated by SFMGW are principally found in two geographic zones, South Rim and the Inner Canyon -Gorge. On the South Rim, the SFMGW sites are located on the western-central section of the Park, near the present day South Rim Village. This location would have been readily accessible, by a relatively level route, from the Cohonina heartland near Williams approximately 70 miles away. The second cluster of sites is near the confluence of Havasu Creek and then Colorado River (home of the modern Havasupai tribe), which gives some credence to the notion of a relationship between the Cohonina and later Havasupai, at least in terms of a shared geography.

Table 6.1. Sites parsed by ware correlated to geographic regions.

	SFMGW		**TGW**		**VGW**		**Mixed**	
	#	%	#	%	#	%	#	%
North Rim	1	0.39	139	23.72	111	46.06	34	15.74
South Rim	144	55.81	166	28.33	1	0.41	79	36.57
Upper Canyon	0	0.00	4	0.68	1	0.41	2	0.93
East Canyon	2	0.78	88	15.02	17	7.05	24	11.11
Gorge	107	41.47	187	31.91	29	12.03	65	30.09
Lower Canyon	4	1.55	2	0.34	82	34.02	12	5.56
TOTAL	258	100	586	100	241	100	216	100

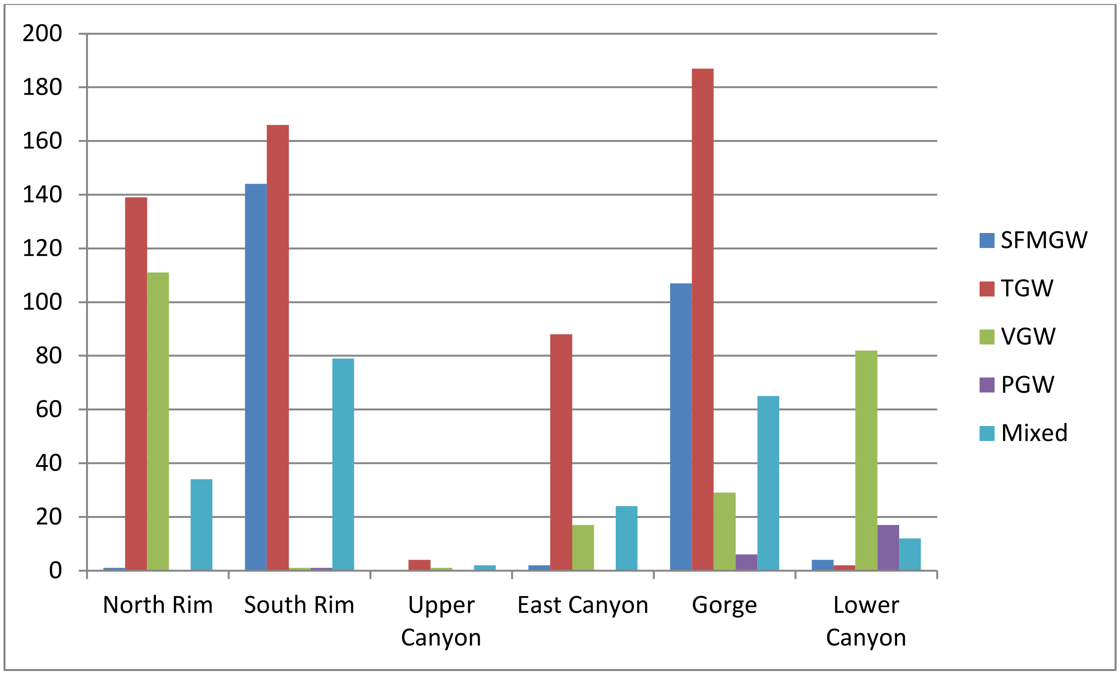

Figure 6.5. Bar chart showing frequency of sites by geographic region.

Sites with primary TGW assemblages are located in almost equal amounts on the North Rim, South Rim, and Inner Canyon. On the North Rim, TGW sites are almost exclusively found on the Kaibab Plateau, very close to the rimline. On the South Rim, again most of the sites are close to the rim, with the densest cluster occurring in the eastern half of the Canyon in the Upper Basin. A second dense cluster is located near the rim in the South Rim village area. While in the Inner Canyon, there are two distribution patterns identified for TGW sites. In the Inner Canyon -East Canyon zone TGW sites are located primarily along the river on the large deltas for which this part of the Inner Canyon is known. In the Inner Canyon - Gorge zone most of the TGW sites are located either on small plateau below the rimline or in the upstream reaches of a variety of side canyons. The lack of large deltas on this portion of the Colorado leaves little room for settlement along the River itself, with a few exceptions where small deltas exist (e.g., Bright Angel Pueblo).

VGW sites occur principally on the North Rim in the Kanab/ Uinkaret plateaus. A second much smaller distribution occurs in the Inner Canyon, primarily in the Lower Canyon with small clusters in the Gorge and East Canyon. In the Lower Canyon, VGW sites are located either along the river on deltas at the mouth of side canyons or on just below rimline plateaus. In the Gorge, VGW sites are principally located on small plateaus just below the larger Kanab and Uinkaret plateaus, with a couple sites occurring along the river (again where small deltas exist).

Socio-Environmental Relationships: Biotic Communities

An analysis of the association of archaeological sites to biotic communities was conducted to determine if a particular life zone was favored or avoided by people who deposited a particular ware group. Such data are useful for making inferences not only about settlement patterns but also about subsistence strategies. The data correlating the ware groups to biotic communities are found in Figure 6.6-6.7 and Table 6.2. The description and implication of those correlations are presented below.

The association of sites dominated by SFMGW to biotic communities definitely illustrates a pattern of preference for some life zones and an avoidance of others. In terms of preference, the pinyon juniper and ponderosa pine communities occur at a higher percentage than would be expected for a random distribution. In regards to avoidance, there are almost 15% fewer sites in the warm desert scrub community and 10% fewer sites in the cold dessert community when compared to their areal coverage in the Park. These distribution patterns seem to indicate, that without regard to time,

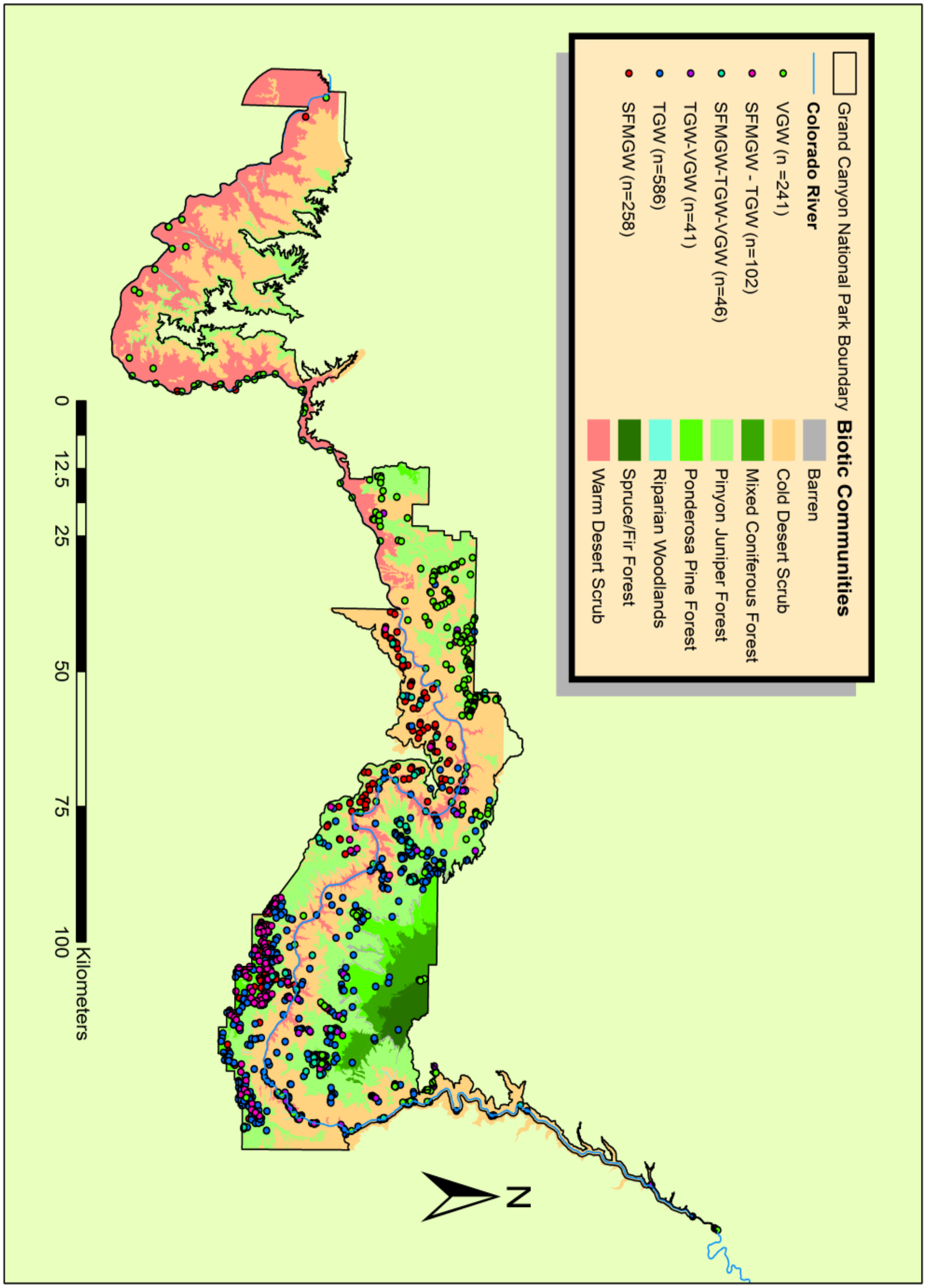

Figure 6.6. Distribution map of archaeological sites parsed by ware and corresponding biotic communities.

Table 6.2 Archaeological sites parsed by ware and corresponding biotic communities.

	Biomes		SFMGW		TGW		VGW		Mixed	
	hectares	%	#	%	#	%	#	%	#	%
Barren	3870	0.79	0	0.00	10	1.71	0	0.00	2	0.93
Cold Desert Scrub	213418	43.72	87	33.72	130	22.18	90	37.34	52	24.07
Mixed coniferous	15208	3.12	0	0.00	7	1.19	0	0.00	0	0.00
Pinyon Juniper	133546	27.36	123	47.67	189	32.25	78	32.37	80	37.04
Ponderosa Pine	24137	4.94	37	14.34	181	30.89	9	3.73	49	22.69
Riparian	1522	0.31	1	0.39	15	2.56	3	1.24	6	2.78
Spruce/Fir	7144	1.46	0	0.00	2	0.34	2	0.83	0	0.00
Warm Desert Scrub	89328	18.30	10	3.88	52	8.87	59	24.48	27	12.50
	488173	100	258	100	586	100	241	100	216	100

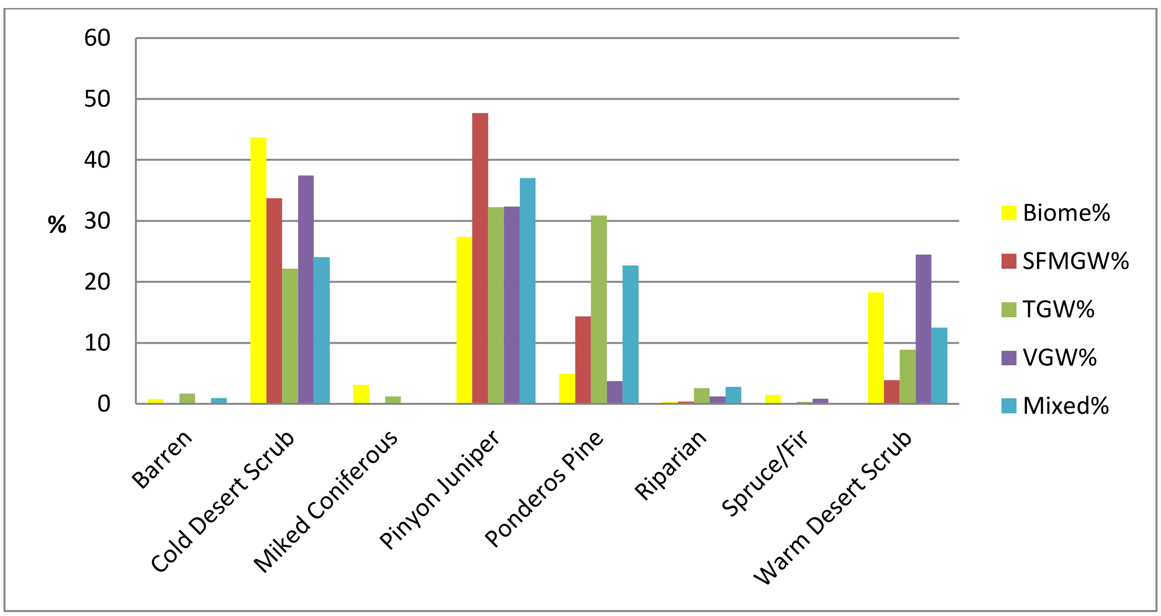

Figure 6.7. Bar chart showing frequency of archaeological sites parsed by ware and corresponding biotic communities.

SFMGW sites are located preferentially in the middle elevation forests locales and the lower elevation deserts found in the Inner Canyon.

The sites with dominant TGW assemblages are also placed with a preference for the ponderosa pine and pinyon juniper forest biotic communities. However, there seems to be a very strong predilection for the ponderosa pine community with almost 25% more TGW sites occurring in that zone then would be expected by chance. The data also indicate a slight (~5%) increased preference for the pinyon juniper community but it is clear the TGW sites are located with a preference in the ponderosa biotic community. As with the SFMGW sites, TGW-dominant sites avoid the desert scrub communities.

Sites with VGW-dominant assemblages correspond positively with both the pinyon juniper biotic community and the warm desert community, and show a slightly lower correspondence to the cold desert scrub community. While there does seem to be a slight avoidance of the cold desert scrub environment and a slight preference of the pinyon juniper community, the rest of the distributions are almost equal to the percentage of areal coverage of the zone, which indicates sites being placed without regard for biotic community. The one exception is the warm desert scrub biotic community. VGW sites are the only ware group where the locations seem to show a slight preference for this environment.

Vegetation Communities

The next analysis conducted for this study was to examine the association between archaeological sites, parsed by ware, and vegetation communities. As was discussed in Chapter 3, a wide variety of plants were used by indigenous peoples in the Southwest. For this analysis I will use the correspondence between archaeological sites and vegetation associations as one source of inference about a group's subsistence strategy. If sites are placed in vegetation associations that contain saltbush, greasewood, or rabbitbrush (plants the Hopi associate with highly productive maize fields [Kuwanwisiwma and Ferguson 2009]) in a higher proportion than what would be expected based on a random distribution (e.g., in a higher percentage than the percentage of areal coverage of the vegetation association) then I will argue for a maize agriculture subsistence. The sites located disproportionally in vegetation associations without any of the three maize linked plants will be more closely examined. In particular, the makeup of the vegetation association will be examined in regards to the possibility of an area with the potential for wild plant production. The data correlating the ware groups to vegetation associates are found in Table 6.3 and Figures 6.8-6.9. The descriptions and implications of those correlations are presented below.

SFMGW sites occur in higher percentages then would be expected in the following vegetation associations: Ponderosa-Pinyon-Gambel_Oak, Juniper-Big_Sagebrush-Pinyon, Pinyon-Juniper-Bluegrass, and Scrub_Oak-Snakeweed-Beargrass-Blackbush. The heavy prevalance of Pinyon in these vegetation associations is not surprising given the Cohonina preference for the Pinyon Juniper biotic community discussed earlier. These associations hint at a SFMGW subsistence system with reliance to some degree on the Pinyon. The SFMGW sites also are located with a small preference for Juniper-Pinyon-Mormon_Tea-Greasebush association (2.9% coverage and 4.26% of sites), which is one of the vegetation groups with high potential for maize agriculture.

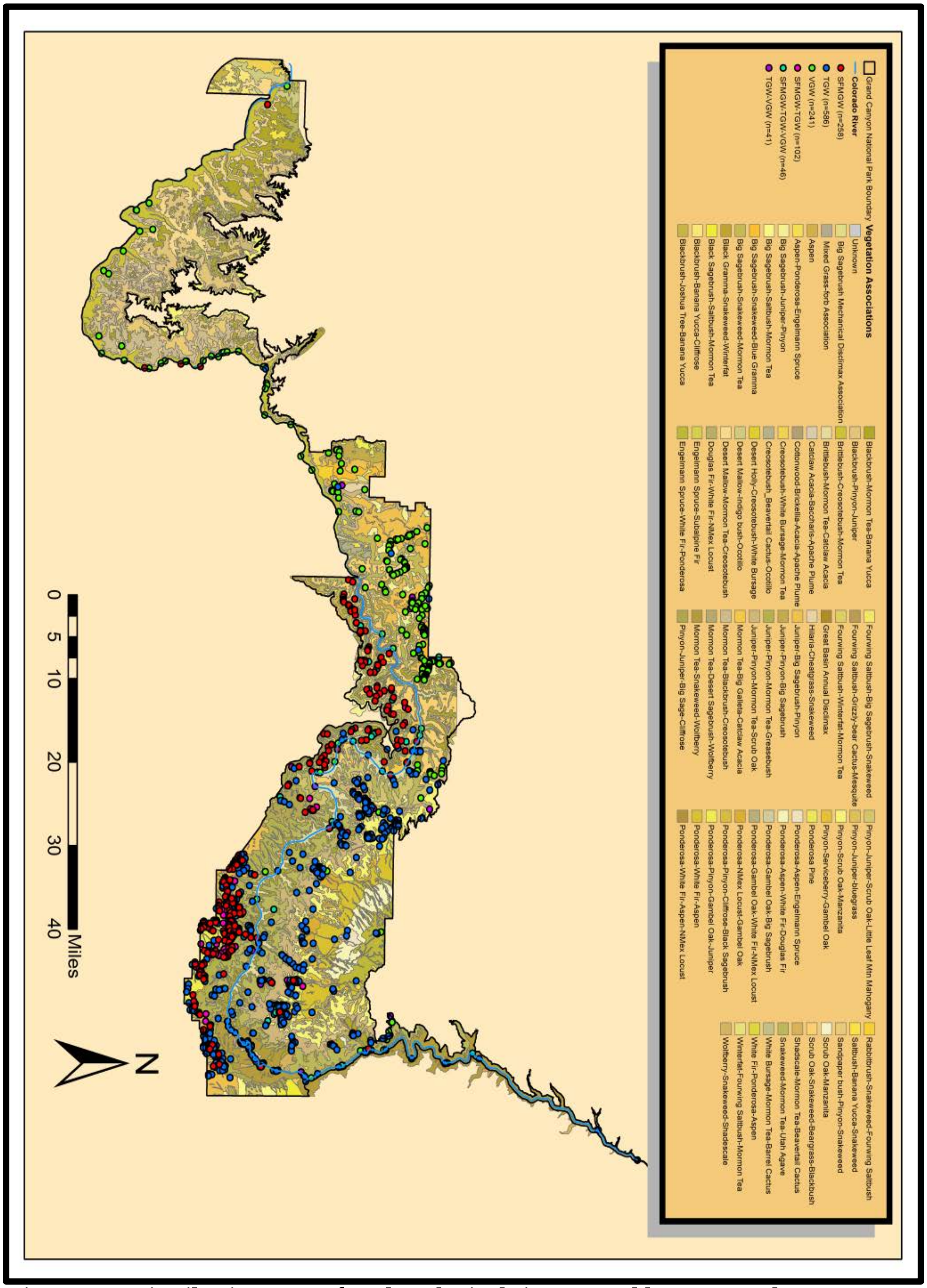

Figure 6.8. Distribution map of archaeological sites parsed by ware and corresponding to vegetation communities.

Table 6.3. Archaeological sites parsed by ware and corresponding to vegetation communities.

NAME		Hectares		SFMGW		TGW		VGW		Mixed
	hectare	%	#	%	#	%	#	%	#	%
Engelmann Spruce-Subalpine Fir	2194.00	0.45	0	0.00	0	0.00	0	0.00	0	0.00
Engelmann Spruce-White Fir-Ponderosa	6240.99	1.28	0	0.00	1	0.17	0	0.00	0	0.00
Ponderosa-Aspen-Engelmann Spruce	83.61	0.02	0	0.00	1	0.17	0	0.00	0	0.00
Ponderosa Pine	5322.64	1.09	2	0.78	109	18.60	5	2.07	27	12.50
Ponderosa-Aspen-White Fir-Douglas Fir	6133.24	1.26	0	0.00	0	0.00	0	0.00	0	0.00
Ponderosa-NMex Locust-Gambel Oak	3631.35	0.74	0	0.00	47	8.02	2	0.83	4	1.85
Ponderosa-Pinyon-Cliffrose-Black Sagebrush	367.57	0.08	0	0.00	10	1.71	0	0.00	1	0.46
Ponderosa-Pinyon-Gambel Oak-Juniper	8581.55	1.76	63	24.42	38	6.48	0	0.00	30	13.89
Ponderosa-Gambel Oak-Big Sagebrush	716.96	0.15	4	1.55	5	0.85	0	0.00	3	1.39
Ponderosa-Aspen-Engelmann Spruce	787.53	0.16	0	0.00	2	0.34	0	0.00	0	0.00
Ponderosa-White Fir-Aspen	11059.14	2.27	0	0.00	4	0.68	0	0.00	0	0.00
Ponderosa-White Fir-Aspen-NMex Locust	157.32	0.03	0	0.00	1	0.17	0	0.00	0	0.00
Pinyon-Juniper-Scrub Oak-Little Leaf Mtn Mahogany	7493.06	1.54	6	2.33	5	0.85	1	0.41	2	0.93
Juniper-Pinyon-Mormon Tea-Greasebush	14138.64	2.90	11	4.26	6	1.02	0	0.00	6	2.78
Juniper-Pinyon-Mormon Tea-Scrub Oak	32882.70	6.74	0	0.00	8	1.37	1	0.41	3	1.39
Juniper-Pinyon-Big Sagebrush	4297.82	0.88	0	0.00	0	0.00	8	3.32	1	0.46
Juniper-Big Sagebrush-Pinyon	27519.65	5.64	35	13.57	91	15.53	66	27.39	24	11.11
Pinyon-Juniper-Big Sage-Cliffrose	8330.54	1.71	6	2.33	9	1.54	4	1.66	5	2.31
Pinyon-Scrub Oak-Manzanita	24821.02	5.09	0	0.00	10	1.71	0	0.00	3	1.39
Blackbrush-Pinyon-Juniper	21408.97	4.39	1	0.39	4	0.68	0	0.00	3	1.39
Pinyon-Serviceberry-Gambel Oak	10834.67	2.22	5	1.94	8	1.37	0	0.00	1	0.46
Pinyon-Juniper-bluegrass	2827.65	0.58	30	11.63	32	5.46	0	0.00	21	9.72
Hilaria-Cheatgrass-Snakeweed	1197.67	0.25	0	0.00	0	0.00	3	1.24	1	0.46
Mixed Grass-forb Association	1809.42	0.37	0	0.00	2	0.34	2	0.83	0	0.00
Black Gramma-Snakeweed-Winterfat	185.14	0.04	0	0.00	0	0.00	0	0.00	1	0.46
Big Sagebrush-Snakeweed-Blue Gramma	7225.81	1.48	2	0.78	2	0.34	24	9.96	2	0.93
Big Sagebrush-Juniper-Pinyon	7316.57	1.50	0	0.00	2	0.34	11	4.56	0	0.00
Big Sagebrush-Snakeweed-Mormon	12443.11	2.55	2	0.78	0	0.00	0	0.00	0	0.00

Table 6.3, cont.

Blackbrush-Mormon Tea-Banana Yucca	9053.19	1.86	21	8.14	3	0.51	5	2.07	2	0.93
Rabbitbrush-Snakeweed-Fourwing Saltbush	816.69	0.17	0	0.00	0	0.00	1	0.41	0	0.00
Scrub Oak-Snakeweed-Beargrass-Blackbush	1197.06	0.25	50	19.38	5	0.85	24	9.96	17	7.87
Fourwing Saltbush-Big Sagebrush-Snakeweed	423.92	0.09	0	0.00	0	0.00	0	0.00	0	0.00
Saltbush-Banana Yucca-Snakeweed	2861.91	0.59	0	0.00	0	0.00	2	0.83	0	0.00
Snakeweed-Mormon Tea-Utah Agave	52494.68	10.77	4	1.55	45	7.68	7	2.90	4	1.85
White Bursage-Mormon Tea-Barrel Cactus	1685.18	0.35	0	0.00	12	2.05	1	0.41	1	0.46
Mormon Tea-Snakeweed-Wolfberry	26388.59	5.41	3	1.16	38	6.48	8	3.32	11	5.09
Mormon Tea-Big Galleta-Catclaw Acacia	3491.80	0.72	3	1.16	2	0.34	4	1.66	2	0.93
Creosotebush_Beavertail Cactus-Ocotillo	2647.03	0.54	0	0.00	1	0.17	12	4.98	0	0.00
Creosotebush-White Bursage-Mormon Tea	3523.70	0.72	0	0.00	0	0.00	3	1.24	0	0.00
Blackbrush-Mormon Tea-Banana Yucca	36447.43	7.47	2	0.78	24	4.10	5	2.07	10	4.63
Blackbrush-Joshua Tree-Banana Yucca	582.73	0.12	0	0.00	0	0.00	0	0.00	0	0.00
Blackbrush-Banana Yucca-Cliffrose	2574.16	0.53	0	0.00	0	0.00	0	0.00	0	0.00
Fourwing Saltbush-Grizzly-bear Cactus-Mesquite	41.58	0.01	0	0.00	2	0.34	0	0.00	1	0.46
Shadscale-Mormon Tea-Beavertail Cactus	2638.62	0.54	0	0.00	7	1.19	1	0.41	2	0.93
Desert Mallow-Mormon Tea-Creosotebush	16960.91	3.48	0	0.00	0	0.00	0	0.00	0	0.00
Brittlebush-Creosotebush-Mormon Tea	24385.16	5.00	4	1.55	1	0.17	32	13.28	11	5.09
Brittlebush-Mormon Tea-Catclaw Acacia	15209.80	3.12	3	1.16	34	5.80	6	2.49	11	5.09
Cottonwood-Brickellia-Acacia-Apache Plume	540.47	0.11	0	0.00	8	1.37	2	0.83	6	2.78
Catclaw Acacia-Baccharis-Apache Plume	980.66	0.20	1	0.39	7	1.19	1	0.41	0	0.00
Others not correlated to arch sites	52672.06	10.80	0	0.00	0	0.00	0	0.00	0	0.00

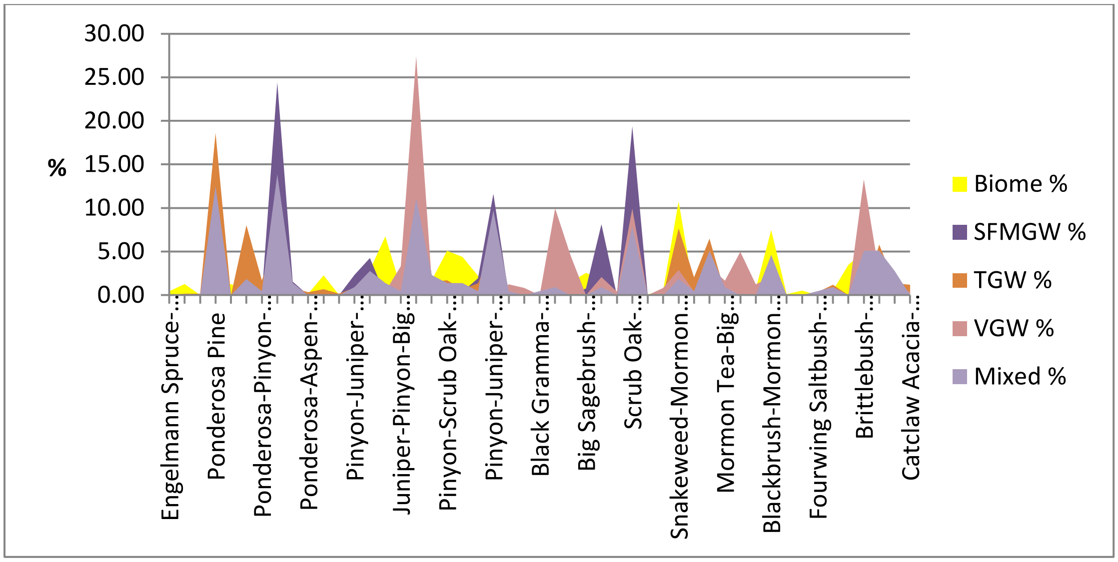

Figure 6.9 Bar chart showing frequency of archaeological sites parsed by ware and corresponding vegetation communities.

All of the vegetation associations that correspond positively to SFMGW sites contain wild resources as either “Characteristic” or “Associated” species (Warren et al. 1982) that were exploited prehistorically (Dunmire and Tierney 1997). Three of the corresponding vegetation associations (Juniper-Pinyon-Mormon_Tea-Greasebush, Juniper-Big_Sagebrush-Pinyon, Scrub_Oak-Snakeweed-Beargrass-Blackbush) contain characteristic or associated species the Hopi correlate with potential for productive maize agriculture. Two of the positively correlated vegetation associations (Ponderosa-Pinyon-Gambel_Oak, Pinyon-Juniper-Bluegrass) contain small quantities (listed as occasional species by Warren et al. 1982) of land the Hopi would consider as good for maize agriculture.

The distribution of SFMGW sites in relation to these vegetation associations seems to provide evidence for a mixed subsistence system, as sites SFMGW sites occur in the highest percentages (76.35% in all vegetation groups or 65.12% in vegetation groups that have higher percentage of sites compared to the overall coverage percentage in the study area) in vegetation groups that are suitable for both wild plant production and maize agriculture. The Ponderosa-Pinyon-Gamble_Oak-Juniper association contains the largest percentage of sites (24.42%) and largest difference between areal coverage percentage (1.76%) and percentage of sites (24.42%), which indicates a definite exploitation of wild resources. Areas most suitable for wild plant production contain 15.87% of the SFMGW sites and a small but notable percentage of sites are located in vegetation association that contain vegetation the Hopi note are indications land with a good potential for maize agriculture. This site distribution pattern is suggestive of a seasonal subsistence strategy where maize would be planted and harvested during the spring and summer and wild resources, in particular pinyon, acorn, juniper and buckwheat, harvested in the fall.

TGW sites correspond in higher than expected percentages to the following vegetation associations: Ponderosa Pine, Ponderosa-New_Mexican_Locust-Gambel_Oak, and Ponderosa-Pinyon-Gamble_Oak-Juniper, Juniper-Big_Sagebrush-Pinyon, and Pinyon-Juniper-Bluegrass vegetation associations. It is interesting to note that almost all of these vegetation associations contain a mixture of pine trees, and second almost all of them also contain another subsistence resource, either oak or grass. While bluegrass itself was likely not used, it indicates the area was a prime for wild plants, like amaranth, to grow

A closer look at the “Characteristic” and “Associated” species that occur as part of the vegetation associations that correspond to the TGW sites results in some surprising conclusions in regards to traditional interpretations of the Canyon's indigenous settlement during the Pueblo Period. Three of the vegetation groups Juniper-Big_Sagebrush-Pinyon, Ponderosa-Pinyon-Gamble_Oak-Juniper, Pinyon-Juniper-Bluegrass vegetation association contain small areas suitable for maize agriculture based on the documented Hopi correlates (Kuwanwisiwma and Ferguson 2009), but as I previously stated these are also areas where Cheno-Ams could also be produced. The other two vegetation associations positively corresponded to TGW sites are the Ponderosa Pine and Ponderosa-New_Mexican_Locust-Gambel_Oak associations. Both of which contain an abundance of wild resources that could be exploited (Dunmire and Tierney 1997) and would be suitable for wild resource production.

The correspondence of TGW sites to vegetation associations suggests a subsistence pattern for this group that is heavily reliant on wild resources (50.03% of TGW sites correspond to vegetation associations with only wild resource production potential). While limited maize agriculture would have likely been practiced its importance would have been minimal, as reflected in the smaller percentage of sites (1.36%) corresponding to vegetation associations that are classified as areas appropriate for maize agriculture. The final two vegetation associations that show indicate a non-random distribution (Ponderosa-Pinyon-Gamble_Oak-Juniper, Pinyon-Juniper-Bluegrass) contain small areas suitable for maize agriculture but also extensive wild resources that could be exploited. In fact, even the agriculturally suitable land could be just as suited to grow wild resources. This reliance on wild resources fits the models proposed by Sullivan et al. (2014) for the inhabitants of the Upper Basin in the eastern Grand Canyon.

VGW sites occur in the higher than expected percentages in the following vegetation associations: Ponderosa, Juniper-Pinyon-Big_Sagebrush, Juniper-Big_Sagebrush-Pinyon, Big_Sagebrush-Snakeweed-Blue-Gramma, Big_SageBrush-Juniper-Pinyon, Scrub_Oak-Snakeweed-Beargrass-Blackbrush, Creosotebush-Beavertail_Cactus-Ocotillo, and Brittlebrush-Creosotebush-Mormon_Tea. None of the vegetation associations that positively correspond to VGW sites contain characteristic species that the Hopi correlate to farmland. However, five out of eight of the vegetation associations (Juniper-Big_Sagebrush-Pinyon, Big_Sagebrush-Snakeweed-Blue-Gramma, Big_SageBrush-Juniper-Pinyon, Scrub_Oak-Snakeweed-Beargrass-Blackbrush, Creosotebush-Beavertail_Cactus-Ocotillo) positively corresponded to VGW sites that contain one of the Hopi correlates as an associated species. These five vegetation associations contain 66.85% of the VGW sites. The other three vegetation associations (Ponderosa, Juniper-Pinyon-Big_Sagebrush, Brittlebush-Creosotebush-Mormon_Tea), which correspond with 18.67% of the VGW sites, all contain numerous characteristic or associated species that are documented wild resources exploited by Southwest native peoples and suited best for wild plant production.

The VGW site distribution pattern is indicative of a mixed subsistence strategy; while there is evidence of some wild resource exploitation, the vast majority of the sites are located in vegetation associations that are suitable for both maize agriculture and wild resource production. This pattern signifies that for VGW sites vegetation association correspondence alone is not suitable for inferring a subsistence strategy with great confidence, additional data from other environmental correlations will be required to develop a model that adequately explains the VGW site distribution.

Range Productivity

Analyses of the correspondence of archaeological sites to range productivity estimates were undertaken to determine if a particular production class was favored or avoided by any of the ware groups. As previously noted, range productivity values are calculated from the NRCS soil database and are an estimate (in pounds per acre per year) of the amount of vegetation that can be expected to grow annually in a managed area during a normal year (Lindsay et. al 2003). Because many of the wild plants utilized prehistorically in the Grand Canyon (Sullivan 2015, Sullivan et al. 2014) would be captured by this productivity range, I use it as a proxy for wild plant productivity. The data correlating the ware groups to soil taxonomy are found in Table 6.4 and Figures 6.10-6.11. The descriptions and implications of those correlations are presented below.

The range productivity data (Figure 6.10) indicate a positive association with Range Production Class 4 (from 475 - 1010 lbs./acre/year) across all ware groups, with SFMGW, VGW, and mixed sites all having a high positive association with this productivity zone (Table 6.4). TGW site distribution also indicates a preference for this class but too a much lower degree than the other three ware groups. The TGW site percentages are almost equal to the areal coverage percentages of the range productivity zones, but the TGW sites are definitely being located preferably in the two highest productivity zones. In fact, the percentage of TGW sites occurring in the highest productivity class (Class 5, from 1010 - 3520 lbs/acre/year) is larger by far than any of the other ware groups. If the range productivity data are in fact a good proxy for wild plant productivity then it seems all of the ware groups are placing their sites with a preference (Figure 6.11) for areas that when managed can produce high yields of vegetation.

