A SPATIAL ANALYSIS AND ZOOARCHAEOLOGICAL INTERPRETATION OF ARCHAEOLOGICAL BISON REMAINS IN THE SOUTHWEST AND THE WILDLIFE MANAGEMENT IMPLICATIONS FOR THE HOUSE ROCK VALLEY BISON HERD IN GRAND CANYON NATIONAL PARK, ARIZONA

by

Donelle Joy Huffer

A Thesis Submitted to the Faculty of the

SCHOOL OF ANTHROPOLOGY

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF ARTS

In the Graduate College

THE UNIVERSITY OF ARIZONA

2013

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at the University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the copyright holder.

SIGNED: Donelle Joy Huffer

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

_____	12-6-2013
Barnet Pavao-Zuckerman Associate Professor in Anthropology	Date

ACKNOWLEDGMENTS

First and foremost, I want to thank the Grand Canyon Historical Society and its supporting members for their generous scholarship award. Appreciation is also due to my advisor and chair, Dr. Barnet Pavao-Zuckerman, for giving me assistance and support to pursue a topic on the conservation applications of zooarchaeology. Thank you as well to my committee members, Drs. Mary Stiner and John Koprowski, for offering their expertise to help me communicate the utility of this research to a multi-disciplinary audience. I also wish to express my gratefulness to Sarah Wolff for kindly sharing conversations and information on the topic of bison in the Southwest.

Many dear friends offered their undying optimism and support along my path to pursue a graduate degree. I would like to thank two of the many beautiful, strong, and immensely intelligent women in my life, each of whom embodies a piece of the person I aspire to be. Thank you to Ellen Brennan for her enduring support as a supervisor, mentor, and friend, and for the hours of trail time during which she provided ideas, conversation, and a shared awe of the unparalleled beauty of the Grand Canyon. To Maren Hopkins I wish to express immense gratitude for granting me an empathetic ear and frequent escapes to the mountains, dirt roads, trails, and quaint establishments of southern Arizona. You remind me every day what matters, and I am glad to know you, however long that it has been.

Lastly, to the truly special people in my life: you know who you are, you know what you mean to me, and you know how thankful I am. No regrets. Ramble on.

DEDICATION

To Dylan.

TABLE OF CONTENTS

TABLE OF CONTENTS - *Continued*

TABLE OF CONTENTS - *Continued*

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The historically introduced House Rock Valley bison herd has, in recent years, migrated from the eastern Arizona Strip onto the Kaibab Plateau within Grand Canyon National Park. Bison are considered a nonnative species to the southern Colorado Plateau, and the animals adversely impact sensitive ecosystems prompting National Park Service wildlife managers to pursue their removal. Archaeofaunal evidence of bison in the Grand Canyon and neighboring regions, however, raises concern that bison may in fact be native. Assessing the evidence within a zooarchaeological interpretive framework is critical since mere presence/absence lists of bison remains do not address the potentially complex cultural processes involved in the formation of archaeofaunal assemblages. Inter-assemblage comparisons illustrate a decline in relative abundance and skeletal completeness correlated to distance from traditionally understood historical bison distribution. If bison were present in the Southwest, as the evidence suggests, they likely entered the region only occasionally as small, dispersed herds.

CHAPTER 1: INTRODUCTION

For over 100 years a herd of American bison (*Bison bison*) has ranged on portions of the Arizona Strip; the remote stretch of Arizona in Coconino and Mohave Counties that is located north and west of the Colorado River between the Grand and Glen Canyons and the States of Utah and Nevada. The animals are the legacy of a failed ranching operation formed in the early 1900s that attempted to crossbreed bison with cattle to produce a hybrid meat animal capable of enduring harsh conditions (Haines 1975). For most of the past century, the herd was confined to a small portion of the House Rock Valley located east of the Kaibab Plateau on land administered by the North Kaibab National Forest (Figure 1). In recent years, a drought-induced decline in the high desert grassland habitat of the House Rock Valley pushed many bison south and west to the higher elevation Kaibab Plateau (Minard 2003), the southern portion of which is managed by the Grand Canyon National Park (GRCA). GRCA wildlife managers consider bison to be a nonnative species, and the bison adversely impact park resources (Reimondo 2012), prompting managers to pursue actions to remove them from GRCA to preserve the natural character of the park.

The House Rock Valley bison herd was transported from Yellowstone National Park and private ranches to Arizona between 1906 and 1907 by James T. "Uncle Jim" Owens (Anderson 1998). In 1905 Owens met Charles Jesse "Buffalo" Jones who was employed as game warden of Yellowstone National Park where he labored to reestablish wild bison in an attempt to save the species from extinction (Anderson 1998; Garretson 1938). At this time, Jones was also trying to crossbreed bison with Galloway cattle to

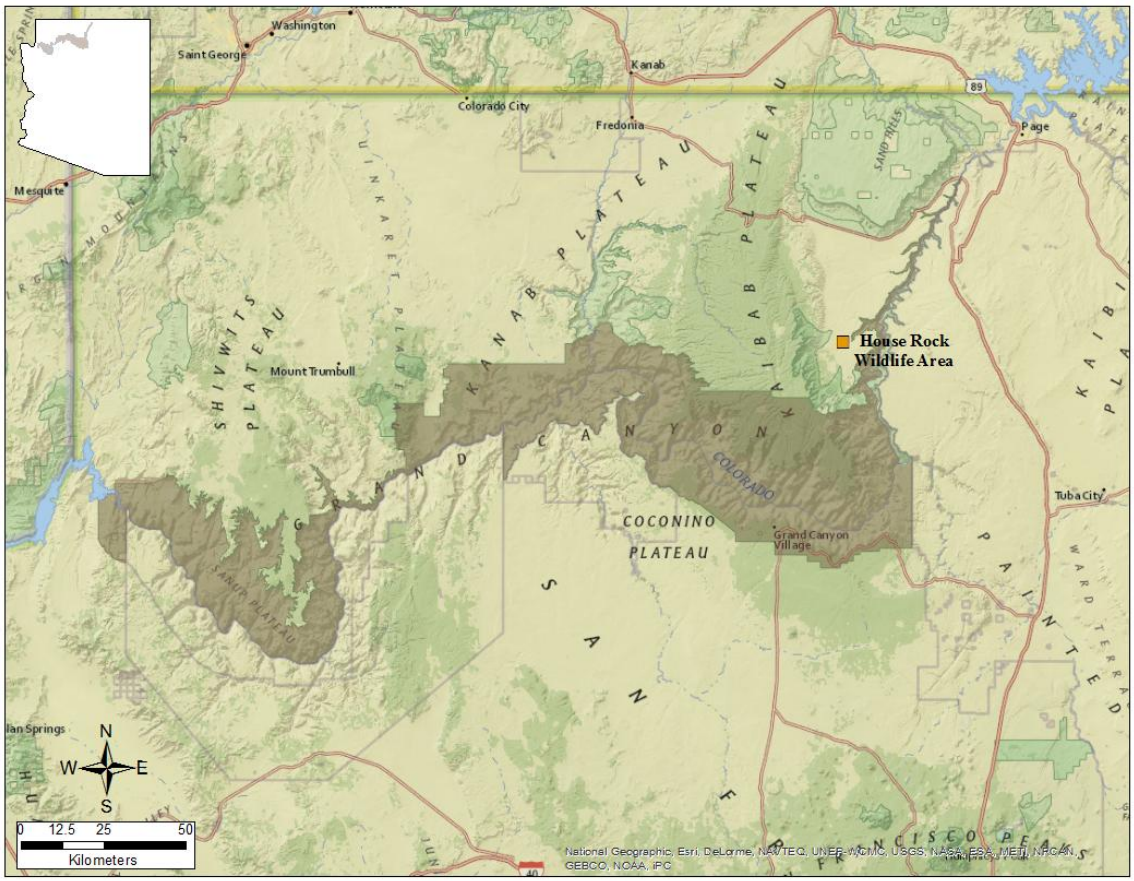

Figure 1. Grand Canyon National Park and the House Rock Valley Wildlife Area, Coconino and Mohave Counties, Arizona.

produce a hardy meat animal (Haines 1975). In 1906 he secured a permit to range bison at a location near Bright Angel Point on the Kaibab Plateau, and Jones and Owens, along with a small group of other investors, formed a cattalo breeding business (Anderson 1998). In 1907 or 1908 the herd was moved from Bright Angel Point to the House Rock Valley. Although hybrids were produced, crossbreeding bison with cattle proved difficult and unprofitable (Haines 1975). The business was abandoned by the mid-1910s, and all investors except "Uncle Jim" Owens backed out, leaving him the sole owner of the bison (Anderson 1998).

During this time, Owens also served as the game warden on the Kaibab Plateau for the Forest Service (Anderson 1998). This position authorized him to exterminate all predators for the protection of livestock and wild game. Capitalizing on his position, Owens offered guided mountain lion hunts, and in later years, he drove the herd of bison up onto the plateau to draw tourists and clients. Owens eventually sold the bison to the State of Arizona in 1926. He left the Arizona Strip in the late 1920s, but not without leaving his mark on the landscape and leaving behind a bison herd that has become the focus of an ongoing wildlife management controversy.

The bison herd remains the property of the State of Arizona. The animals are managed by the Arizona Game and Fish Department (AZGFD), which has held public bison hunts since the 1920s and continues to manage the herd for wildlife viewing and sport-hunting. In 1950 the AZGFD signed a Memorandum of Understanding with the USDA Forest Service, which required the AZGFD to confine the bison to an area designated as the House Rock Wildlife Area (Figure 1; Leslie 2003). Beginning in the mid-1990s, however, individual bison were observed to the south within the boundaries of GRCA. With increasing frequency and in increasing numbers, the bison migrated to the mixed conifer forest and montane meadows of the Kaibab Plateau. At first the animals moved between the plateau and the House Rock Valley, but it now appears that the bison spend most of the year and may be resident on the Kaibab Plateau (Reimondo 2012).

Until recently, quantitative research on the ecological impacts of bison on the Kaibab Plateau did not exist, complicating productive collaboration among agencies and

stakeholders (Reimondo 2012). Wildlife managers at GRCA consider bison to be a nonnative species introduced by humans just over 100 years ago, and Reimondo (2012) documented a significant relationship between the presence of bison and the loss of vegetation cover and decline in plant species composition and abundance. Bison adversely impact springs, ponds, and the associated wetland vegetation (Reimondo 2012) by trampling the ground and creating mud and dust wallows. Additionally, although these animals are managed by the AZGFD as a game species, they cannot be hunted within National Park Service (NPS) boundaries. The predator eradication program that began in 1906 and continued until the 1930s decimated large predator populations in the region, and now sport hunting is the only means to control herd numbers. The end result is that the bison herd continues to expand unchecked, as do the adverse effects of the animals on the landscape.