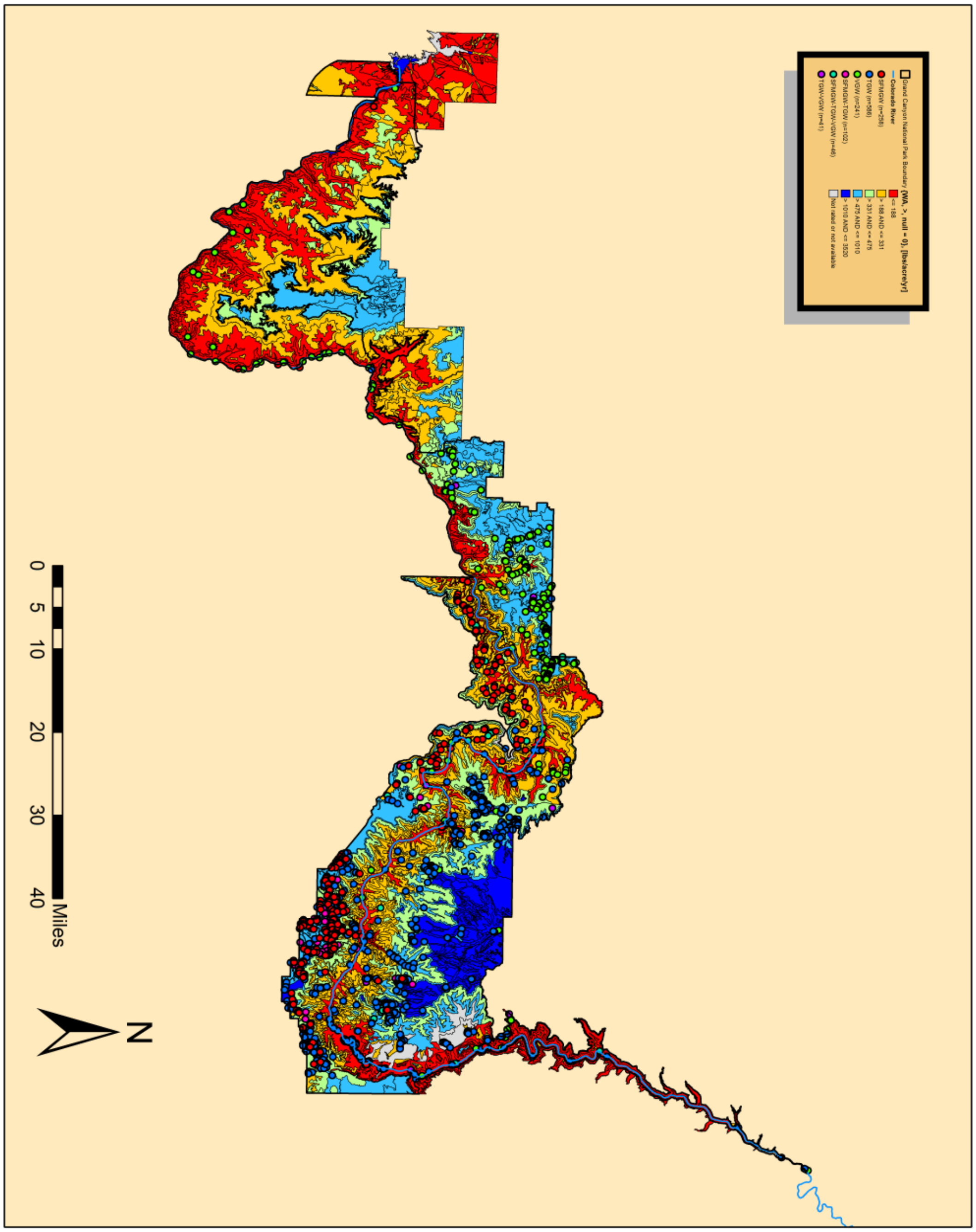

Figure 6.10 Distribution maps of archaeological sites parsed by ware and corresponding range production.

Table 6.4 Archaeological sites parsed by ware and corresponding range production.

Range Production					SFMGW		TGW		VGW		Mixed
Class		# (ha)	%	#	%	#	%	#	%	#	%
1	<= 188	167972	29.07	11	4.26	101	17.24	75	31.12	38	17.59
2	>188 AND <=331	163954	28.37	83	32.17	98	16.72	24	9.96	39	18.06
3	>331 AND <=475	97650	16.90	46	17.83	74	12.63	16	6.64	27	12.50
4	>475 AND <=1010	108687	18.81	111	43.02	152	25.94	115	47.72	85	39.35
5	>1010 AND <=3520	39652	6.86	7	2.71	161	27.47	11	4.56	27	12.50
	TOTAL	577915	100	258	100	586	100	241	100	216	100

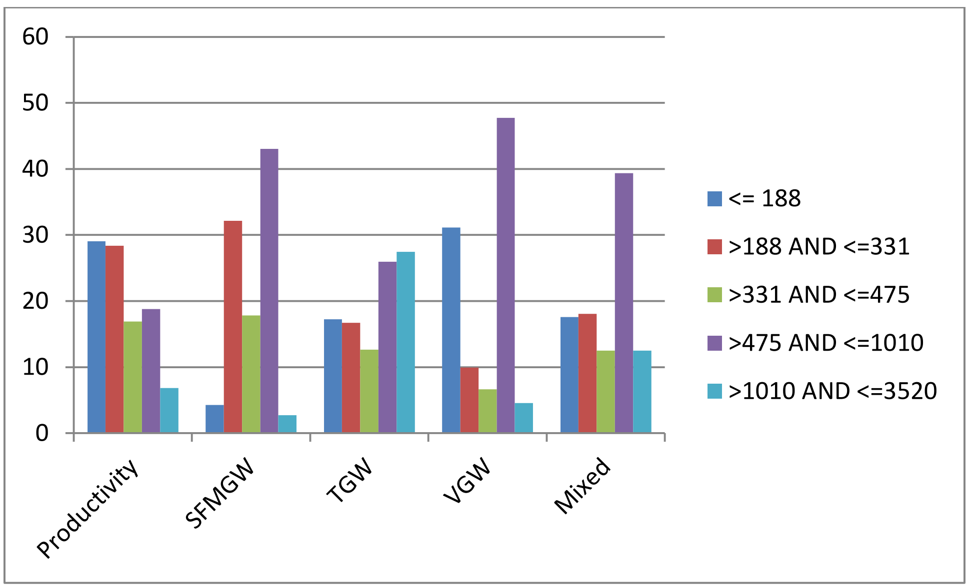

Figure 6.11 Bar chart showing frequency of archaeological sites parsed by ware and corresponding range production.

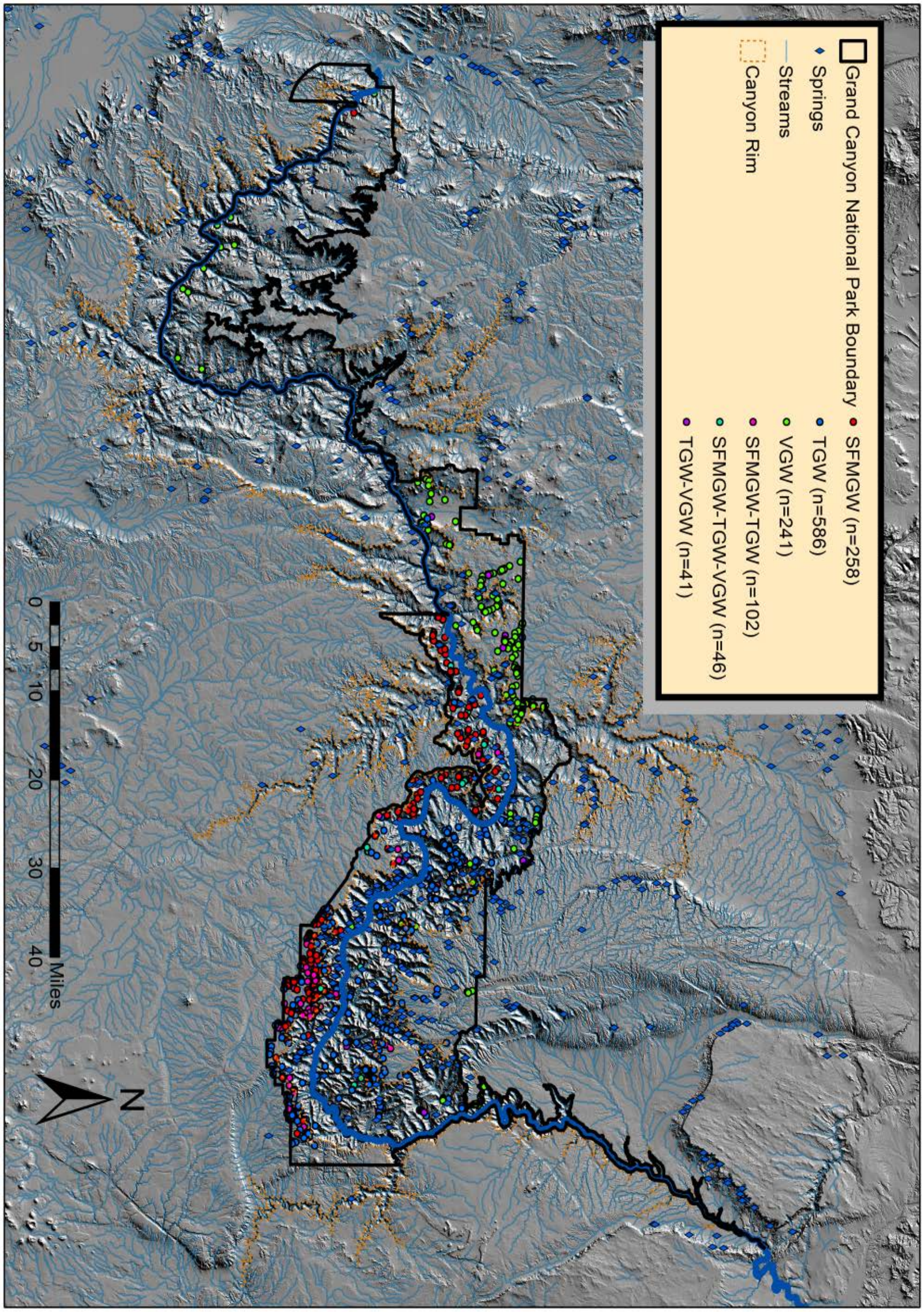

Figure 6.12. Distribution maps of archaeological sites parsed by ware and corresponding to hydrologic system.

Table 6.5. Archaeological sites parsed by ware and corresponding hydrologic system.

	SFMGW	TGW	VGW
Stream			
Min	1	1	1
Max	1654	1471	1595
Mean	473	331	328
SD	355	276	311
Spring			
Min	78	40	77
Max	9030	9026	11796
Mean	3027	2757	3424
SD	1920	1785	2436

Hydrology

The distances between archaeological sites to both streams and springs were calculated to determine the relationship between sites and water. These calculations are most useful when comparing the variation between ware groups or time periods, as this helps an investigator determine if there are any difference either between time periods or among ware groups, and for making inferences in terms of access to surface water sources. The hydrologic calculations for ware groups are found in Table 6.5 and Figure 6.12. The description and implication of those correlations are presented below.

The distance to streams and springs were calculated within ArcGIS utilizing the NEAR tool in the Proximity Toolbox. Among the three main ware groups the VGW sites are located closest to streams while the TGW sites are located closest to springs. The furthest mean distance to streams are found among SFMGW sites and the farthest mean distances to springs were located in association with the VGW sites. The variation among these groups indicates that access and usage to surface water was managed differently by each group. However, it does not appear that site placement depended as heavily on natural water sources as one might assume. At first glance the placement of sites regardless of natural water sources seems counterintuitive in the arid Southwest but water management features have been documented in the Grand Canyon (Norr 1997), so location near water sources seem to be less important since technological solutions for collecting water existed.

Settlement Organization

The next sets of analyses are concerned with examining settlement organization. Data will be examined by site type, frequency of masonry structures, number of rooms, population estimates, and artifact density. These analyses are intended to provide additional information on indigenous settlement relationships in addition to the ecological correlations.

<u>Site Type</u>

Examining the relationship between ware group and site-type frequency provides an insight into what types of activities (e.g., habitation, economic, ritual, etc.) were undertaken by the various groups at a particular site. In my discussion below habitation site percentages were calculated by adding data from Site Types 1, 1.1,1.2, 1.3,1.4,1.5, 1.7, and 2.1,subsistence site-types were calculated using Site Types 4, 6, and 6.1, and artifact scatter site type percentage were computed by adding data for Site Types 5, 5.1 and 5.2. Descriptive site type data are listed in Table 6.6, below.

Table 6.6 Ware Groups correlated to site type.

Code	Description	SFMGW		TGW		VGW	
		#	%	#	%	#	%
1	Masonry Structure	1	0.39	3	0.51	0	0.00
1.1	Masonry Structure 1 Room	21	8.14	109	18.60	27	11.20
1.2	Masonry Structure Multiple Rooms	3	1.16	86	14.68	17	7.05
1.3	Multiple Masonry Structures All Single Rooms	10	3.88	52	8.87	17	7.05
1.4	Multiple Masonry Structures at least 1 with Multiple Rooms	9	3.49	94	16.04	17	7.05
1.5	Rockshelter with Multiple Rooms	1	0.39	1	0.17	0	0.00
1.6	Rock Alignment with Artifacts (no agricultural)	0	0.00	5	0.85	0	0.00
1.7	Possible Pithouse (depression with artifact scatter)	2	0.78	1	0.17	1	0.41
2	Rockshelter without masonry	34	13.18	10	1.71	25	10.37
2.1	Rockshelter with masonry	30	11.63	38	6.48	21	8.71
2.2	Rockshelter-Granary	1	0.39	5	0.85	2	0.83
3	Cave	0	0.00	0	0.00	0	0.00
4	Agriculture Features	0	0.00	8	1.37	0	0.00
5	Artifact Scatter Unknown	73	28.29	110	18.77	52	21.58
5.1	Lithic scatter	7	2.71	8	1.37	12	4.98
5.2	Sherd and lithic scatter	30	11.63	26	4.44	3	1.24
6	FCR	17	6.59	23	3.92	25	10.37
6.1	Mescal Pit	19	7.36	4	0.68	13	5.39
12	Rock Art (Both Pictographs and Petroglyphs or Unknown)	0	0.00	2	0.34	4	1.66
12.1	Petroglyph	0	0.00	1	0.17	2	0.83
12.2	Pictograph	0	0.00	0	0.00	3	1.24
	Total	258	100	586	100	241	100

SFMGW sites (n=259) can be parsed into 29.68% habitation, 14.34% subsistence, and 42.64% artifact scatter activity categories. The fact that the habitation class of the SFMGW sites was the lowest amongst any of the ceramic wares but also contained the largest percentage of artifact scatters is an interesting finding. There are two possibilities for the discrepancy: (1) the groups that extensively used SFMGW exploited the Canyon for a variety of economic reasons but did not live in the Canyon at a very intense level; or

(2) some of the artifact scatters contain pit structures that were not identified when the site was recorded. Because previous research (Schwartz 1980, Sullivan 1995) has demonstrated that the Cohonina did settle in the Park and their sites contained not only structures but also resource processing and pottery manufacturing areas, one possible explanation for the low habitation site percentage is that some of the artifact scatters are habitation structures, but further research, perhaps with geophysical techniques, would need to be conducted to test this hypothesis.

A dissection of the habitation class sites indicates that the largest numbers of habitation sites occur in rockshelters (13.18% without masonry and 11.63% with masonry walls) and the second greatest numbers of habitation sites are single-room masonry structures (8.14%). If we presume that no more than half of the artifact scatters are actually mis-identified pit structures then the artifact scatter percentage is closer to twenty-five percent (which is similar to the other ware groups) and the habitation is closer to fifty-percent (still the lowest but closer to the VGW site distribution).

TGW sites (n=586) can be parsed into 68.09% habitation, 6.82% subsistence, 0.51% ritual, and 24.58% artifact scatter activity categories. When the habitation class is subdivided, the distribution indicates that the largest percentage of TGW sites are one-room one-structure habitations (18.6%), but just barely, as the multi-room single-structure (14.68%) and multi-structure with multi-room (16.04%) site types are also well represented. The ratio between habitation class sites and subsistence sites (fire-cracked-rock) is intriguing. It is likely that the subsistence economic activities occurred within and near the habitation areas, so distinct storage sites do not exist. Such a pattern and difference from both the SFMGW and VGW sites implies a different subsistence system practiced by the TGW group (Sullivan 1995).

VGW sites (n=241) can be segregated into habitation (51.85%), subsistence (16.59%), rock art (3.74%), and artifact scatter (27.81%) activity categories. The distribution of sites across these categories seems to indicate a distribution similar to the SFMGW site percentages, if the percent of SFMGW artifact scatters and habitation sites are adjusted as previously described. However, if the SFMGW percentages are not adjusted, then the VGW artifact scatters percentages fall between the SFMGW and TGW site proportions.

The number of structures and rooms will be examined to determine intensity of occupation and population estimates (Table 6.7). This small-scale examination of settlement organization provides additional data settlement at the Canyon from AD 700-1225.

Table 6.7. Ware Groups correlated to number Structures, number of rooms, artifact density, and population estimate.

	SFMGW	TGW	VGW
Number of Structures	178	739	226
Number of Rooms	178	1276	288
Average Number of Rooms per Structure	1.0	1.73	1.27
Population Estimate	217.60	2041.60	460.80
Artifact Density (mean / structure)	59.49	31.79	18.46

The largest number of structures and rooms and highest populations are found at the TGW sites. The TGW ware group contains almost the same number of structures, rooms, and population as both of the other two ware groups combined. However, when comparing the intensity of occupation, as determined by artifact density, TGW sites only contain a moderate density of artifacts per room. The SFMGW sites contain the smallest number of structures and rooms and lowest population estimate of all of the groups but based on artifact density one of the most intensive occupations in the Canyon. The VGW groups have more structures, rooms, and a higher population estimate than the SFMGW groups but VGW has the lowest artifact densities of all of the ware groups. The lower density suggests a less intensive utilization of the Park by the groups who primarily used VGW ceramics.

SUMMARY OF WARE GROUP ANALYSES

The previous discussion demonstrates that there are definitely differences among the three ware groups in terms of association with environmental variables and in settlement organization. So, in addition to variation in ceramic wares these groups also varied in where they placed their settlements across the landscape and how and to what degree they exploited the Grand Canyon. Below is a brief summary of the ware group analyses.

The preceding analyses all demonstrate that while portions of the current thinking on Grand Canyon Pueblo Period settlement are correct the reality is much more complex. Each of the three archaeological groups, represented in this discussion by their principal gray ware, utilized the Canyon's diverse ecosystem in different ways. The availability of some many resources in such a confined geographic region presented the indigenous inhabitants of the Canyon with a wide variety of subsistence strategies, as discussed below.

SFMGW

SFMGW sites are principally located south of the Colorado River in two clusters, one on the South Rim on the Coconino Plateau near the South Rim Village and a second cluster in the Inner Canyon near the mouth of Havasu Creek. Both of these locales are easily accessible from the heartland of the Cohonina, the principal makers of SFMGW ceramics.

The association of SFMGW sites to biotic communities demonstrates a preference for SFMGW sites to be located in middle elevation forests -primarily Pinyon-Juniper but with a number of sites also occurring in the Ponderosa and Cold Desert Scrub biotic communities. The analysis of the distribution of SFMGW sites in relation to vegetation association, indicates that 15.87% of SFMGW sites occur in areas principally suitable for wild resource production, 4.26% of sites occur in areas deemed appropriate chiefly for maize agriculture, and 65.12% of SFMGW sites occur in areas where both wild plant production and maize agriculture can be successfully practiced. This site distribution pattern is suggestive of a seasonal subsistence strategy where maize would be planted and harvested during the spring and summer and wild resources, in particular pinyon, acorn, juniper and buckwheat, harvested in the fall. This pattern of mixed site locations is suggestive of a seasonal subsistence strategy where maize and other domesticates would be planted and harvested during the spring and summer, and wild resources, in particular pinyon, acorn, juniper and buckwheat, harvested in the fall. Since many of the SFMGW sites are located in the same areas of the Havasupai it is not a stretch to suggest the ethnographically documented Havasupai settlement subsistence strategy was similarly followed prehistorically by groups who predominately used SFMGW ceramics.

SFMGW sites are located most frequently (43.02%) in the second highest range productivity class (475-1010 lbs./acre/year). However, SFMGW sites also occur 32.17% of the time in the second least range productivity class (188-331 lbs./acres/year), the largest percentage of sites in that category. If, as I argue, range productivity can be used as a proxy for wild plant production (see earlier discussion for my reasoning) then this pattern supports the idea of a mixed subsistence strategy that included wild plant production in areas with high range productivity and maize agriculture in the areas of low range productivity.

TGW

TGW sites are found throughout the central part of Grand Canyon National Park, and several distinct geographic distributions can be discerned. North Rim TGW sites are primarily located on the Kaibab Plateau, near the Canyon rim. TGW sites are scattered across the entire South Rim geographic province, with the densest clusters located in the eastern portion of the Park, near Desert View. In the Inner Canyon TGW sites occur in both the East Canyon and Gorge provinces. In the Inner Canyon – Gorge geographic locale TGW sites are located just below the rim on smaller plateaus, such as the Powell Plateau, while in the Inner Canyon –East Canyon province TGW sites are located on the wide deltas found along the Colorado River in this section of the Park.

TGW sites are associated most strongly with Ponderosa Pine and Pinyon Juniper biotic communities, with the strongest association with the Ponderosa Pine community, which contains 25% more sites than what would be expected based on a random distribution. The correspondence of TGW sites to vegetation associations suggests a subsistence pattern for this group that is heavily reliant on wild resources with limited maize agriculture. This reliance on wild resources fits the models proposed by Sullivan and Forste (2014) for the inhabitants of the Upper Basin in the eastern Grand Canyon and expands it throughout the Canyon for groups who predominately use TGW.

TGW sites are located in almost equal proportions in the two highest range productivity classes (475-1010 lbs./acre/year = 25.94% and 1010 -3520 lbs./acres/year = 27.47%). The percentage of sites locates in the highest range productivity category is the largest of any of the ware groups, definitely an indication of wild plant production. The percentage of sites in the lowest three categories range from 12.63% to 17.24% is lower but still high enough to suggest some maize agriculture was practiced. These patterns suggest a mixed subsistence strategy that relied heavily on wild plant production with limited maize agriculture.

VGW

VGW sites are primarily located on the North Rim and in the Inner Canyon-Lower Canyon provinces. The VGW sites on the North Rim are mainly located in the western part of the Park on the Kanab Plateau with a half-dozen sites located on the Kaibab Plateau. In the Inner Canyon most of the VGW sites are located within the Lower Canyon in two clusters, one along the River below the Shivwits Plateau and one in the Toroweap Valley below the eastern edge of the Uinkaret Plateau. The other Inner Canyon VGW sites are located along trails in both the Gorge and East Canyon area.

Sites containing a majority of VGW ceramics are positively associated with the Pinyon-Juniper and Warm Desert biotic communities.   While there seems to be a slight avoidance of the cold desert scrub environment and a slight preference of the pinyon juniper community, the other distributions are almost equal to the percentage of areal coverage of the zone, which indicates sites being placed without regard for biotic community. The one exception is the warm desert scrub biotic community. VGW sites are the only ware group where the locations seem to show a slight preference for this environment. The VGW site distribution pattern is indicative of a mixed subsistence strategy, while there is evidence of some wild resource exploitation the vast majority of the sites are located in vegetation associations that are suitable for both maize agriculture and wild resource production. Therefore, for VGW sites, vegetation association correspondence alone is not suitable for inferring a subsistence strategy with great confidence, additional data from other environmental correlations will be required to develop a VGW settlement model.

VGW sites occur most frequently (47.72%) in areas classified with the second highest range productivity (475-1010 lbs./acre/year), which indicates a heavy reliance on wild plant production. VGW sites also contain the largest percentage of sites in the lowest range productivity area (< 188 lbs./acre/year), which would indicate only slightly less reliance on maize agriculture than on wild plant production. These patterns are indicative of a split subsistence strategy, where both maize agriculture and wild plant production were practiced. This pattern is similar to what has been documented for the Virgin Anasazi in the Arizona strip areas and definitely is suggestive of lowland agriculture subsistence in the low range productivity areas in the Inner Canyon and upland wild plant production subsistence in the higher range productivity areas on the Kanab Plateau.

There are identifiable variations in the settlement patterns among of the three ware groups. The distribution pattern of SFMGW sites indicates a subsistence settlement strategy similar to what has been documented for the historic Havasupai. This pattern indicates that those peoples who produced SFMGW ceramics likely practiced a mixed subsistence strategy, where they grew maize in the Inner Canyon around Havasu Canyon and exploited wild resources in the Pinyon Juniper forests and Ponderosa forests on the South Rim. The TGW settlement pattern also seems to suggest a mixed subsistence strategy but one that is more reliant on wild resources than both the SFMGW or TGW groups and only limited maize agriculture. The VGW settlement pattern is suggestive of a spilt subsistence strategy, with upland wild plant production and lowland maize agriculture contributing to the livelihoods of these peoples in almost equal proportions. This pattern is similar to what has been documented for the Virgin Anasazi in other areas of the Arizona Strip.

SETTLEMENT VARIATION THROUGH TIME: DIACHRONIC ANALYSES OF GRCA DATABASE

In order to understand the indigenous occupation of the Grand Canyon during the Pueblo Period, diachronic analyses of site distribution during this Period were undertaken. The diachronic analyses follow the same approach as those previously discussed for sites parsed by ware. However, these additional analyses were undertaken to provide insight to how settlement at the Grand Canyon changed from AD 700 -1225. It should be noted that there are a couple discrepancies between the date range that is the focus of this study (AD 700 – 1225) and the Time Period dates presented in both Chapter 5 and in the diachronic analyses that follow. Officially Time Period 1 begins in AD 675 but this is based on only one site (B:09:0217) a VGW site that dates to AD 677; all of the rest of the sites assigned to Time Period 1 date to AD 700 or later. In terms of the end date for this study AD 1225, the data for Time Period 6 (AD 1201 -1300) are slightly skewed. Seven of the 29 sites assigned to this Period date to AD 1227 or earlier and are all assigned to one of the ware groups, while the remaining twenty two sites date to AD 1250 or later and mostly do not have a primary ware, and the couple of sites that due have a primary ware also contain later Proto-historic ceramics that likely moved their mean-ceramic-date slightly later in time. Based on these factors I thought it was best to confine this study to the dates of AD 700 -1225.

Time Period 1 (AD 675 – AD 800)

There are 31 sites dating to Time Period 1 (AD 675-800) distributed primarily in the North Rim zone (Figure 6.13). The vast majority of sites (n=24) are dominated by the VGW ceramic group. Most of the VGW sites are located on the Kanab Plateau in the North Rim zone but six sites are located below the rimline in the Lower Canyon province, four in Cottonwood Canyon and the other two closer to the river. A majority of the Kayenta sites are located in the South Rim zone (n=4) with the other two being located adjacent to the river.

Table 6.8. Time Period 1 sites and corresponding geographic regions.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
North Rim	18	48	71	107	48	0	0
South Rim	3	22	183	141	51	6	17
Upper Canyon	0	1	0	1	2	0	0
East Canyon	0	8	15	44	74	2	4
Gorge	3	14	110	183	101	10	12
Lower Canyon	6	24	17	28	11	4	7

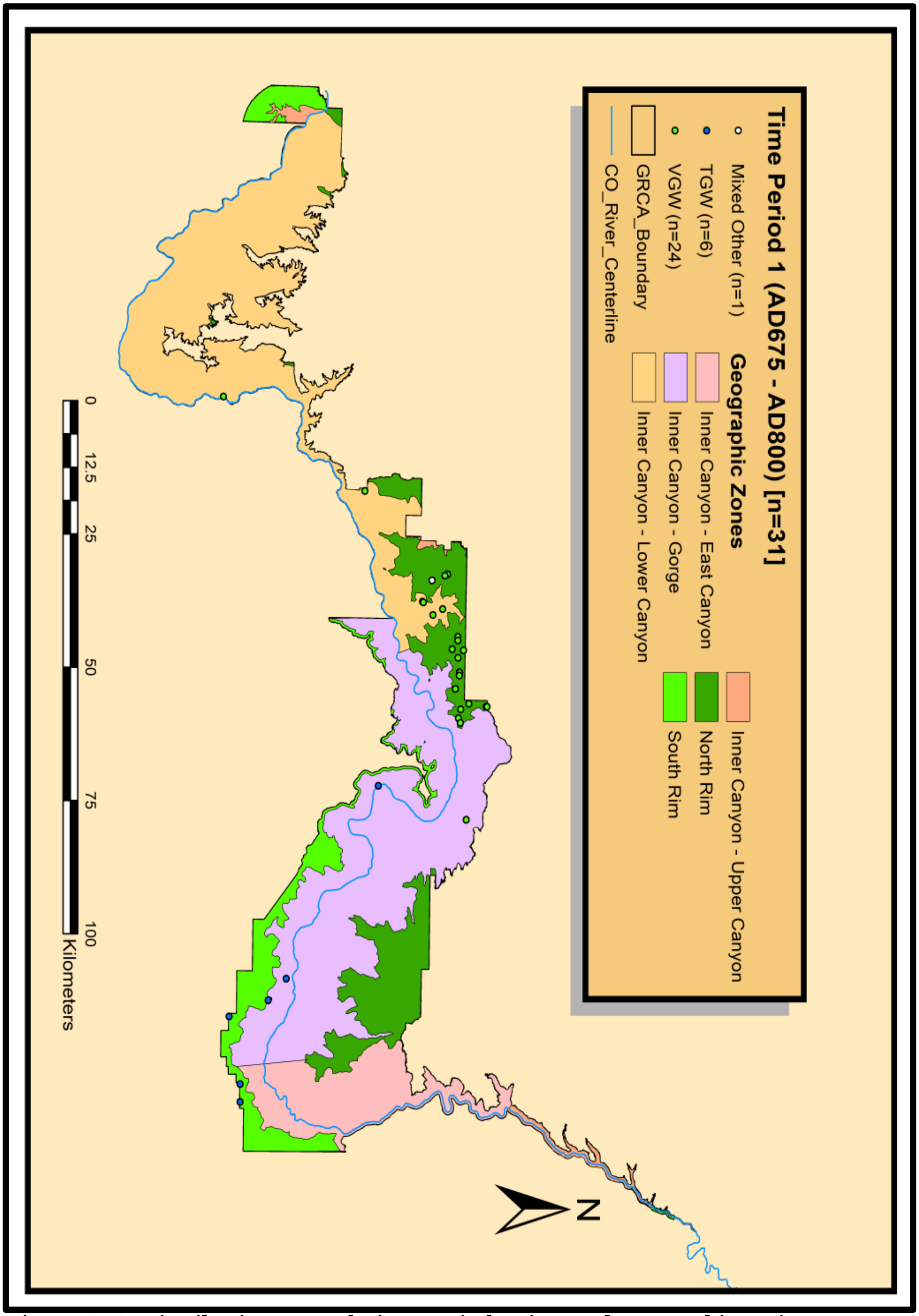

Figure 6.13. Distribution map of Time Period 1 sites and geographic regions.

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Biotic Community

In Time Period 1, there is a definite preference for the pinyon juniper life zone (Figure 6.14) with over 50% of the sites occurring in that biotic community, which only covers about 27% of the Park (Table 6.9). There also seems to be an avoidance of both types of scrub environments with more avoidance of the warm desert scrub. The high correlation with the pinyon juniper community is a bit surprising because Time Period 1 sites are by a large majority VGW sites. The previous examination of sites parsed by ware groups seemed to indicate that while the VGW sites occurred in a slightly higher percentage in the Pinyon Juniper community than would be expected by chance their distribution was a bit more random (i.e., percentages of sites equal to area covered by the zone). This may indicate that the earliest use of the Canyon by VGW groups practiced more wild plant production than maize agriculture.

Table 6.9. Time Period 1 sites and corresponding biotic communities.

Name	Areas hectares	%	TP1 freq	%
Barren	3870	0.79	0	0.00
Cold Desert Scrub	213418	43.72	13	41.94
Mixed coniferous	15208	3.12	0	0.00
Pinyon Juniper	133546	27.36	16	51.61
Ponderosa Pine	24137	4.94	0	0.00
Riparian	1522	0.31	0	0.00
Spruce/Fir	7144	1.46	0	0.00
Warm Desert Scrub	89328	18.30	2	6.45
	488173	100.00	31	100.00

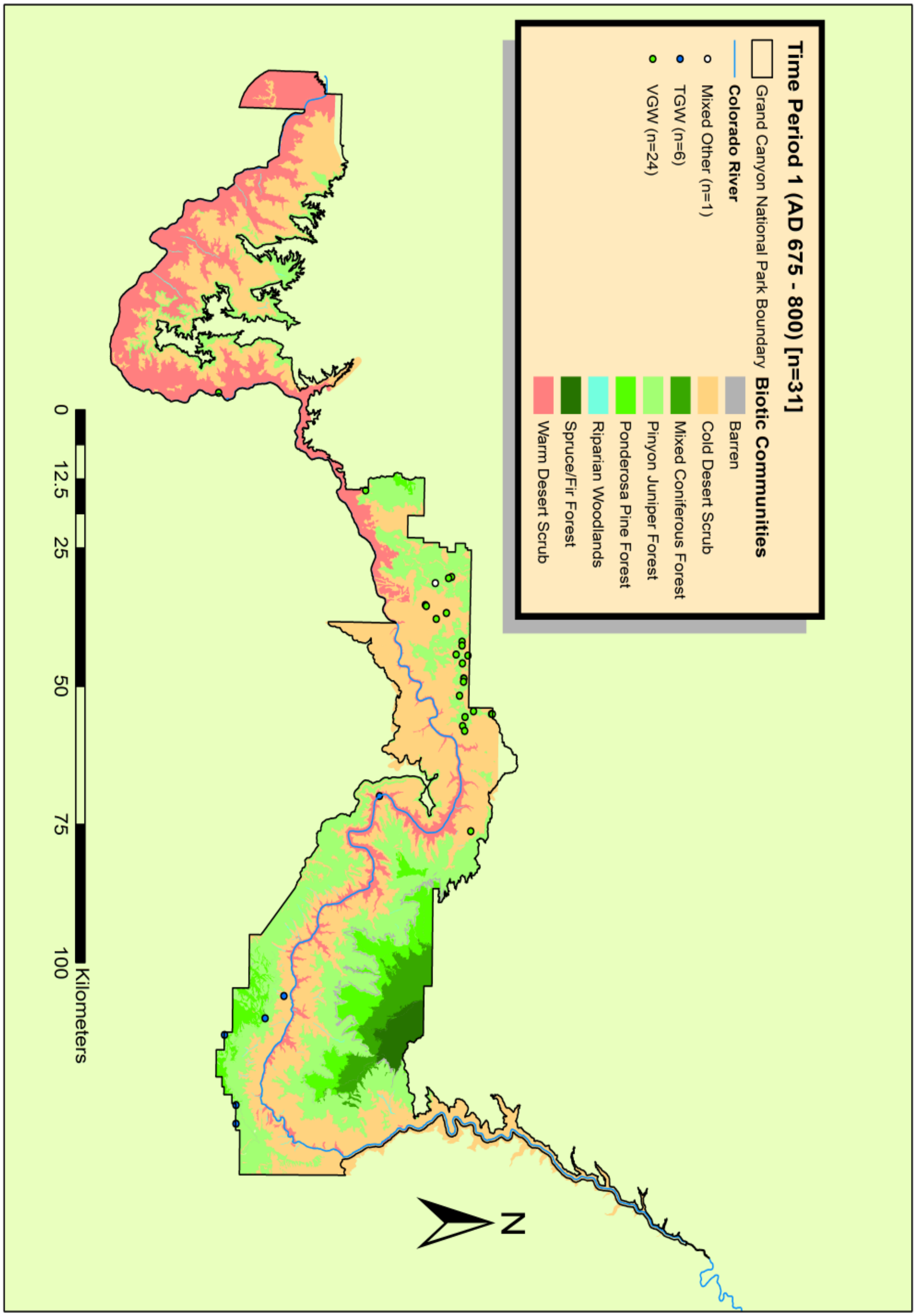

Figure 6.14. Distribution map of Time Period 1 sites and biotic communities.

Vegetation Association

As Figure 6.15 and Table 6.10 illustrate, sites dating to Time Period 1 occur in higher than expected percentages in the following vegetation associations: Pinyon-Juniper-Scrub_Oak-Little_Leaf_Mountain_Mahogany, Big_Sagebrush-Snakeweed-Blue_Gamma, and Scrub_Oak-Sankeweed-Beargrass-Blackbush. This diverse set of vegetation associations reflects the fact that the VGW sites dominated at the time. The largest percentage of Time Period 1 sites (41.94%) correspond at the highest level with a vegetation association that is suitable for wild plant production (Pinyon-Juniper-Scrub_Oak-Little_Leaf_Mountain_Mahogany). The other positive correspondence between Time Period 1 sites and vegetation associations are in locations that are classified as mixed vegetation associations, meaning they are suitable for both maize agriculture and wild plant production.

Table 6.10. Time Period 1 site correlated to vegetation associations.

Name	Area hectares	%	TP1 Freq	%
Engelmann Spruce-Subalpine Fir	2194.00	0.45	0	0.00
Engelmann Spruce-White Fir-Ponderosa	6240.99	1.28	0	0.00
Ponderosa-Aspen-Engelmann Spruce	83.61	0.02	0	0.00
Ponderosa Pine	5322.64	1.09	0	0.00
Ponderosa-Aspen-White Fir-Douglas Fir	6133.24	1.26	0	0.00
Ponderosa-NMex Locust-Gambel Oak	3631.35	0.74	0	0.00
Ponderosa-Pinyon-Cliffrose-Black Sagebrush	367.57	0.08	0	0.00
Ponderosa-Pinyon-Gambel Oak-Juniper	8581.55	1.76	1	3.23
Ponderosa-Gambel Oak-Big Sagebrush	716.96	0.15	1	3.23
Ponderosa-Aspen-Engelmann Spruce	787.53	0.16	0	0.00
Ponderosa-White Fir-Aspen	11059.14	2.27	0	0.00
Ponderosa-White Fir-Aspen-NMex Locust	157.32	0.03	0	0.00
Pinyon-Juniper-Scrub Oak-Little Leaf Mtn	7493.06	1.54	13	41.94
Juniper-Pinyon-Mormon Tea-Greasebush	14138.64	2.90	0	0.00

Table 6.10, cont.

Juniper-Pinyon-Mormon Tea-Scrub Oak	32882.70	6.74	0	0.00
Juniper-Pinyon-Big Sagebrush	4297.82	0.88	1	3.23
Juniper-Big Sagebrush-Pinyon	27519.65	5.64	0	0.00
Pinyon-Juniper-Big Sage-Cliffrose	8330.54	1.71	0	0.00
Pinyon-Scrub Oak-Manzanita	24821.02	5.09	0	0.00
Blackbrush-Pinyon-Juniper	21408.97	4.39	0	0.00
Pinyon-Serviceberry-Gambel Oak	10834.67	2.22	0	0.00
Pinyon-Juniper-bluegrass	2827.65	0.58	0	0.00
Hilaria-Cheatgrass-Snakeweed	1197.67	0.25	0	0.00
Mixed Grass-forb Association	1809.42	0.37	0	0.00
Black Gramma-Snakeweed-Winterfat	185.14	0.04	0	0.00
Big Sagebrush-Snakeweed-Blue Gramma	7225.81	1.48	4	12.90
Big Sagebrush-Juniper-Pinyon	7316.57	1.50	3	9.68
Big Sagebrush-Snakeweed-Mormon Tea	12443.11	2.55	0	0.00
Blackbrush-Mormon Tea-Banana Yucca	9053.19	1.86	0	0.00
Rabbitbrush-Snakeweed-Fourwing Saltbush	816.69	0.17	0	0.00
Scrub Oak-Snakeweed-Beargrass-Blackbush	1197.06	0.25	5	16.13
Fourwing Saltbush-Big Sagebrush-Snakeweed	423.92	0.09	0	0.00
Saltbush-Banana Yucca-Snakeweed	2861.91	0.59	0	0.00
Snakeweed-Mormon Tea-Utah Agave	52494.68	10.77	0	0.00
White Bursage-Mormon Tea-Barrel Cactus	1685.18	0.35	0	0.00
Mormon Tea-Snakeweed-Wolfberry	26388.59	5.41	0	0.00
Mormon Tea-Big Galleta-Catclaw Acacia	3491.80	0.72	0	0.00
Creosotebush_Beavertail Cactus-Ocotillo	2647.03	0.54	0	0.00
Creosotebush-White Bursage-Mormon Tea	3523.70	0.72	0	0.00
Blackbrush-Mormon Tea-Banana Yucca	36447.43	7.47	1	3.23
Blackbrush-Joshua Tree-Banana Yucca	582.73	0.12	0	0.00
Blackbrush-Banana Yucca-Cliffrose	2574.16	0.53	0	0.00
Fourwing Saltbush-Grizzly-bear Cactus-Mesquite	41.58	0.01	0	0.00
Shadscale-Mormon Tea-Beavertail Cactus	2638.62	0.54	0	0.00
Desert Mallow-Mormon Tea-Creosotebush	16960.91	3.48	0	0.00
Brittlebush-Creosotebush-Mormon Tea	24385.16	5.00	1	3.23
Brittlebush-Mormon Tea-Catclaw Acacia	15209.80	3.12	1	3.23
Cottonwood-Brickellia-Acacia-Apache Plume	540.47	0.11	0	0.00
Catclaw Acacia-Baccharis-Apache Plume	980.66	0.20	0	0.00
Others not correlated to arch sites	52672.06	10.80	0	0.00

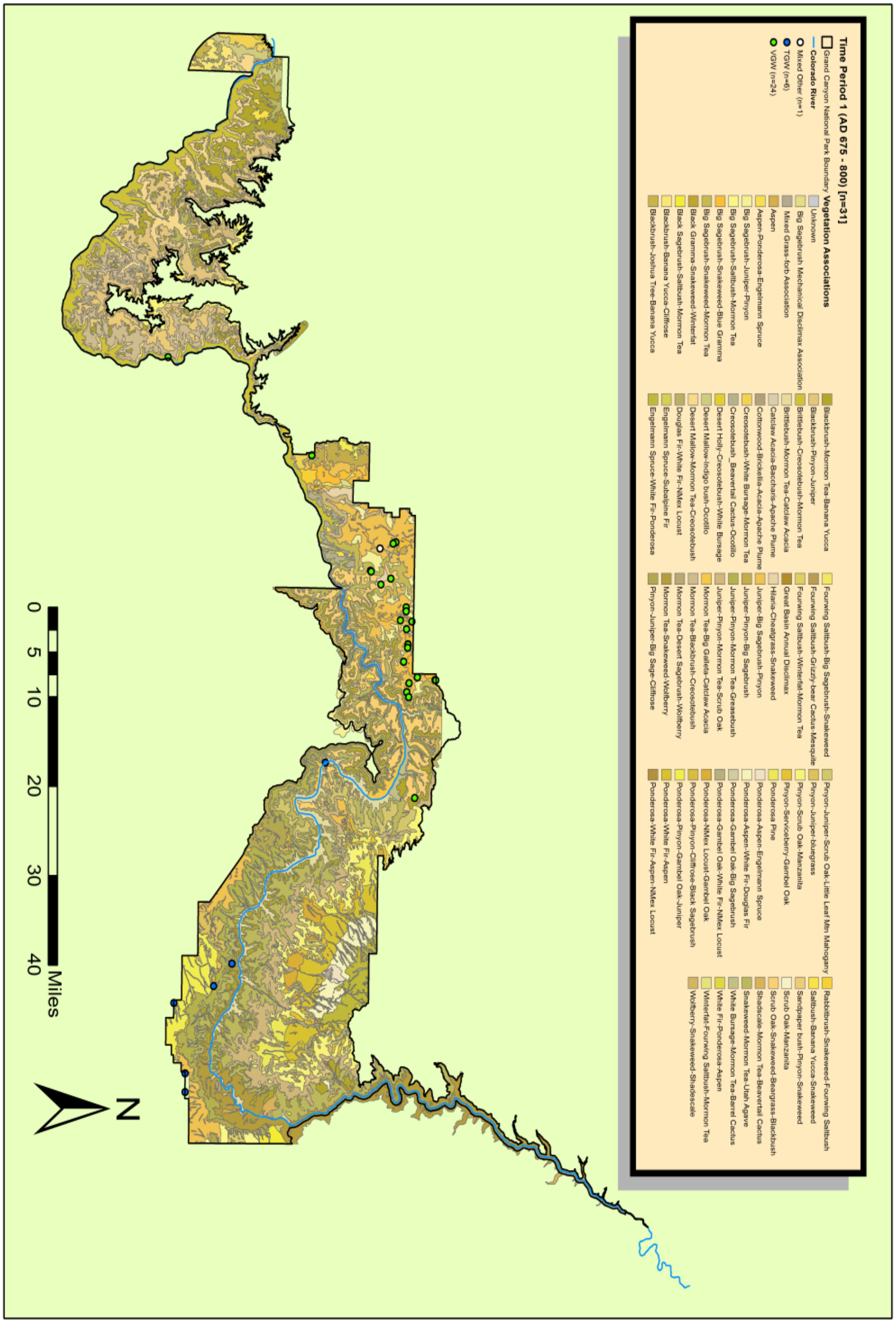

Figure 6.15. Distribution map of Time Period 1 sites to vegetation associations.

Range Productivity

As Figure 6.16 and Table 6.11 illustrate the overwhelmingly preferred range productivity class was from 475-1010 lbs./acre/year. This second highest area of productivity is not too surprising, because Time Period 1 sites are dominated by VGW sites and the biotic community and vegetation data presented in the ware group analyses above suggest the VGW groups utilized wild resource extensively.

Table 6.11. Time Period 1 sites and corresponding range productivity.

	# (ha)	%	#	TP1 %
<= 188	167972	29.07	3	9.68
>188 AND <=331	163954	28.37	4	12.90
>331 AND <=475	97650	16.90	4	12.90
>475 AND <=1010	108687	18.81	20	64.52
>1010 AND <=3520	39652	6.86	0	0.00
TOTAL	577915	100	31	100

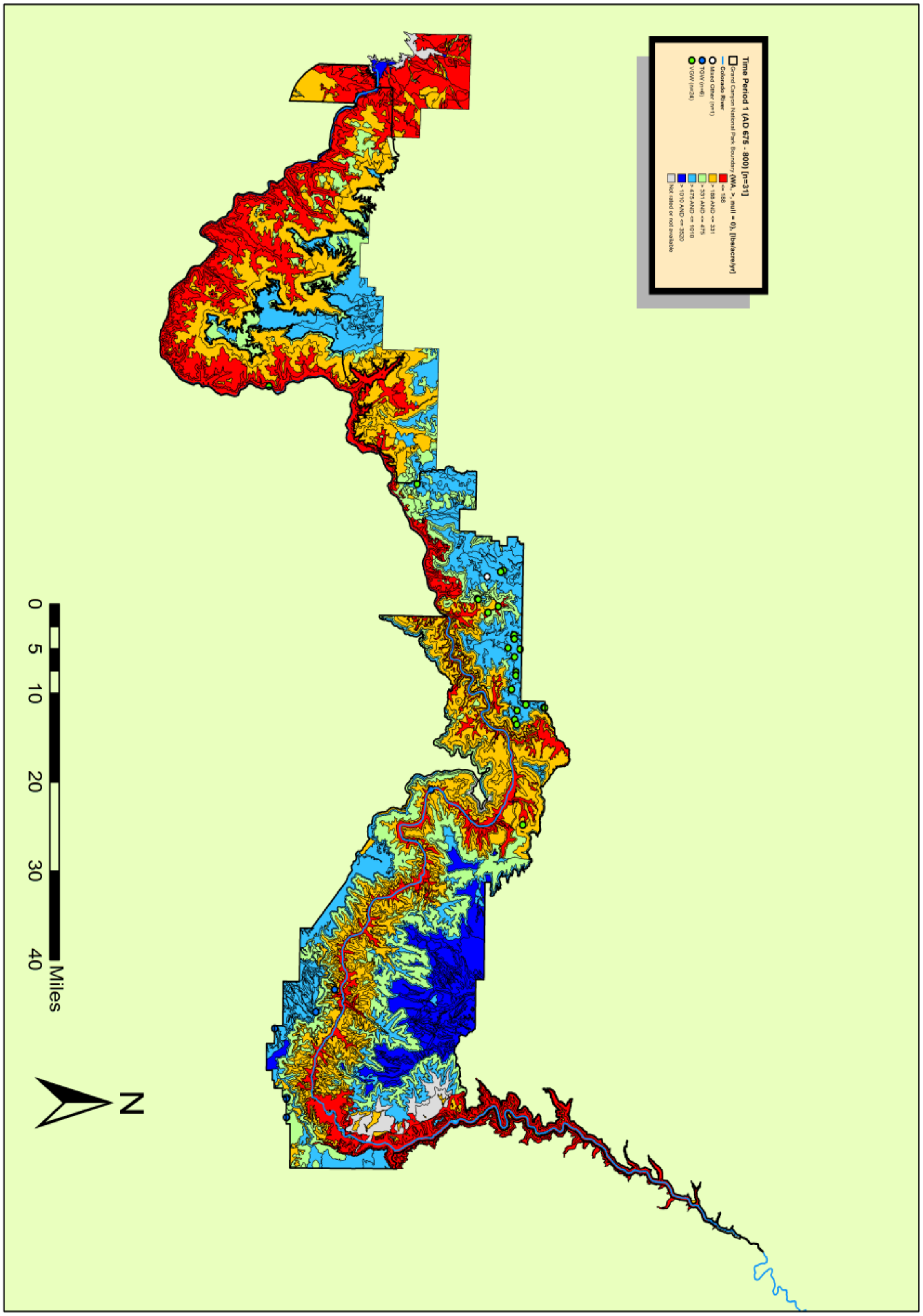

Figure 6.16. Distribution map of Time Period 1 sites and range productivity.

Hydrology

Figure 6.17 and Table 6.12 illustrate that during Time Period 1 the mean distance to streams and springs is about average compared to all of the time periods. All of the distances are easily traveled in a day but the distance to springs is a little further than one may expect to actually using them as a source of drinking water, indicating they may have been using springs for another reason, such as an area to sow wild plant seeds to later harvest, a practice Smith (2011) has documented in other parts of the Americas.

Table 6.12. Time Period 1 sites and corresponding hydrology.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
Stream							
Min	42	10	1	4	1	1	1
Max	1260	1202	1654	1509	1595	741	1098
Mean	336	387	414	343	293	206	233
SD	293	298	324	290	305	211	268
Spring	TP1	TP2	TP3	TP4	TP5	TP6	TP7
Min	250	40	77	78	49	503	22
Max	6994	9026	11107	11283	11796	9826	11930
Mean	3200	3182	3169	2845	2753	3994	4260
SD	1757	2033	1972	1975	1896	2382	2867

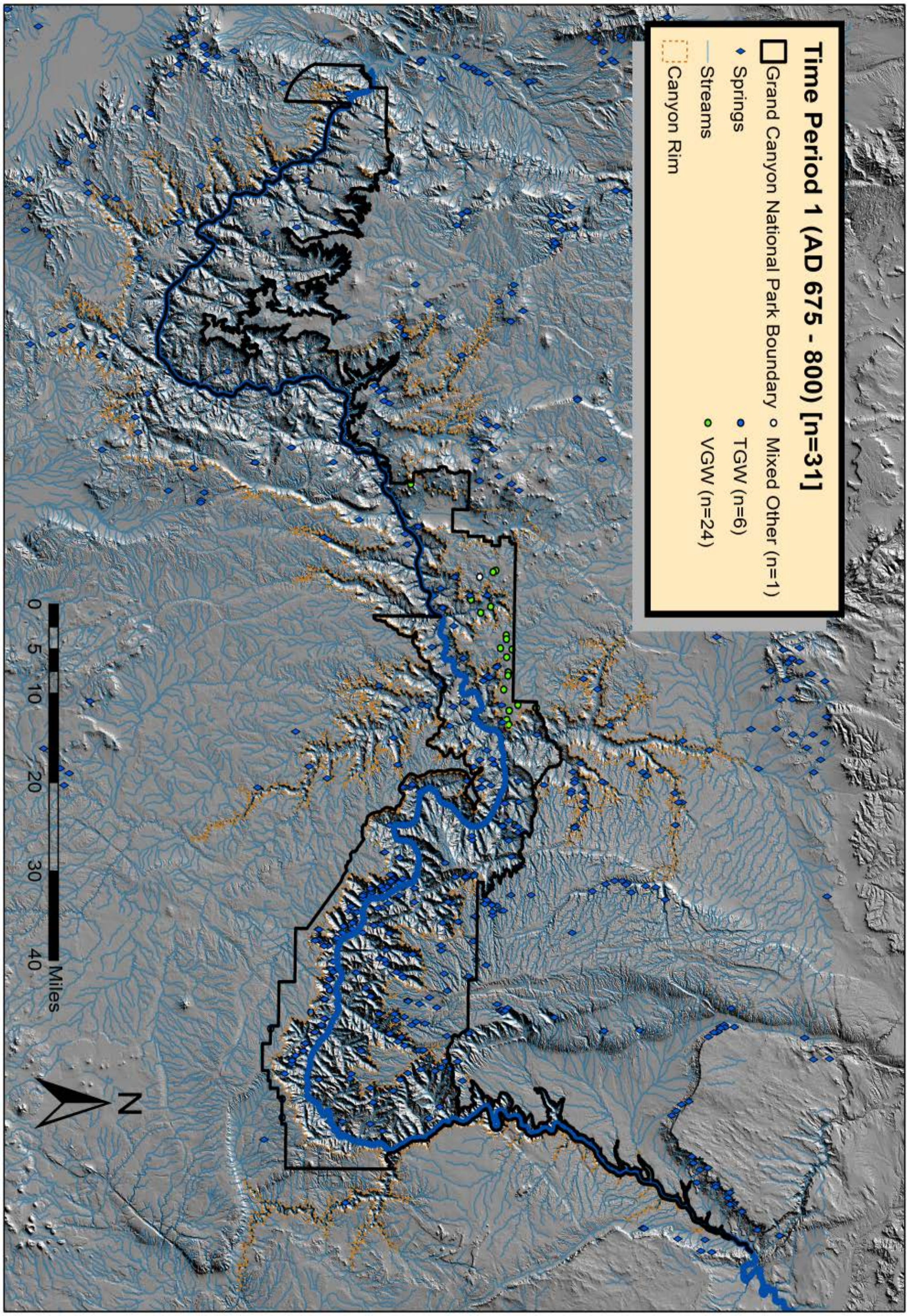

Figure 6.17. Distribution map of Time Period 1 sites and hydrology.

Settlement Organization

Time Period 1 sites (n=31) can be divided into habitation (16.14%), subsistence (16.13%), rock art (3.23%), and artifact scatter (64.52%) categories (Table 6.13). The habitation site type is dominated by single-structure single-room sites (9.68%) and the overall distribution pattern of sites within the categories is different than what is found in all of the other time periods, with an extremely low percentage of sites occurring in the habitation category coupled with very high percentage of artifact scatters. This pattern is similar to what is seen in the SFMGW sites but even more extreme. The same possible explanations presented in the SFMGW discussion also apply: (1) the peoples occupying the Canyon during Time Period 1 (principally VGW using groups) utilized the Canyon for a variety of economic reasons but did not live in the Canyon at a very intense level, or (2) some of the artifact scatters likely contain pit structures that were not identified when the site was recorded. The Time Period 1 pattern which principally consists of small single-room structures, high numbers of artifact scatters and a higher number of subsistence sites seems to indicate that pioneering groups of peoples began to enter the Canyon.

The number of structures and rooms will be examined to determine intensity of occupation and population estimates. This small-scale examination of settlement organization provides additional data on settlement at the Canyon from AD 700 -1225. Table 6.14 contains the data on Time Period 1 settlement organization. The data suggest very small but intensive occupation during Time Period 1. However, the sample size of site for this time period is so low that both the population estimate and artifact density are not good for comparison to the other time periods.

Table 6.13. Time Period 1 sites correlated to site type.

Code	Description	TP1 Freq	%
1	Masonry Structure	0	0.00
1.1	Masonry Structure 1 Room	3	9.68
1.2	Masonry Structure Multiple Rooms	0	0.00
1.3	Multiple Masonry Structures All Single Rooms	1	3.23
1.4	Multiple Masonry Structures at least 1 with Multiple Rooms	0	0.00
1.5	Rockshelter with Multiple Rooms	0	0.00
1.6	Rock Alignment with Artifacts (no agricultural)	0	0.00
1.7	Possible Pithouse (depression with artifact scatter)	0	0.00
2	Rockshelter without masonry	1	3.23
2.1	Rockshelter with masonry	0	0.00
2.2	Rockshelter-Granary	0	0.00
3	Cave	0	0.00
4	Agriculture Features	0	0.00
5	Artifact Scatter Unknown	9	29.03
5.1	Lithic scatter	10	32.26
5.2	Sherd and lithic scatter	1	3.23
6	FCR	5	16.13
6.1	Mescal Pit	0	0.00
12	Rock Art (Both Pictographs and Petroglyphs or Unknown)	1	3.23
12.1	Petroglyph	0	0.00
12.2	Pictograph	0	0.00
		31	100

Table 6.14. Time Period 1 settlement organization data.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
# Structures	8	89	291	640	429	26	42
#Room	4	132	400	1005	644	24	37
Average # Rooms / Structure	0.50	1.48	1.37	1.57	1.50	0.92	0.88
Population Estimate	6.40	211.20	640.00	1608.00	1030.40	38.40	59.20
Artifact Density (mean / structure)	20.92	14.58	40.44	78.49	32.63	15.71	14.09

Time Period 2 (AD 801 – AD 900)

The data for Time Period 2 (AD 801 - 900) indicate an increase in number of sites (n=119) including the first cases of mixed ceramic assemblages. The distribution of Time Period 2 sites (Figure 6.18) is more uniform across the Canyon. Two clusters one of VGW sites occurs in the Kanab portion of the North Rim, while the majority of the TGW sites are located on the South Rim. SFMGW sites are not present in high numbers within the Canyon at this time, in fact only one predominately SFMGW site and seven mixed sites containing a small proportion of SFMGW ceramics have been assigned to Time Period 2, they are located mainly in the South Rim or East Canyon zones.

Table 6.15. Time Period 2 site and corresponding geographic regions.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
North Rim	18	48	71	107	48	0	0
South Rim	3	22	183	141	51	6	17
Upper Canyon	0	1	0	1	2	0	0
East Canyon	0	8	15	44	74	2	4
Gorge	3	14	110	183	101	10	12
Lower Canyon	6	24	17	28	11	4	7

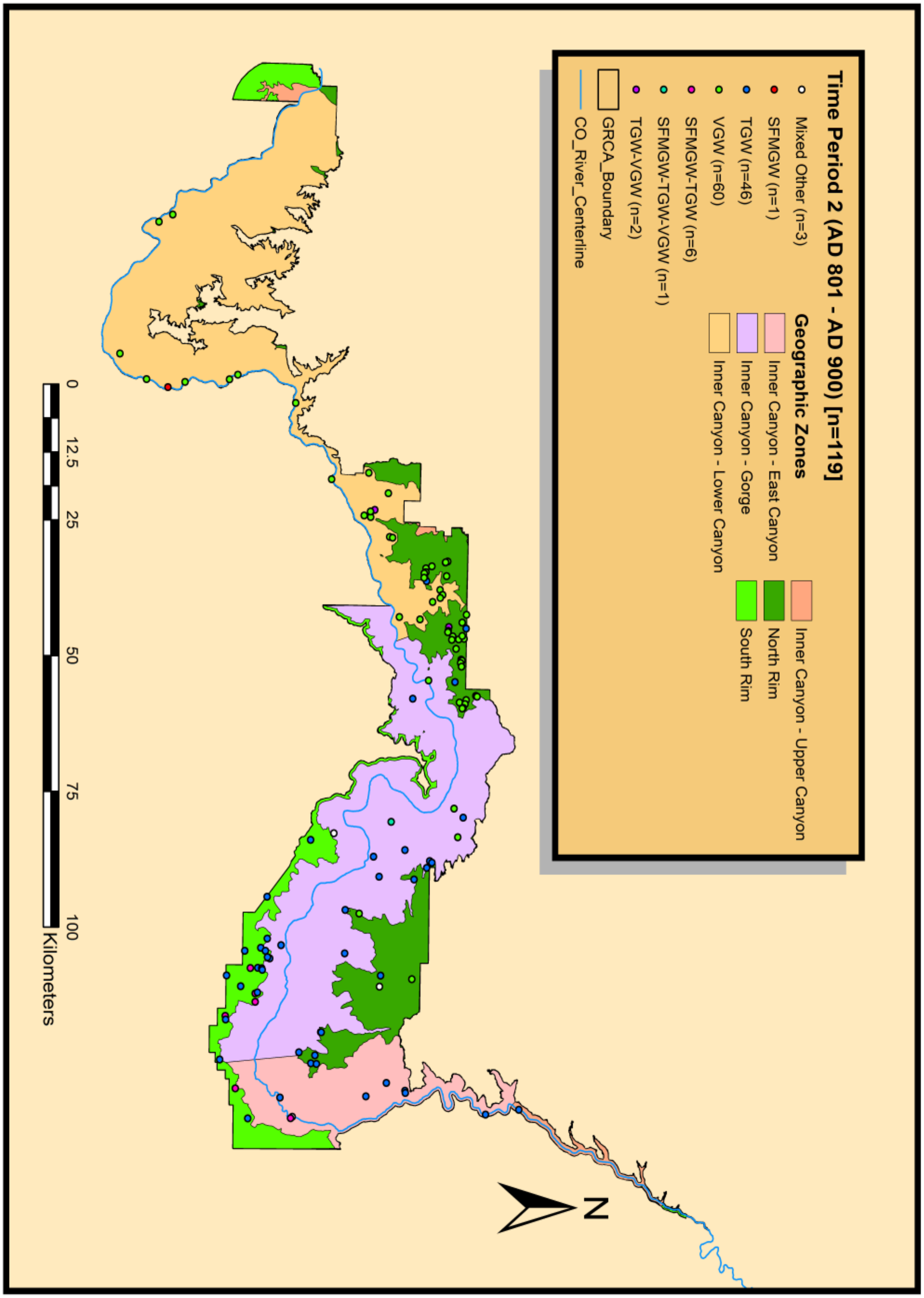

Figure 6.18. Distribution map of Time Period 2 sites and geographic regions.

Biotic Community

As Figure 6.19 and Table 6.16 illustrate, during Time Period 2 a shift in site distribution between biotic communities occurs. During this period while we still see a preference for placing sites in the Pinyon Juniper life zone there is also a jump in the number of sites occurring in the Ponderosa Pine biotic community. This pattern results from an increase in the number of TGW sites, which occur in a much higher percentage in the Ponderosa Pine zone than any other ware group. Also, during Time Period 2 there is a slight increase in the percentage of sites in the Warm Desert Scrub biotic zone, likely due to the increasing number of VGW sites that occur in that zone with some regularity.

Table 6.16. Time Period 2 sites and corresponding biotic communities.

Name	Areas hectares	%	TP2 freq	%
Barren	3870	0.79	3	2.52
Cold Desert Scrub	213418	43.72	34	28.57
Mixed coniferous	15208	3.12	2	1.68
Pinyon Juniper	133546	27.36	44	36.97
Ponderosa Pine	24137	4.94	18	15.13
Riparian	1522	0.31	0	0.00
Spruce/Fir	7144	1.46	1	0.84
Warm Desert Scrub	89328	18.30	17	14.29
	488173	100.00	119	100.00

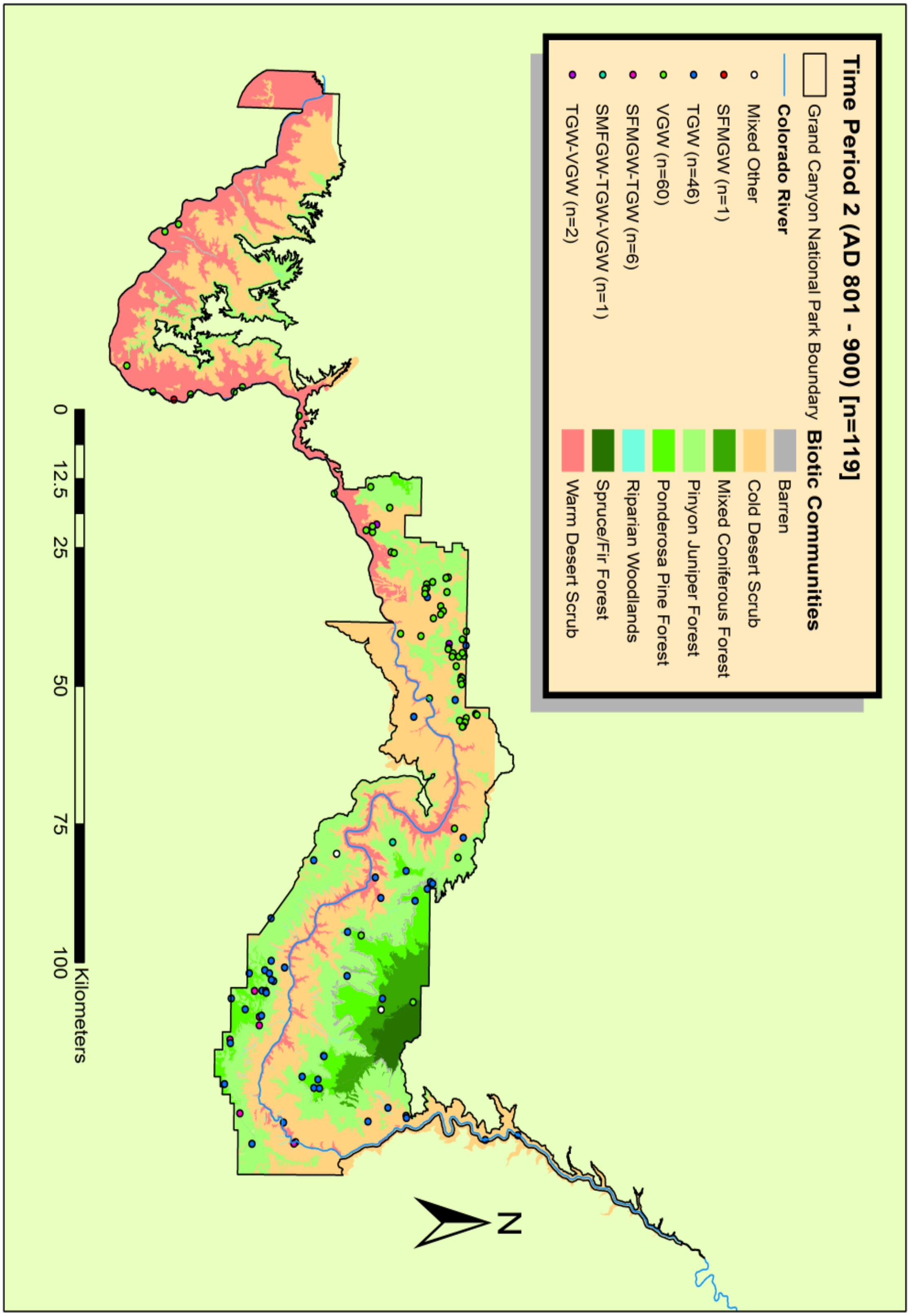

Figure 6.19. Distribution map of Time Period 2 sites and biotic communities.

Vegetation Association

As Figure 6.20 and Table 6.17 illustrate, sites dating to Time Period 2 occur in the higher than expected percentages in the following vegetation associations: Ponderosa Pine, Ponderosa-New_Mexican_Locust-Gamble_Oak, Pinyon-Juniper-Scrub_Oak-Little_Leaf_Mountain_Mahogany, Pinyon-Juniper-Bluegrass, Big_Sagebrush-Pinyon-Juniper, Big-Sagebrush-Snakeweek-Blue_Gramma, and Scrub_Oak-Snakeweed-BearGrass_Blackbush. This set of vegetation association like Time Period 1 is quite diverse and includes some additional ponderosa and pinyon juniper associations. During this time period the VGW sites still dominates thus the diverse set of associations but the TGW sites also begin to appear which results in the increasing number of Ponderosa and Pinyon Juniper vegetation associations. Most of these vegetation associations correspond to areas with the potential of wild plant exploitation and production, which is not surprising due to the increasing number of TGW sites. The previous analyses of TGW sites presented above demonstrated that these sites were located within wild plant production areas at a higher than expected rate.

Table 6.17. Time Period 2 sites and corresponding vegetation associations.

NAME	Area hectares	%	TP2 Freq	%
Engelmann Spruce-Subalpine Fir	2194.00	0.45	0	0.00
Engelmann Spruce-White Fir-Ponderosa	6240.99	1.28	0	0.00
Ponderosa-Aspen-Engelmann Spruce	83.61	0.02	0	0.00
Ponderosa Pine	5322.64	1.09	8	6.72
Ponderosa-Aspen-White Fir-Douglas Fir	6133.24	1.26	0	0.00
Ponderosa-NMex Locust-Gambel Oak	3631.35	0.74	3	2.52
Ponderosa-Pinyon-Cliffrose-Black Sagebrush	367.57	0.08	1	0.84
Ponderosa-Pinyon-Gambel Oak-Juniper	8581.55	1.76	9	7.56
Ponderosa-Gambel Oak-Big Sagebrush	716.96	0.15	2	1.68
Ponderosa-Aspen-Engelmann Spruce	787.53	0.16	1	0.84

Table 6.17, cont.

Ponderosa-White Fir-Aspen	11059.14	2.27	0	0.00
Ponderosa-White Fir-Aspen-NMex Locust	157.32	0.03	0	0.00
Pinyon-Juniper-Scrub Oak-Little Leaf Mtn Mahogany	7493.06	1.54	30	25.21
Juniper-Pinyon-Mormon Tea-Greasebush	14138.64	2.90	1	0.84
Juniper-Pinyon-Mormon Tea-Scrub Oak	32882.70	6.74	1	0.84
Juniper-Pinyon-Big Sagebrush	4297.82	0.88	2	1.68
Juniper-Big Sagebrush-Pinyon	27519.65	5.64	0	0.00
Pinyon-Juniper-Big Sage-Cliffrose	8330.54	1.71	2	1.68
Pinyon-Scrub Oak-Manzanita	24821.02	5.09	0	0.00
Blackbrush-Pinyon-Juniper	21408.97	4.39	0	0.00
Pinyon-Serviceberry-Gambel Oak	10834.67	2.22	0	0.00
Pinyon-Juniper-bluegrass	2827.65	0.58	6	5.04
Hilaria-Cheatgrass-Snakeweed	1197.67	0.25	1	0.84
Mixed Grass-forb Association	1809.42	0.37	2	1.68
Black Gramma-Snakeweed-Winterfat	185.14	0.04	0	0.00
Big Sagebrush-Snakeweed-Blue Gramma	7225.81	1.48	5	4.20
Big Sagebrush-Juniper-Pinyon	7316.57	1.50	6	5.04
Big Sagebrush-Snakeweed-Mormon Tea	12443.11	2.55	0	0.00
Blackbrush-Mormon Tea-Banana Yucca	9053.19	1.86	1	0.84
Rabbitbrush-Snakeweed-Fourwing Saltbush	816.69	0.17	0	0.00
Scrub Oak-Snakeweed-Beargrass-Blackbush	1197.06	0.25	7	5.88
Fourwing Saltbush-Big Sagebrush-Snakeweed	423.92	0.09	0	0.00
Saltbush-Banana Yucca-Snakeweed	2861.91	0.59	1	0.84
Snakeweed-Mormon Tea-Utah Agave	52494.68	10.77	4	3.36
White Bursage-Mormon Tea-Barrel Cactus	1685.18	0.35	0	0.00
Mormon Tea-Snakeweed-Wolfberry	26388.59	5.41	4	3.36
Mormon Tea-Big Galleta-Catclaw Acacia	3491.80	0.72	0	0.00
Creosotebush_Beavertail Cactus-Ocotillo	2647.03	0.54	6	5.04
Creosotebush-White Bursage-Mormon Tea	3523.70	0.72	0	0.00
Blackbrush-Mormon Tea-Banana Yucca	36447.43	7.47	5	4.20
Blackbrush-Joshua Tree-Banana Yucca	582.73	0.12	0	0.00
Blackbrush-Banana Yucca-Cliffrose	2574.16	0.53	0	0.00
Fourwing Saltbush-Grizzly-bear Cactus-Mesquite	41.58	0.01	0	0.00
Shadscale-Mormon Tea-Beavertail Cactus	2638.62	0.54	0	0.00
Desert Mallow-Mormon Tea-Creosotebush	16960.91	3.48	0	0.00
Brittlebush-Creosotebush-Mormon Tea	24385.16	5.00	9	7.56
Brittlebush-Mormon Tea-Catclaw Acacia	15209.80	3.12	2	1.68
Cottonwood-Brickellia-Acacia-Apache Plume	540.47	0.11	0	0.00
Catclaw Acacia-Baccharis-Apache Plume	980.66	0.20	0	0.00
Others not correlated to arch sites	52672.06	10.80	0	0.00

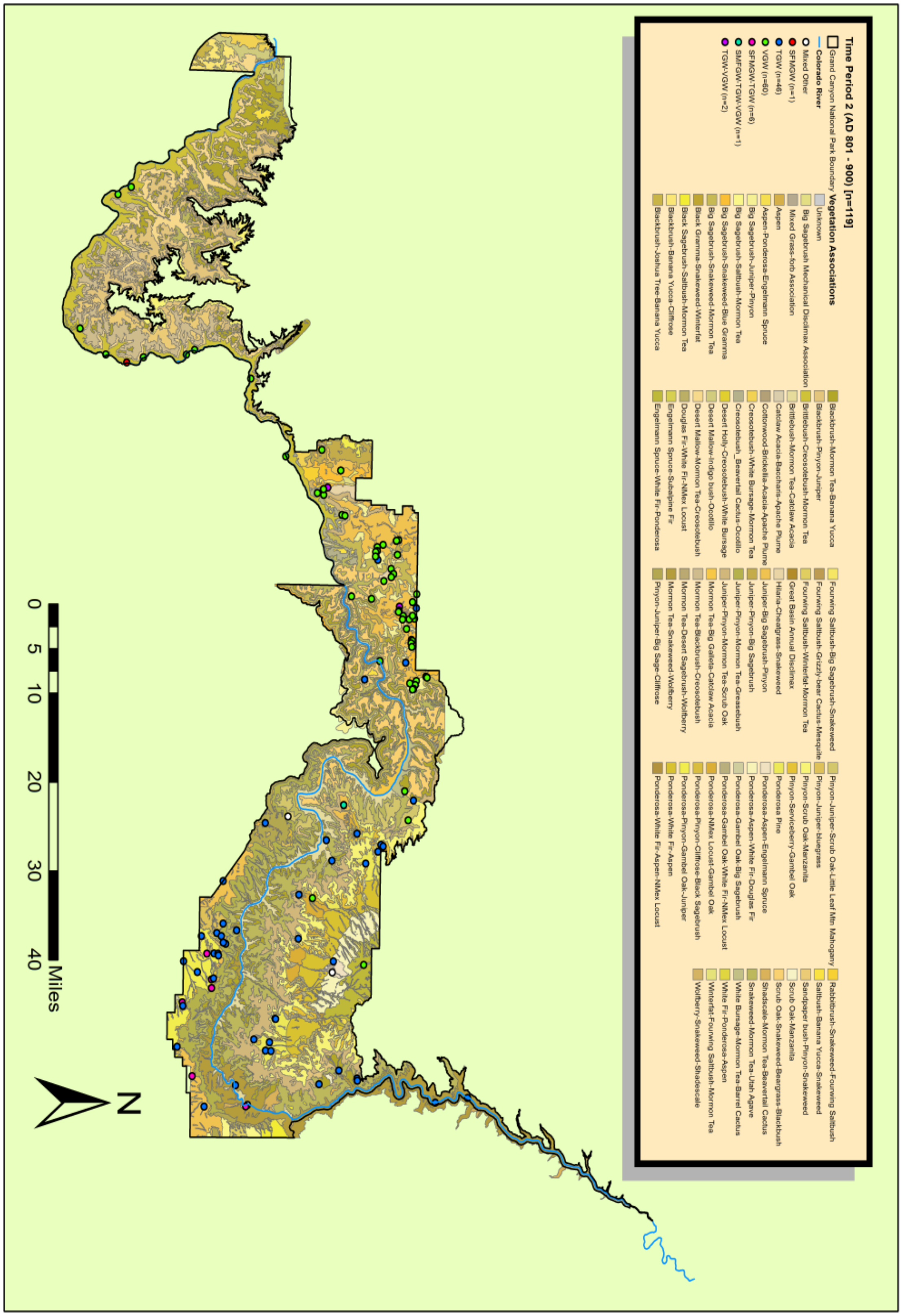

Figure 6.20. Distribution map of Time Period 2 sites and vegetation associations.