The AZGFD wants bison to remain in the region since hunting permits bring in revenue (up to $5,500 per permit tag [AZGFD 2013-14 Arizona Hunting Regulations]) and sport-hunting enthusiasts want the experience of hunting a wild bison. The NPS management policies, however, require the mitigation of anthropogenic impacts on natural systems (e.g. the introduction of exotic species), the protection of all native plant and animal species, and the restoration to natural conditions and processes of all damaged resources (National Park Service 2006). If bison are nonnative to the Grand Canyon region, then the NPS mission statement authorizes GRCA managers to seek their removal and restore natural conditions. The assessment that bison are nonnative to the Grand Canyon region is questioned (Wolf 2005), however, because the remains of bison are

documented in both paleontological and archaeological contexts within GRCA, raising concern that the NPS is pursuing the removal of a species that may in fact be native.

There have been several concerted attempts to shed light on the distribution of bison in the Southwest of the United States and Mexico as evidenced in the paleontological, archaeological, historical, and environmental records. Each makes valuable contributions to research on the topic from different perspectives. Mead (2002), Wolff (2013), and Reed (1955) approach the issue geographically by pinpointing evidence of bison in the Grand Canyon region, Arizona, and the greater Southwest, respectively. Truett (1996) employs a pre- and post-Columbian ecosystem comparison to understand what factors may have influenced bison distribution in the Southwest. The general conclusion reached by all is that if bison were present in the Southwest during the Holocene, as the evidence suggests, they were rare and characterized by small, dispersed herds that only ranged into the region intermittently.

The Colorado Plateau is a sizeable "blank spot" on the map of Holocene bison distribution, and this has been attributed, in part, to a simple lack of field research to locate bison remains (Mead 2002). Systematic field research directed towards locating evidence of bison across such an expansive landscape could not guarantee the collection of a quantity and quality of data sufficient to radically change current perceptions of the historical range of bison in the Southwest. Implicating a lack of field research for the paucity of bison remains also misrepresents the quantity of archaeological research that has been conducted throughout the Colorado Plateau, including the Grand Canyon region. Furthermore, discussions of the known archaeofaunal remains from a

zooarchaeological perspective are currently lacking as previous works were historical sketches of the species beginning with Spanish colonial observations (Allen 1974 [1876]; Danz 1997; Dary 1974; Garretson 1938; Hornaday 2002 [1889]) or the presentation of archaeofaunal data in terms of a presence/absence analysis (Mead 2002; Reed 1955).

Herein, I contribute to the understanding of the biogeography of bison in the Southwest and apply what can be gleaned from the zooarchaeological record to the question of whether bison are an exotic or a native species to the southern Colorado Plateau. Applied zooarchaeology, which is the study of paleofaunal and archaeofaunal data sets as they pertain to conservation and restoration issues (Lyman 1996, 2006; Lyman and Cannon 2004; Wolverton and Lyman 2012), can provide a more empirical and deeper temporal perspective on the historical range of species. Presence/absence lists of archaeological bison remains presented as evidence of the existence of bison in the proximal site environment is specious, particularly considering the prolific exchange of trade goods throughout the Southwest that resulted in bison remains found well beyond the species' known primary range. A thorough zooarchaeological evaluation of the available evidence is essential in order to address the potentially complex cultural and natural formation processes that construct the archaeological record.

In order to accomplish this goal, previously reported bison remains from Holocene archaeological faunal assemblages in Arizona, Utah, Colorado, and New Mexico are assessed within a zooarchaeological interpretive framework, which acknowledges the potentially complex history affecting the creation, deposition, preservation, and recovery of archaeofaunal remains. The taphonomic history of

archaeological bison remains found in GRCA is first examined to address concerns that the remains were deposited by natural means and not by humans. This is important to clarify since non-archaeological faunal remains were more likely part of the proximal community, whereas archaeofaunal remains may have been transported by people over remarkably long distances. The site type, number of identified specimens, skeletal parts represented, and age group composition of bison remains from sites across the Four Corners states both inside and outside of known historical bison range are examined, compared, and spatially analyzed in an effort to characterize pre-Columbian Holocene *B. bison* populations in the Grand Canyon region.

CHAPTER 2: APPLIED ZOOARCHAEOLOGY

Applied zooarchaeology concerns the application of paleofaunal and archaeofaunal data sets to issues relevant to conservation biology (Lauwerier and Plug 2004; Lyman 1996, 2006; Lyman and Cannon 2004; Wolverton and Lyman 2012). Adopting the epistemology of historical ecology in its recognition that modern environments are the products of a legacy of human-nature interactions, applied zooarchaeology further explicates how historical data sets enhance ecological research and inform modern wildlife management (Lyman and Cannon 2004). These data sets have potential to illuminate spatial and temporal patterns of interest to wildlife science to determine exotic versus native or recolonizing taxa, understand range shifts or reductions resulting from anthropogenic impacts or environmental change, and identify culturally modified environments and the appropriate ecological reference conditions needed to guide effective resource management decisions to recreate or maintain natural ecosystem structure and function.

Conservation and restoration scientists grapple with what constitutes "natural" or "pristine" in a given environment, and any definition of such is inherently value-laden and driven by prevailing theory, economics, politics, socio-cultural beliefs, and personal opinion (Lyman and Cannon 2004). Environmental laws and regulations explicitly state or otherwise implicitly assume there is a "primeval" state of nature which "generally appears to have been affected primarily by the forces of nature, with the imprints of man's work substantially unnoticeable" (Wilderness Act 1964 Public Law 88-577 Section 2c). A general lack of agreement among policy makers and stakeholders due to

contention over differing values, motivations, and definitions of natural further complicates the matter. Our perceptions of nature are shaped by our experiences, cultural background, and political and economic policies and agendas, and as society changes, so too do our values and conceptions regarding the natural world and humanity's place within it.

The mechanical removal of trout from the confluence of the Little Colorado and Colorado Rivers in the Grand Canyon illustrates the conflict of values and concepts of natural. Rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) are considered invasive species in the Grand Canyon, and they outcompete and predate humpback chub (*Gila cypha*), an endangered fish endemic to the Colorado River Basin (U.S. Fish and Wildlife Service 1990, 2002). Wildlife managers remove trout from the rivers to ensure successful reintroduction of humpback chub. The Pueblo of Zuni expresses grave concern for both the location of the trout removal (the confluence is a sacred site to the Zuni and many other tribes in the region) and the act of killing thousands of fish to aid reintroduction efforts (Dongoske 2009). The Zuni believe in the interconnectedness of all things in the universe, and the bottom of the Grand Canyon and everything that exists there, including invasive species, are sacred and connected to Zuni religious beliefs, ceremonies, and prayers. The balance that must be maintained is for the continued prosperity of all people, and the removal of trout from the confluence "creates a counter-productive energy to the Zuni's ceremonial efforts to ensure rainfall and the prosperity of all life" (2009:2).

Disagreements among agencies and the lay public over management

recommendations for the House Rock Valley bison herd are laden with similar complex challenges. The National Park Service (NPS) is authorized to pursue removal of exotic species (National Park Service 2006), which they consider bison to be. But the State of Arizona owns and gains revenue from the herd (Minard 2003). The bison were introduced prior to the establishment of Grand Canyon National Park (GRCA) with President Theodore Roosevelt's endorsement for the perpetuation of the species at a time in history when bison were nearly hunted to extinction. Furthermore, sport-hunters want bison to hunt, tourists like to see bison when they visit GRCA since the animals are such an iconic species of the American West, and others raise concern over the expenditure of Federal dollars to pursue the removal of a species that may be native.

It is not, of course, within the capacity of applied zooarchaeology to resolve the web of political, social, cultural, and economic variables facing conservation or restoration undertakings. However, with a deeper temporal perspective and interpretive tool-kit for understanding the formation of the prehistoric record, conservation applications of zooarchaeology can facilitate practical management decisions based on all available information. A zooarchaeological perspective is particularly vital in the case of the House Rock Valley bison herd since concerns arose among the lay public upon learning that bison are present in the archaeological record of GRCA (e.g. Wolf 2005). These concerns, however, are based on an assumption that the presence of archaeofaunal remains equates to the natural occurrence of those taxa in the nearby environments. This is not necessarily the case and disregards the inherently complex natural and cultural processes as well as sampling and analytical biases that shape the archaeological record,

which zooarchaeologists are keenly aware of and equipped to interpret.

The accumulation of non-local raw materials, artifacts, animals, and animal products at archaeological sites as a result of economic exchange systems exemplifies the potentially complex cultural processes involved. Trade networks were widespread among indigenous populations in the Southwest, and established trade routes moved goods 800 km or more across the entire region (see Hedquist 2012:Figure 19.2; Riley 1975). Desired animal products included but were not limited to shell from the Gulf of California (Bradley 1993), live scarlet macaws from Chihuahua, Mexico (Minnis et al. 1993), and bison hides from the southern Plains (Creel 1991). Furthermore, people went on long distance hunting trips and traded for animal meat with other regions further accumulating the remains of non-local taxa. If archaeofaunal data sets are utilized to reconstruct pre-Columbian ecosystems, then the processes involved in the construction of faunal assemblages must be explored and properly interpreted.

The goal of any conservation project involves identifying a target set of environmental conditions to restore or maintain in a modern ecosystem. These referenced conditions, also called ecological benchmarks, are based on a specific point in time implied to represent a natural and native local ecosystem. In the United States, the point in time most commonly referenced is the pre-Columbian (Hunter 1996), or the time just prior to European arrival in the Americas, both because there are written historic period records that document North American environments at the onset of European colonization, and because it is industrial-era influences that conservation and restoration scientists seek to mitigate or reverse (Lyman 2006).

Historic documents are typically employed as the primary source of information and the best available proxy for defining the set of environmental conditions sought for the restoration of pre-Columbian-like natural landscapes. In order to understand the distribution of fauna that inhabited an ecosystem, wildlife biologists recreate the geographic ranges of taxa based on observations recorded in various early historic period documents. Relying solely on historic accounts as documentation of "pristine" pre-Columbian landscapes on which to base the establishment of an ecological benchmark may be problematic for a variety of reasons (Denevan 1992; Hunter 1996; Lauwerier and Plug 2004; Lyman and Cannon 2004; Wolverton and Lyman 2012). The historic record may be incomplete (Etnier 2002), biased (Gipson et al. 1998), or an unreliable representation of natural faunal abundance and distribution (Broughton 2004).