Range Productivity

Figure 6.21 and Table 6.18 illustrate that during Time Period 2 there is a continued preference for the 475-1010 lbs./acre/year productivity range. As with Time Period 1, the large number of VGW sites, which have a demonstrated reliance on wild resources, makes such an association not too surprising because the TGW sites, which appear in increasing numbers during Time Period 2, are distributed in higher numbers in areas associated with wild plant production.

Table 6.18. Time Period 2 sites and corresponding range productivity.

				TP2
lbs/acre/year	# (ha)	%	#	%
<= 188	167972	29.07	25	21.01
>188 AND <=331	163954	28.37	9	7.56
>331 AND <=475	97650	16.90	9	7.56
>475 AND <=1010	108687	18.81	66	55.46
>1010 AND <=3520	39652	6.86	10	8.40
TOTAL	577915	100	119	100

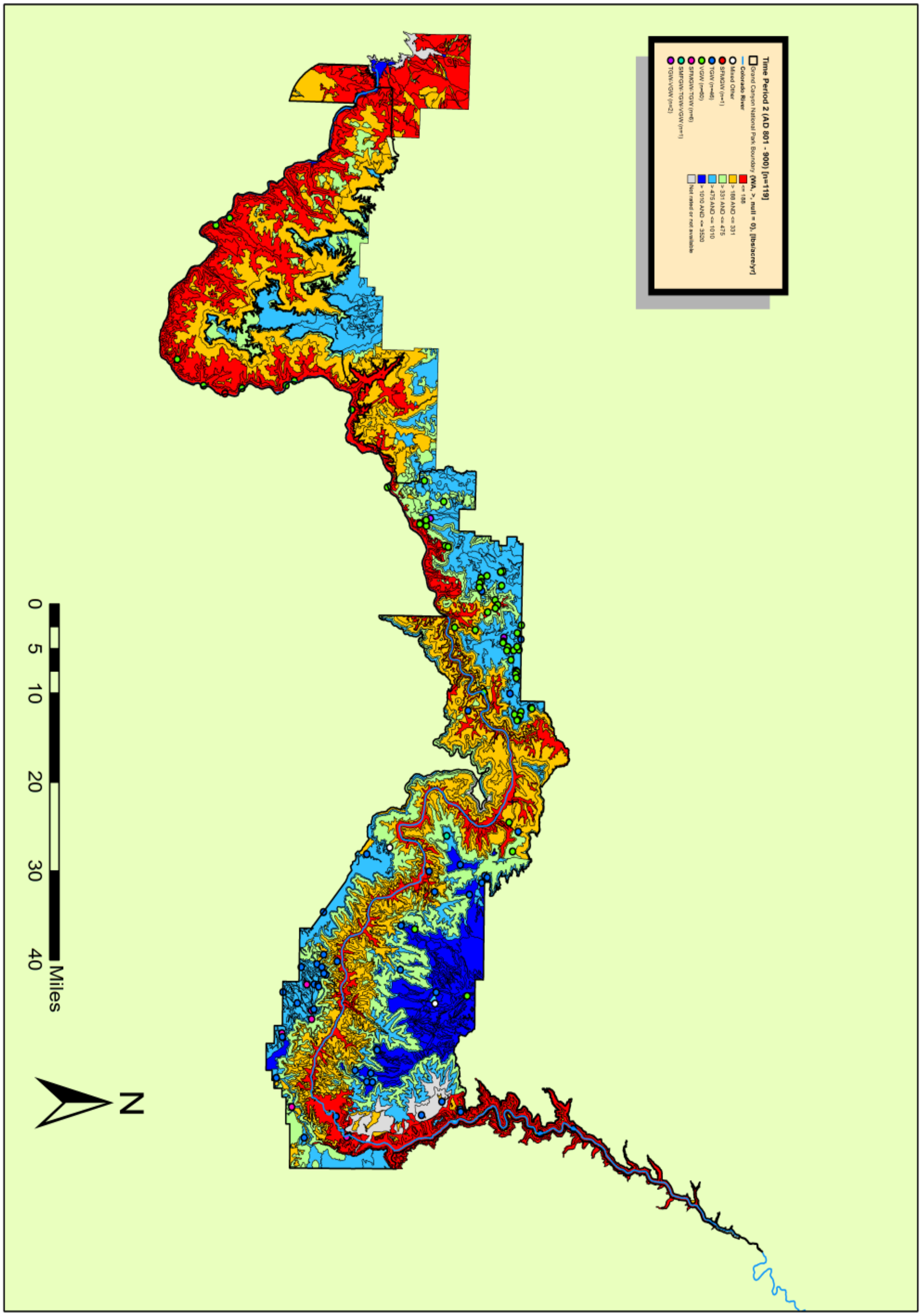

Figure 6.21. Distribution map of Time Period 2 sites and range productivity.

Hydrology

As Figure 6.22 and Table 6.19 illustrate during Time Period 2 there is a slight 50 meter increase in distance from streams but a slight decrease in the distance to springs. Again all of the distances are with easy walking distance, though the distance to springs is a bit further than one might expect for gathering drinking water and could indicate they were used as a place to casually produce wild plants.

Table 6.19. Time Period 2 sites and corresponding hydrology.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
Stream							
Min	42	10	1	4	1	1	1
Max	1260	1202	1654	1509	1595	741	1098
Mean	336	387	414	343	293	206	233
SD	293	298	324	290	305	211	268
Spring	TP1	TP2	TP3	TP4	TP5	TP6	TP7
Min	250	40	77	78	49	503	22
Max	6994	9026	11107	11283	11796	9826	11930
Mean	3200	3182	3169	2845	2753	3994	4260
SD	1757	2033	1972	1975	1896	2382	2867

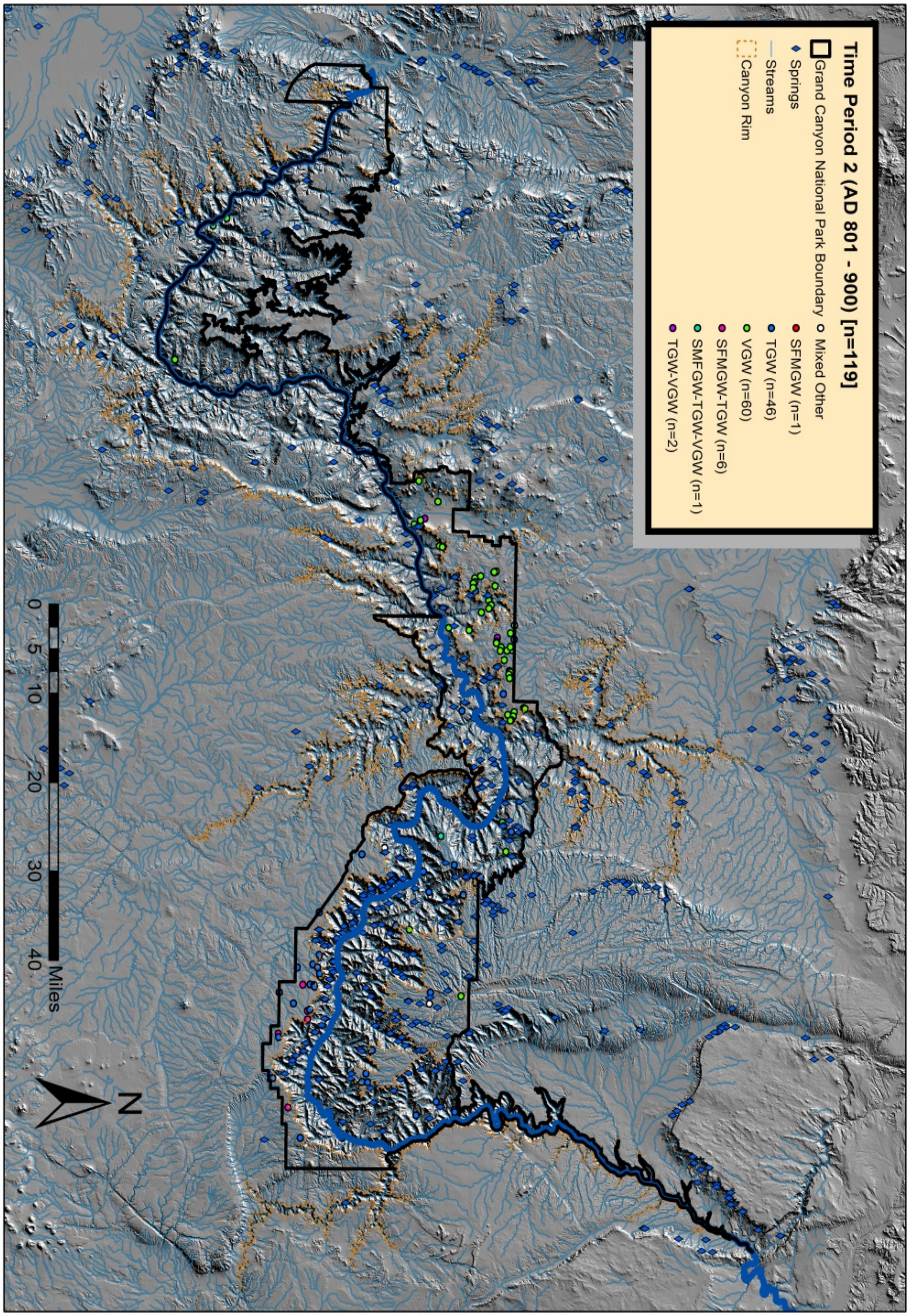

Figure 6.22. Distribution map of Time Period 2 sites and hydrology.

Settlement Organization

Time Period 2 sites (n=117) can be divided into habitation (49.56%), subsistence (14.53%), rock art (2.56%), and artifact scatter (33.33%) categories (Table 6.20). The number of TGW sites increases during Time Period 2, which results in a shift to a larger number of habitation sites. Habitation sites are dominated by single-room single-structures (12.82%) with an even distribution of the remaining habitation categories. The number of artifact scatters present is reduced to only half the percentage found in Time Period 1 but is still relatively high. Again it is possible that some of the artifact scatters contain unrecognized pit structures, a common habitation feature at both TGW and VGW sites elsewhere in the Southwest.

During Time Period 2 there is an increase across all categories (#Structures, # rooms and population estimate), except for artifact density (Table 6.21). The lower artifact density compared to Time Period 1 may be a result of differing sample sizes but the fact that the Time Period 2 artifact density is the lowest is telling. Because a low artifact density indicates a less intensive occupation, this pattern seems to support the idea that Time Period 2 was a time when peoples were just beginning to expand into the Canyon and learning how to live here full time.

Table 6.20. Time Period 2 sites and corresponding site types.

Code	Description	TP2 Freq	%
1	Masonry Structure	0	0.00
1.1	Masonry Structure 1 Room	15	12.82
1.2	Masonry Structure Multiple Rooms	7	5.98
1.3	Multiple Masonry Structures All Single Rooms	9	7.69
1.4	Multiple Masonry Structures at least 1 with Multiple Rooms	7	5.98
1.5	Rockshelter with Multiple Rooms	0	0.00
1.6	Rock Alignment with Artifacts (no agricultural)	2	1.71
1.7	Possible Pithouse (depression with artifact scatter)	2	1.71
2	Rockshelter without masonry	7	5.98
2.1	Rockshelter with masonry	9	7.69
2.2	Rockshelter-Granary	0	0.00
3	Cave	0	0.00
4	Agriculture Features	0	0.00
5	Artifact Scatter Unknown	29	24.79
5.1	Lithic scatter	3	2.56
5.2	Sherd and lithic scatter	7	5.98
6	FCR	11	9.40
6.1	Mescal Pit	6	5.13
12	Rock Art (Both Pictographs and Petroglyphs or Unknown)	1	0.85
12.1	Petroglyph	2	1.71
12.2	Pictograph	0	0.00
		117	100

Table 6.21. Time Period 2 settlement organization data.

	TP1	TP2	TP3	TP4	TP5	TP6
# Structures	8	89	291	640	429	26
#Room	4	132	400	1005	644	24
Average # Rooms / Structure	0.50	1.48	1.37	1.57	1.50	0.92
Population Estimate	6.40	211.20	640.00	1608.00	1030.40	38.40
Artifact Density (mean / structure)	20.92	14.58	40.44	78.49	32.63	15.71

Time Period 3 (AD 901 – AD 1000)

The site data for Time Period 3 (AD 901-1000) indicate that this is the time of the SFMGW florescence. As Figure 6.23 and Table 6.22 illustrate, during Time Period 3 sites (n=398) are clustered in what previous Grand Canyon archaeologists have identified as their core cultural areas, i.e., VGW on the North Rim, SFMGW on the South Rim and near Havasu Canyon, and TGW sites on the South Rim, North Rim and in the Inner Canyon (Gorge and East Canyon). VGW sites during this Period are distributed between the Kanab Plateau, Cottonwood Canyon, and Toroweap Valley. SFMGW sites during this Period are located in two clusters, one in the South Rim zone with a majority of sites occurring in the western portion of the South Rim, and second cluster in the Inner Canyon - Gorge zone flanking Havasu Canyon. TGW sites are located in the South Rim, East Canyon and Gorge zones.

Table 6.22. Time Period 3 sites and corresponding geographic regions.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
North Rim	18	48	71	107	48	0	0
South Rim	3	22	183	141	51	6	17
Upper Canyon	0	1	0	1	2	0	0
East Canyon	0	8	15	44	74	2	4
Gorge	3	14	110	183	101	10	12
Lower Canyon	6	24	17	28	11	4	7

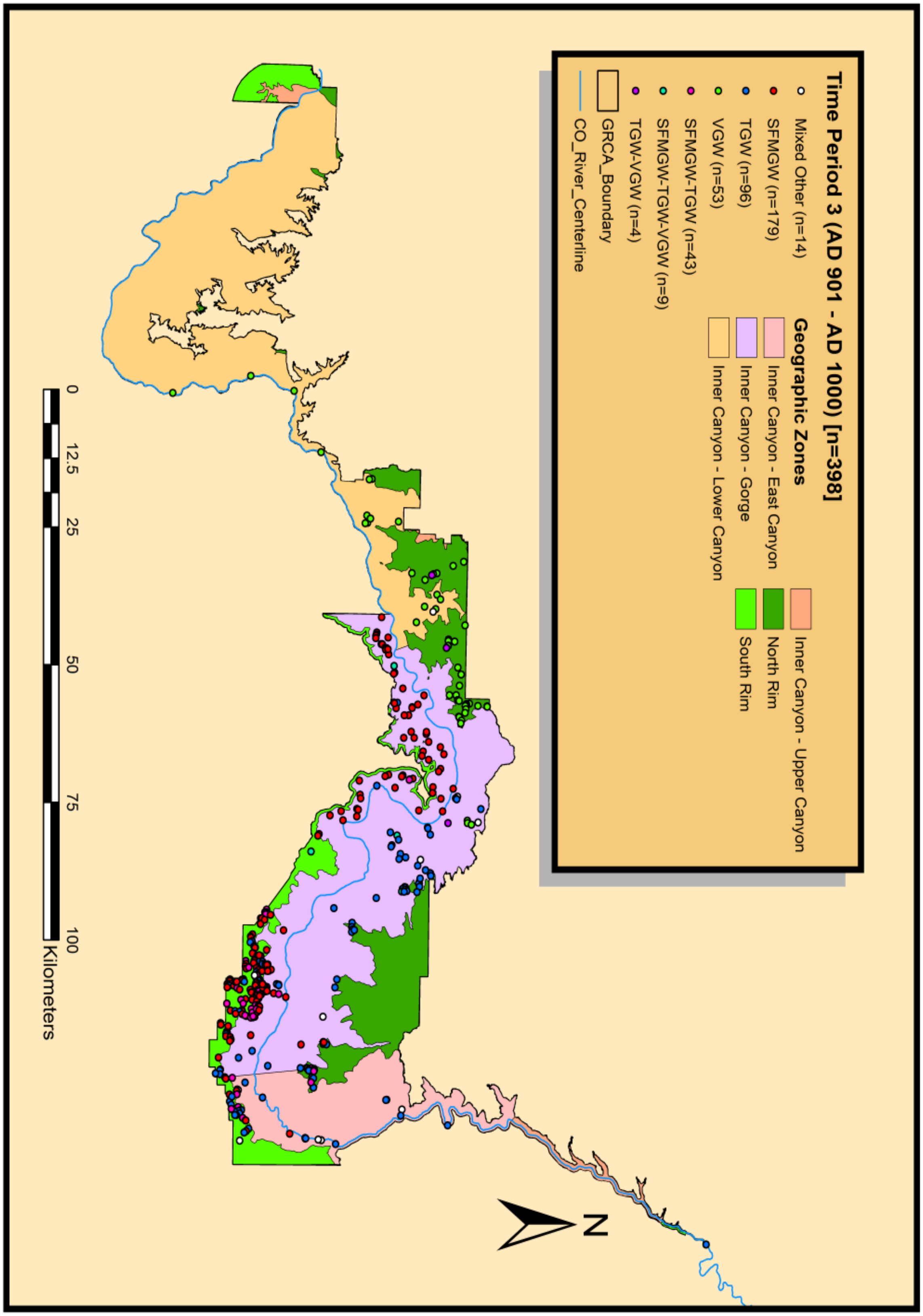

Figure 6.23. Distribution map of Time Period 3 sites and geographic regions.

Biotic Community

As Figure 6.24 and Table 6.23 illustrate, Time Period 3 site distribution indicate a shift in site placement relative to biotic communities. Both the Warm Desert Scrub zone and the Cold Desert Scrub were avoided. There is a slight increase in the number of sites occurring in the Ponderosa Pine biotic community, however, the largest change is in the increased percentage of sites occurring in the Pinyon Juniper life zone. The increase in sites located in the Pinyon Juniper community is not surprising because Time Period 3 is the pinnacle of the SFMGW occupation in the Canyon. As previously discussed in the ware group analyses section of this chapter, SFMGW sites were located in the Pinyon Juniper biotic community in a much higher percentage than any other life zone.

Table 6.23. Time Period 3 sites and corresponding biotic communities.

Name	Areas hectares	%	TP3 freq	%
Barren	3870	0.79	1	0.25
Cold Desert Scrub	213418	43.72	104	26.13
Mixed coniferous	15208	3.12	0	0.00
Pinyon Juniper	133546	27.36	185	46.48
Ponderosa Pine	24137	4.94	84	21.11
Riparian	1522	0.31	3	0.75
Spruce/Fir	7144	1.46	0	0.00
Warm Desert Scrub	89328	18.30	21	5.28
	488173	100.00	398	100.00

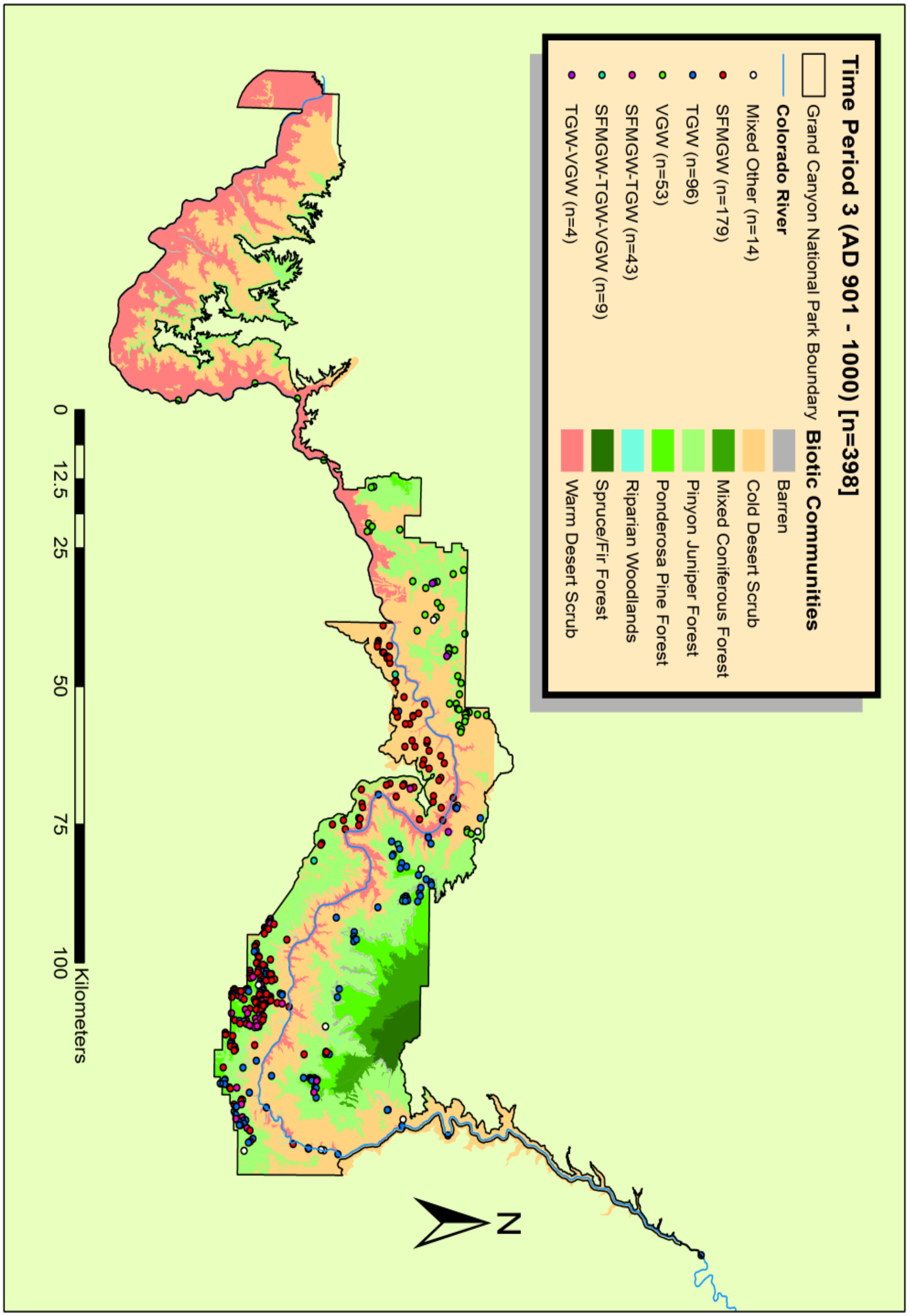

Figure 6.24. Distribution map of Time Period 3 sites and biotic communities.

Vegetation Association

As Figure 6.25 and Table 6.24 illustrate, sites dating to Time Period 3 occur in higher than expected percentages in the following vegetation associations: Ponderosa Pine, Ponderosa-Pinyon-Gambel_Oak-Juniper, Juniper-Big_Sagebrush-Pinyon, Pinyon-Juniper-Bluegrass, Blackbrush-Mormon_Tea-Bannana_Yucca, and Scrub_oak-Snakeweek-Beargrass-Blackbush. The vegetation associations during this time are dominated by Pinyon Juniper, which is not surprising as this is the height of the SFMGW occupation of the Canyon. In regards to land suitable either for wild plant production or maize agriculture, 33.67% of sites are in areas primarily suitable for wild plant production, while 78.49% of Time Period 3 sites are located in areas that are suitable for both wild plant production and some degree of maize agriculture. These data suggest that the inhabitants of the Canyon during Time Period 3 practiced a mixed subsistence strategy, with maize farming increasing in importance, at least for some of the ware groups.

Table 6.24. Time Period 3 sites and corresponding vegetation associations.

Name	Area hectares	%	TP3 Freq	%
Engelmann Spruce-Subalpine Fir	2194.00	0.45	0	0.00
Engelmann Spruce-White Fir-Ponderosa	6240.99	1.28	0	0.00
Ponderosa-Aspen-Engelmann Spruce	83.61	0.02	0	0.00
Ponderosa Pine	5322.64	1.09	29	7.29
Ponderosa-Aspen-White Fir-Douglas Fir	6133.24	1.26	0	0.00
Ponderosa-NMex Locust-Gambel Oak	3631.35	0.74	11	2.76
Ponderosa-Pinyon-Cliffrose-Black Sagebrush	367.57	0.08	1	0.25
Ponderosa-Pinyon-Gambel Oak-Juniper	8581.55	1.76	78	19.60
Ponderosa-Gambel Oak-Big Sagebrush	716.96	0.15	6	1.51
Ponderosa-Aspen-Engelmann Spruce	787.53	0.16	0	0.00
Ponderosa-White Fir-Aspen	11059.14	2.27	0	0.00
Ponderosa-White Fir-Aspen-NMex Locust	157.32	0.03	0	0.00

Table 6.24, cont.

Pinyon-Juniper-Scrub Oak-Little Leaf Mtn Mahogany	7493.06	1.54	4	1.01
Juniper-Pinyon-Mormon Tea-Greasebush	14138.64	2.90	9	2.26
Juniper-Pinyon-Mormon Tea-Scrub Oak	32882.70	6.74	1	0.25
Juniper-Pinyon-Big Sagebrush	4297.82	0.88	2	0.50
Juniper-Big Sagebrush-Pinyon	27519.65	5.64	77	19.35
Pinyon-Juniper-Big Sage-Cliffrose	8330.54	1.71	6	1.51
Pinyon-Scrub Oak-Manzanita	24821.02	5.09	4	1.01
Blackbrush-Pinyon-Juniper	21408.97	4.39	0	0.00
Pinyon-Serviceberry-Gambel Oak	10834.67	2.22	4	1.01
Pinyon-Juniper-bluegrass	2827.65	0.58	38	9.55
Hilaria-Cheatgrass-Snakeweed	1197.67	0.25	2	0.50
Mixed Grass-forb Association	1809.42	0.37	0	0.00
Black Gramma-Snakeweed-Winterfat	185.14	0.04	0	0.00
Big Sagebrush-Snakeweed-Blue Gramma	7225.81	1.48	9	2.26
Big Sagebrush-Juniper-Pinyon	7316.57	1.50	4	1.01
Big Sagebrush-Snakeweed-Mormon Tea	12443.11	2.55	1	0.25
Blackbrush-Mormon Tea-Banana Yucca	9053.19	1.86	19	4.77
Rabbitbrush-Snakeweed-Fourwing Saltbush	816.69	0.17	1	0.25
Scrub Oak-Snakeweed-Beargrass-Blackbush	1197.06	0.25	43	10.80
Fourwing Saltbush-Big Sagebrush-Snakeweed	423.92	0.09	0	0.00
Saltbush-Banana Yucca-Snakeweed	2861.91	0.59	0	0.00
Snakeweed-Mormon Tea-Utah Agave	52494.68	10.77	9	2.26
White Bursage-Mormon Tea-Barrel Cactus	1685.18	0.35	4	1.01
Mormon Tea-Snakeweed-Wolfberry	26388.59	5.41	9	2.26
Mormon Tea-Big Galleta-Catclaw Acacia	3491.80	0.72	3	0.75
Creosotebush_Beavertail Cactus-Ocotillo	2647.03	0.54	4	1.01
Creosotebush-White Bursage-Mormon Tea	3523.70	0.72	1	0.25
Blackbrush-Mormon Tea-Banana Yucca	36447.43	7.47	7	1.76
Blackbrush-Joshua Tree-Banana Yucca	582.73	0.12	0	0.00
Blackbrush-Banana Yucca-Cliffrose	2574.16	0.53	0	0.00
Fourwing Saltbush-Grizzly-bear Cactus-Mesquite	41.58	0.01	0	0.00
Shadscale-Mormon Tea-Beavertail Cactus	2638.62	0.54	1	0.25
Desert Mallow-Mormon Tea-Creosotebush	16960.91	3.48	0	0.00
Brittlebush-Creosotebush-Mormon Tea	24385.16	5.00	3	0.75
Brittlebush-Mormon Tea-Catclaw Acacia	15209.80	3.12	5	1.26
Cottonwood-Brickellia-Acacia-Apache Plume	540.47	0.11	1	0.25
Catclaw Acacia-Baccharis-Apache Plume	980.66	0.20	2	0.50
Others not correlated to arch sites	52672.06	10.80	0	0.00

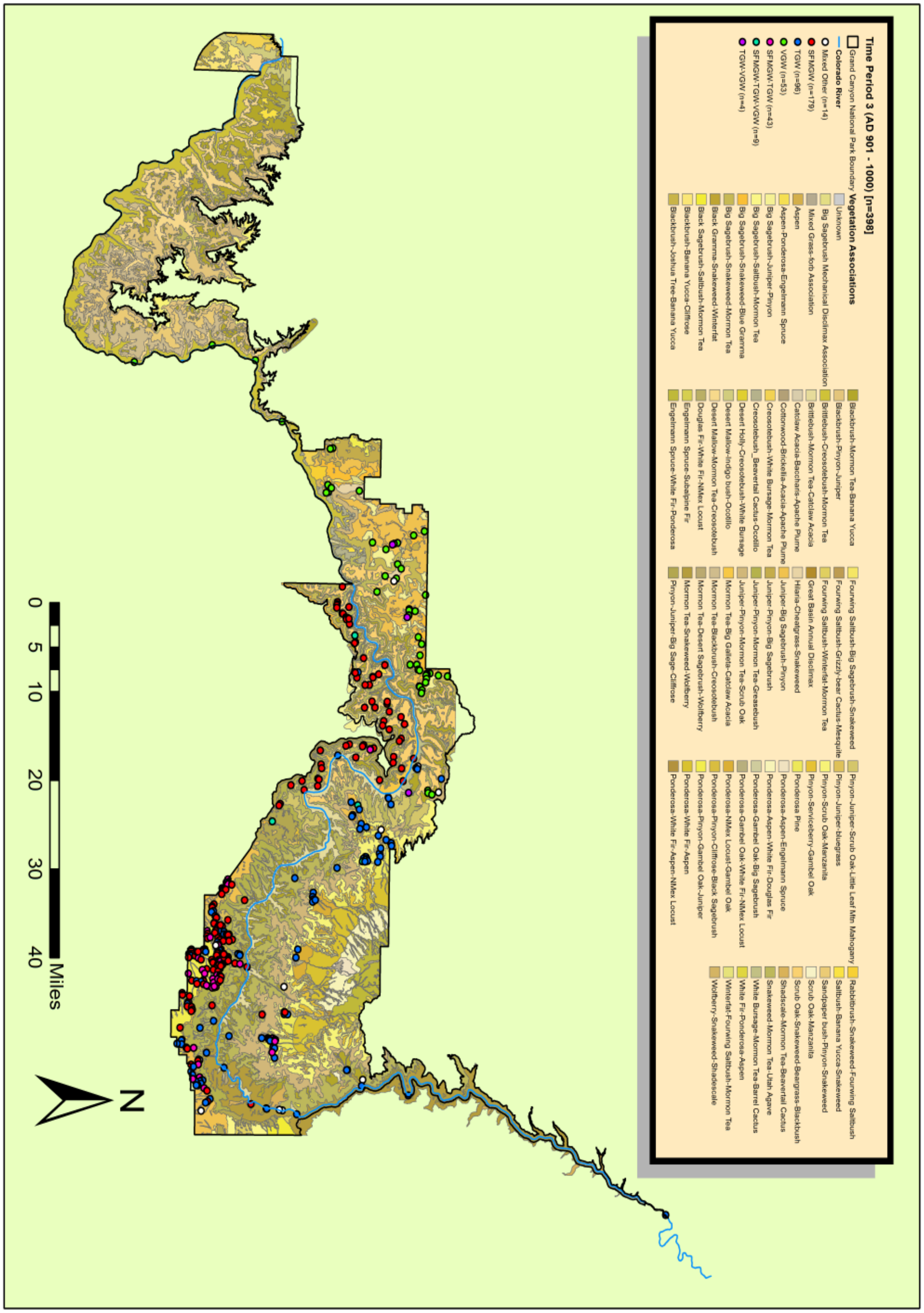

Figure 6.25. Distribution map of Time Period 3 sites and vegetation associations.

Range Productivity

Figure 6.26 and Table 6.25 indicate that during Time Period 3 the 475-1010 lbs./acre/year range productivity class still dominates. Again, if range productivity is a good proxy for wild plant productivity then the associations between Time Period 3 sites and range productivity indicate that sites are being located with regard to areas of high productivity for wild plants.

Table 6.25. Time Period 3 sites and corresponding range productivity.

Lbs/acre/year	# (ha)	%	#	TP3 %
<= 188	167972	29.07	31	7.788945
>188 AND <=331	163954	28.37	82	20.60302
>331 AND <=475	97650	16.90	59	14.82412
>475 AND <=1010	108687	18.81	185	46.48241
>1010 AND <=3520	39652	6.86	41	10.30151
TOTAL	577915	100	398	100

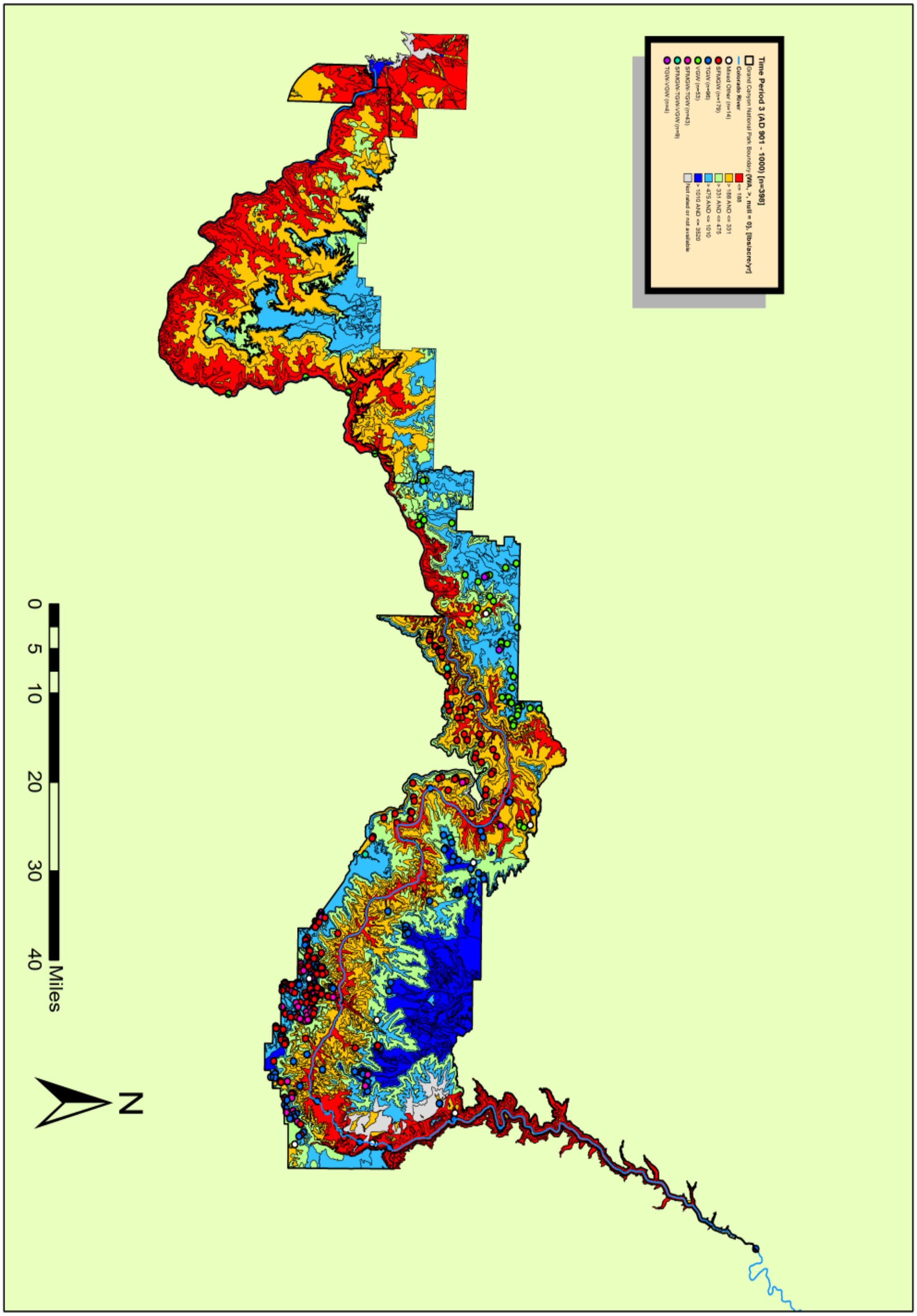

Figure 6.26. Distribution map of Time Period 3 sites and range productivity.

Hydrology

Figure 6.27 and Table 6.26 demonstrate that, during Time Period 3, sites are placed at the farthest distance from streams compared to any of the other time periods and the second farthest from springs besides Time Period 6. This pattern seems to suggest that it is unlikely that there was a heavy reliance on maize during this period, as maize is a water intensive plant or that other methods for managing water were developed.

Table 6.26. Time Period 3 sites and corresponding hydrology data.

	TP1	TP2	TP3	TP4	TP5	TP6
Stream						
Min	42	10	1	4	1	1
Max	1260	1202	1654	1509	1595	741
Mean	336	387	414	343	293	206
SD	293	298	324	290	305	211
Spring	TP1	TP2	TP3	TP4	TP5	TP6
Min	250	40	77	78	49	503
Max	6994	9026	11107	11283	11796	9826
Mean	3200	3182	3169	2845	2753	3994
SD	1757	2033	1972	1975	1896	2382

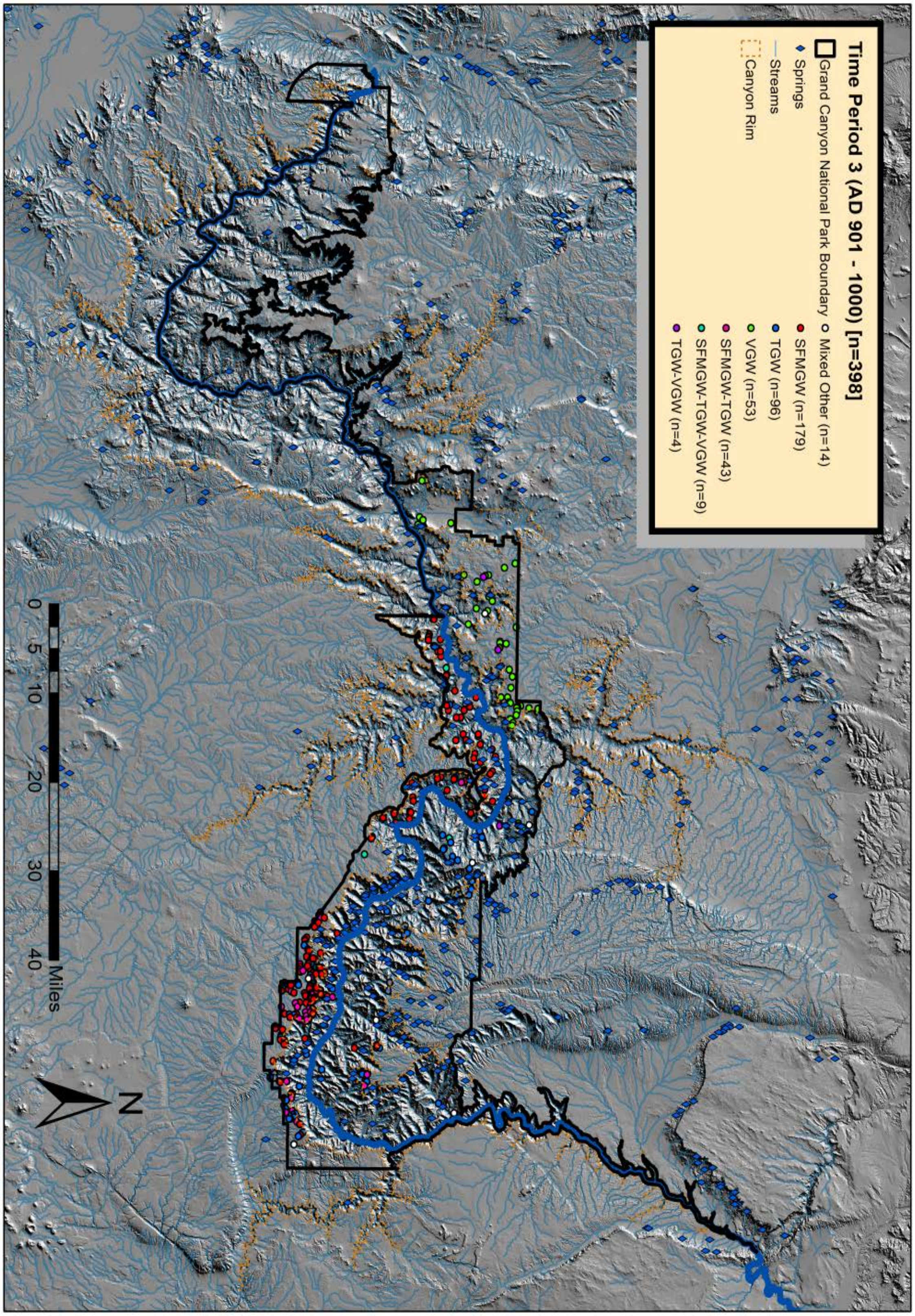

Figure 6.27. Distribution map of Time Period 3 sites and hydrology.

Settlement Organization

Time Period 3 sites (n=398) can be divided into habitation (45.71%), subsistence (10.05%), rock art (0.75%), and artifact scatter (43.47%) categories (Table 6.27). The dominant form of habitation site during this time was a single-room structure, followed by rockshelters (13.56% for those with and without masonry walls) and a small percentages of multi-room solo structures (4.77%), multi-structures with only one room (5.28%), and multi-structure multi-room (5.53%). The percentage of artifact scatters increased to 43.47% up from 33.33% in Time Period 2, while the percentage of subsistence sites also dropped. Several factors likely account for this pattern. First, Time Period 3 is the highpoint of the SFMGW site occurrence in the Canyon with almost 50% of the recorded sites being identified as having a majority SFMGW ceramic assemblage. This factor alone may account for why the percentage of habitation sites decreased as the artifact scatters increased. However, the increase in TGW sites and continuing numbers of VGW sites also played a role in the adjustment of those percentages.

During Time Period 3 there is an increase in the number of structure and rooms but the number of rooms per structures dropped slightly (Table 6.28). The artifact density increases quite dramatically from Time Period 2 and the population estimate triples. Time Period 3 is the time when there is a large increase of SFMGW sites, which then dramatically decline in number during the following time periods. These data suggest Time Period 3 was a time when groups who made SFMGW ceramics entered the Canyon and settled quite intensively.

Table 6.27. Time Period 3 sites and corresponding site types.

Code	Description	TP3 Freq	%
1	Masonry Structure	2	0.50
1.1	Masonry Structure 1 Room	59	14.82
1.2	Masonry Structure Multiple Rooms	19	4.77
1.3	Multiple Masonry Structures All Single Rooms	21	5.28
1.4	Multiple Masonry Structures at least 1 with Multiple Rooms	22	5.53
1.5	Rockshelter with Multiple Rooms	1	0.25
1.6	Rock Alignment with Artifacts (no agricultural)	1	0.25
1.7	Possible Pithouse (depression with artifact scatter)	3	0.75
2	Rockshelter without masonry	27	6.78
2.1	Rockshelter with masonry	27	6.78
2.2	Rockshelter-Granary	1	0.25
3	Cave	0	0.00
4	Agriculture Features	0	0.00
5	Artifact Scatter Unknown	126	31.66
5.1	Lithic scatter	8	2.01
5.2	Sherd and lithic scatter	39	9.80
6	FCR	18	4.52
6.1	Mescal Pit	21	5.28
12	Rock Art (Both Pictographs and Petroglyphs or Unknown)	0	0.00
12.1	Petroglyph	2	0.50
12.2	Pictograph	1	0.25
		398	100

Table 6.28. Time Period 3 settlement organization.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
# Structures	8	89	291	640	429	26	42
#Room	4	132	400	1005	644	24	37
Average # Rooms / Structure	0.50	1.48	1.37	1.57	1.50	0.92	0.88
Population Estimate	6.40	211.20	640.00	1608.0	1030.4	38.40	59.20
Artifact Density (mean / structure)	20.92	14.58	40.44	78.49	32.63	15.71	14.09

Time Period 4 (AD 1001 – AD 1100)

The number of sites (n = 514) dating to Time Period 4 (1001-1100) indicates that this was the densest occupation of the Canyon. Sites belonging to the TGW Series dominate the site population (n=241) during this Period (Figure 6.28). The TGW sites occur throughout the eastern and central sections of the Canyon (Table 6.29) but are most visible in three clusters. Cluster 1 is located in the Inner Canyon - Gorge zone on the Powell Plateau, while a second cluster is located in the North Rim zone on the Walhalla Plateau and finally, the third cluster is located in the eastern half of the South Rim in the Upper Basin. SFMGW sites are located primarily around Havasu Creek but decrease in number compared to Time Period 3 in the western half of the South Rim, around the South Rim Village area. The low numbers of SFMGW sites on South Rim zone are replaced by mixed SFMGW-TGW assemblages. This pattern of increasing mixed assemblage sites suggests that there is interaction between the SFMGW and TGW groups. It is also possible that some of the mixed sites are a result of sites being occupied by each group at different times; however, the large number of mixed sites is compelling evidence for some interaction. The distribution of VGW sites during Time Period 4 shifts both toward the western end of the Lower Canyon zone, along the Colorado River, and eastward out of Cottonwood Canyon, toward the Kanab and Kaibab plateaus.

Table 6.29. Time Period 4 sites and corresponding geographic regions.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
North Rim	18	48	71	107	48	0	0
South Rim	3	22	183	141	51	6	17
Upper Canyon	0	1	0	1	2	0	0
East Canyon	0	8	15	44	74	2	4
Gorge	3	14	110	183	101	10	12
Lower Canyon	6	24	17	28	11	4	7

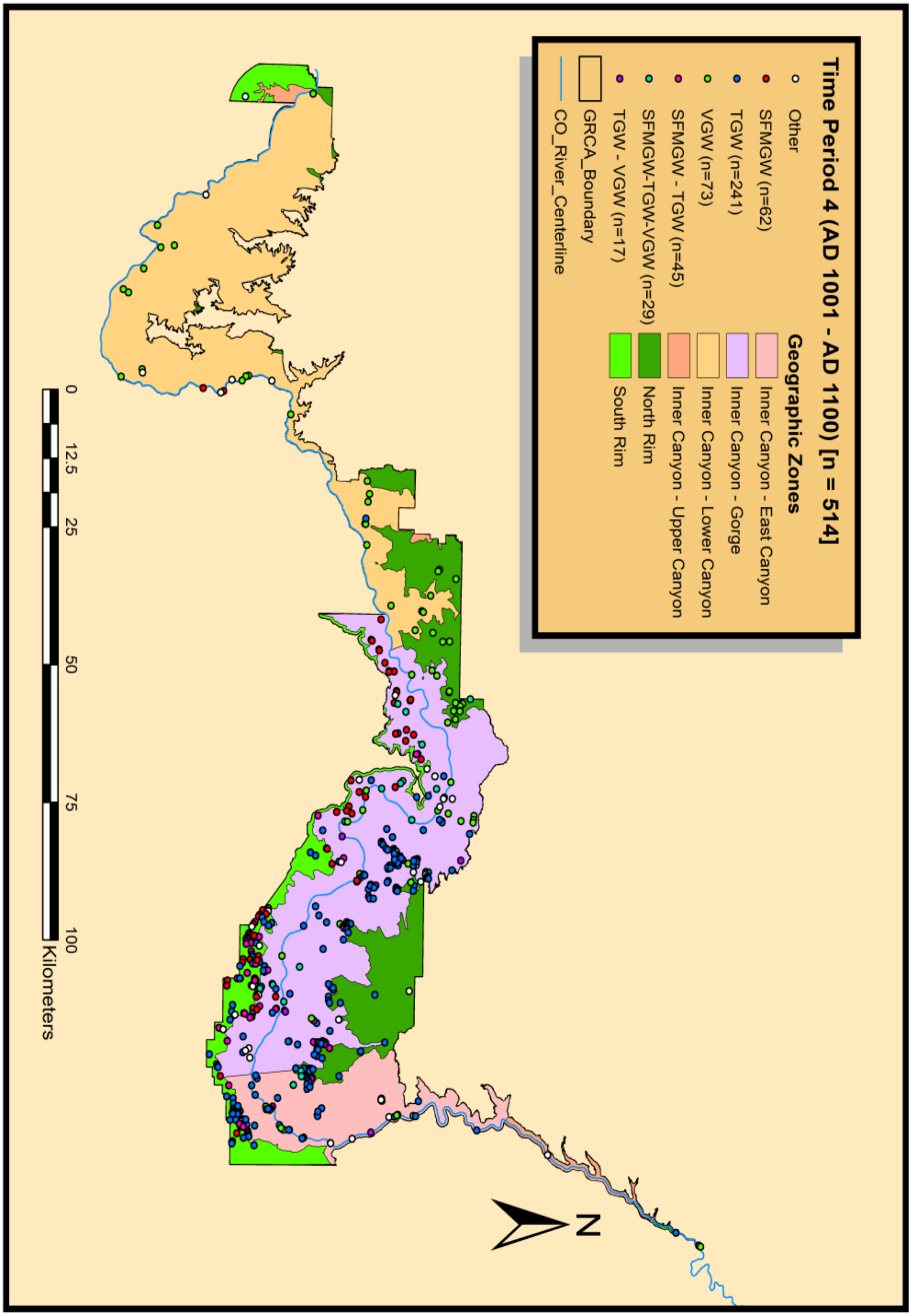

Figure 6.28. Distribution map of Time Period 4 sites and geographic regions.

Biotic Community

Time Period 4 provides an interesting glimpse into Pueblo Period Grand Canyon settlement. As Figure 6.29 and Table 6.30 indicate, the number of sites dated to Time Period 4 is the largest of any of the time periods. The peak of TGW sites occurs during Time Period 4 (though it also stays high in Time Period 5) and the number of SFMGW sites begins to decline. The percentage of sites occurring in the Ponderosa Pine biotic community increases by about 5%; meanwhile there is a 13% decrease in sites in the Pinyon Juniper zone. Both of these changes are the result of an inversion in site percentages from the Time Period 3 majority SFMGW sites to Time Period 4 where TGW sites dominate.

Table 6.30. Time Period 4 sites and corresponding biotic communities.

Name	Areas hectares	%	TP4 freq	%
Barren	3870	0.79	2	0.39
Cold Desert Scrub	213418	43.72	122	23.74
Mixed coniferous	15208	3.12	4	0.78
Pinyon Juniper	133546	27.36	171	33.27
Ponderosa Pine	24137	4.94	132	25.68
Riparian	1522	0.31	12	2.33
Spruce/Fir	7144	1.46	2	0.39
Warm Desert Scrub	89328	18.30	69	13.42
	488173	100.00	514	100.00

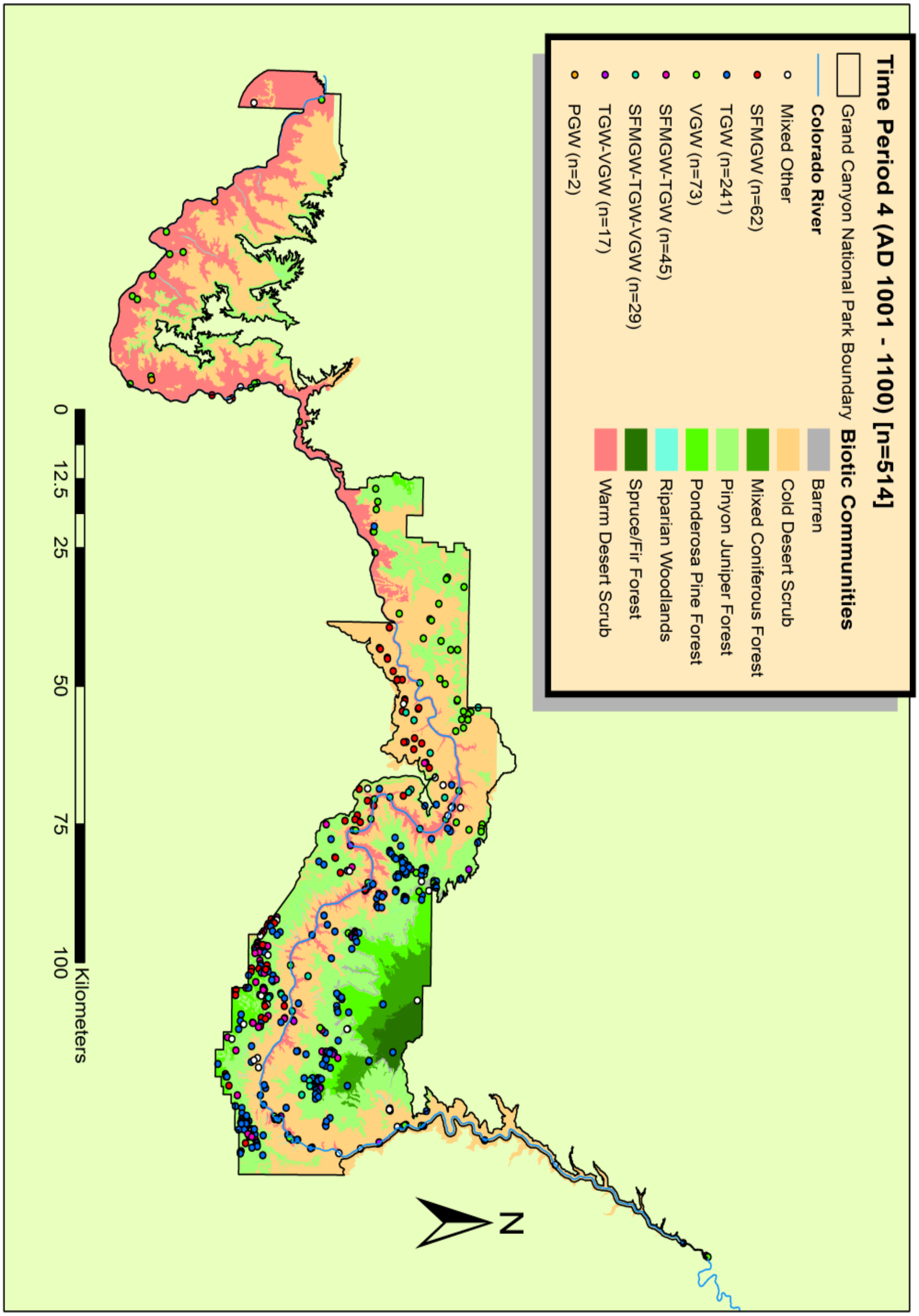

Figure 6.29. Distribution map of Time Period 4 sites and biotic communities.

Vegetation Association

As Figure 6.30 and Table 6.31 indicate, sites dating to Time Period 4 occur in higher than expected percentages in the following vegetation associations: Ponderosa Pine, Ponderosa-New_Mexican_Locust-Gamble_Oak, Ponderosa-Pinyon-Gambel_Oak-Juniper, Juniper-Big_Sagebrush-Pinyon, Pinyon-Juniper-Bluegrass, and Scrub Oak-Snakeweed-Beargrass-Blackbush. During this period there is a shift away from the pinyon-juniper vegetation association and an increase in ponderosa pine association, and a shift from sites located in areas where both wild and domesticate plant production were favorable to vegetation associations that are more promising for wild plant production. This pattern is related to the increase in TGW sites occurring during this time that, as the earlier discussion of ware group analyses suggested, were more heavily reliant on wild plant production instead of maize agriculture.

Table 6.31. Time Period 4 sites and corresponding vegetation associations.

NAME	Area hectares	%	TP4 Freq	%
Engelmann Spruce-Subalpine Fir	2194.00	0.45	0	0.00
Engelmann Spruce-White Fir-Ponderosa	6240.99	1.28	1	0.19
Ponderosa-Aspen-Engelmann Spruce	83.61	0.02	0	0.00
Ponderosa Pine	5322.64	1.09	82	15.95
Ponderosa-Aspen-White Fir-Douglas Fir	6133.24	1.26	0	0.00
Ponderosa-NMex Locust-Gambel Oak	3631.35	0.74	33	6.42
Ponderosa-Pinyon-Cliffrose-Black Sagebrush	367.57	0.08	6	1.17
Ponderosa-Pinyon-Gambel Oak-Juniper	8581.55	1.76	34	6.61
Ponderosa-Gambel Oak-Big Sagebrush	716.96	0.15	2	0.39
Ponderosa-Aspen-Engelmann Spruce	787.53	0.16	0	0.00
Ponderosa-White Fir-Aspen	11059.14	2.27	2	0.39
Ponderosa-White Fir-Aspen-NMex Locust	157.32	0.03	1	0.19
Pinyon-Juniper-Scrub Oak-Little Leaf Mtn Mahogany	7493.06	1.54	4	0.78
Juniper-Pinyon-Mormon Tea-Greasebush	14138.64	2.90	9	1.75

Table 6.31, cont.

Juniper-Pinyon-Mormon Tea-Scrub Oak	32882.70	6.74	1	0.19
Juniper-Pinyon-Big Sagebrush	4297.82	0.88	2	0.39
Juniper-Big Sagebrush-Pinyon	27519.65	5.64	75	14.59
Pinyon-Juniper-Big Sage-Cliffrose	8330.54	1.71	13	2.53
Pinyon-Scrub Oak-Manzanita	24821.02	5.09	7	1.36
Blackbrush-Pinyon-Juniper	21408.97	4.39	4	0.78
Pinyon-Serviceberry-Gambel Oak	10834.67	2.22	8	1.56
Pinyon-Juniper-bluegrass	2827.65	0.58	31	6.03
Hilaria-Cheatgrass-Snakeweed	1197.67	0.25	1	0.19
Mixed Grass-forb Association	1809.42	0.37	2	0.39
Black Gramma-Snakeweed-Winterfat	185.14	0.04	1	0.19
Big Sagebrush-Snakeweed-Blue Gramma	7225.81	1.48	11	2.14
Big Sagebrush-Juniper-Pinyon	7316.57	1.50	0	0.00
Big Sagebrush-Snakeweed-Mormon Tea	12443.11	2.55	1	0.19
Blackbrush-Mormon Tea-Banana Yucca	9053.19	1.86	10	1.95
Rabbitbrush-Snakeweed-Fourwing Saltbush	816.69	0.17	0	0.00
Scrub Oak-Snakeweed-Beargrass-Blackbush	1197.06	0.25	32	6.23
Fourwing Saltbush-Big Sagebrush-Snakeweed	423.92	0.09	0	0.00
Saltbush-Banana Yucca-Snakeweed	2861.91	0.59	0	0.00
Snakeweed-Mormon Tea-Utah Agave	52494.68	10.77	16	3.11
White Bursage-Mormon Tea-Barrel Cactus	1685.18	0.35	6	1.17
Mormon Tea-Snakeweed-Wolfberry	26388.59	5.41	22	4.28
Mormon Tea-Big Galleta-Catclaw Acacia	3491.80	0.72	9	1.75
Creosotebush_Beavertail Cactus-Ocotillo	2647.03	0.54	3	0.58
Creosotebush-White Bursage-Mormon Tea	3523.70	0.72	1	0.19
Blackbrush-Mormon Tea-Banana Yucca	36447.43	7.47	19	3.70
Blackbrush-Joshua Tree-Banana Yucca	582.73	0.12	0	0.00
Blackbrush-Banana Yucca-Cliffrose	2574.16	0.53	0	0.00
Fourwing Saltbush-Grizzly-bear Cactus-Mesquite	41.58	0.01	0	0.00
Shadscale-Mormon Tea-Beavertail Cactus	2638.62	0.54	4	0.78
Desert Mallow-Mormon Tea-Creosotebush	16960.91	3.48	0	0.00
Brittlebush-Creosotebush-Mormon Tea	24385.16	5.00	20	3.89
Brittlebush-Mormon Tea-Catclaw Acacia	15209.80	3.12	29	5.64
Cottonwood-Brickellia-Acacia-Apache Plume	540.47	0.11	8	1.56
Catclaw Acacia-Baccharis-Apache Plume	980.66	0.20	4	0.78
Others not correlated to arch sites	52672.06	10.80	0	0.00

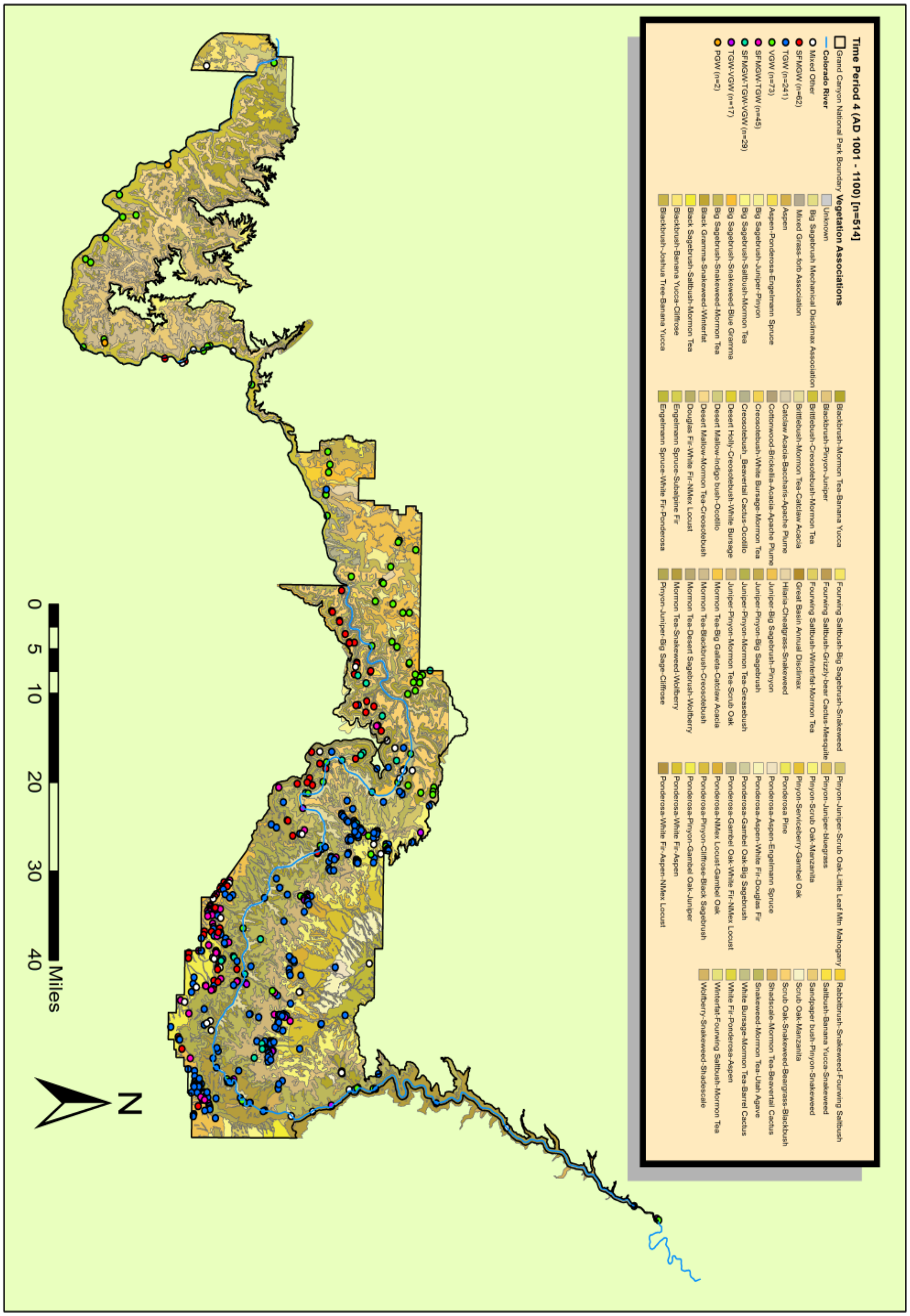

Figure 6.30. Distribution map of Time Period 4 sites and vegetation associations.

Range Productivity

Figure 6.31 and Table 6.32 illustrate that, during Time Period 4, there is a decrease in the percentage of sites occurring in the 475-1010 lbs./acre/year productivity range but a corresponding increase in the highest productivity range, 1010 -3520 lbs./acre/year. Also, during this time there is an increase in the number of sites occurring in the lower productivity ranges. This pattern seems to indicate that, with an increased population (represented by a larger number of sites) there is a shift in locating sites into higher wild resource production areas and possibly pressure to settle in less productive zones for wild resources. It should be noted that even with the increase in sites occurring in the lower range productivity zones if these data are cross-tabulated with the vegetation data there are still no sites located in the vegetation associations that the Hopi would consider prime for agriculture (Kuwanwisiwma and Ferguson 2009).

Table 6.32. Time Period 4 sites corresponding to range productivity.

				TP4
Lbs/acre/year	**# (ha)**	**%**	**#**	**%**
<= 188	167972	29.07	88	17.12
>188 AND <=331	163954	28.37	107	20.82
>331 AND <=475	97650	16.90	65	12.65
>475 AND <=1010	108687	18.81	139	27.04
>1010 AND <=3520	39652	6.86	115	22.37
TOTAL	577915	100	514	100

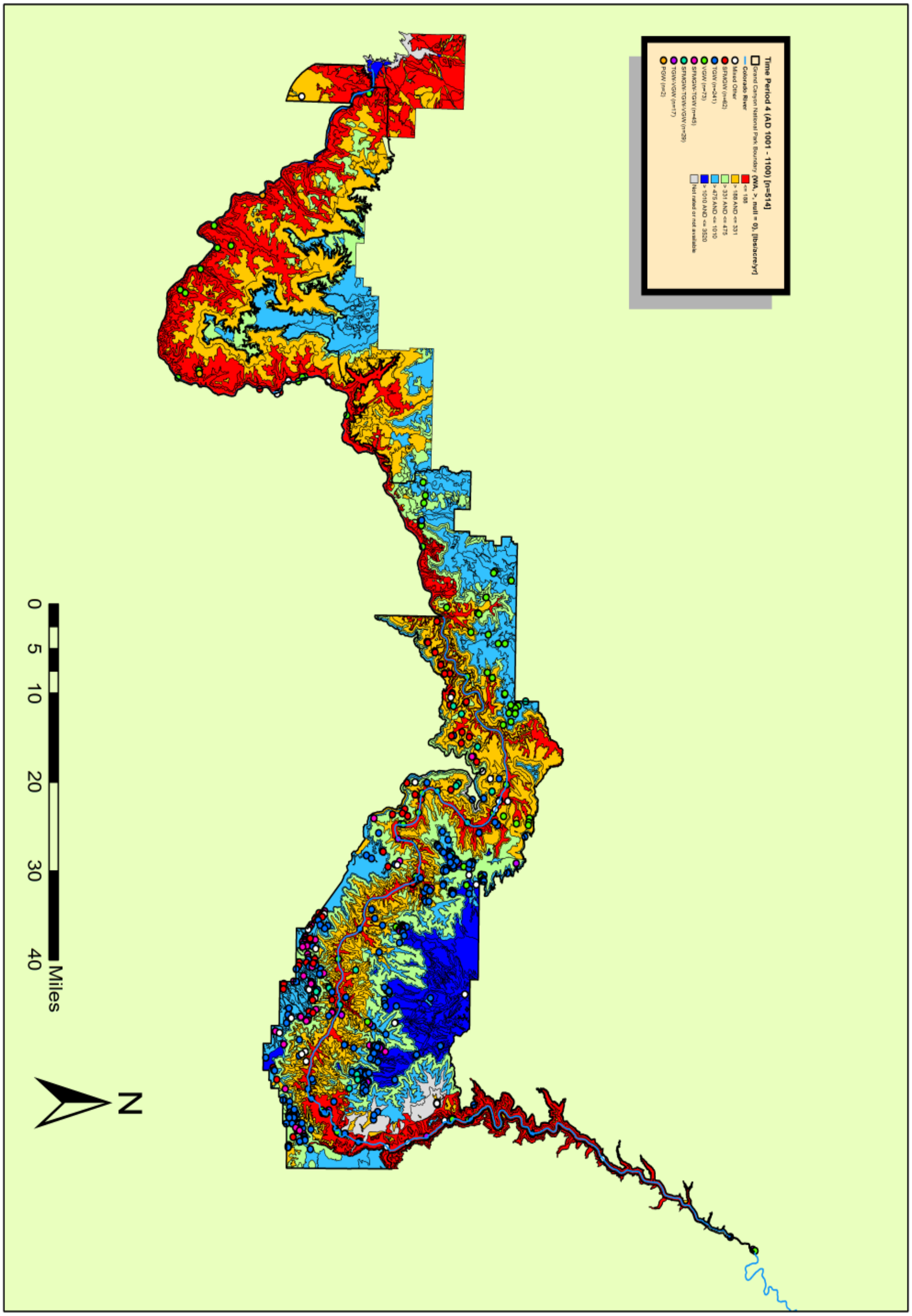

Figure 6.31. Distribution map of Time Period 4 sites and range productivity.

Hydrology

As Figure 6.32 and Table 6.33 indicate, during Time Period 4 there is the beginning of a small trend towards moving closer to water, both streams and springs. This shift could indicate an increase in the production of water-dependent vegetation, such as maize but also could indicate the increased population required a larger amount of water.