A pre-Columbian ecological reference condition also implies that Native Americans had minimal influence on their environments, either because they were too few in number (Sluyter 2001) or because they somehow maintained a harmonious balance with their environments (Krech 1999). This romanticized "noble savage" myth portrays indigenous people as "ecologically aware conservationists" (Krech 1999:123) affecting little environmental change. Yet, a growing amount of research from numerous disciplines indicates people all over the world had significant and lasting influences on their environments, and there is no post-Pleistocene landscape in North America that is unmodified by humans (Crumley 1994; Kay and Simmons 2002; Krech 1999; Redman 1999).

Spanish colonial journals are commonly referenced to determine historical bison

range between the sixteenth and eighteenth centuries. These journals provide invaluable observations of natural and cultural phenomena in general; however, the Grand Canyon was rarely visited by Europeans prior to the nineteenth century. The few observations documented for the southern Colorado Plateau provide relatively little information with which to reconstruct the historical range of taxa. If bison only occasionally ranged into the Grand Canyon region throughout the Holocene, then it is not surprising they were not encountered by Spanish expeditions in the sixteenth and eighteenth centuries, and this is why it is imperative that the temporal scale of analysis be extended farther back in time in the hopes of painting a more complete environmental picture. Nabhan et al. (2004) propose defining a "reference envelope" as opposed to an ecological benchmark to capture the range of variation of conditions in an ecosystem. This seems a particularly useful approach for a region such as the Grand Canyon, which was likely only ever on the margin of historical bison distribution and was only infrequently visited by Europeans prior to the 1800s.

No single source of information on historic ecosystems offers a complete picture, and assembling multiple lines of evidence on a landscape's history allows conclusions to be cross-checked (Crumley 1994). If we attempt to re-create a set of environmental conditions that represent some interpretation of "natural" or "pristine," we must acknowledge what constitutes "natural" in a given environment, and we must address ecosystem dynamics and pre-contact anthropogenic impacts to landscapes if those impacts have bearing on how we interpret that landscape and what we attempt to re-create today (Lyman and Cannon 2004; Wolverton and Lyman 2012). The long-term

temporal perspectives offered by paleontology, dendrochronology, ethnobiology, archaeology, and the many other related disciplines that study the historic and prehistoric records have valuable potential to contribute a multi-disciplinary, comprehensive data set with which to supplement historic-era observations. These disciplines are inherently equipped with knowledge of the evolution and history of ecosystems, climate, human interaction with and influences on plants, animals, and landscapes, and the taphonomic processes that transform the prehistoric record. These data sets can make for better-informed conservation decisions since increasing the depth of time allows researchers to determine if perceived changes are directional, chaotic, or cyclical and whether observed changes in the environment are natural or anthropogenic (Landres 1992).

CHAPTER 3: RESEARCH OBJECTIVES AND METHODS

Objectives

The principal objective of this research is to demonstrate the utility of archaeofaunal data to wildlife management issues in the Grand Canyon region through an examination of the historical distribution of bison using faunal remains recovered from Holocene-aged archaeological sites. The central question addressed is: did historical bison range include the southern Colorado Plateau, and if bison were present, how rare or common were they?

In order to explore this theme and to characterize bison populations available to human hunters, the following sub-questions are discussed in an inter- assemblage comparison between archaeological sites located outside historical bison range and sites located inside historical range (Figure 2):

1. What are the archaeological site types associated with bison remains?
2. How does the relative abundance of bison specimens in archaeofaunal assemblages change across the study region relative to known historical bison range?
3. What skeletal elements of bison are represented in archaeofaunal assemblages?
4. What sexes and age groups of bison are represented in archaeofaunal assemblages?

Methods

No consensus exists on the historical range of *Bison bison* in the Southwest.

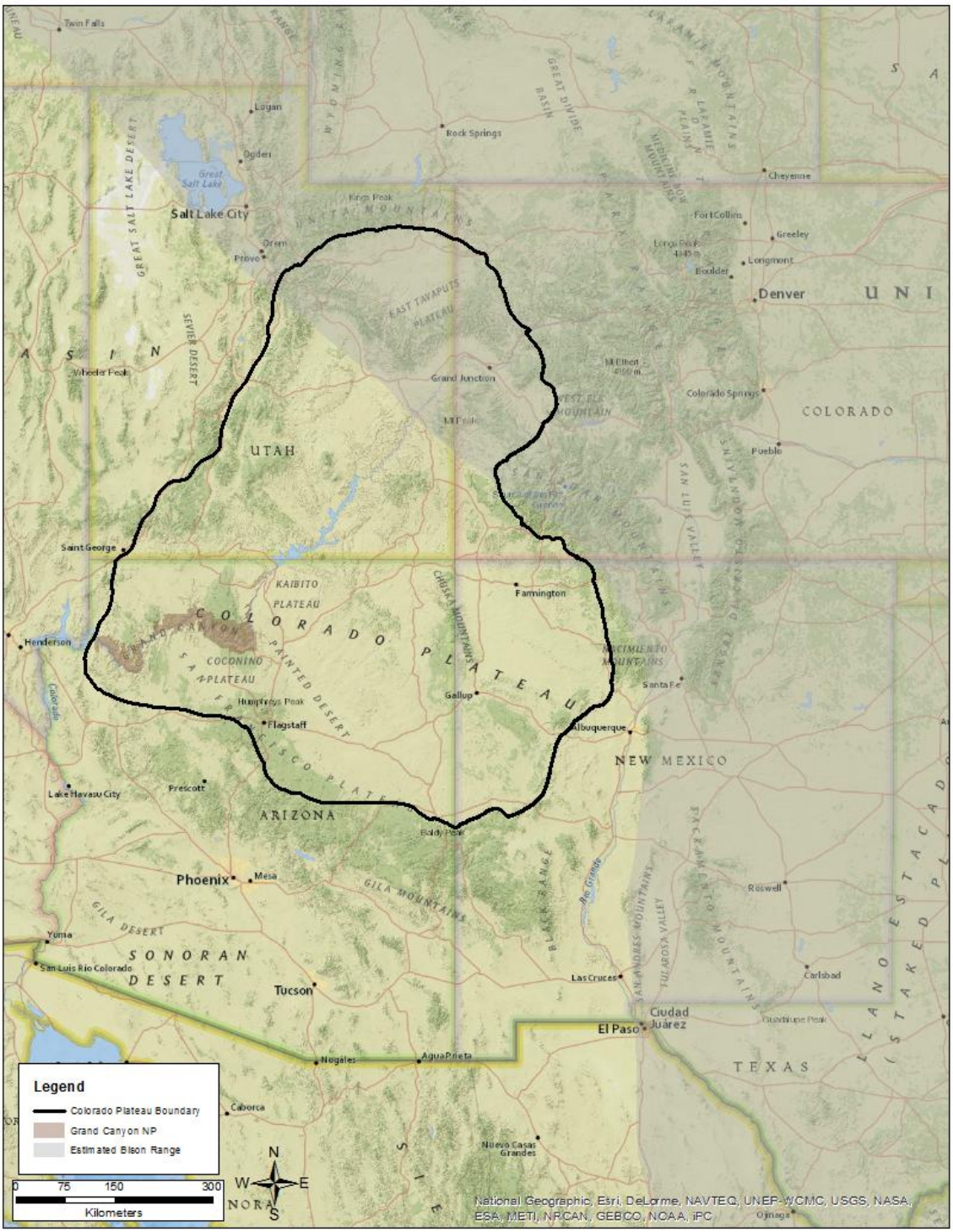

Figure 2. Study region in the southwestern United States and estimated historical range of *B. bison* based on traditionally understood distribution.

Conservative distributions place the western range limits at the Pecos River in New Mexico and exclude the southwest quarter of Colorado, most of Utah (except for the northeast corner), and all of Arizona (McHugh 1972). Other distribution maps include all of New Mexico and Colorado, the northeastern half of Utah, and a small portion of east-central Arizona (Olsen 1960:Figure 1). McDonald (1981:Figure 23) includes the entire southwest within secondary bison range. The historical distribution used in this analysis (Figure 2) is approximated from these various maps and most closely resembles that illustrated in Allen (1974 [1876]).

The archaeological sites discussed here include those with bison remains from Arizona, Utah, Colorado, and New Mexico. Sites are divided for inter-assemblage comparison based upon whether they are located inside or outside traditionally understood historical range of bison (Figure 2). However, since there is no consensus regarding what is in or out of range, particularly for New Mexico, many of the sites included within range in this study may be more accurately characterized as in peripheral range. Teasing out this level of biogeographic precision, however, is beyond the scope addressed here.

Previously reported archaeofaunal data were gathered from published and unpublished sources. No new faunal collections or analyses were performed as part of this study. All archaeological excavation reports housed at Grand Canyon National Park (GRCA) were reviewed, and the GRCA collections database was queried for archaeological bison specimens. Faunal data from GRCA paleontological sites and archaeological and paleontological faunal data from non-GRCA sites were obtained from

published sources. A significant percentage of archaeological reports with bison remains are unpublished or under controlled access and thus inaccessible without visiting every government agency office and curatorial facility in the study region. Consequently, the non-GRCA archaeological sites discussed in this report do not represent every possible site in Arizona, Utah, Colorado, and New Mexico that contain bison remains, and the sample of non-GRCA archaeofaunal assemblages was defined by what was located in the published scientific literature. All reports were researched for site type and provenience of bison remains, number of identified specimens (NISP), skeletal elements represented, and sex and age groups represented.

In addition to a literature search, the Arizona State Museum's FaunAZ database was queried for archaeological bison remains located throughout Arizona. FaunAZ (http://faunaz.asu.edu) is an online database of vertebrate zooarchaeological data, which is populated from the pre-existing online GIS-linked state archaeological site records database known as AZSITE (Pavao-Zuckerman et al. 2011). Although FaunAZ includes nearly 7,000 records of vertebrate archaeofaunal remains documented from over 600 prehistoric and historic sites in Arizona, not all institutions and agencies in Arizona report their findings to the Arizona State Museum. Furthermore, access to archaeological site information on Tribal lands is restricted and requires expressed permission from Tribal Historic Preservation Officers. Therefore, archaeological research for some portions of the state is underrepresented or under restricted access in the database.