Table 6.33. Time Period 4 sites and corresponding hydrology data.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
Stream							
Min	42	10	1	4	1	1	1
Max	1260	1202	1654	1509	1595	741	1098
Mean	336	387	414	343	293	206	233
SD	293	298	324	290	305	211	268
Spring	TP1	TP2	TP3	TP4	TP5	TP6	TP7
Min	250	40	77	78	49	503	22
Max	6994	9026	11107	11283	11796	9826	11930
Mean	3200	3182	3169	2845	2753	3994	4260
SD	1757	2033	1972	1975	1896	2382	2867

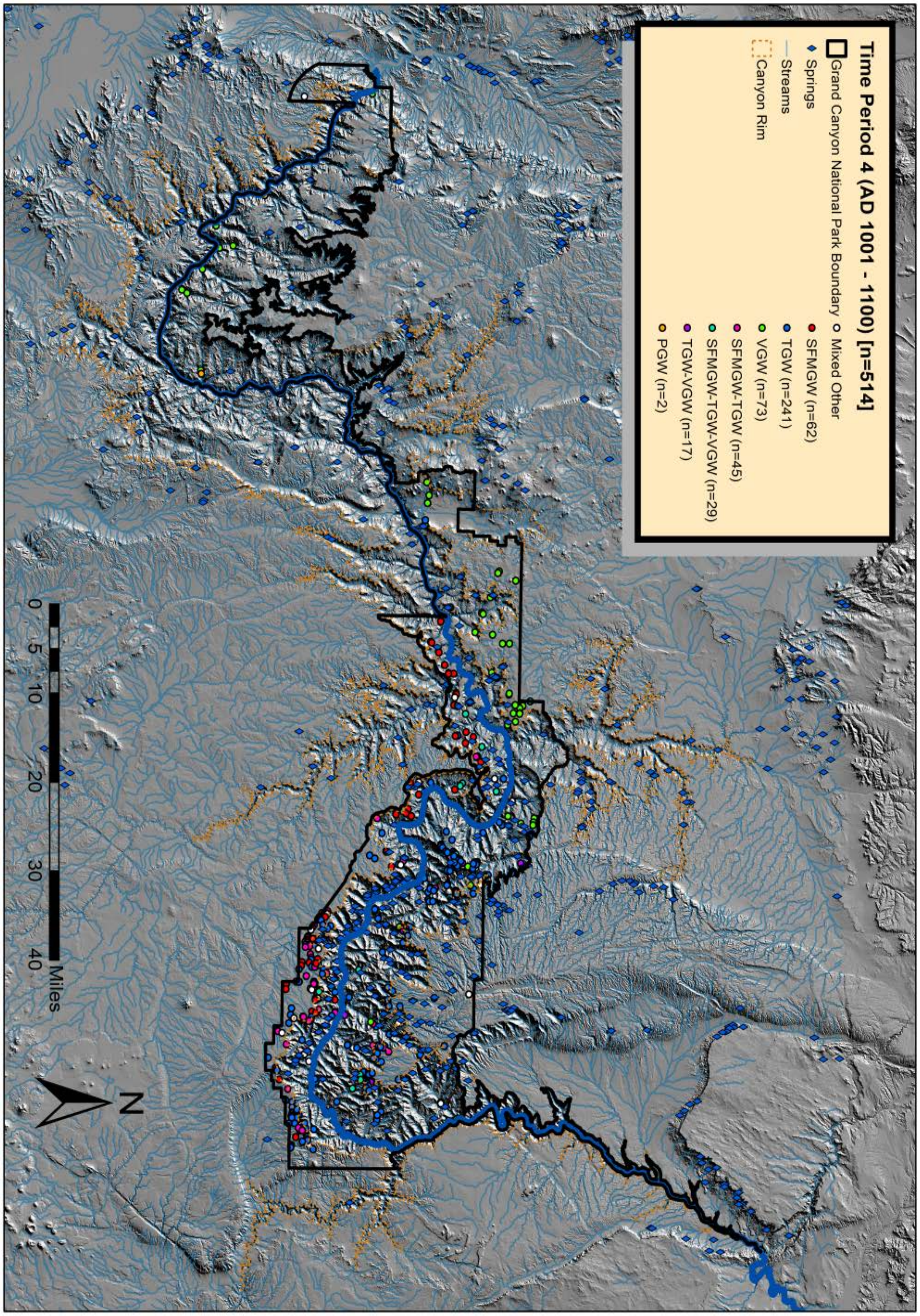

Figure 6.32. Distribution map of Time Period 4 sites and hydrology.

Settlement Organization

Time Period 4 sites (n=514) can be divided into habitation (66.91%), subsistence (8.56%), rock art (0.97%), and artifact scatter (23.54%) categories (Table 6.34). If Time Period 3 was the highpoint of the SFMGW site occurrences, Time Period 4 is the pinnacle of TGW site occurrences and the correspondence of site types reflects this fact. A comparison of the TGW site type percentages (Table 6.6) with the Time Period 4 percentages (Table 6.34) confirms almost identical values. Habitation sites account for over two-thirds of the recorded sites, while the percentage of subsistence site types drops to the lowest of any time period (8.56%). No single habitation site type dominates with multi-structure multi-room sites (15.37%), multi-room structures (13.42%), and single-room structure sites (14.01%) represented by almost equal percentages. In other parts of the Kayenta and Virgin cultural areas this is the point at which pithouses are being replaced almost exclusively by masonry structures, so it is not surprising to see an increase in habitation and a decrease in possible unrecognized pithouses (often recorded as artifact scatters). The lower percentage of subsistence sites is reflective of the fact that subsistence system sites are being subsumed within the habitation sites.

As Table 6.35 illustrates, during Time Period 4 there are the largest number of structures and rooms and the highest population estimates compared to the other time periods. This was the time of the most intensive occupation of the Canyon based on the number of structures, rooms, population estimate and artifact density.

Table 6.34. Time Period 4 sites and corresponding site types.

Code	Description	TP4 Freq	%
1	Masonry Structure	1	0.19
1.1	Masonry Structure 1 Room	72	14.01
1.2	Masonry Structure Multiple Rooms	69	13.42
1.3	Multiple Masonry Structures All Single Rooms	46	8.95
1.4	Multiple Masonry Structures at least 1 with Multiple Rooms	79	15.37
1.5	Rockshelter with Multiple Rooms	1	0.19
1.6	Rock Alignment with Artifacts (non- agricultural)	2	0.39
1.7	Possible Pithouse (depression with artifact scatter)	2	0.39
2	Rockshelter without masonry	36	7.00
2.1	Rockshelter with masonry	36	7.00
2.2	Rockshelter-Granary	6	1.17
3	Cave	0	0.00
4	Agriculture Features	5	0.97
5	Artifact Scatter Unknown	90	17.51
5.1	Lithic scatter	9	1.75
5.2	Sherd and lithic scatter	22	4.28
6	FCR	19	3.70
6.1	Mescal Pit	14	2.72
12	Rock Art (Both Pictographs and Petroglyphs or Unknown)	3	0.58
12.1	Petroglyph	0	0.00
12.2	Pictograph	2	0.39
		514	100

Table 6.35. Time Period 4 settlement organization.

	TP1	TP2	TP3	TP4	TP5	TP6
# Structures	8	89	291	640	429	26
#Room	4	132	400	1005	644	24
Average # Rooms / Structure	0.50	1.48	1.37	1.57	1.50	0.92
Population Estimate	6.40	211.20	640.00	1608.0	1030.4	38.40
Artifact Density (mean / structure)	20.92	14.58	40.44	78.49	32.63	15.71

Time Period 5 (AD 1101 – AD 1200)

The site data recorded for Time Period 5 (AD1101-1200) indicates a reduction in the number of sites (n=300) and the homogenization of ceramic assemblages (Figure 6.33 and Table 6.36). VGW sites are dispersed more widely throughout the north side of the Canyon. The clustering of VGW sites on the Kanab Plateau is absent and only two sites are located in this once densely occupied region. In the western most portion of the Lower Canyon zone there are no VGW sites dating to this Periods but five VGW sites are located along the Colorado River east of Shivwits Plateau. Most surprising is a cluster of VGW sites located in the East Canyon near Nankoweap. Because the Nankoweap area is over 100 kilometers from the Kanab Plateau and as earlier Time Periods did not seem to indicate a migration across the North Rim zone (Kaibab Plateau) it is likely that these sites may represent a separate migration into the Canyon by peoples who produce VGW from other nearby areas in the Arizona Strip, such as around Fredonia, Arizona or Kanab, Utah (not to be confused with the Kanab Plateau, which is located further west).

The SFMGW sites all but disappear during this time period with only six sites recorded as containing a primary SFMGW assemblage and only 12 additional sites containing a proportion of SFMGW ceramics. The TGW sites occur in the largest numbers during this time (n=191) and they are distributed throughout the eastern half of the Canyon on the South Rim (both the eastern and western halves), on the North Rim, Kaibab Plateau and within the Inner Canyon (both the Gorge and East Canyon regions). It is unclear from these data if the change in dominant ceramic series representation is due to an out migration of the VGW and SFMGW groups, or the TGW group subsuming the other two groups, or some combination of events.

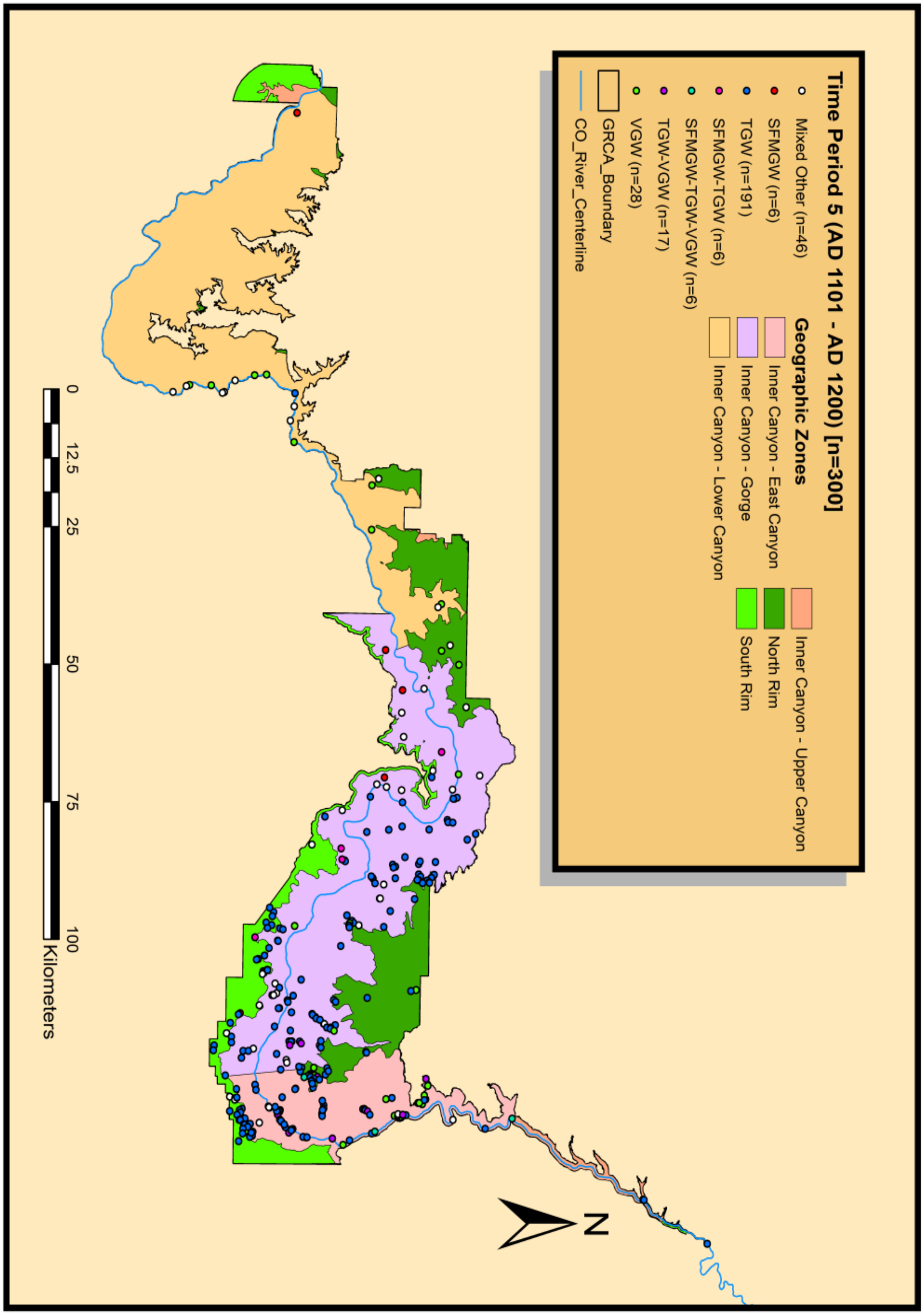

Figure 6.33. Distribution map of Time Period 5 sites and geographic regions.

Table 6.36. Time Period 5 sites and corresponding geographic regions.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
North Rim	18	48	71	107	48	0	0
South Rim	3	22	183	141	51	6	17
Upper Canyon	0	1	0	1	2	0	0
East Canyon	0	8	15	44	74	2	4
Gorge	3	14	110	183	101	10	12
Lower Canyon	6	24	17	28	11	4	7

Biotic Community

During Time Period 5 there is a drop in the percentage of sites (Figure 6.34 and Table 6.37) occurring in the woodlands (Pinyon Juniper and Ponderosa) and an increase in the number of sites occurring in the desert scrublands. There is definitely still a preference for sites being located in the Pinon Juniper and Ponderosa biotic communities and their distributions seem to indicate a non-random pattern. However, even though there is a negative correspondence (lower percentage of sites in an environmental zone compared to the areal coverage of that zone) between the archaeological sites and both the Cold Desert Scrub and Warm Desert Scrub communities, the overall percentage of sites in these zones increases compared to the earlier two time periods. This pattern seems to suggest a shift of settlement into the Inner Canyon by the TGW-producing groups as they are still contain the largest number and percentage of sites.

The abandonment of the area by large portion of the indigenous peoples before or during the early part of Time Period 5 is evident in the distributions of sites. While there are still a higher percentage of sites in the Ponderosa biotic community than would be expected, the percentage of sites occurring in the Pinyon Juniper life zone is a full ten percentage points lower than what would be expected. What is most apparent is the large percentage of sites occurring in the Warm Desert Scrub biotic community, which may be indicative of the movement of possible, other groups, such as the Prescott Groups, into the Canyon. There are data to support the idea that sites whose utilitarian wares are dominated by Prescott Gray Ware move into the Canyon, principally along the river, and are represented almost exclusively by agave roasting pits.

Table 6.37. Time Period 5 sites and corresponding biotic communities.

Name	Areas hectares	%	TP5 freq	%
Barren	3870	0.79	5	1.67
Cold Desert Scrub	213418	43.72	108	36.00
Mixed coniferous	15208	3.12	2	0.67
Pinyon Juniper	133546	27.36	77	25.67
Ponderosa Pine	24137	4.94	48	16.00
Riparian	1522	0.31	15	5.00
Spruce/Fir	7144	1.46	2	0.67
Warm Desert Scrub	89328	18.30	43	14.33
	488173	100.00	300	100.00

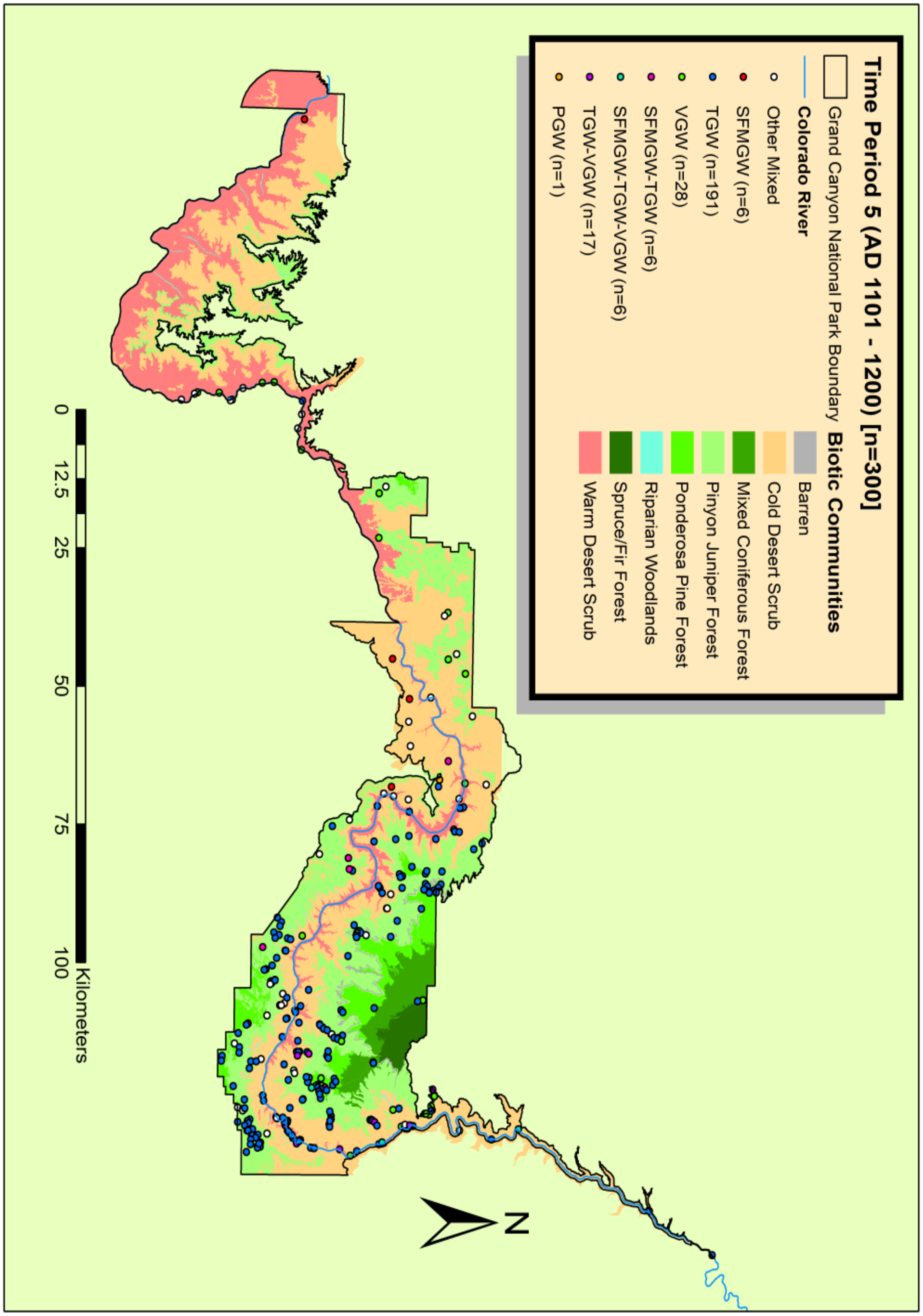

Figure 6.34. Distribution map of Time Period 5 sites and biotic communities.

Vegetation Association

As Figure 6.35 and Table 6.38 indicate, sites dating to Time Period 5 occur in higher than expected percentages in the following vegetation associations: Ponderosa Pine, Ponderosa-Pinyon-Gambel Oak-Juniper, Juniper-Big Sagebrush-Pinyon, Mormon Tea-Snakeweed-Wolfberry. During Time Period 5 Ponderosa Pine vegetation associations still dominate, which is likely a reflection on the fact that the TGW sites are still the most abundant and outnumber all of the other ware groups combined. There does appear to be an increasing diversity of vegetation associations where sites are located during this time and a shift toward vegetation associations corresponding with the Warm Desert Scrub biotic community. This site distribution pattern demonstrates an expansion by the TGW producing groups into the Inner Canyon.

Table 6.38. Time Period 5 sites corresponding to vegetation associations.

NAME	Area hectares	%	TP5 Freq	%
Engelmann Spruce-Subalpine Fir	2194.00	0.45	0	0.00
Engelmann Spruce-White Fir-Ponderosa	6240.99	1.28	0	0.00
Ponderosa-Aspen-Engelmann Spruce	83.61	0.02	1	0.33
Ponderosa Pine	5322.64	1.09	31	10.33
Ponderosa-Aspen-White Fir-Douglas Fir	6133.24	1.26	0	0.00
Ponderosa-NMex Locust-Gambel Oak	3631.35	0.74	9	3.00
Ponderosa-Pinyon-Cliffrose-Black Sagebrush	367.57	0.08	3	1.00
Ponderosa-Pinyon-Gambel Oak-Juniper	8581.55	1.76	11	3.67
Ponderosa-Gambel Oak-Big Sagebrush	716.96	0.15	0	0.00
Ponderosa-Aspen-Engelmann Spruce	787.53	0.16	1	0.33
Ponderosa-White Fir-Aspen	11059.14	2.27	2	0.67
Ponderosa-White Fir-Aspen-NMex Locust	157.32	0.03	0	0.00
Pinyon-Juniper-Scrub Oak-Little Leaf Mtn Mahogany	7493.06	1.54	4	1.33
Juniper-Pinyon-Mormon Tea-Greasebush	14138.64	2.90	8	2.67
Juniper-Pinyon-Mormon Tea-Scrub Oak	32882.70	6.74	10	3.33
Juniper-Pinyon-Big Sagebrush	4297.82	0.88	2	0.67

Table 6.38, cont.

Juniper-Big Sagebrush-Pinyon	27519.65	5.64	32	10.67
Pinyon-Juniper-Big Sage-Cliffrose	8330.54	1.71	5	1.67
Pinyon-Scrub Oak-Manzanita	24821.02	5.09	4	1.33
Blackbrush-Pinyon-Juniper	21408.97	4.39	3	1.00
Pinyon-Serviceberry-Gambel Oak	10834.67	2.22	3	1.00
Pinyon-Juniper-bluegrass	2827.65	0.58	7	2.33
Hilaria-Cheatgrass-Snakeweed	1197.67	0.25	0	0.00
Mixed Grass-forb Association	1809.42	0.37	2	0.67
Black Gramma-Snakeweed-Winterfat	185.14	0.04	0	0.00
Big Sagebrush-Snakeweed-Blue Gramma	7225.81	1.48	2	0.67
Big Sagebrush-Juniper-Pinyon	7316.57	1.50	0	0.00
Big Sagebrush-Snakeweed-Mormon Tea	12443.11	2.55	0	0.00
Blackbrush-Mormon Tea-Banana Yucca	9053.19	1.86	1	0.33
Rabbitbrush-Snakeweed-Fourwing Saltbush	816.69	0.17	0	0.00
Scrub Oak-Snakeweed-Beargrass-Blackbush	1197.06	0.25	11	3.67
Fourwing Saltbush-Big Sagebrush-Snakeweed	423.92	0.09	0	0.00
Saltbush-Banana Yucca-Snakeweed	2861.91	0.59	1	0.33
Snakeweed-Mormon Tea-Utah Agave	52494.68	10.77	36	12.00
White Bursage-Mormon Tea-Barrel Cactus	1685.18	0.35	6	2.00
Mormon Tea-Snakeweed-Wolfberry	26388.59	5.41	34	11.33
Mormon Tea-Big Galleta-Catclaw Acacia	3491.80	0.72	1	0.33
Creosotebush_Beavertail Cactus-Ocotillo	2647.03	0.54	0	0.00
Creosotebush-White Bursage-Mormon Tea	3523.70	0.72	1	0.33
Blackbrush-Mormon Tea-Banana Yucca	36447.43	7.47	14	4.67
Blackbrush-Joshua Tree-Banana Yucca	582.73	0.12	0	0.00
Blackbrush-Banana Yucca-Cliffrose	2574.16	0.53	0	0.00
Fourwing Saltbush-Grizzly-bear Cactus-Mesquite	41.58	0.01	4	1.33
Shadscale-Mormon Tea-Beavertail Cactus	2638.62	0.54	5	1.67
Desert Mallow-Mormon Tea-Creosotebush	16960.91	3.48	0	0.00
Brittlebush-Creosotebush-Mormon Tea	24385.16	5.00	13	4.33
Brittlebush-Mormon Tea-Catclaw Acacia	15209.80	3.12	18	6.00
Cottonwood-Brickellia-Acacia-Apache Plume	540.47	0.11	11	3.67
Catclaw Acacia-Baccharis-Apache Plume	980.66	0.20	4	1.33
Others not correlated to arch sites	52672.06	10.80	0	0.00

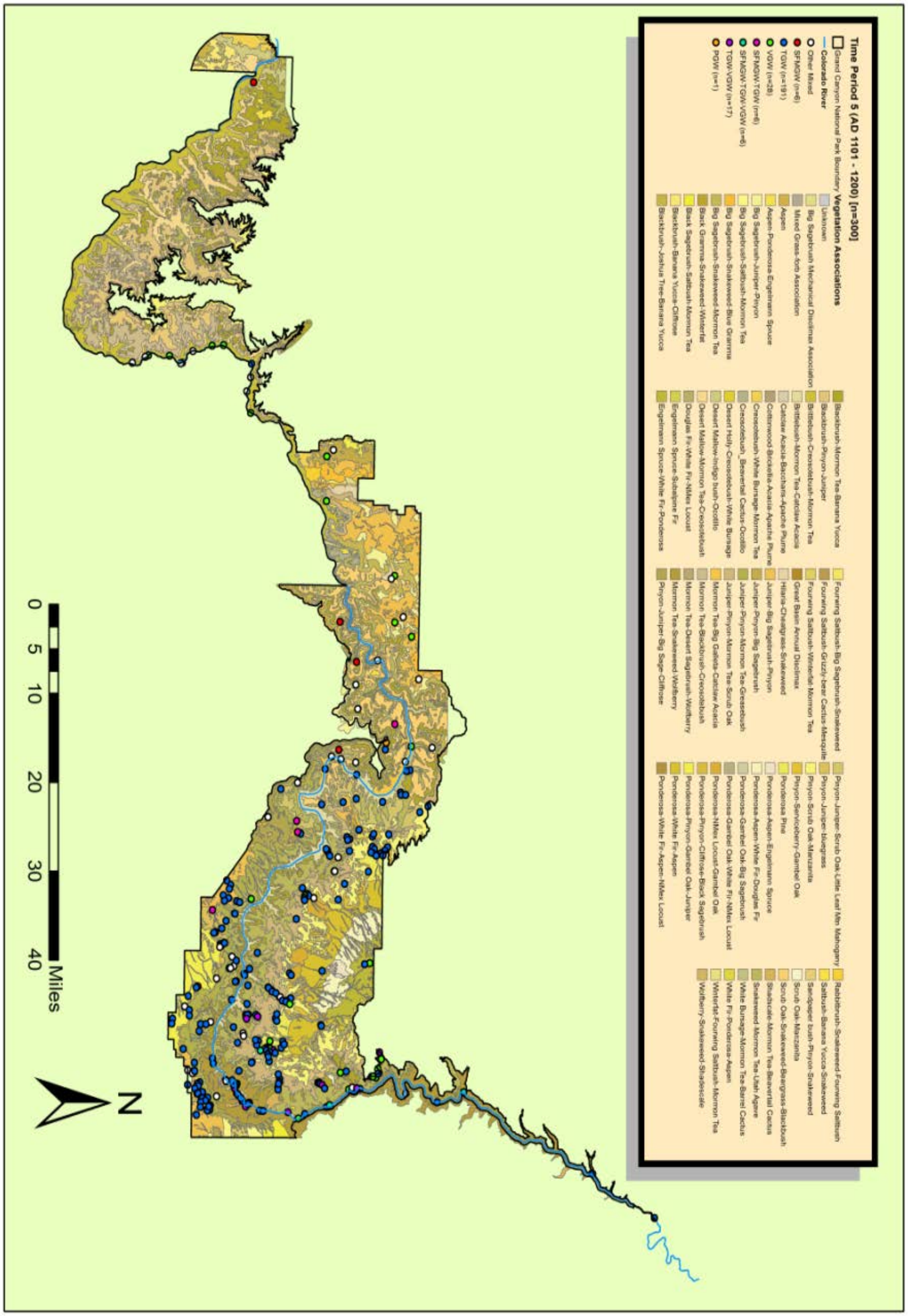

Figure 6.35. Distribution map of Time Period 5 sites and vegetation associations.

Range Productivity

Figure 6.36 and Table 6.39 illustrate that, during Time Period 5 the placement of sites in regards to range productivity seems become more random. Though the highest percentages of sites occur in the lowest (< 188 lbs/acre/year) and second highest (475 – 1010 lbas/acre/year), which suggests a continued reliance on both wild plant production and maize agriculture.

Table 6.39. Time Period 5 sites and corresponding range productivity.

Lbs/acre/year	# (ha)	%	#	TP5 %
<= 188	167972	29.07	94	31.33
>188 AND <=331	163954	28.37	52	17.33
>331 AND <=475	97650	16.90	40	13.33
>475 AND <=1010	108687	18.81	64	21.33
>1010 AND <=3520	39652	6.86	50	16.67
TOTAL	577915	100	300	100

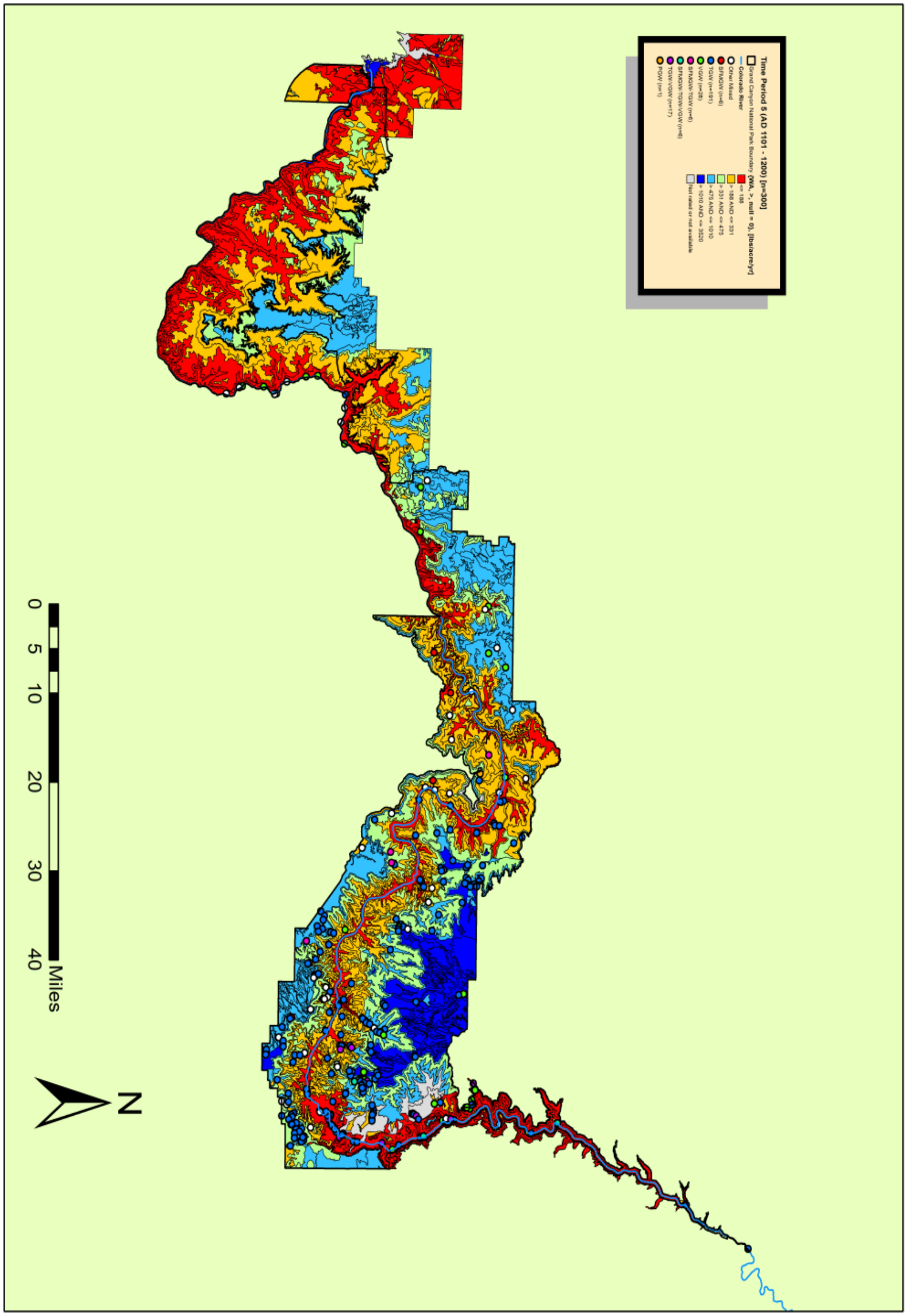

Figure 6.36. Distribution map of Time Period 5 sites and range productivity.

Hydrology

During Time Period 5 the trend of locating sites closer to water continues (Figure 6.37 and Table 6.40). Again this pattern is indicative of an increase in the need for water, possibly due to an increased reliance on maize agriculture.

Table 6.40. Time Period 5 sites and corresponding hydrology data.

Stream	TP1	TP2	TP3	TP4	TP5	TP6
Min	42	10	1	4	1	1
Max	1260	1202	1654	1509	1595	741
Mean	336	387	414	343	293	206
SD	293	298	324	290	305	211

Spring	TP1	TP2	TP3	TP4	TP5	TP6
Min	250	40	77	78	49	503
Max	6994	9026	11107	11283	11796	9826
Mean	3200	3182	3169	2845	2753	3994
SD	1757	2033	1972	1975	1896	2382

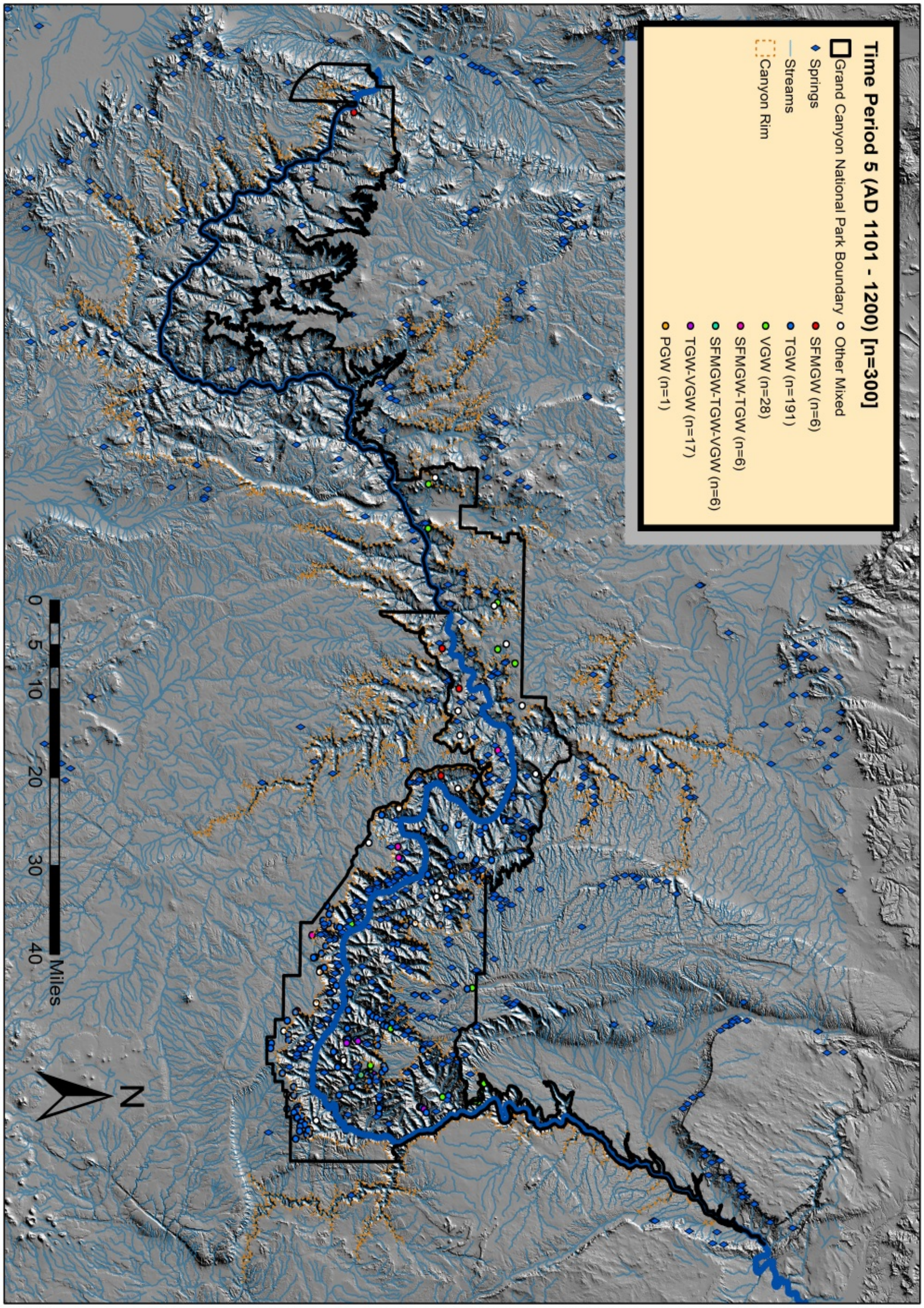

Figure 6.37. Distribution map of Time Period 5 sites and hydrology.

Settlement Organization

Time Period 5 sites (n=300) can be divided into habitation (67.33%), subsistence (12.34%), rock art (1.33%), and artifact scatter (18.99%) categories. During this time period the number of sites within the Canyon drops by a third, a trend that continues into Time Period 6. TGW sites still dominate the landscape and again the habitation site types occur in the largest percentage (67.33%). During Time Period 5 a wide variety of habitation sites, including multi-structure multi-room sites (15.67%), single-room structures (15.33%), rockshelters with masonry sites (12.33%), Multi-room structures (9.67%) and multi-structure single room sites (8.33%) have been identified. While the lower number of sites does indicate a decline in population there is only sparse evidence of aggregation, as the percentage of single-room solo structure sites is almost identical to the percentage of multi-room multi-structure sites. One could posit that the increase in rockshelters with masonry walls in Time Period 5 and Time Period 6 is an indication of some sort of defensive stance but that fact is not clear.

During Time Period 5 the population and number of structure and rooms decreased along with the artifact density (Table 6.42). The population estimate is still relatively high but the decrease in artifact density indicates the occupation was not as intense. It is possible that an increasing production of maize and decrease in wild plant production during this time period decrease the intensity of occupation, but it is also possible that the decrease in artifact density may be due to groups occupying sites for much shorter time spans, creating less artifacts, which suggests a possible more mobile subsistence strategy.

Table 6.41. Time Period 5 sites correlated to site type.

Code	Description	TP5 Freq	%
1	Masonry Structure	4	1.33
1.1	Masonry Structure 1 Room	46	15.33
1.2	Masonry Structure Multiple Rooms	29	9.67
1.3	Multiple Masonry Structures All Single Rooms	25	8.33
1.4	Multiple Masonry Structures at least 1 with Multiple Rooms	47	15.67
1.5	Rockshelter with Multiple Rooms	0	0.00
1.6	Rock Alignment with Artifacts (no agricultural)	2	0.67
1.7	Possible Pithouse (depression with artifact scatter)	0	0.00
2	Rockshelter without masonry	12	4.00
2.1	Rockshelter with masonry	37	12.33
2.2	Rockshelter-Granary	5	1.67
3	Cave	0	0.00
4	Agriculture Features	2	0.67
5	Artifact Scatter Unknown	46	15.33
5.1	Lithic scatter	4	1.33
5.2	Sherd and lithic scatter	7	2.33
6	FCR	22	7.33
6.1	Mescal Pit	8	2.67
12	Rock Art (Both Pictographs and Petroglyphs or Unknown)	1	0.33
12.1	Petroglyph	0	0.00
12.2	Pictograph	3	1.00
		300	100

Table 6.42. Time Period 5 settlement organization.

	TP1	TP2	TP3	TP4	TP5	TP6
# Structures	8	89	291	640	429	26
#Room	4	132	400	1005	644	24
Average # Rooms / Structure	0.50	1.48	1.37	1.57	1.50	0.92
Population Estimate	6.40	211.20	640.00	1608.0	1030.4	38.40
Artifact Density (mean / structure)	20.92	14.58	40.44	78.49	32.63	15.71

Time Period 6 (AD 1201 – AD 1300)

As Figure 6.38 and Table 6.43 indicate, the number of sites (n=29) present during Time Period 6 (AD 1200-1300) indicates that the Canyon seems to have been abandoned during this Period (Figure 6.11). The number of TGW and VGW sites have dramatically decreased, with only three sites for each group dating to this Period. The VGW sites are located along the Colorado River below the Uinkaret Plateau, while the TGW sites are located on the South Rim (n=2) and in the East Canyon zone (n=1) near the confluence of the Little Colorado and Colorado rivers. The SFMGW sites recorded are all situated near Havasu Canyon and their dates are suspect.

Table 6.43. Time Period 6 sites and corresponding geographic regions.

	TP1	TP2	TP3	TP4	TP5	TP6	TP7
North Rim	18	48	71	107	48	0	0
South Rim	3	22	183	141	51	6	17
Upper Canyon	0	1	0	1	2	0	0
East Canyon	0	8	15	44	74	2	4
Gorge	3	14	110	183	101	10	12
Lower Canyon	6	24	17	28	11	4	7

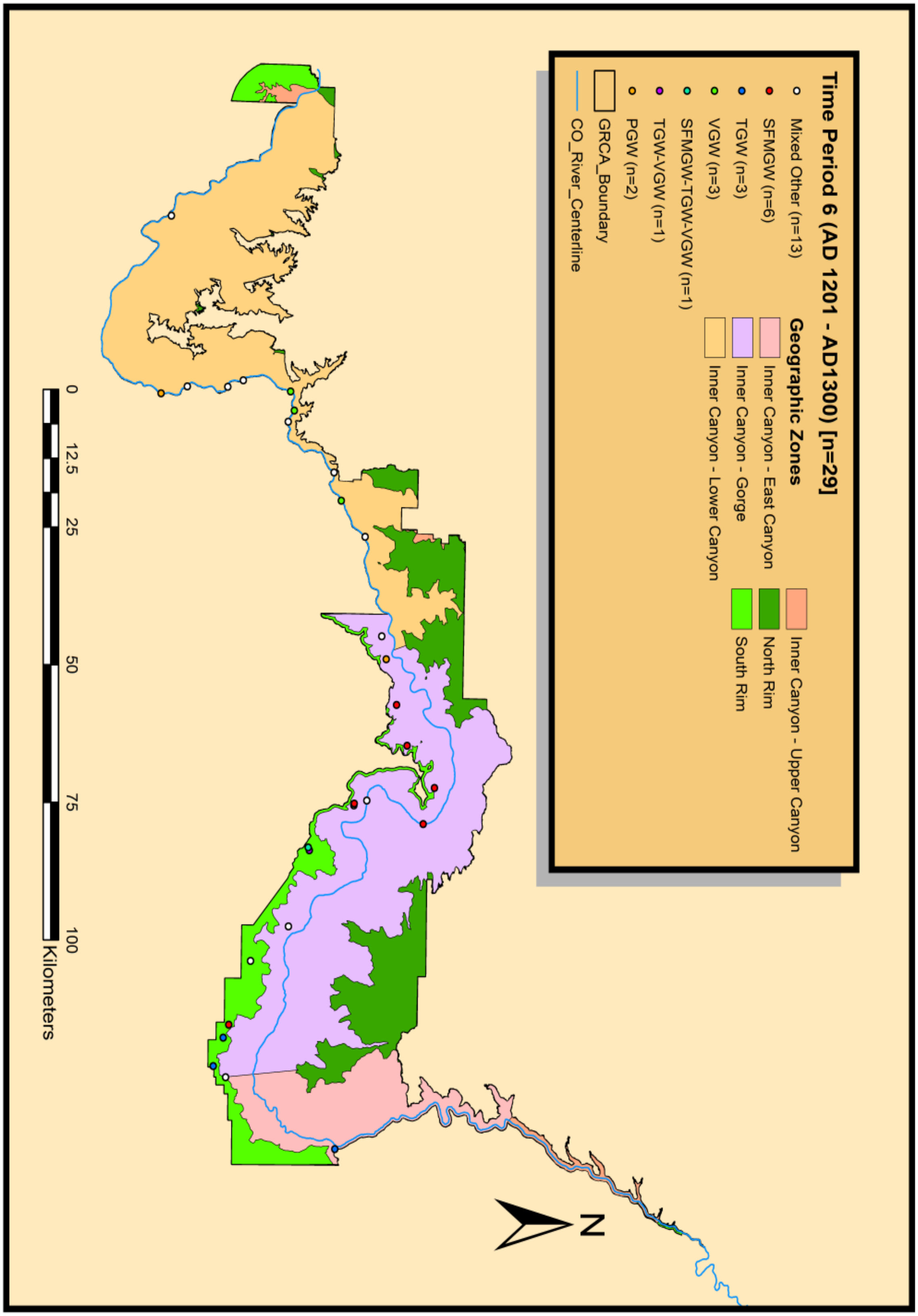

Figure 6.38. Distribution map of Time Period 6 sites and geographic region.

Biotic Community

As Figure 6.39 and Table 6.44 illustrate, during Time Period 6 site placement seems to occur with little regard to biotic community, with the exception of the Warm Desert Scrub life zone. The increased number of sites in the Warm Desert Scrub biotic communities is a reflection on the types of activities taking place during this period. By late Time Period 6 (after AD 1225) the Pueblo Period (SFMGW, TGW, VGW) groups have all abandoned the Canyon and smaller hunter gathering bands (prehistoric Prescott peoples and the ancestral Paiute, Pai, and Navajo) are only utilizing the Canyon on a limited basis.

Table 6.44. Time Period 6 sites and corresponding biotic communities.

NAME	Areas hectares	%	TP6 freq	%
Barren	3870	0.79	0	0.00
Cold Desert Scrub	213418	43.72	8	27.59
Mixed coniferous	15208	3.12	0	0.00
Pinyon Juniper	133546	27.36	5	17.24
Ponderosa Pine	24137	4.94	3	10.34
Riparian	1522	0.31	0	0.00
Spruce/Fir	7144	1.46	0	0.00
Warm Desert Scrub	89328	18.30	13	44.83
	488173	100.00	29	100.00

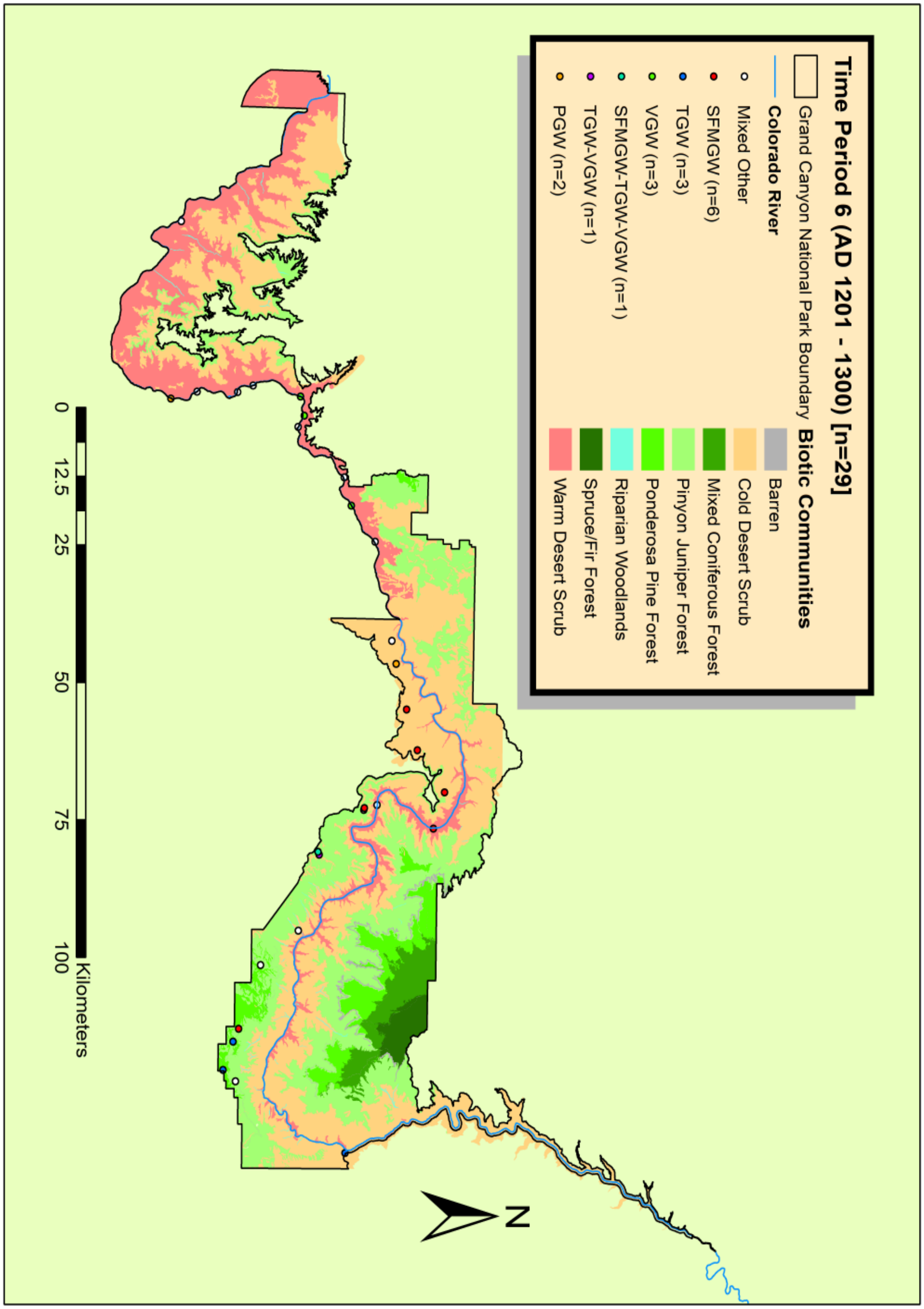

Figure 6.39. Distribution map of Time Period 6 sites and biotic communities.

Vegetation Association

Sites dating to Time Period 6 occur in higher than expected percentages (Figure 6.40 and Table 6.45) in the following vegetation associations: Ponderosa-Pinyon-Gambel Oak-Juniper, Pinyon-Juniper-Big Sage-Cliffrose, Scrub Oak-Snakeweed-Beargrass-Blackbush, Brittlebush-Creosotebush-Mormon Tea. During this period there are still a few sites associated with Pinyon Juniper and Ponderosa Pine vegetation communities that are likely associated with the last of the pueblo groups in the Canyon. The bulk of the sites, however, occur in vegetation associations that occur in the Inner Canyon, which reflects a shift to a post-pueblo occupation that focuses on small scale resource exploitation by mobile hunting and gathering bands.

Table 6.45. Time Period 6 sites and corresponding vegetation associations.

NAME	Area hectares	%	TP6 Freq	%
Engelmann Spruce-Subalpine Fir	2194.00	0.45	0	0.00
Engelmann Spruce-White Fir-Ponderosa	6240.99	1.28	0	0.00
Ponderosa-Aspen-Engelmann Spruce	83.61	0.02	0	0.00
Ponderosa Pine	5322.64	1.09	0	0.00
Ponderosa-Aspen-White Fir-Douglas Fir	6133.24	1.26	0	0.00
Ponderosa-NMex Locust-Gambel Oak	3631.35	0.74	0	0.00
Ponderosa-Pinyon-Cliffrose-Black Sagebrush	367.57	0.08	0	0.00
Ponderosa-Pinyon-Gambel Oak-Juniper	8581.55	1.76	3	10.34
Ponderosa-Gambel Oak-Big Sagebrush	716.96	0.15	0	0.00
Ponderosa-Aspen-Engelmann Spruce	787.53	0.16	0	0.00
Ponderosa-White Fir-Aspen	11059.14	2.27	0	0.00
Ponderosa-White Fir-Aspen-NMex Locust	157.32	0.03	0	0.00
Pinyon-Juniper-Scrub Oak-Little Leaf Mtn Mahogany	7493.06	1.54	2	6.90
Juniper-Pinyon-Mormon Tea-Greasebush	14138.64	2.90	0	0.00
Juniper-Pinyon-Mormon Tea-Scrub Oak	32882.70	6.74	0	0.00
Juniper-Pinyon-Big Sagebrush	4297.82	0.88	0	0.00
Juniper-Big Sagebrush-Pinyon	27519.65	5.64	0	0.00
Pinyon-Juniper-Big Sage-Cliffrose	8330.54	1.71	1	3.45

Table 6.45, cont.

Pinyon-Scrub Oak-Manzanita	24821.02	5.09	0	0.00
Blackbrush-Pinyon-Juniper	21408.97	4.39	0	0.00
Pinyon-Serviceberry-Gambel Oak	10834.67	2.22	1	3.45
Pinyon-Juniper-bluegrass	2827.65	0.58	1	3.45
Hilaria-Cheatgrass-Snakeweed	1197.67	0.25	0	0.00
Mixed Grass-forb Association	1809.42	0.37	0	0.00
Black Gramma-Snakeweed-Winterfat	185.14	0.04	0	0.00
Big Sagebrush-Snakeweed-Blue Gramma	7225.81	1.48	1	3.45
Big Sagebrush-Juniper-Pinyon	7316.57	1.50	0	0.00
Big Sagebrush-Snakeweed-Mormon Tea	12443.11	2.55	0	0.00
Blackbrush-Mormon Tea-Banana Yucca	9053.19	1.86	1	3.45
Rabbitbrush-Snakeweed-Fourwing Saltbush	816.69	0.17	0	0.00
Scrub Oak-Snakeweed-Beargrass-Blackbush	1197.06	0.25	3	10.34
Fourwing Saltbush-Big Sagebrush-Snakeweed	423.92	0.09	0	0.00
Saltbush-Banana Yucca-Snakeweed	2861.91	0.59	0	0.00
Snakeweed-Mormon Tea-Utah Agave	52494.68	10.77	1	3.45
White Bursage-Mormon Tea-Barrel Cactus	1685.18	0.35	0	0.00
Mormon Tea-Snakeweed-Wolfberry	26388.59	5.41	1	3.45
Mormon Tea-Big Galleta-Catclaw Acacia	3491.80	0.72	1	3.45
Creosotebush_Beavertail Cactus-Ocotillo	2647.03	0.54	0	0.00
Creosotebush-White Bursage-Mormon Tea	3523.70	0.72	0	0.00
Blackbrush-Mormon Tea-Banana Yucca	36447.43	7.47	1	3.45
Blackbrush-Joshua Tree-Banana Yucca	582.73	0.12	0	0.00
Blackbrush-Banana Yucca-Cliffrose	2574.16	0.53	0	0.00
Fourwing Saltbush-Grizzly-bear Cactus-Mesquite	41.58	0.01	0	0.00
Shadscale-Mormon Tea-Beavertail Cactus	2638.62	0.54	0	0.00
Desert Mallow-Mormon Tea-Creosotebush	16960.91	3.48	0	0.00
Brittlebush-Creosotebush-Mormon Tea	24385.16	5.00	11	37.93
Brittlebush-Mormon Tea-Catclaw Acacia	15209.80	3.12	1	3.45
Cottonwood-Brickellia-Acacia-Apache Plume	540.47	0.11	0	0.00
Catclaw Acacia-Baccharis-Apache Plume	980.66	0.20	0	0.00
Others not correlated to arch sites	52672.06	10.80	0	0.00

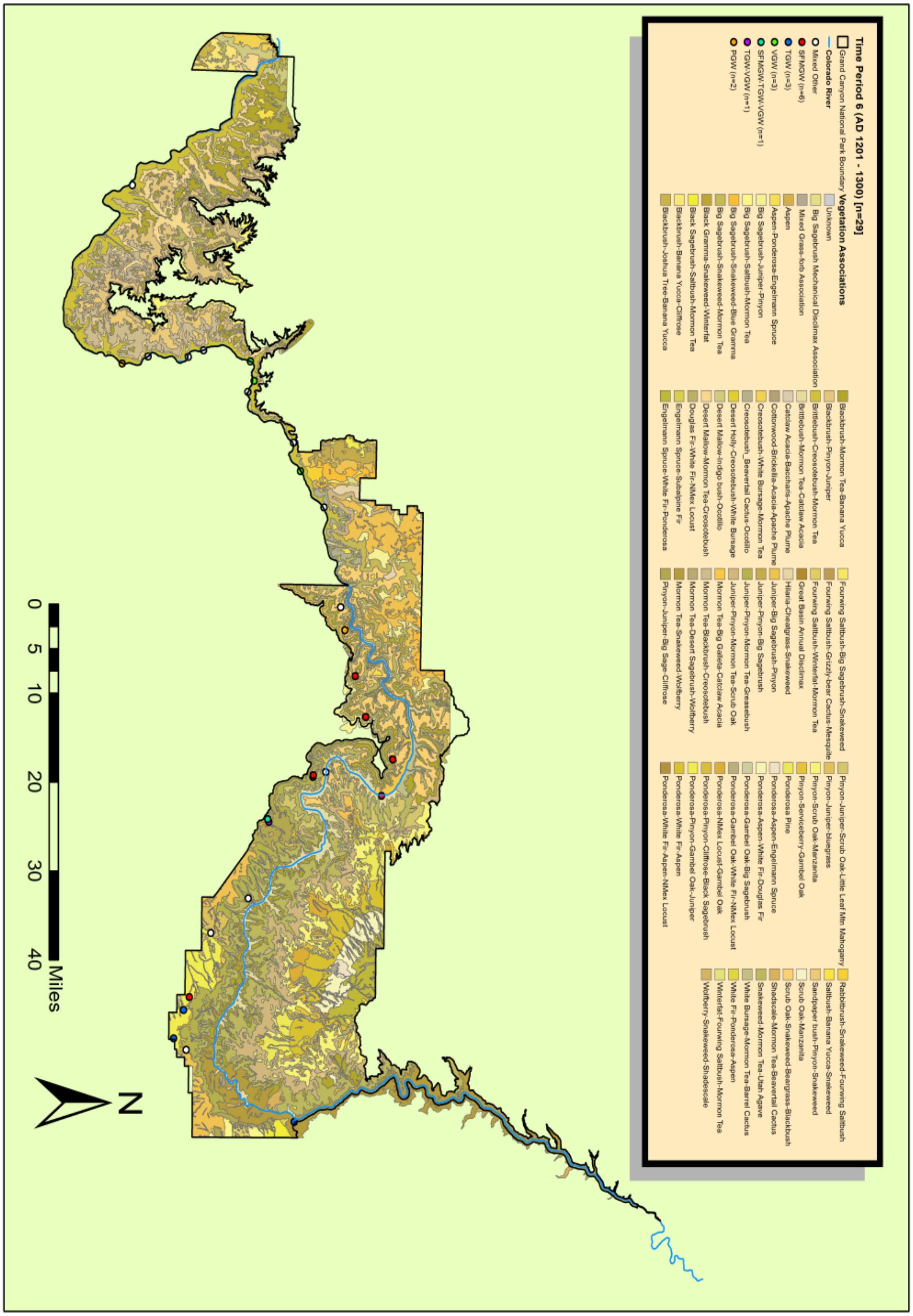

Figure 6.40. Distribution map of Time Period 6 sites and vegetation associations.

Range Productivity

The Range Productivity distribution (Figure 6.41 and Table 6.46) during Time Period 6 indicates a shift away from high wild plant-production areas and is more indicative of a post-Puebloan hunting and gathering subsistence system.

Table 6.46. Time Period 6 sites and corresponding range productivity.

Lbs/acre/year	# (ha)	%	#	TP6 %
<= 188	167972	29.07	10	41.67
>188 AND <=331	163954	28.37	6	25.00
>331 AND <=475	97650	16.90	2	8.33
>475 AND <=1010	108687	18.81	5	20.83
>1010 AND <=3520	39652	6.86	1	4.17
TOTAL	577915	100	24	100

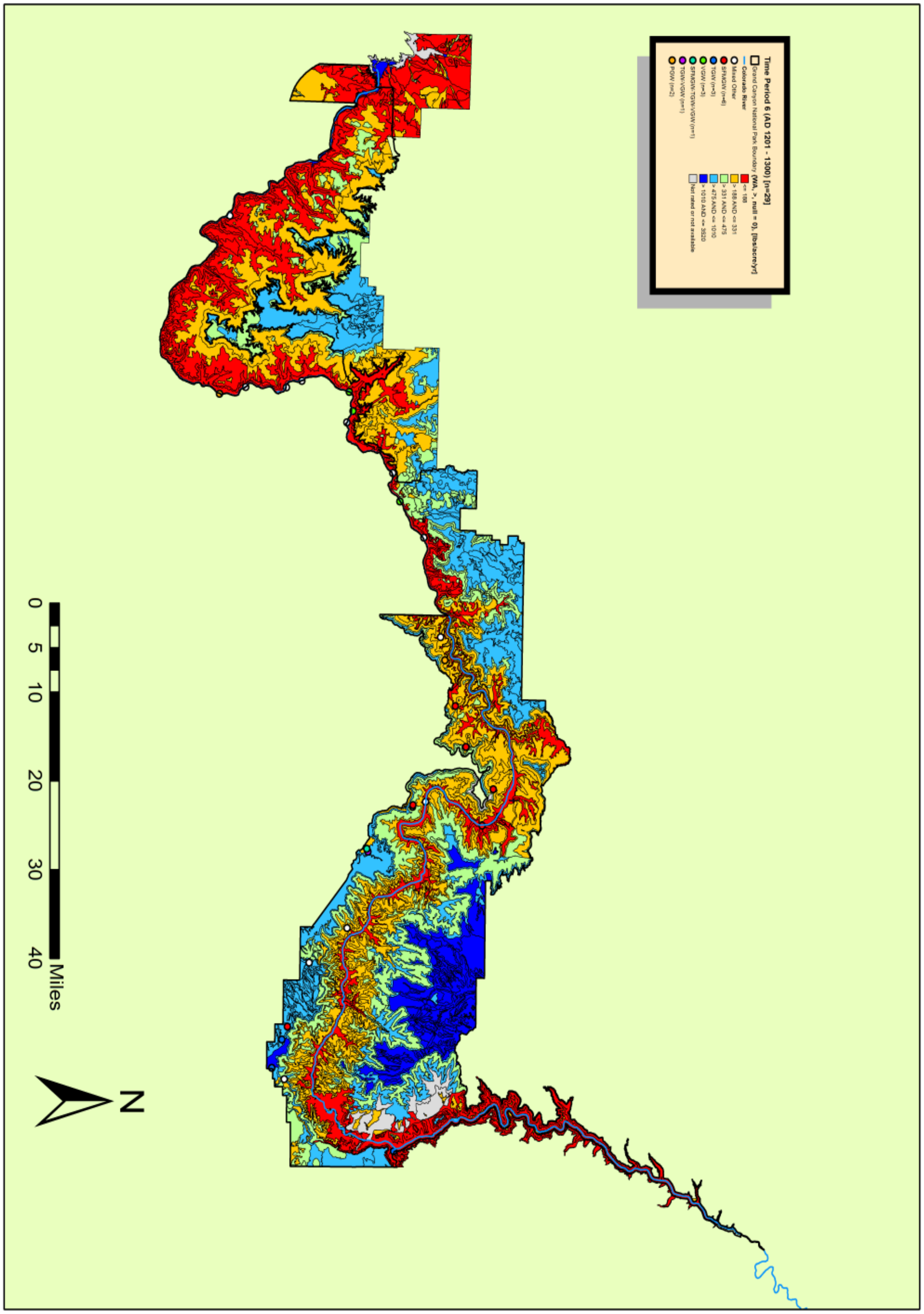

Figure 6.41. Distribution map of Time Period 6 sites and range productivity.

Hydrology

During Time Period 6 sites are located closer to streams but further from springs than during any other time period (Figure 6.42 and Table 6.47). Again this shift is likely the result of the abandonment of the Canyon and an increasing number of post-pueblo hunting and gathering groups utilizing the area.

Table 6.47. Time Period 6 sites and corresponding hydrology data.

Stream	TP1	TP2	TP3	TP4	TP5	TP6
Min	42	10	1	4	1	1
Max	1260	1202	1654	1509	1595	741
Mean	336	387	414	343	293	206
SD	293	298	324	290	305	211

Spring	TP1	TP2	TP3	TP4	TP5	TP6
Min	250	40	77	78	49	503
Max	6994	9026	11107	11283	11796	9826
Mean	3200	3182	3169	2845	2753	3994
SD	1757	2033	1972	1975	1896	2382

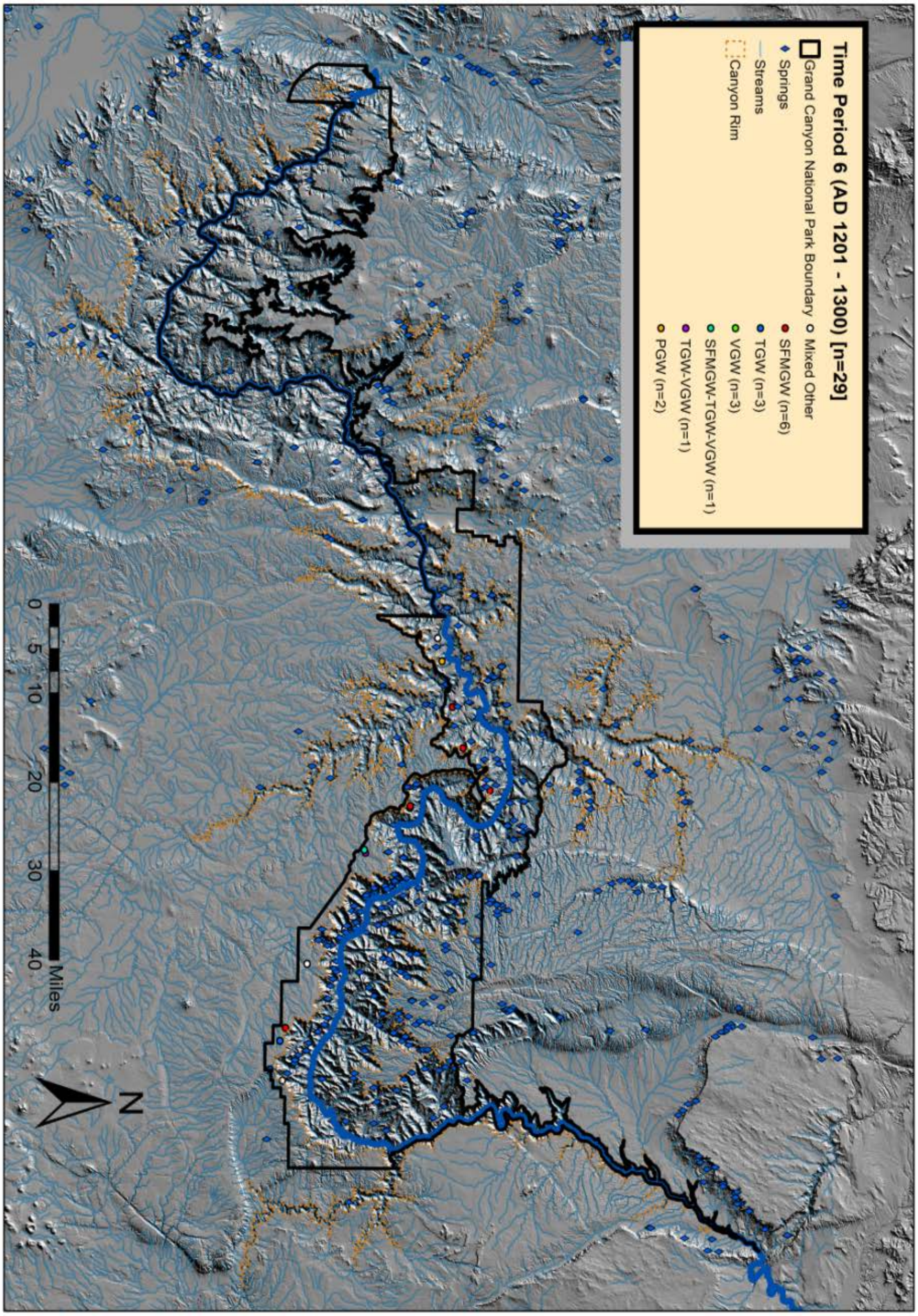

Figure 6.42. Distribution map of Time Period 6 sites and hydrology.

Settlement Organization

Time Period 6 sites (n=29) can be divided into habitation (51.72%), subsistence (27.59%), and artifact scatter (20.69%) categories. During this time period, the number of sites is the lowest of any of the time periods. Habitation sites are still the primary represented site type but subsistence site types increase to their highest levels. An examination of the site type distributions indicates that the increase in subsistence category sites is due to a spike in the occurrence of mescal pits. These later period archaeological features were used by indigenous people to process the agave plant. This process likely began with the prehistoric Prescott peoples and continued until historic times with modern groups such as the Kaibab Paiute.

During Time Period 6 there is a very definite drop in the number of structures, rooms, and population (Table 6.49). The almost equal proportion of structures to rooms indicates a shift to one-room structures and the low artifact density seems to indicate low-intensity occupation at these sites.

Table 6.48. Time Period 6 sites and corresponding site types.

Code	Description	TP6 Freq	%
1	Masonry Structure	0	0.00
1.1	Masonry Structure 1 Room	1	3.45
1.2	Masonry Structure Multiple Rooms	0	0.00
1.3	Multiple Masonry Structures All Single Rooms	1	3.45
1.4	Multiple Masonry Structures at least 1 with Multiple Rooms	3	10.34
1.5	Rockshelter with Multiple Rooms	0	0.00
1.6	Rock Alignment with Artifacts (no agricultural)	0	0.00
1.7	Possible Pithouse (depression with artifact scatter)	0	0.00
2	Rockshelter without masonry	6	20.69
2.1	Rockshelter with masonry	4	13.79
2.2	Rockshelter-Granary	0	0.00
3	Cave	0	0.00
4	Agriculture Features	0	0.00
5	Artifact Scatter Unknown	3	10.34
5.1	Lithic scatter	1	3.45
5.2	Sherd and lithic scatter	2	6.90
6	FCR	2	6.90
6.1	Mescal Pit	6	20.69
12	Rock Art (Both Pictographs and Petroglyphs or Unknown)	0	0.00
12.1	Petroglyph	0	0.00
12.2	Pictograph	0	0.00
		29	100

Table 6.49. Time Period 6 settlement organization.

	TP1	TP2	TP3	TP4	TP5	TP6
# Structures	8	89	291	640	429	26
#Room	4	132	400	1005	644	24
Average # Rooms / Structure	0.50	1.48	1.37	1.57	1.50	0.92
Population Estimate	6.40	211.20	640.00	1608.00	1030.40	38.40
Artifact Density (mean / structure)	20.92	14.58	40.44	78.49	32.63	15.71

SUMMARY

An examination of archaeological sites in relation to a variety of environmental data generated new data on settlement patterns that were used to make inferences concerning indigenous use of the Grand Canyon from AD 700 - 1225. The first item to note is that there seems to be a direct relationship among ware group, time period, and environmental associations. So, that during the time period when sites of a particular primary group dominated the site occurrences the overall environmental correlations during that time period match what was identified in the earlier analyses corresponding ware group to environmental variables. For example, the number of SFMGW sites reached peak during Time Period 3. If one were to examine the correspondence between the Time Period 3 sites and biotic communities and then compare that distribution to the overall SFMGW sites biotic communities' correspondence pattern both are very similar. Because the diachronic analyses did not indicate any major changes in subsistence by each group through time the null hypothesis that time period impacted ware group associations does not hold. Since the primary ware group at a site seems to be the prime indicator of how the site was utilized the following inferences can be made.

Overall it appears that the VGW sites are located in the most variable zones within the Canyon. VGW site distribution indicates a split between the middle elevation pinyon and juniper plateaus, which while dominate was not the only location for VGW sites, as there also seemed to be a fair number of the VGW sites located in the scrubland deserts of the Inner Canyon. VGW sites also occur most frequently in areas classified with the second highest range productivity (475-1010 lbs./acres/year) which, along with a pattern of most VGW sites corresponding to vegetation associations that are prime for both wild plant production and maize agriculture, suggests a mixed subsistence strategy. My analyses suggest that similar to other areas in the Arizona Strip, the VGW sites in the Canyon are likely the result of a split subsistence strategy with lowland maize agriculture and upland wild plant production both providing almost equal amounts of resources to sustain these peoples.

The SFMGW sites seem to be dominant in the Pinyon Juniper biotic communities on the South Rim of the Canyon and in the Cold Desert Scrub biotic communities in the Inner Canyon near Havasu Creek. The correspondence between SFMGW sites and vegetation associations indicates 15.87% of SFMGW sites occur in areas principally suitable for wild resource production, 4.26% of sites occur in areas deemed appropriate chiefly for maize agriculture, and 65.12% of SFMGW sites occur in areas suitable for both wild plant production and maize agriculture. This pattern is suggestive of a seasonal subsistence strategy where maize and other domesticates would be planted and harvested during the spring and summer, and wild resources, in particular pinyon, acorn, juniper and buckwheat, harvested in the fall.

The largest number of sites recorded in the Canyon belongs to the peoples who produced TGW. TGW sites are found throughout the Grand Canyon National Park, on the North Rim, South Rim, and Inner Canyon. TGW sites are associated most strongly with Ponderosa Pine and Pinyon Juniper biotic communities, with the strongest association to then Ponderosa Pine community. The correspondence of TGW sites to vegetation associations analyses suggest a subsistence pattern for this group that is heavily reliant on wild resource production with limited maize agriculture. This inference is supported by the association between TGW sites and range productivity.

TGW sites are located in almost equal proportions in the two highest range productivity classes (475-1010 lbs./acre/year = 25.94% and 1010 -3520 lbs./acres/year = 27.47%), which is the largest percentage of any of the ware groups and definitely an indication of wild plant production. The percentage of sites in the lowest three categories range from 12.63% to 17.24% is low but still enough to suggest some maize agriculture was practiced. This pattern indicates a mixed subsistence strategy that relied heavily on wild plant production with limited maize agriculture. This reliance on wild resources with limited maize agriculture fits the models proposed by Sullivan and Forste (2014) for the inhabitants of the Upper Basin in the eastern Grand Canyon and expands it throughout the Canyon for groups that primarily utilize TGW.

The data presented in this chapter do challenge traditional interpretations of Grand Canyon settlement from AD 700 - 1225. The analyses indicate that all three of the groups who settled in the Canyon during the Pueblo Period practiced a mixed subsistence strategy that exploited the great variation of habitats present in the Canyon. The relationship between the people and the Grand Canyon environments during this time is more complex than originally proposed. Both wild plant production and maize agriculture were important to these prehistoric peoples, in varying degrees. However, the notion that the prehistoric occupants of the Grand Canyon followed a subsistence strategy that was the same as either the Historic Hopi or the anomalous prehistoric Chaco and Mesa Verde people's needs to be revised. First, the inhabitants of the Grand Canyon from AD 700 – 1225 were not homogenous and were in fact three very distinct groups. While some maize was grown by these groups they were not corn farmers. In varying degrees a wide range of wild plants were utilized. In some cases this utilization may just have been exploiting the natural cycles of availability but in many cases these people engineered their environments using techniques such as burning, broadcast sowing of seeds, or tree tending to increase the production of these wild plants. In Chapter 7 I will discuss how these new inferences challenge us to rethink our models on how the Grand Canyon was utilized by indigenous peoples from AD 700 – 1225.