Two of the three bison bone elements recovered from archaeological contexts in GRCA were re-examined to confirm provenience information, element type, condition,

and bone surface modifications. The palatine bone fragments (GRCA Catalog #62526) and the metapodial fragment (GRCA Catalog #67556) are housed at the GRCA collections facility at Grand Canyon National Park. The femur fragment recovered from the recent River Corridor Archaeological Project excavations and reported by Spurr and Cannon (2013) is currently kept at the Western Archaeological Conservation Center (WACC) in Tucson. The collection of artifacts and materials from this project is not catalogued, and access to the collection was denied. Non-GRCA faunal remains were not re-examined.

The archaeological site types associated with bison were identified in order to determine the general context of remains and ascertain whether the site type indicates bison existed in habitats near the site location. Sites were categorized as bison artifact cache, bison kill/carcass processing location, or habitation. Archaeological bison kill/carcass processing sites are expected within bison range since hunters would not transport such a large animal in its entirety far from the kill site. These sites serve as good indicators that bison lived in the nearby environment. Bison artifact caches are anticipated to occur inside or outside historical bison range since these types of specimens could have been traded with other regions far from the cache location. Items found in caches might include hide, bone tools, horns, items of adornment, etc. that were easily transported because of their small size or light weight. Lastly, habitation sites with bison remains are expected to be located throughout the Southwest, but NISP, the skeletal elements represented, and the sex and age groups represented are predicted to vary relative to the site's location inside, on the margins of, or outside historical range.

NISP is used to assess the relative abundance of bison remains in archaeological site assemblages and determine whether the relative abundance changes across the study region. Only habitation sites are used to assess comparative relative abundance since these site types are comparable with Grand Canyon sites and most archaeological sites with bison remains. The NISP for *Bison bison*, *Bison* sp., and *Bison*/*Bos* are all included and lumped together since some reports do not elucidate the taxonomic level determined when discussing bison finds. The presence of bison remains at habitation sites does not necessarily mean bison lived in the site environment since people were capable of pursuing game across long distances and exchanged animal meat and goods with groups in other regions. However, the relative abundance of bison specimens is expected to be highest for sites within bison range where the animal could be hunted a short distance from the habitation site, and relative abundance is expected to be lowest for sites outside bison range where bison goods were either obtained through trade or the animals were hunted at significant distances from the habitation site.

NISP is simply the count of specimens, representing fragmentary or whole skeletal parts, in a faunal assemblage (Reitz and Wing 2008). The Minimum Number of Individuals (MNI), another common quantification method, represents the estimated minimum number of individual animals of a particular taxon required to account for the most frequently occurring skeletal element. NISP is used in this study for inter-assemblage comparisons of abundance since it is the most commonly reported quantitative measure. Moreover, although NISP is influenced by several biases, it is a primary observation of measure of abundance in faunal assemblages, whereas MNI is a

derived measure subject to analytical bias in the way that the faunal assemblage is aggregated by the analyst (Grayson 1984).

The skeletal elements represented in the archaeofaunal assemblages is used to infer distance between kill/processing sites and the final location of deposition, in this case, habitation sites. The representation of skeletal elements in an assemblage is affected by various factors including but not limited to carcass transportation decisions between kill/processing site and habitation site (Binford 1978, 1981; O'Connell et al. 1988, 1990), butchering, preparation, disposal, exchange of animal products, ritual significance of animals or portions of animals, and various non-cultural biotic and abiotic taphonomic mechanisms (Lyman 1994; Reitz and Wing 2008). A high degree of skeletal completeness may indicate the animal was killed nearby, part of the proximal environment, or intentionally buried complete (e.g. a pet or ritual offering), while a low degree of skeletal completeness may indicate an animal killed some distance from habitation site, extensively butchered or processed, or a species with desired raw materials or ritually significant portions that were traded with other groups (Reitz and Wing 2008). It is expected that sites located within bison range will have a high degree of skeletal completeness since, if bison were available in the vicinity, more of the carcass would be transported back to the habitation site. Sites located outside of bison range are anticipated to have a low degree of skeletal completeness since the remains may represent long distance trade goods or bison hunted at a great distance from the habitation site.

The sexes and age groups represented in the assemblages are used to characterize

the types of bison herds available to human hunters. Anatomical indicators of age include the degree of epiphyseal fusion, cranial suture closure, dentition, antler horn development and size, and specimen form and porosity (Reitz and Wing 2008). Those indicating sex include size, secondary sexual characteristics, and distinctive morphological features. Not all specimens provide information on age and sex (sexually diagnostic features are uncommon), and assemblages characterized by a high percentage of highly fragmented specimens may provide very little demographic data.

Demographic data may reveal what types of bison groups were exploited by human hunters, and therefore whether the habitation site was near to or distant from breeding populations. Sites located within breeding populations of bison are expected to have various age groups and both sexes represented. Conversely, sites located outside the distribution of breeding populations may have only adults and mostly males represented. Since mature bull groups and solitary bulls range farther than do mixed or matriarchal herds (Allen 1974 [1876]; Hanson 1984), bulls may have occasionally traveled beyond traditional range limits and become intermittently available to human hunters outside typical bison range.

The study presented here is only a spatial analysis of archaeological bison remains. Analysis of temporal change requires chronological and provenience controls correlated with faunal quantifications. Ensuring that the presence/absence and changes in abundance of bison remains correlates with actual biogeographic range shifts, and not shifting human settlement patterns or field and analytical biases, would be exceptionally difficult for such a large study area. Moreover, these data are often unavailable from early

archaeological excavation projects, and this is particularly troublesome for sites, such as those along the Rio Grande in New Mexico, that were occupied for centuries spanning the Formative period through Historic times.

It is likely that more bison specimens are currently unidentified or misidentified in collections from archaeological sites in the Grand Canyon region. Many early project faunal collections remain unanalyzed, and modern-day projects do not always have funding to conduct faunal analyses. Furthermore, bison remains are sometimes overlooked or misidentified as domestic cattle (*Bos taurus*) if the faunal analyst did not consider the potential for bison remains in the assemblage.

Bison and domestic cattle are difficult to differentiate skeletally, and entire manuals have been written to distinguish the two (e.g. Brown and Gustafson 1979; Lawrence 1951a; Olsen 1960). A combination of skeletal element characteristics is needed to confidently differentiate between *Bison* and *Bos* (Lawrence 1951a; Olsen 1960). Articular surfaces, the shape and outline of epiphyseal muscle scars, and proportional measurements are considered diagnostic of species, whereas overall size, rugosity of ridges, and prominence of muscle attachments can vary individually in the same species relative to age or sex (Olsen 1960). Further, there are two recognized subspecies of bison in North America, the wood bison (*Bison bison athabascae*; Rhoads 1897) and the plains bison (*Bison bison bison*; Linnaeus 1758). Although the wood bison is known to grow to a larger size than the plains sub-species (Allen 1974 [1876]; Ogilvie 1893; Seton 1886), an osteological study aiding differentiation of the two in fragmentary assemblages is not available, and Olsen (1960) states it is doubtful the two sub-species

could be differentiated skeletally.

A reanalysis of specimens identified as indeterminate artiodactyl, indeterminate ungulate, and *Bison/Bos* is warranted, but beyond the scope of the study reported here. Future zooarchaeological research on old and newly collected assemblages should consider the potential for bison remains in faunal assemblages throughout the Southwest either as native species or as exotic trade goods. This is likely to provide additional information with which to illuminate the bison biogeography beyond traditionally understood range limits.

CHAPTER 4: ENVIRONMENTAL SETTING

The Grand Canyon is located on the southwestern edge of the Colorado Plateau, which is the physiographic province covering approximately 340,000 km^2 of the Southwest's Four Corners region bounded by the Great Basin to the west, the Rocky Mountains to the east, the Mogollon Rim to the south, and the southern flank of the Uinta Mountains to the north (Figure 2; Grahame and Sisk 2002). Grand Canyon National Park (GRCA) protects over 1.2 million acres of the southern Colorado Plateau and 277 Colorado River miles within northern Arizona. The park is a diverse landscape with ecosystems that range in elevation from 365 m along the Colorado River to 2,793 m on the Kaibab Plateau of the North Rim. Two billion years of Earth's geological history is exposed in the canyon walls, and 30,000 years of the canyon's biological history is preserved in caves, archaeological sites, and animal middens in the form of bone, keratinous elements, dung, and botanical remains.

The physical environment exerts a strong influence over human settlement and subsistence patterns and determines the depositional environment and preservation quality of paleontological and archaeological remains. A brief review of the geology, ecology, and climate is presented below in order to establish the environmental backdrop of human activities and the contexts of deposition.

Geology

The geology exposed in the Grand Canyon is one of the region's most spectacular features. The earliest exposed strata formed during the Precambrian Era and constitute

the metamorphic and tilted sedimentary rocks of the inner gorge (Abbott and Cook 2004). The overlying geologic layers were deposited during the Paleozoic Era and are represented by horizontal sandstones, limestones, shales, siltstones, and mudstones formed from ancient deserts, beaches, swamps, and seas. These various sedimentary deposits and their differential permeability and erosion create an arid and rugged landscape interspersed with springs, sinkholes, tinajas, and caverns.

The Kaibab Limestone, which forms the land surface of the South Rim and the Kaibab Plateau of the North Rim, is highly permeable. Despite receiving abundant annual rain and snow fall, the rims of the Grand Canyon retain surface water only in sediment-filled drainages or sink holes created from collapsed underground karst features. The water that falls on the remaining Kaibab Limestone surface percolates down through permeable sedimentary strata until reaching an impermeable contact. Water then flows down slope until emerging from exposed surfaces as gentle seeps, small springs, or strong rivers gushing from cliff walls.

The solubility of various layers also creates solution caverns in which are found the remains of extinct and extant species of flora and fauna as well as material evidence of human presence in the Grand Canyon. The Redwall Limestone, which forms a 150- to 250-m cliff, contains numerous solution caverns. Many cave localities in the region, including Rampart and Stanton's Caves, have received intensive study (e.g. Carpenter 2003; Cole and Mead 1981; deSaussure 1956; Emslie 1988; Euler 1984; Harrington 1972; Iberall 1972; Martin et al. 1961; Mead and Phillips 1981; Mead et al. 2003; Miller 1960; Parmalee 1969; Phillips and Van Devender 1974; Wilson 1942), and species such

as extinct mountain goat (*Oreamnos harringtoni*), ground sloth (*Northrotheriops shastensis*), camel (*Camelops* sp.), condor (*Gymnogyps californianus*), bison (*Bison* sp.), and many others have been documented (Mead 1981). These caves are also well known for deposits of split-twig figurines, which are effigies of ungulates such as deer or mountain sheep placed by people during the Late Archaic time period, possibly as religious offerings associated with hunting practices (Emslie et al. 1995; Emslie et al. 1987; Euler and Olsen 1965; Schroedl 1977).