Chapter 7:
Grand Canyon Settlement AD 700 -1225: Discussion and Concluding Thoughts

My objective for this dissertation was to challenge traditional interpretations of indigenous settlement of the Grand Canyon from AD 700 -1225 by developing new settlement models. These new models take into account the Canyon's diverse environmental landscape, both horizontally and vertically, and focus on archaeological site distribution patterns that indicate that the Pueblo Period settlers of the Canyon engineered their surroundings to increase wild plant productivity, as part of a more diverse subsistence strategy than previously proposed for the Park. The ecological diversity created in the Canyon by climate, elevation, and topography has provided those who settled the Canyon with wide-ranging challenges and opportunities to live in this place that today we recognize as being unique. The indigenous peoples who inhabited the Canyon during the Pueblo Period varied in how they utilized this diverse environment, with each of the three archaeologically defined groups exploiting different habitats. While each group exploited different environmental niches, their ability to engineer the economic resources needed to survive in this seemingly harsh environment allowed them to establish settlements throughout the Canyon. Below, I briefly critique previous attempt to interpret indigenous settlement of the Grand Canyon during the Pueblo Period and present my new models and discuss how they do a better job of explaining the diversity observed in the archaeological record.

Most studies of settlement in the Grand Canyon follow what I have termed the SARG Approach (see Chapter 2). These interpretations tend to view the indigenous groups who settled the Canyon from AD 700 - 1225 as maize agriculturalists who followed a lifeway similar to that described historically for Puebloan peoples on the Colorado Plateau, such as the Hopi. This approach is grounded in a cultural ecological paradigm, which promotes the role of the natural environment in shaping cultural practices. These subsistence models tend to presume that all Pueblo Period peoples were agriculturist who only settled in areas where the natural environment was suitable for growing maize (frost-free days, precipitation, water-table depth, etc.). While some technological improvements, particularly water control, were undertaken to improve the odds of a successful harvest, the vast majority of the growing conditions cannot be mitigated, so people are obligated to find locations that meet the environmental constraints required to grow maize.

From a paleo-botanical perspective, those following the SARG Approach posit that one maize cob or a single grain of corn pollen is sufficient to establish that Pueblo Period groups intensively cultivated maize. The assertion that the mere presence of maize equals an intensive reliance on cultivated crops is dubious, given the paucity of paleo-botanical evidence of maize-based agriculture in the Canyon. To date, only about 100 cobs and 184 grains of corn pollen have been documented in the Grand Canyon archaeological literature. This is quite low when compared to other regions in the northern Southwest. In fact, at many Pueblo Period sites in the region there is more paleo-botanical evidence for maize than has been recorded in the entire Grand Canyon National Park.

Not only do many Grand Canyon researchers hold on to the belief that all Pueblo Period groups were full-time agriculturalists, but a many sites, such as at the Bright

Angel Pueblo granary and several sites on Unkar Delta, where substantial quantities of wild resources were documented, often dismissed the importance of these resources to Pueblo Period subsistence strategies. This disregard of the significance of wild plants in indigenous subsistence systems has led to researchers to assume that a single maize pollen grain is enough to indicate intensive maize agriculture but abundant wild plant material is insufficient to argue for wild plant resources being a primary/major component of the subsistence strategy. Given the concentrations of sites documented during the course of this study in areas within the Canyon not suitable for maize agriculture, this position needs to be reconsidered.

The Grand Canyon is claimed as a sacred space by numerous Native American groups whose beliefs about and understanding of the world are quite different from western-scientific notions. However, in many cases their interpretations of the Pueblo Period archaeological record are often quite similar to inferences made by archaeologists. Such similarities in understanding the prehistoric indigenous settlement of the Canyon are not surprising because the SARG interpretations draw inferences from ethnographic and ethno-historic records. Because the origin stories of the Hopi and the Pai groups all intimately involve the Grand Canyon and many of these groups claim a direct lineage from earlier Puebloan groups, it is to be expected that they believe the archaeological remains document a lifeway similar to theirs. This avenue of inquiry, often termed the direct historical approach has been employed in Southwest archaeology since its beginning. However, I posit that ethnographies written long after Spanish and American colonization provide limited evidence on earliest Puebloan lifeways. This position does not mean that archaeologists should ignore these ethnographic sources but rather recognition that they are one of several explanatory frameworks that can be engaged to understand the Pueblo Period at the Grand Canyon.

In challenging the SARG interpretations of the Grand Canyon Pueblo Period, I build on the work of Alan Sullivan and his colleagues (Berkebile 2014, Noor 1997, Cook 1995, Roos et al 2010, Sullivan 1986, 2015, Sullivan et. al. 2002, 2007, Sullivan and Ruter 2006, Sullivan and Forste 2014, Uphus 2003). The Upper Basin Archaeological Research Project (UBARP) Approach is grounded in agentive ecological paradigms, such as niche construction theory. Rather than focusing on the environmental limitations this approach implies that people and economies are not restricted by a particular set of environmental conditions. Instead, this approach recognizes human agency, and acknowledges that they have the ability to engineer their environments to increase the production of wild resources and incorporate them into subsistence strategies that also include low-intensity maize horticulture (Sullivan et. al. 2002). In UBARP interpretations of the archaeological record, paleo-botanical evidence of both maize agriculture and wild plant production is considered equally; with no one sample being privileged over others. When the macro-botanical and pollen remains of maize and other domesticates and wild plants are considered equally, a more complex and nuisance interpretation of indigenous settlement is possible. This approach has led to explanations that put greater emphasis on production of wild resources, such as pinyon nuts and cheno-ams, and the identification of subsistence a pattern that had a minimal reliance on domesticated cultigens, such as maize, and a greater reliance on wild resources.

While the UBARP interpretations have done a better job documenting the complexity of the subsistence strategies practiced by prehistoric groups that occupied the

Canyon form A.D. 700-1225, they were based are limited data from a relatively restricted area on the Grand Canyon's South Rim. In order to address this critique, my study examined the distribution of all Pueblo Period sites within the Park regardless of time period and possible cultural affiliation. By following this approach I was able to improve upon the UBARP interpretations, and identify differences in the archaeological record that are related to how various groups adapt-to and manipulated their environment to develop a subsistence strategy that took advantage of what the Canyon had to offer. As with the others who have employed the UBARP approach, my models presume that Pueblo Period peoples had and the ability to manipulate their surroundings to increase the production of wild plants, in addition to knowledge of maize agriculture practices. In my data summary and new interpretations below I will discuss how this approach demonstrates the complex and diverse subsistence strategies undertaken by the Pueblo Period peoples who inhabited the Grand Canyon.

GRAND CANYON PUEBLO PERIOD SITE DISTRIBUTIONS

The examination of archaeological site distributions within the Canyon and corresponding environmental variables that they associated with indicates that the occupation of the Grand Canyon from AD 700 – 1225 was more complex than previously thought. Each of the three archaeological groups who occupied all or part of the Canyon utilized their surroundings differently and settled in a variety of ecological niches. After the observed patterns are summarized, they are compared and contrasted and new models are presented.

Virgin Gray Ware Group

Sites created by peoples principally utilizing Virgin Gray Ware (VGW) ceramics are located primarily on the North Rim and in the Inner Canyon-Lower Canyon provinces. The North Rim VGW sites are mainly located on the Kanab Plateau with a only a few being associated with the Kaibab Plateau. Inner Canyon VGW sites are primarily found along the Colorado River below the Shivwits Plateau and in the Toroweap Valley below the eastern edge of the Uinkaret Plateau. A few VGW sites also are located along trails in both the Gorge and East Canyon area.

The distribution of VGA sites is suggestive of a slight avoidance of cold desert scrub biotic communities and a slight preference for the pinyon juniper and warm desert scrub biotic communities. The remainder of the sites appear to have been situated without regard for biotic community. Two –thirds of VGW sites are located within vegetation associations that are suitable for both wild plant production and maize agriculture. Almost half of the VGW sites are located in areas with high wild plant productivity potential but a third of the sites are located in areas with the lowest productivity. These patterns suggest a split subsistence system where people moved seasonally and where both maize agriculture and wild plant production contribute almost equally to the lifeway of VGW producing peoples.

The observed distribution of VGW sites is similar to what has been documented for the Virgin Anasazi in the Arizona Strip and in the Saint George and Escalante areas of Utah. When the distribution of VGW sites is examined in-light of the Canyon's geographic regions their settlement system is suggestive of seasonal maize agriculture in the low range productivity areas in the Inner Canyon and upland wild plant production in the higher range productivity areas on the Kanab Plateau.

Tusayan Gray Ware Group

Sites created by peoples principally producing Tusayan Gray Ware ceramics (TGW) are located throughout the central-part of the Park. On the North Rim, sites are primarily located on the Kaibab Plateau, near the Canyon rim; in contrast, TGW sites are scattered across the entire South Rim, with the densest clusters located in the eastern section of the Park, near Desert View. In the Inner Canyon, TGW sites occur in both the East Canyon and Gorge provinces. In the Inner Canyon – Gorge, TGW sites are located just below the rim on smaller plateaus, such as the Powell Plateau, while in the Inner Canyon –East Canyon province TGW sites are located on the wide deltas found along this segment of the Colorado River.

TGW sites are associated most strongly with Ponderosa Pine and Pinyon Juniper biotic communities, with the strongest correspondence to the Ponderosa Pine community. The association of TGW sites to these two biotic communities provides the first line of evidence for strong reliance on wild plant production, as the Ponderosa biotic community contains only limited areas (vegetation associations) that have a high potential for maize agriculture.

An examination of TGW sites correspondence to vegetation associations also implies a wild plant dominated subsistence strategy. The distribution of TGW sites and corresponding vegetation, compared to what one would expect if the sites were randomly distributed within the canyon, indicates there is a strong preference for sites to be associated with wild plant production areas instead of those areas that are more suitable mixed economy (43.86% vs 18.42, respectively). Likewise, the distribution of TGW sites and range productivity estimates indicates that over fifty percent of sites are located in the two highest range productivity categories, the highest percentage among the ware groups. This is another indication of the importance of wild plant production.

The distribution of TGW sites in relation to biotic community, vegetation association, and range productivity suggest a subsistence strategy that relied heavily on wild plant production with limited maize agriculture. This heavy reliance on wild resources fits the UBARP patterns described for inhabitants of the Upper Basin in the eastern Grand Canyon. The results of this study suggest a similar subsistence strategy was employed by TGW ceramic groups throughout the Canyon.

San Francisco Mountain Gray Ware Group

Sites created by people primarily using San Francisco Mountain Gray Ware (SFMGW) ceramics are principally located south of the Colorado River. They tend to be found on the South Rim on the Coconino Plateau near the South Rim Village and in the Inner Canyon near the mouth of Havasu Creek.

SFMGW sites are preferentially located in middle elevation forests, primarily Pinyon-Juniper, but with a large number of sites also occurring in the Ponderosa Pine and Cold Desert Scrub biotic communities. The distribution of SFMGW sites in relation to vegetation groups is suggestive of a mixed subsistence system with a greater reliance on maize agriculture relative to other groups that occupied the Canyon from A.D. 700 – 1125. Support for this proposition comes from an examination of SFMGW sites and corresponding vegetation associations, relative to what one would expect if they were randomly distributed within the canyon. This analysis revealed that almost two-thirds of the SFMGW sites are located in areas that were suitable for both wild plant production and maize farming, while only about fifteen percent corresponded to areas most suitable for wild plant production. Almost five-percent of the SFMGW sites were located within vegetation associations primarily suited for maize agriculture, the highest percentage amongst all the ware groups. Though this pattern indicates a greater reliance on maize relative to the other three groups, it still reflects a continued reliance on wild plants. The analysis of the association of SFMGW sites and wild plant productivity also is suggestive of a subsistence economy that included wild plant production in areas with high range productivity (South Rim) and maize agriculture in the areas of low range productivity (Inner Canyon).

Summary

This study identified variation in how the various Pueblo Period groups settled the Canyon. Those who produced VGW ceramics employed a seasonal and more vertical subsistence strategy; one that relied equally on upland wild plant collection and lowland maize agriculture. This pattern is similar to that documented for the Virgin Anasazi in other areas of the Arizona Strip. Producers of TGW ceramics followed a mixed subsistence strategy that was more reliant on wild plant production and deemphasized maize agriculture. This strategy has been documented for the Kayenta in the Upper Basin. Those who produced SFMGW ceramics likely practiced a more maize dominated subsistence strategy, where maize was grown in the Inner Canyon around Havasu Canyon, and wild resources were exploited in the pinyon juniper forests and ponderosa pine forests along the western South Rim.

RETHINKING GRAND CANYON INDIGENOUS SETTLEMENT FROM AD 700 -1225

The subsistence models I propose follow an agentive ecological paradigm that recognizes people have the ability to modify their surroundings to encourage the production of wild resources. I posit, based on my GIS analyses of the distribution of archaeological sites, that from AD 700 – 1225 inhabitants of the Grand Canyon, employed three of the niche-construction methods identified by Smith (2011): (1) modification of vegetative communities via anthropogenic burning to encourage the growth of ruderal (disturbance) taxa, (2) broadcast sowing of wild seeds (principally cheno-ams and grasses) near springs, seeps, and along the Colorado River where annual flooding created nutrient rich soil, and (3) in-place encouragement of nut-bearing trees (principally pinyon but also oak) creating point resources that could be harvested seasonally. With these understandings, I have developed three new models of Pueblo Period Grand Canyon settlement.

Virgin Anasazi (VGW Producing Peoples)

People who primarily utilized VGW ceramics arrived at the Grand Canyon around A.D. 700. There settlements were located north of the Colorado River, and principally on the Kanab Plateau on the North Rim, and in the western part of the Inner Canyon, in Cottonwood Canyon and Torweap Valley and below Shivwits Plateau. The distribution of VGW sites indicates their settlement distributions are indicative of a seasonally split subsistence strategy, where both maize agriculture and wild plant production were practiced in almost equal proportions. This subsistence strategy consisted of lowland maize agriculture combined with broadcast sowing of wild plant seeds along the Colorado River in the Inner Canyon and upland sowing of seeds at seeps and springs. The maize agriculture and wild seed sowing was combined with ruderal wild plant production and pinyon/oak tree management on the Kanab Plateau.

VGW producing peoples abandoned the area sometime between AD 1150 and AD 1200. It is likely the Canyon VGW groups, like the rest of the Virgin Anasazi, disbanded into smaller groups at the outset of a major drought period beginning in the 1200s. Initially, the VGW producing peoples may have migrated into the Virgin heartland around the Virgin River but they may have also moved eastward and integrated with the Kayenta.

Kayenta Anasazi (TGW Producing Peoples)

The peoples producing TGW ceramics were the largest group to inhabit the Canyon from AD 700 -1225, and occupied the area for a slightly longer period of time than those who produced VGW or SFMGW ceramics. The highest percentage of TGW sites are associated with Ponderosa Pine biotic communities and are predominately located in vegetation zones that were more favorable for wild resource production but not for maize agriculture. TGW site distributions suggest a subsistence strategy that relied more heavily on wild plant production and less on maize agriculture relative to their VGW and SFMGW neighbors.

On both the North and South rims ruderal agriculture encouraged by anthropogenic burning, may have been practiced along with management of pinyon trees. Broadcast sowing of cheno-am seeds along the Colorado River and near seeps and springs subsidized the ruderal agriculture and low-level maize farming was conducted on the broad East Canyon deltas in the Inner Canyon and in smaller areas on the Rims.

While no definitive studies have traced the Kayenta (or Kayenta/Cohonina) to their destinations after abandoning the Canyon (around AD 1225), it seems likely they migrated eastward toward the Hopi Mesas and the Little Colorado River drainage to sites such as Homolovi.

Cohonina (SFMGW Producing Peoples)

The peoples who produced SFMGW ceramics, who in the earliest interpretations of the Grand Canyon Pueblo Period were the first to enter the region, were actually the last to inhabit the Canyon arriving around A.D 900. They also appear to have been the first to leave. Around A.D. 1100 SFMGW peoples abandoned the area or they were subsumed by the groups producing TGW ceramics, who stay in the Canyon over 100-years longer. SFMGW sites are concentrated primarily in the Inner Canyon around the mouth of Havasu Creek and on the Coconino Plateau in the western portion of the South Rim. They tend to be located in middle-elevation forests, primarily pinyon-juniper woodlands, but also occur in the highest percentages amongst all the ware groups in areas most suitable for maize agriculture.

The SFMGW site distribution pattern suggests a subsistence strategy divided between the Inner Canyon and South Rim. In the Inner Canyon, near Havasu Canyon, maize and other domesticates would have been planted along with some broadcast sowing of wild grasses near seeps and springs. On the western South Rim, wild resources including pinyon would have been exploited in the fall and a variety of wild grasses whose production would have been enhanced by burning were produced.

AN EVALUATION OF ECOLOGICAL PARADIGMS IN GRAND CANYON ARCHAEOLOGY

In addition to examining Pueblo Period indigenous settlement within the Grand Canyon, I assessed how differing ecological paradigms affect the inferences about the archaeological record. Specifically, I compared the traditional cultural ecologically maize based SARG approach with agentive mixed economy UBARP approach. The results of my study indicate that settlements were not being located in areas that were most conducive for maize agriculture. In fact, depending on the primary ware found at a site, they were being located either in areas favorable for wild plant production or in locales where both wild plant production and maize agriculture could be practiced. They also appear to have been moving between the Inner Canyon and the Rims throughout the year. Therefore, it is quite evident that distribution of sites within the Canyon does not support the maize dependent SARG interpretations.

The only way to reconcile the site distributions documented during the course of this study, where sites are located in areas that were minimally favorable to- and in many case hostile toward maize agriculture, is to identify another explanation for the data patterns. The UBARP approach which is predicated on Puebloan groups engineering their environments for wild plant production appears to better explain the distributions patterns documented in Grand Canyon National Park. This approach does not require the observer to elevate minor data points (the limited amount of maize pollen and cobs recorded in the Park) to a level of importance that their sample size cannot support, and by doing so does not obligate groups to finding areas in a hostile ecosystem that were suitable for growing such a delicate crop (maize). Instead, local populations are viewed as having a complex relationship with the Grand Canyon ecosystem. Although, these peoples did practice low-level maize agriculture (we do find cobs and pollen, after all) they also manipulated their surroundings in a variety of ways, including burning, broadcast sowing of seeds, and nut tree maintenance, to increase the wild plant production, -a subsistence strategy for which the ecologically diverse Grand Canyon was better suited.

FUTURE RESEARCH

As with any project, this dissertation, while answering some questions, also exposed old problems and posed new questions. My analyses were produced principally using GIS analyses; additional fieldwork including survey, geophysical prospection, and excavation will be required to test the models I have proposed and to determine if Niche Construction Theory or some other agentive ecological paradigm is the most appropriate framework for understanding Pueblo Period indigenous settlement in Grand Canyon National Park. Below are the five most important avenues for future research that will build on my current study. First, some of the site distribution patterns seem to indicate biases due to data only being collected in developed locations and associated with Park operations. While analyses using large databases derived principally to comply with legislative mandates will always contain some biases, it would be appropriate to conduct additional surveys far from the developed areas of the Park to determine if the site distribution patterns identified in this dissertation hold for data collected in less visited parts of the Grand Canyon. Second, many of the sites in the site files contain minimal information on artifact density and there is little consistency in how artifact counts were determined. I would recommend that, during new survey and re-visits of existing sites, artifact count data be acquired for each site in a controlled manner. One approach is to create a 5-meter diameter artifact enumeration unit (AEU) in the densest cluster of artifacts and count everything in the AEU, noting as well any other diagnostic material that occurs outside of the AEU. Third, site boundaries should be compressed and limited to related components, i.e., historic sites should be recorded separately from prehistoric sites and not lumped into one big unit. Large, unrelated, multi-component sites are difficult to use in any analysis. Furthermore, large archaeological polygons in resource management datasets just encourage other resource managers to treat the archaeological data as suspect, as they seem to indicate that sites are everywhere. Fourth, a defined program of geophysical survey of Pueblo Period sites combined with limited anomaly testing should be undertaken (Mink and Pollack 2013). Geophysical prospection is still in its infancy at the Park, so geophysical survey alone will not produce definitive data on the subsurface archaeological record. But a program that includes a wide variety of techniques (magnetometer, GPR, electrical resistance) applied to many sites, combined with limited anomaly testing would provide resource managers with an archaeo-geophysical signature database. This geophysical signature database could be employed in the future so that the standard recording procedure for new sites includes geophysical survey, and so that all identified anomalies could be corresponded to signatures for known archaeological feature types. Finally, a broader historical ecological project to identify evidence of niche construction (in particular anthropogenic burning and broadcast sowing of seeds) should be undertaken. This proposed project should include not only the excavation of archaeological sites, preferably those endangered by ongoing Park operations, but also a wider paleo-ecological sampling strategy throughout the Park.

Such a study would not only contribute to our understanding of the Pueblo Period but would increase our perceptions of Grand Canyon dynamics during the Anthropocene.

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1999 M.A., Anthropology. University of Cincinnati.

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PROFESSIONAL POSITIONS

2/2008 – present Staff Archeologist III/GIS Manager. University of Kentucky, William S. Webb Museum of Anthropology and Kentucky Archaeological Survey

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6/1997-9/1999 Graduate Assistant. University of Cincinnati, Department of Anthropology.

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PUBLICATIONS

Mink, Philip B., II
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CONFERENCE AND PUBLIC PRESENTATIONS

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W. Stephen McBride, Philip B. Mink, and Edward R. Henry
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2014 Down the River without a Shovel: Investigating the Usefulness of Archaeogeophysical Survey along the Colorado River through the Grand Canyon. A paper presented in the Methodology in Southwestern Archaeology session at the 79th Annual Meeting of the Society for American Archaeology, Austin, TX. (Philip Mink was also chair of this session).

Mink, Philip B., II, David Pollack, Christina Pappas, Kim Istok
2013 Modern Tools with Minimum Impact and Maximum Benefits: Several Recent Archaeological Geophysical Projects in Grand Canyon National Park. Poster presented at the 2013 Pecos Conference, Flagstaff, AZ.

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Philip B. Mink, II, Carl Shields, Ted Grossardt, John Ripy,
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Philip B. Mink, II
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Philip B. Mink, II and Carl Shields
2010 A New Approach to GIS Modeling for Transportation Planning: Case Studies from the Inner Bluegrass and Hazard Hills Physiographic Provinces. A paper presented at the 27th Meeting of the Kentucky Heritage Council, Cumberland Falls, Kentucky.

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2010 Expanding the KYTC Archaeological Planning Model: A Data Gathering Exercise. A paper presented at the 27th Meeting of the Kentucky Heritage Council, Cumberland Falls, Kentucky.

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2008 Geophysical Investigations of Regional Variability in West Virginia Frontier Forts. A paper presented at the 2008 Society for Historical Archaeology Conference, Albuquerque, NM.

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2008 Modeling Archaeological Site Potential with Cognitive Mapping and GIS. A paper presented at the 2008 Kentucky GIS Conference, Lexington, KY.

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2007 Modeling Disturbance: Employing GIS and Archaeological Geophysics to Investigate a Twentieth Century Community at Fort Leonard Wood, Missouri. A poster presented at the 2007 Annual meeting of the Southeastern Archaeological Conference, Knoxville, TN.

Mink, P.B., II
2007 Mapping the Commonwealth's Historical and Cultural Resources. A paper presented at the 2007 Kentucky GIS Conference, Louisville.

Henry, Edward R. and P.B. Mink, II
2007 A Ground Penetrating Radar Survey of an Early Nineteenth Century Farmstead in Lexington, Kentucky. A paper presented at the 2007 Indiana Archaeology Society Annual Meeting, Strawtown, IN.

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2006 Ground Penetrating Radar and Heritage Resource Management on an Early Nineteenth Century Homestead in Lexington, Kentucky. A poster presented at the 2006 Annual Meeting of the Southeastern Archaeological Conference, Little Rock, AR.

Simpson, D. and P.B. Mink, II
2006 Geophysical Cemetery Investigations within the Ohio Valley Region: Results and Implications. Paper presented at the 71st Annual Meeting of the Society for American Archaeology, San Juan, Puerto Rico.

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2005 Examination of Statewide Geographic Information Systems Role in Elucidating Regional Archaeological Research Questions: A Case Study Examining Woodland Mound Distribution in Kentucky. Poster presented at the 70th Annual Meeting of the Society for American Archaeology, Salt Lake City, UT.

Hadley, A., L. Grench, P.B. Mink, II
2005 A Contextual Historical Analysis of the William S. Webb Museum of Anthropology at the University of Kentucky. Paper presented at 21st Kentucky Heritage Council Annual Archaeological Meeting, Lexington, Kentucky.

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2002 Nominating the Gorge: A National Register District Nomination in Eastern Kentucky. Poster presented at the 2002 annual meeting of the Southeastern Archaeological Conference, Biloxi, Mississippi.

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2001 Points vs. Polygons: Predictive Modeling in a Statewide Geographic Information System. Paper presented at the GIS and Archaeology Conference, Argonne National Labs, Chicago.

J. Fenton, P.Mink, S. Neumeyer
2001 Kentucky's Cave Sites: Underground and Under-Reported. Paper presented in the Archaeological Session at the 2001 annual meeting of the National Speleological Society, Mt. Vernon, Kentucky.

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2000 Distribution of Prehistoric Archaeological Sites and Historic Structures in Central Kentucky. Poster presented at the 2000 University of Kentucky GIS Day, Lexington, Kentucky.

Sullivan, A.P., III, P.B. Mink, M.V. Pelt
1999 Inferring the Origins of Archaeological Landscapes: Problems Involving Units of Observation and Units of Analysis. Paper presented at the 64th annual meeting of the Society for American Archaeology, Chicago.

TECHNICAL REPORTS

Mink, Philip B. II, and George M. Crothers
Forthcoming A Ground Penetrating Radar and Electrical Resistance Survey of Historic Jamestowne. A report being prepared for the Jamestown Rediscovery Archaeological Project, Jamestown, VA.

Mink, Philip B., II
2014 A Ground Penetrating Radar Survey of the Cemetery at the Judge Joseph Holt Home, Breckinridge County, Kentucky. Report on file with the Kentucky Office of State Archaeology, Lexington.

Mink, Philip B., II and M. Jay Stottman
2014 A Ground Penetrating Radar Survey of a Probable Cemetery Location at Fort Duffield, West Point, Hardin County, Kentucky. Report on file with the Kentucky Office of State Archaeology, Lexington.

Mink, Philip B., II
2014 A Ground Penetrating Radar Survey of Three Locations in the Rosedale Cemetery, Hopkins County, Kentucky. Report on file with the Kentucky Office of State Archaeology, Lexington.

Mink, Philip B., II
2014 A Ground Penetrating Radar Survey of the Randall McCoy House Pike County, Kentucky. Results on file with Kentucky Archaeological Survey.

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2014 A Ground Penetrating Radar Survey of the Domino Cemetery, Dixiana Farm, Fayette County, Kentucky. Report on file with the Kentucky Office of State Archaeology, Lexington.

Mink, Philip B., II
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Mink, Philip B., II
2014 A Ground Penetrating Radar Survey of Seven Possible Cisterns and One Grave on the Blythewood Farm, Boyle County, Kentucky. Report on file with the Kentucky Office of State Archaeology, Lexington.

Mink, Philip B. II
2014 A Grand Cemetery: A Recent Archaeogeomatic Investigation of the Pioneer Cemetery in Grand Canyon National Park. A report to be submitted to Grand Canyon National Park.

Mink, Philip B., II
2013 Remote Sensing Five Archaeological Sites Along the Colorado River, Report Number 239. Kentucky Archaeological Survey, Lexington.

Mink, Philip B., II
2013 A Ground Penetrating Radar Survey of Three Locations in Covington's Linden Grove Cemetery, Kenton County, Kentucky. Report on file with the Kentucky Office of State Archaeology, Lexington.

Mink, Philip B., II
2013 Geophysical Investigations at 15Cu110. In Phase II Testing of sites 15CU109 and 15CU110 in Cumberland County, Kentucky, Report No. x edited by Scot Jones. University of Kentucky, Program for Archaeological Research, Lexington.

Mink Philip B., II
2012 A Technical Report of An Electrical Resistance and Magnetic Survey of Preceramic Features at the El Brujo Archaeology Complex, Magdalena de Cao, La Libertad Region, Peru. Report submitted on file with Tom Dillehay, Vanderbilt University, Nashville.

Mink, Philip B.
2011 An Archaeological Geophysical Survey of Selected Locales on the Christian Log House Property (15JF776). In An Archaeological Investigation of the Christian Log House Property (15JF776, in Jefferson County, Kentucky, by M. Jay Stottman. Report on file with the Kentucky Archaeological Survey, Lexington.

Mink, Philip B., II and E. Henry

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Mink, Philip B., II
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Mink, Philip B., II
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Mink, Philip B., II
2010 Searching for a Civil War Mass Grave: Using Archaeological Geophysics to Investigate the Simpsonville Massacre of 1865, Report Number 183, Kentucky Archaeological Survey, Lexington.

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Handshoe, Donald, L. P.B. Mink, II
2009 Geophysical Investigations at 33CT0684, A Late Archaic Site In Clermont County, Ohio. A letter report on file with the Kentucky Archaeological Survey, Lexington, Kentucky.

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Mink, Philip B., II
2008 A Ground Penetrating Radar Survey of Selected Portions of the Abner Gaines House, 15Be577 Property. Kentucky Archaeological Survey, Lexington.

Mink, Philip B. II
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2005 Testing the Effectiveness of Ground Penetrating Radar and Non-site Archaeology for Reconstructing Cultural Landscapes in the Grand Canyon region, northern Arizona. 2005 Investigators Annual Report, National Park Service, Washington D.C.

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2005 A Ground Penetrating Radar Survey of a Potential Cemetery at the Cynthiana Recreation Complex, Harrison County, Kentucky. Report on file with the Kentucky Office of State Archaeology.

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2004 A Geophysical Survey of the Baxter Cemetery, Boone National Guard Center, Frankfort, Kentucky. Letter Report on file with the Kentucky Archaeological Survey.

Mink, Philip B., II and G.Crothers
2004 Environmental Background, Settlement Patterns and Site Location Modeling. In Archaeological Overview And Assessment Of New River Gorge National River, West Virginia, edited by D. Pollack and G. Crothers. Research Report No. 8. Kentucky Archaeological Survey, Lexington.

Mink, Philip B., II
2003 GIS Modeling of Study Area 8. In Archaeological Survey Methodology and Results, edited by A.P. Sullivan, A.M. Ioannides, and R.C. Frohn. Report on file with the Ohio Department of Transportation, Columbus.

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1999 Results of Archaeological Survey Conducted under USDA Forest Service Special-Use Permit User #5166 in Tusayan Ranger District, Kaibab National Forest, Cocconino, Arizona. Report submitted to USDA Forest Service.

AWARDS, CONTRACTS AND GRANTS

***NPS* (\$60,705)**

2015-16 **National Park Service, (Grand Canyon National Park)** Pilot Undergraduate Heritage Management Field School for Summer 2016, \$17,698 with David Pollack

2012 **National Park Service, (Grand Canyon National Park)** Remote Sensing of Six Archaeological Sites along the Colorado River, \$15,000, with David Pollack

2011 **National Park Service, (Grand Canyon National Park)** Ground Penetrating Radar Survey of the Entire Grand Canyon Pioneer Cemetery, \$23,007, with David Pollack

2010 **National Park Service**, **(Grand Canyon National Park)** A Ground Penetrating Radar Survey of Burial Plots, 34, 35, and 36 in the Grand Canyon Pioneer Cemetery, \$2500

2008 **National Park Service**, **(Grand Canyon National Park)** A Ground Penetrating Radar Survey of Selected Locales within the Pioneer Cemetery in Grand Canyon National Park, \$2500

***GIS* (\$121,000)**

2014-15 **National Resources Conservation Service**, Developing an Online ArcGIS Service for Integration into NRCS KICT, \$6000, with David Pollack

2011 **Kentucky Transportation Center**, Testing the Impact of LiDAR Elevation Models on the Performance of the Draft Statewide Archaeological GIS Models, \$35,000, with David Pollack

2010 **Kentucky Transportation Center**, Testing the Draft Archaeological Site Location Models Developed for Western Kentucky, \$35,000, with David Pollack

2009 **Kentucky Transportation Center**, Testing the Draft Archaeological Site Location Models Developed for Eastern Kentucky, \$35,000, with David Pollack

2008 **University of Cincinnati**, Geospatial (GIS and GPS) Field and Lab Support for the Upper Basin Archaeological Research Project, $5000

2008 **Kentucky Transportation Study**, A Pilot Study to Develop and Test a Countywide Archaeological Site Location Model, $5000, with David Pollack

***Service Projects* ($50,603)**

2014 **Fort Duffield Heritage Commission,** GPR Survey and Testing at Fort Duffield Park and Historic Site, $1000

2014 **Friends of the Holt Home,** GPR Survey Holt House Cemetery, $1000

2014 **Rosedale Cemetery, Inc.,** GPR Survey of Rosedale Cemetery, $1000

2014 **Dixiana Farm,** GPR Survey of Domino Cemetery, $650

2014 **CDM Smith,** Geophysical Survey 15Me98, $4000, with Steve Ahler, UK PAR

2014 **Michael Rankin, MD,** GPR Survey Blythewood Farm, $500

2013 **Western Kentucky University,** Geophysical Survey of Massey Springs Earthworks, $1500

2012 **Historic Linden Grove Cemetery,** GPR Survey of 3 Areas in Linden Grove Cemetery, $1200

2011 **Missouri State University**, Ground Penetrating Radar of Civil War Era Cemetery, $2500

2011 **Wyatt Etzell**, Ground Penetrating Radar Survey at the Auburn Cemetery, $500

2010 **Kentucky State Parks** A Geophysical Survey of the Purported Slave Cemetery at My Old Kentucky Home State Park, $2500, with David Pollack

2010 **Shelby County Historical Society**, A Geophysical Survey and Testing for a Civil War Mass Grave Associated with the Simpsonville Massacre, $4000

2010 **Natural & Ethical and Environmental Solutions**, A Geophysical Investigation of a Possible Mound in Butler County, Ohio, $2300

2010 **James Harrod Trust**, A Ground Penetrating Radar Survey and Archaeological Testing at the Mercer County Courthouse, $3500

2009 **Northern Kentucky University**, A Geophysical Investigation at the Linden Grove Cemetery in Covington, Kentucky, $1000

2009 **Perryville Battlefield Preservation Association**, A ground Penetrating Radar Survey of the Entire Arnold Hardin House and Civil War Hospital, $1500

2009 **James Harrod Trust**, Geophysical Investigations at the McAfee Family Cemetery, $500

2009 **Marc and Cindy Ford**, A Geophysical Survey and Testing of the Colby Tavern in Clark County, Kentucky, $3185

2008 **Natural & Ethical and Environmental Solutions**, Geophysical Investigations at an Archaic Period Site (33CT00684) along the Ohio River, $2484

2008 **Natural & Ethical and Environmental Solutions**, A Ground Penetrating Radar Survey of Selected Portions of the Abner Gaines House, $500

2007 **Jefferson County Board of Education**, Geophysical Survey of the Churchill Family Cemetery, $2000 with Jay Stottman

2007 **AMEC Earth and Environment**, A GPR Survey at Two Indiana National Guard Cemeteries in the Muscatatuk Urban Training Center, $2284

2007 **Old Green River Cemetery Association**, A Geophsyical Survey and Archaeological Testing of a Possible Civil War Mass Grave, $1500 with Jay Stottman

2007 **Louisville Metro Parks**, Geophysical Investigations at the Clark Family Cemetery in George Rogers Clark Park, $2000, with Jay Stottman

2007 **Ben Breeding**, A ground Penetrating Radar Survey of a Portion of the Arnold Hardin House and Civil War Hospital, $500

2006 **Hamilton County Parks**, A Ground Penetrating Radar Survey to Identify Unmarked Graves on the Karr Family Homestead, $1500

2006 **Duncan Family**, A Ground Penetrating Radar Survey of the Duncan Family Cemetery, $500

2006 **LFUCG Division of Parks and Recreation**, A Geophysical Survey of the Prather Property at Raven Run Nature Sanctuary, $2500

2005 **Walnut Hill Church Cemetery Association**, A Ground Penetrating Radar Survey of a Portion of the Walnut Hill Church Cemetery, $500

2005 **Holy Rosary Saint Dominics Cemetery Association**, A Ground Penetrating Radar Survey of a Portion of the Holy Rosary Saint Dominics Cemetery, $500

2004 **Harrison County Fiscal Court**, A Ground Penetrating Radar Survey of the Possible Handy Farm Cemetery in the Harrison-Cynthiana Recreation Park, $500

2004 **Kentucky Department of Military Affairs**, A Geophysical Survey of the Baxter Cemetery in the Boone National Guard Center, $1000, with Sarah Miller and David Pollack

Student Funding

2004 **University of Kentucky, Department of Anthropology** Susan Abbott-Jamieson Pre-Dissertation Award,. $1200

2004 **University of Kentucky, Graduate School**, Student Research Fund Award, $800