Ecology

The Grand Canyon is an ecologically diverse landscape consisting of five of the seven Merriam life zones (Merriam and Steineger 1890), and more than 500 faunal and 2,000 floral species live within the canyon's ecosystems. Some of these species are endemic to Grand Canyon National Park, and many others are listed as endangered, threatened, or species of special concern (see United States Department of the Interior 66 FR 54808, 50 CFR 17.11-17.12, AGFD 2003). Native large mammals, such as black bear (*Ursus americanus*), mountain lion (*Puma concolor*), bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*), have been adversely impacted since the arrival of Europeans, the introduction of domestic livestock, and the implementation of some early wildlife management policies such as the predator eradication program of the early 1900s. Other large mammals, such as the American bison (*Bison bison*), burro (*Equus asinus*), and Rocky Mountain elk (*Cervus elaphus nelsoni*) were introduced historically to the Grand Canyon National Park and neighboring regions. Burros were used by prospectors in the late nineteenth century, and many of

these animals either escaped or were abandoned. Arizona's native Merriam's elk (*Cervus elaphus merriami*) is believed to have been extirpated from its range in the White Mountains by the 1920s (Hoffmeister 1986). Rocky Mountain elk (*C. e. nelsoni*) were transplanted to the Sitgreaves National Forest as early as 1913, and elk now occupy the South Rim of GRCA well beyond the known former distribution.

The resident herd of bison on the eastern Arizona Strip was historically introduced as part of Owens' and Jones' cattalo ranching operation; however, there is evidence that extinct and extant species of bison inhabited the Southwest, at least intermittently, since the Pleistocene (McDonald 1981). There is well-documented evidence of bison in the Grand Canyon region during the late Pleistocene (Agenbroad and Haynes 1975; Emslie 1987; Harington 1984; Mead 2002; Mead and Agenbroad 1992) and sparse evidence exists in archaeological sites from the Holocene (LaMotta 2006; McGregor 1941; Spurr and Cannon 2013; Yoshikawa 1986). Fossil remains of bison in North America are documented from up to approximately 570,000 B.P (Mead et al. 2006), and bison represented one of the most common large herbivores for most of the last 100,000 years (Feldhamer et al. 2003).

The evolutionary history of bison is not well-understood or agreed upon, but it has been suggested that *B. priscus* was the first bison to enter the New World across Beringia (Meagher and Meyer 2007). *B. latrifons* evolved from *B. priscus*, and the two species occupied different latitudes of North American until *B. latrifons* went extinct 22,000 B.P. *B. antiquus* then appears as the dominant species until its extinction 10,000 B.P. (Lott 2002). *B. occidentalis*, a possible evolutionary offshoot of *B. priscus*, appears after

10,000 B.P. and persists until approximately 5,000 B.P. when modern *B. bison* appear.

Bison barely survived the megafuana extinctions at the end of the Pleistocene in North America, which resulted in a population crash and reduction in distribution after about 11,000 B.P (Mead and Agenbroad 1992). Populations rebounded after 9,000 B.P (Mead and Agenbroad 1992), and the two modern sub-species (*B. b. bison* and *B. b. athabascae*) that evolved during the Holocene are now the largest terrestrial mammals on the continent. Wood bison (*B. b. athabascae*) are larger than plains bison (*B. b. bison*; Allen 1974 [1876]; Ogilvie 1893; Seton 1886), and body weight and measurements differ considerably between sexes and among different localities (Feldhamer et al. 2003). Males are larger in both sub-species and have a larger hump, thicker neck, and thicker horns than females. Adults can range in weight between 350 and 1,000 kg (Nowak 1991).

On average, bison move approximately 3 km throughout the day (Banfield 1974), and formerly, herds migrated seasonally several hundred kilometers between summer and winter ranges (Nowak 1991). The average seasonal range of bison herds has been estimated at 30 sq km in summer and 100 sq km in winter (Banfield 1974). A single herd represents a small group of probably related individuals, but during migrations, breeding seasons, or on favorable feeding grounds, multiple small herds may aggregate into herds of many hundreds or thousands of individuals (Nowak 1991).

Bison form three types of social groups over the course of a year (Feldhamer et al. 2003). These are matriarchal groups (consisting of cows, calves, yearlings, and occasionally older bulls), mature bull groups, and breeding groups (mixed matriarchal and bull groups). Bull groups are more mobile than mixed herds (Hanson 1984), and

bulls rarely form groups consisting of more than a few animals (Feldhamer et al. 2003). Solitary bulls are common, even during rutting season, and older bulls, in particular, may leave herds and roam as stragglers (Allen 1974 [1876]). Pregnant cows also wander away from the herd for 1-2 days immediately prior to parturition (Feldhamer et al. 2003). Individuals are documented to travel beyond customary range, and during McHugh's (1972) study, he observed three bulls from Yellowstone 45 miles south of traditional range. If bison were not year-round residents of the southern Colorado Plateau, these behaviors may account for the sparse and occasional occurrences of bison in the archaeological record.

Climate

The Colorado Plateau climate is generally classified as arid to semi-arid, and precipitation in Arizona is bimodal, occurring during the warmest and coolest portions of the year (Horn et al. 1957; Smith 1956). The unique geographic position of the Colorado Plateau, located at the interior boundaries of two sources of atmospheric moisture, makes the region more susceptible to extreme climate fluctuations than other arid regions nearby (Schwinning et al. 2008). Shifting climatic boundaries controlled by complex atmospheric conditions cause dramatic fluctuations in the abundance of summer and winter precipitation with multi-decadal deviations from the climatic mean (Dean 1988; Dean and Robinson 1977, 1978, 1979; Rose 1989). Precipitation and temperature also vary considerably with elevation and the nearly 2,500 m elevation gradient and complex topography of the Grand Canyon further contribute to highly variable annual precipitation and average temperature ranges by creating different microclimates within a

relatively small geographic area.

The archaeological record indicates that human occupation on the Colorado Plateau was discontinuous and variable in intensity. Holocene climatic variability is frequently cited to have contributed to both interruptions in and intensification of human settlement (Axtell et al. 2002; Coltrain and Leavitt 2002; Dean et al. 1985; Gumerman 1988; Larsen and Michaelsen 1990). One noteworthy period of drought identified in dendroclimatic reconstructions of the Southwest occurred sometime between A.D. 1275 and 1299 and coincides with the abandonment of sites throughout the Four Corners region (Dean 2012). As the next chapter illustrates, gaps in the archaeological record of the Southwest may be attributable, in part, to inhospitable climates, which resulted in either regional abandonments or significant shifts in residential and subsistence patterns.

CHAPTER 5: CULTURAL AND HISTORICAL SETTING

Humans have occupied the Grand Canyon region for at least the last 12,000 years, but much remains unknown about significant portions of that time. These knowledge gaps are due to several factors including a paucity of identified cultural remains from certain time periods, the challenging terrain and remoteness of the Grand Canyon that hinders field research, and the National Park Service policy of preservation rather than the excavation of cultural resources that are not in danger of destruction by natural or anthropogenic disturbances. Despite these obstacles, numerous archaeological pedestrian surveys and excavations have been undertaken and thousands of archaeological sites have been recorded. This work, in conjunction with abundant archaeological and paleoenvironmental research from throughout the region, allows archaeologists to piece together a narrative about human history in the Grand Canyon, albeit one that is still incomplete.

Culture history of the Grand Canyon region is divided into seven temporal periods. These are the Paleoinidan (ca. 10000-8000 B.C.), the Archaic (ca. 8000-1000 B.C.), the Preformative (1000 B.C. - A.D. 400), the Formative (A.D. 400-1250), the late Prehistoric (A.D. 1250-1540), the Protohistoric (A.D. 1540-1776), and the Historic (A.D. 1776-1960s). Following the lead of previous discussions of Grand Canyon culture history (Ahlstrom et al. 1993; Fairley 1989, 2003), a framework of generic temporal divisions, or lifeways (Ahlstrom et al. 1993), is employed instead of the Pecos Classification (i.e. Basketmaker II-III and Pueblo I-V), which applies specifically to the region's Ancestral Puebloan cultures. This is to avoid the implication of the existence of a single,

homogenous cultural group and to acknowledge the other cultures that existed contemporaneously with Ancestral Puebloans in the Grand Canyon region.

Paleoindian Period (ca. 10000-8000 B.C.)

The Paleoindian period represents the earliest known human occupation of North America. Archaeologists actually know very little about this time period as scant diagnostic evidence exists to illuminate who these people were and how they lived. What is known is that the people who lived during the Pleistocene Epoch were mobile hunters and gatherers that produced well-made lithic projectile points suitable for hunting Rancholabrean megafauna such as mammoth, mastodon, and bison. In fact, most Paleoindian period finds are comprised of isolated projectile points, and although more substantial sites do exist, they are rare. Such sites in Arizona (e.g. Murray Springs [Haynes and Huckell 2007], Naco [Haury et al. 1953], and Lehner [Haury et al. 1959]) have Paleoindian projectile points in direct association with mammoth and bison remains. The degree to which Paleoindian people focused on hunting megafuana is debatable (Cannon and Meltzer 2004; Grayson and Meltzer 2002; Haynes 2002; Kelly and Todd 1988; Meltzer 1993, 2002, 2004). However, other smaller animal and plant resources undoubtedly contributed to the diet as well (e.g. Ferring and Ellias 2001; McNett 1985; Yates and Lundelius 2001).

In the greater Grand Canyon region, evidence from the Paleoindian period is similarly scant and also principally limited to isolated projectile points. Clovis, Folsum, and other Paleoindian–era points were found from numerous localities in northern Arizona and neighboring states, but only two projectile points were found within Grand

Canyon National Park (Hollenshead 2007). Although Pleistocene large mammal remains (e.g. *Bison* sp. [bison], *Oreamnos harringtoni* [Harington's mountain goat], *Equus* sp. [horse], *Camelops* sp. [camel], and *Nothrotherium shastense* [Shasta ground sloth) were identified from several cave localities in the Grand Canyon region (Carpenter 2003; Cole and Mead 1981; Emslie 1988; Euler 1984; Harrington 1972; Mead 1981, 1983; Mead and Phillips 1981; Mead et al. 2003; Wilson 1942), none bear evidence that they were killed, butchered, or otherwise used in any way by humans.

Archaic Period (ca. 8000-1000 B.C.)

The Archaic period is the 7,000 years following the end of the Pleistocene Epoch and preceding the introduction of horticulture on the Colorado Plateau. The extinction of Pleistocene megafuana and the drier and warmer Holocene climate required a shift in human subsistence strategies and consequently in residential patterns (Fairly 2003). Archaic people continued the hunting and gathering lifestyle, but they moved between seasonal resource procurement areas to exploit a diversity of available wild plants and animals. Subsequent technological changes included modified projectile point morphology, lithic grinding implements for processing wild plant resources, and the creation of textiles and basketry.

The Archaic is sub-divided into Early (8000-5000 B.C.), Middle (5000-3000 B.C.), and Late (3000-1000 B.C.) periods. Very little evidence exists for a human presence in the Grand Canyon during the Archaic (Fairly 2003). Early Archaic sites in Glen Canyon and southeastern Utah indicate foraging activities were organized around repeatedly reused residential base camps (Geib 1996:31). The Middle Archaic is

generally interpreted as a time of low population density across the entire Colorado Plateau because few sites dating to this time period have been identified (Fairly 2003). The reason behind the apparent lack of Middle Archaic sites is debated. Some argue that the Colorado Plateau was abandoned during this time, perhaps due to regional climate change (Berry and Berry 1986), while others claim a hotter and drier climate than previous or subsequent periods (Benedict 1979) resulted in altered settlement and subsistence strategies whose signatures are difficult to identify archaeologically (Fairley 1989; Geib 1996; Schroedl 1988). Evidence from the Late Archaic is more substantial. In the Grand Canyon this evidence is primarily limited to split-twig figurines, which were placed under deliberately constructed cairns of rock or slabs of indurated pack-rat midden within at least 12 separate caves (Emslie et al. 1987; Euler 1984; Euler and Olsen 1965; Schroedl 1977; Schwartz 1989). Data from which to infer settlement and subsistence practices, social organization, and systems of exchange of the Late Archaic in the Grand Canyon region, however, are still lacking (Fairly 2003).

Preformative Period (ca. 1000 B.C.-A.D. 400)

The Preformative period marks the earliest evidence of cultigens on the southern Colorado Plateau (Gilpin 1994; Smiley 1994, 2002). To what degree people initially incorporated cultigens into their subsistence strategy is currently undetermined, but by 500 to 300 B.C., maize (*Zea mays*) appears as a significant food source supplementing wild plant and animal foraging. This led to increased sedentism and the construction of more substantial habitation and storage structures (Berg et al. 2003; Fairley 1989; Talbot 1990). Technological developments include the use of slab and basin metates with one-

handed manos, sandals, baskets, and stemmed and notched dart points.

This time period is one of the least known in the Grand Canyon. Although Preformative features have been identified and directly radiocarbon dated to this time, no diagnostic artifacts in direct association with these features have been found to infer cultural affiliation (Fairly 2003).

Formative Period (ca. A.D. 400-1250)

During the Formative period reliance on agriculture intensified, ceramic technology developed, and people employed a semi-sedentary settlement strategy to accommodate a mixed horticultural foraging regime (Fairly 2003). Other technological and residential developments included the use of trough metates with two-handed manos, the bow and arrow, slab-lined storage features, and slab-lined pithouses (Heid 1982; McFadden 2000; Thompson and Thompson 1978) as well as large multi-room masonry pueblos with abundant agricultural terraces and garden plots (Fairley 1989). People grew maize, beans (*Phaseolus* sp.), squash (*Curcurbita* sp.), and cotton (*Gossypium* sp.) while continuing to gather wild plants and hunt game. Zooarchaeological research from across the Southwest shows that people during this time hunted both large and small animals. In the greater Grand Canyon region, this included bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*), while smaller game included jackrabbits (*Lepus* sp.), cottontails (*Sylvilagus* sp.), and large rodents such as prairie dogs (*Cynomys* sp).

The cultural traditions present during this time in the Grand Canyon region include the Cohonina, the Virgin Ancestral Puebloan, and the Kayenta Ancestral

Puebloan. These cultural traditions are characterized by archaeologists based on differences in ceramic and lithic technologies, settlement and subsistence patterns, and architectural styles. Archaeological sites of these cultural traditions are located throughout the Arizona Strip, South Rim, along the Colorado River and its tributaries, and in travel corridors throughout the canyon. These sites include resource procurement and processing areas, rock art panels, short term habitations such as small camps and fieldhouses, and long-term habitations.

The Cohonina occupied the Coconino Plateau south of the Colorado River from the Grand Wash Cliffs to the Sunset Crater region north of the San Francisco Peaks from ca. A.D. 700-1100 (Ahlstrom 1986; Cartledge 1979; Euler 1967; McGregor 1951). The Cohonina were originally defined by Hargrave (1938) as a semi-sedentary culture, living in dispersed pithouse communities (Moffitt et al. 1998:19) distinguished from other Formative cultures by San Francisco Mountain Gray Ware ceramic types manufactured using paddle-and-anvil technology (Hargrave 1938).

The Virgin Ancestral Puebloan occupied the region north of the Colorado River from modern-day southern Nevada (e.g. Walling et al. 1986) to the Paria River and Kaiparowits Plateau of Utah (Geib et al. 2001), while the Kayenta Ancestral Puebloan occupied the region north of the Little Colorado River from the eastern edge of the Virgin territory and east to Chinle Wash (Fairley 1989). Puebloan people first entered the Grand Canyon region ca. A.D. 700-800 (Effland et al 1981; Euler 1967), and population numbers gradually increased during the subsequent three centuries (Effland et al. 1981). Kayenta Ancestral Puebloans expanded into the Grand Canyon around A.D. 900-1000,

increasing Puebloan population and site density between A.D. 1000 and 1150.

Most Puebloan sites in the Grand Canyon region were vacated by A.D. 1150, and by A.D. 1200 Ancestral Puebloan occupation appears to have ended (Fairley 2003; Fairly et al. 1994; Jones 1986; Schwartz 1989). Attributing population expansion and subsequent decline of this period to climate fluctuations, Euler (1974) and Euler et al. (1979) suggested that climatic changes towards the end of the Formative period no longer favored occupation of the region. This idea is supported throughout northern Arizona by tree ring data showing increased rainfall with less annual variability between late-A.D. 1000 and early-A.D. 1100 (Dean 1988; Euler et al. 1979) followed by several periods of sustained drought conditions with increased climatic variability between the late tenth and mid-thirteenth centuries and culminating in the occurrence of the Great Drought sometime between A.D. 1275 and 1299 that coincides with the abandonment of sites throughout the Four Corners area (Dean 2012).

Late Prehistoric Period (A.D. 1250-1540)

The Formative period closes with the migration of Ancestral Puebloans out of the Grand Canyon region, and the Late Prehistoric period begins with the first appearance of ancestral Pai (modern-day Havasupai and Hualapai) and Southern Paiute ceramic and lithic projectile point types (Fairly 2003). Whether the Pai and Southern Paiute are descendents of the Cohonina and Virgin Anasazi or whether they are more recent, unrelated immigrants to the region is a matter of continuing debate among archaeologists and Southern Paiute and Pai cultural scholars (see Fairley 2003 for discussion).

Ethnographic accounts document the Kaibab Paiute (Kelly 1964), Havasupai

(Spier 1928), and Hualapai (Kroeber 1935) moved seasonally throughout their territories located north and south of the Colorado River to exploit wild plants and animals and to cultivate small garden plots. To what degree this settlement-subsistence strategy observed in the early 20th century was shaped by European colonial impacts is currently undetermined and more research is required.

At the close of the Formative period, the descendents of the Ancestral Puebloans, modern-day Hopi and Zuni people, came to reside in regions to the south and east. The Hopi moved south, eventually settling on the Hopi Mesas in Arizona. The Zuni migrated east along the Little Colorado River into what is now western New Mexico. After migrating out of the Grand Canyon, both groups maintained traditional ties to the canyon, as they still do today. Among these shared traditions is the belief that they emerged into this world from the sacred Sipapuni, a mineral spring located near the confluence of the Little Colorado River and the Colorado River (Ferguson and Hart 1985; Pearson 2008). Other significant ties include the Hopi collection of sacred salt from the Hopi Salt Mine west of the confluence and the Zuni pilgrimages to collect important plants for ceremonial use that can only be obtained from the canyon.

Protohistoric Period (A.D. 1540-1776)

The first Europeans known to have glimpsed the Grand Canyon were members of the Coronado expedition of 1540 (Anderson 1998), and this event marks the beginning of the Protohistoric period in the Grand Canyon region. Francisco Vásquez de Coronado, in the quest to locate the fabled cities of gold reputed to lie north of Mexico City, traveled from Compostela, Mexico, north towards the Zuni Pueblo of Hawikuh. Guided by

Marcos de Niza, who reported the Zuni Pueblo as the location of the first of such cities, they traveled with Spanish cavalry, infantry, Indian auxiliaries, and thousands of cattle, sheep, and horses to support the enormous undertaking and claim Cíbola for New Spain.

Arriving at the pueblos of Zuni and having found nothing of value to the Spanish empire, Coronado ordered a westward expedition, led by Pedro de Tovar, based on information provided by the Zuni of greater riches further west (Anderson 1998). Tovar arrived at Hopi to find nothing but reports of a great river even farther to the west. Hoping this river could provide passage to the Gulf of California, Coronado sent a second expedition, this time led by García López de Cárdenas, to locate the river and assess its feasibility as a navigable waterway. Hopi guides led the Cárdenas expedition to the South Rim of the Grand Canyon in September of 1540, but upon assessing the canyon's depths and impenetrability, they returned convinced that this region served them no purpose other than as a impediment to further exploration.

More than two centuries passed between the Coronado expedition of 1540 and the arrival of Fathers Garcés, Domínguez, and Escalante to the North and South Rims of the Grand Canyon in 1776. During this time, there is no record of Spanish activity in the region of the Grand Canyon (Pearson 2008). The Kaibab Paiute, Havasupai, Hualapai, Hopi, and Zuni likely continued to occupy or visit the Grand Canyon in much the same manner as they did in preceding centuries prior to ephemeral Spanish contacts. The Navajo also possibly arrived in the region east of the Grand Canyon during this time; however Navajo occupation of the Grand Canyon region prior to the 1800s is uncertain and debated (Fairly 2003). Historically, they came to occupy much of the Four Corners

region that was once used by the Kayenta Ancestral Puebloan people and utilized resources on the eastern edges of the Park as they continue to do today.

Historical Period (A.D. 1776-1960s)

In efforts to tie together the northern boundaries of the Spanish empire, more than two centuries after Coronado journeyed through the Southwest, two expeditions attempted to identify overland routes linking the Spanish capitol of Santa Fe to the newly established settlement of Alta California (Anderson 1998). The Historic period as defined here begins with these first significant explorations of the Grand Canyon region in 1776. These include the expeditions of Father Tomás Garcés and Fathers Francisco Atanasio Domínguez and Silvestre Vélez de Escalante.

Franciscan missionary and explorer, Father Tomás Garcés, embarked on a solo expedition from the lower Colorado River to the Hopi pueblos (Coues 1900). Garcés' journal documents his journey, which began at the Mohave villages along the western segment of the Moqui Trail and proceeded east through Hualapai lands, the Havasupai village of Supai in Havasu Canyon, and the south rim of the Grand Canyon en-route to Oraibi.

In the same year, Franciscan priests Francisco Atanasio Domínguez and Silvestre Vélez de Escalante, accompanied by eight men from Santa Fe, attempted to find a route beginning in Santa Fe and traveling north and west through modern-day Colorado and Utah towards the Spanish missions in California (Warner 1995). Domínguez and Escalante had to turn back before reaching California due to the approaching winter, however, and they returned to Santa Fe by skirting the North Rim of the Grand Canyon

and the Vermilion Cliffs. In searching for a place to cross the Colorado River, theirs become the first documented European exploration of the rugged region immediately north of the Grand Canyon.

Despite these efforts, New Spain never fully achieved the colonization it sought along its northern frontier despite nearly three hundred years of ambitious Spanish exploration, and in 1821 the Mexican War of Independence ended Spanish control (Anderson 2000). Twenty-seven years later in 1848, the Treaty of Guadalupe Hidalgo was ratified, and Mexico ceded its northern territories to the United States. These events opened the Southwest to American colonists and various independent and commercial interests. As people descended upon the region seeking the economic potential of the West, federal explorers, surveyors, and military staked out transportation corridors, identified natural resources, and displaced Native people in the wake of Manifest Destiny. Expanding railroad lines accelerated settlement linking people and goods with the growing West.

It became apparent in time that the West would fall victim to the same unrestricted urbanization, capitalism, and industrialization that affected the eastern states if America did not develop a sense of social responsibility (Anderson 2000). Markets for fur, hide, and meat, for example, fueled the reckless slaughter of millions of animals across the continent. The American bison, for one, was nearly driven to extinction as hunters killed the animal chiefly for its hide, tongue, or prized hump meat or oftentimes merely for sport, leaving behind most or the entire carcass unused. Where once there was an estimated 50 million bison in North America, by 1890, only a few hundred individuals

remained (Nowak 1991). In 1905, the American Bison Society was formed with President Theodore Roosevelt as honorary president, which finally convinced Congress to create the National Bison Range in Montana and supply breeding stock to national parks (Haines 1975). Yellowstone National Park is the only place where wild bison persisted despite the species' near extermination by the late nineteenth century (Nowak 1991) in part through the efforts of Charles Jesse "Buffalo" Jones work to reestablish wild bison in Yellowstone to save the species from extinction (Garretson 1938).

Concerns over unregulated developments, over-exploitation of natural resources, and appropriations of resources grew, and literary, scientific, and bureaucratic endeavors publicized conservation and preservation of natural resources, wildlife, and scenic land for the benefit of future generations of Americans (Library of Congress 2002) inspiring the American public and the U.S. Government to take action. In 1891 the U.S. Congress passed the Forest Reserve Act to protect forested land in the public domain from further settlement and appropriation, and as a result the Grand Canyon Forest Reserve was established in 1893 in an effort to exert Federal regulation over the Grand Canyon and protect it from development (Anderson 2000).

Preservation concerns expanded in the coming years to include America's scenic landscapes as well as prehistoric, historic, and other properties of scientific interest. In an effort to improve federal protection of the Grand Canyon as a valuable scenic landscape and to help protect wildlife therein, President Theodore Roosevelt established the Grand Canyon Game Preserve in 1906, which incorporated land on both rims of the Grand Canyon including all of the Kaibab Plateau (Anderson 2000). Real protection from

uncontrolled development could not be enforced, however, and in yet another effort to protect the Grand Canyon from encroaching commercial interests, President Roosevelt proclaimed the Grand Canyon a National Monument in 1908. This protected the most scenic sections, including narrow strips along both rims, without impinging on those that held interest in forest resources.

In 1906, the United States Congress authorized the protection of mule deer on the Kaibab Plateau, and James "Uncle Jim" Owens was hired as game warden for the United States Forest Service in 1907 (Anderson 1998). In the interests of protecting animals pleasing to tourists and hunters (i.e. game species), Forest Service policy authorized the extermination of all four-legged predators. Primary targets included mountain lion, bobcat, wolves, and coyote that fed on deer, antelope, bighorn sheep, and elk which visitors liked to see and sportsmen like to hunt. The predator eradication duties of Owens' position allowed him to guide hunting parties, and in the twelve years he served as the game warden preceding the establishment of Grand Canyon National Park in 1919, Owens and his clients reportedly killed over 500 mountain lions, among many other predators of the region including badger, wolverine, bobcat, coyote, wolf, and bear. Ironically intended as a measure to protect deer and other favored animals, predator eradication instead had the opposite disastrous consequence. By 1924, it is estimated that 50,000-100,000 deer roamed the region, up from an estimated 4,000 in 1906. The deer herds, growing in size unchecked, over-grazed the landscape, and disease and starvation ran rampant resulting in massive die-offs.

The ultimate goal of proclaiming Grand Canyon a National Park was not

achieved until 1919. The Grand Canyon played an important role in the change of attitude regarding the crucial role predators played in the maintenance of ecosystem health (Anderson 1998). The purpose of national parks was to some extent redefined as a result of a crisis of wildlife management that occurred in the Kaibab National Forest north of the Grand Canyon. In the 1920s, controls against hunting and grazing were tightened, and the predator eradication policy was phased out in the 1930s.

CHAPTER 6: PREVIOUS RESEARCH

This chapter reviews the previous research addressing the historical biogeography of bison in the American Southwest. Since the near extermination of American bison from North America in the 1800s, numerous books have been published chronicling the story of this iconic species (e.g. Allen 1974 [1876]; Danz 1997; Dary 1974; Garretson 1938; Haines 1975; Hornaday 2002 [1889]; McDonald 1981; McHugh 1972; Meagher 1986; Roe 1970). As the evolution, ecology, history, and distribution of bison are so prolifically discussed elsewhere, a thorough review of the available literature is beyond the scope of this thesis. This chapter, therefore, deals exclusively with previous research (Mead 2002; Reed 1955; Truett 1996; Wolff 2013) on the historical distribution of bison as evidenced in the paleontological, archaeological, historical, and environmental records and that include the Grand Canyon region, in whole or in part.

A brief discussion of the differences between paleontological and archaeological deposits is necessary before proceeding. Paleontological faunal remains are those deposited by natural processes and not directly correlated with human activity or artifacts. Archaeological faunal remains, in contrast, are directly associated with human behavior. It is possible, however, for paleontological and archaeological remains to occur at the same location without being directly correlated. For example, although numerous human-made split-twig figurines were recovered from Stanton's cave in the Grand Canyon, none of the faunal remains present in the cave could be directly associated with human activities and therefore were interpreted to be natural (i.e. paleontological) deposits (Euler 1984). Similarly, the well-known Paleoindian period site of Murray

Springs in southeastern Arizona contains the remains of several extinct Pleistocene bison (*Bison antiquus*) that were killed and butchered by humans (Haynes and Huckell 2007), as well as the much younger (A.D. 1610) remains of a modern bison (*Bison bison)* cow and fetus that were deposited as a result of natural death (Agenbroad and Haynes 1975).

The following research addresses the distribution of bison in the Grand Canyon region (Mead 2002), in Arizona (Wolff 2013), and in the Southwest (Reed 1955; Truett 1996). Mead (2002) provides an overview assessment of bison at GRCA and the greater region in response to management concerns over the House Rock Valley bison herd that has taken up residence within National Park boundaries. Wolff (2013) discusses the historical distribution of bison in Arizona and argues that their marginal presence in Arizona and the greater Southwest over long periods of time indicates these areas were within possible bison range and habitat. Reed (1955) provides a review of the distribution of bison west of the Pecos River and concludes that bison disappeared from Arizona prior to the Christian Era and from central and western New Mexico before the arrival of the Spanish, perhaps during the Great Drought in the late 1200s. Truett (1996) addresses the question of why bison were absent in the early historic Southwest if introduced herds are capable of thriving there today. He evaluates five potential causes (forage quality, non-human predation, insufficient water, disease, and hunting pressure by Native Americans prior to European colonization) that could have resulted in the scarcity of these animals by the early historic period.

Paleontological Research

Most evidence for the presence of bison in the Grand Canyon region comes from

Pleistocene-aged paleontological deposits, which are preserved in numerous dry caverns and rock shelters found throughout the Colorado Plateau and in abundance in the inner Grand Canyon. The combination of an arid environment and dry caves and rock shelters creates the right conditions to preserve the dung, bone, hooves, and horns of bison as well as the remains of a wide variety of other taxa. Bison are, in fact, fairly common paleontological fossils in Arizona, and numerous publications include discussion of their occurrence.

Consequently, previous research specifically addressing bison in the Grand Canyon region (Mead 2002) primarily presented empirical evidence documented from Late Pleistocene contexts. Citing Mead and Agenbroad (1992), Mead (2002:Table 1) offers for evidence the presence of bison dung from seven sandstone alcoves in Glen Canyon National Recreation Area and hoof keratin and skeletal elements from two caves (Sandblast Cave and Stanton's Cave) in GRCA. While bison dung signifies the physical presence of bison in Glen Canyon caves during the late Pleistocene, the occurrence of skeletal and keratin elements in Grand Canyon caves may introduce different potential taphonomic scenarios (Mead 2002).

Stanton's Cave and Sandblast Cave are located in the Colorado River corridor in the Marble Gorge in the eastern portion of GRCA. The two elements recovered from Sandblast Cave were collected as part of a project to study difficult to access caves in the Grand Canyon that yielded fossils principally deposited by birds (Emslie 1988). Sandblast cave is located 30 m above modern Colorado River levels, and the faunal remains indicate that the cave was used by roosting or nesting raptors (including condors)

and packrats. The bison tooth and horn fragment found in the cave (Emslie 1987), in addition to the other small fragments of large mammal remains, may have been brought in by condors as food (Emslie 1988:13). Mead (2002) clarifies, however, that condor feet are not equipped to grasp and carry carcass remains. Therefore, if the large mammal elements were transported by condors, they were more likely deposited as regurgitated stomach pellets. Other potential mechanisms include deposition by other raptors, by flood events, or by the physical presence of a bison at or near the cave at the time of death whereupon small skeletal elements could have been transported into the cave by packrats. Unfortunately, evidence is lacking to support any of these scenarios.

Stanton's Cave is located in the Redwall Limestone 44 m above modern Colorado River level (Euler 1984). Mead (2002) reports only one keratin hoof fragment, which was directly dated to the late Pleistocene (Mead and Agenbroad 1992). Additional possible bison remains reported by Harington (1984) include a bison-sized carpal and an acetabulum fragment "generally similar to bison in size and shape" (Harington 1984:72). The hoof and acetabulum were found in pack rat nests and the carpal was recovered from an excavation test unit. None of these remains are associated with human activities and were likely deposited inside the cave by natural means (i.e. raptors, packrats, flood events, or a combination thereof). Again, evidence is lacking to determine the mechanism of deposition.

Wolff (2013) addresses the paleontological evidence of bison throughout Arizona, and presents this as an indication that bison were living in the region as late as the seventeenth century, albeit in marginal, small populations. Stanton's Cave is the only

paleontological faunal site she mentions from northern Arizona, although it is not discussed in any detail. From southern Arizona, Wolff (2013) mentions the presence of two bison crania (Mead and Dryer 2001; Mead and Johnson 2004) and a bison cow and fetus from Murray Springs (Agenbroad and Haynes 1975). The bison crania ,dated A.D. 1440-1640 and A.D. 1580-1630, were found at San Rafael Ranch State Park (Mead and Dryer 2001) and in the San Rafael Valley (Mead and Johnson 2004), respectively. The Murray Springs remains of a female bison with fetus were radiocarbon dated to A.D. 1610 and were deposited as a result of natural death at the head cut of the Murray Springs arroyo (Agenbroad and Haynes 1975).

Archaeological Research

Mead (2002) provides a brief review of bison skeletal and organic remains found in the archaeological record of the Colorado Plateau. The archaeological sites included in his discussion are Awatovi in northeast Arizona (Lawrence 1951b; Olsen 1978), Bison Alcove in Arches National Park in southeast Utah (Mead et al. 1991), and two sites (42SA8502 and 42SA8512) from the Island-in-the-Sky district of Canyonlands National Park in southeast Utah (Osborn 1995). One site, Cowboy Cave in Wayne County Utah, is also discussed, but the bison remains are not archaeological and the stratum from which the remains were found dates to greater than 11,020 years B.P. (Jennings 1980). Specifically addressing the Grand Canyon region, Mead (2002) states that no *Bison* or *Bos* remains were identified from excavations in Glen Canyon (Long 1966), near Navajo Mountain (Lindsay et al. 1968), in the Prayer Rock District Basketmaker Caves (Morris 1980), or from the Colorado River corridor of GRCA (Fairley et al. 1994).

In reference to bison remains in GRCA, Mead (2002) states "no *Bison* were recovered in the narrow Colorado River corridor of the Grand Canyon (Fairley et al. 1994), although excavations and subsurface testings were not conducted in caves" (Mead 2002:9). This is the only report Mead (2002) cites regarding archaeological investigations in the Grand Canyon, although at the time this report was produced, several archaeological testing and data recovery excavations had been conducted at GRCA and some of these projects also contain collections of previously analyzed faunal remains (e.g. Jones 1986; Schwartz et al. 1979; Schwartz et al. 1980; Schwartz et al. 1981). The review of only one project report from the GRCA drastically under represents the quantity of archaeological survey, testing, and data recovery investigations performed. Furthermore, two excavated sites reported in Jones (1986), AZ C:13:0004 (GC) and AZ C:13:0010 (GC), produced one possible bison specimen each, but Mead (2002), for reasons unknown, did not mention these findings.

It is also important to note that the project report by Fairly et al. (1994) presents the results of an archaeological pedestrian survey to inventory and evaluate sites within the Colorado River corridor potentially affected by the operation of Glen Canyon Dam. Pedestrian surveys such as this one do not involve sub-surface testing or data recovery excavations, and typically nothing is collected except in rare circumstances where collection is necessary to further analyze an artifact or to recover an artifact in potential danger of unauthorized collection by visitors. It is therefore not surprising that no bison remains were found as no excavation was conducted in caves or at archaeological sites, very little material was collected, and what was collected was recovered from the modern

ground surface.

Awatovi (occupied ca. A.D. 1250-1700) is frequently cited as one of the archaeological sites in the Southwest to contain bison remains (Agenbroad and Haynes 1975; Johnson 1981; Mead 2002; Reed 1955; Wolff 2013). Although *B. bison* is present in the list of "Mammals Identified" at the Awatovi site (Lawrence 1951b:3-4), the author also reports "No positively identifiable bison fragments were found though a very few of the large bovids are very possibly bison rather than cow" (1951b:3) and "Bos and Bison remains were scarce at the Awatovi site" (1951b:37).

Olsen (1978) conducted a more complete analysis of the Awatovi faunal assemblage and reexamined all fragments labeled *Bison*. He determined these specimens were "undiagnostic scraps that were well within the size range of a large bovid such as the ox (*Bos taurus*)" and "No elements were found that could possibly be assigned to *Bison*" (1978:10). Since a Franciscan mission was established at Awatovi in 1629 (Montgomery et al. 1949) after almost 100 years of Spanish presence and the introduction of domestic cattle (*B. taurus*) in the southwestern United States, the presence of either bison or cattle at Awatovi is plausible. Considering, however, that no positively identified bison specimens were found yet numerous diagnostic elements of domestic cattle were identified, the unidentified large bovid remains are more likely cattle. This is not to imply that an exhaustive excavation and faunal analysis has been conducted at Awatovi; only 10 percent of the habitation area was excavated (Olsen 1978:28), and future investigations at this site may reveal additional information.

Mead (2002) also addresses images of bison in the rock art of the Southwest,

stating that if bison were present in the Grand Canyon region, the species would likely be depicted in petroglyphs (pecked or etched rock art) or pictographs (painted rock art). Bison images are found represented in rock art throughout the Colorado Plateau, although infrequently on the southern Colorado Plateau (Agenbroad and Hesse 2004:Figure 16.6). Bison rock art is found at various locations in Utah including, but not limited to, Nine-mile Canyon (Castelton 1984), Newspaper Rock State Historic Monument outside Canyonlands National Park, and Upper Sand Island outside of Bluff (Malotki and Wallace 2011; Malotki and Weaver 2002).

A systematic survey of bison iconography in the rock art of the Grand Canyon region has not been performed; however, any cursory review of rock art publications illustrates they are a rare occurrence (Christensen 2004, 2007; Christensen and Dickey 2006, 2007; Christensen et al. 2013; Malotki and Weaver 2002). In the Grand Canyon region, the only known bison image is found at the base of the Grand Wash Cliffs north of the Colorado River (Weaver 1984:14). The bison is portrayed alongside a horse with rider, indicating that it may be historic in age if the two images are associated.

Rock art is, of course, not proof of the physical presence of an animal at or even necessarily near the location of the image. The ubiquitous depiction of a species, however, can be interpreted as evidence that the species likely existed in the region, particularly if the imagery is created by different groups over long periods of time. Images of bighorn sheep at the Grand Canyon, for example, can be found in Archaic, Preformative, Formative, Protohistoric, and Historic period panels (Christensen et al. 2013). Much like isolated occurrences of bison remains (i.e. skeletal elements, hide,

hooves, and horns), the presence of isolated bison rock art elements is potentially problematic to interpret. Yet when the distribution of elements is viewed at a larger scale, patterns of abundance and scarcity begin to emerge that appear to correlate with the distribution of physical remains (Agenbroad and Hess 2004).

Wolff (2013) lists 17 Paleoindian period (15,000-8,000 BCE) sites with *Bison antiquus* remains (2013:Figure 1) and 10 ceramic period (AD 1-1650) archaeological sites throughout Arizona with *B. bison* remains (2013:Table 1 and Figure 2). She also mentions, but does not list, the existence of 10 additional sites in northern Mexico, western New Mexico, and southwest Colorado. The only sites mentioned in northern Arizona, Charley Day Spring and Keams Canyon, have *B. antiquus* specimens but not *B. bison* remains. According to Wolff (2013), two archaeological sites of significance that indicate bison were living in or near Arizona during the Holocene are Bat Cave, New Mexico (Dick 1965) and Babocomari Village, Arizona (Di Peso 1951). Bat Cave is located in New Mexico very close to the central Arizona border. The occurrence of 1,047 bison skeletal elements from an archaeological context indicates these animals were hunted by people at or very near the site location (Dick 1965). Another archaeological site that indicates resident bison populations in Arizona is Babocomari Village (DiPeso 1951). The remains of one bison were found intentionally buried in a cremation area. The remains include a disarticulated concentration of the legs, head, and ribs belonging to one animal. Some of the elements were burned, cracked, and painted. Additional bison remains found at or near this site include unspecified skeletal elements recovered from a structure floor and an outdoor cooking pit and the skull cap and horn-core of a bison,

which was found eroding out of the side wall of the Babocomari River one-quarter mile from the village site. All other archaeological sites with *B. bison* remains presented in Wolff (2013:Table 1) contain very few bison elements, making interpretation of their occurrence problematic.

Reed (1955) provides a sizeable list of archaeological sites that have bison remains from Arizona, New Mexico, Colorado, and California. The sparse remains found in Arizona and those remains (of unspecified quantity) recovered from upper Rio Grande sites in New Mexico, Reed (1955) explains, may represent traded bison goods or bison acquired on extended hunting trips into bison range. He does not include a discussion of the specific elements or quantity of specimens recovered from these sites, however, nor does he provide citations referencing these findings.

Historical Research

The earliest written accounts of bison are recorded in the journals of the Spanish religious and military expeditions that occurred during the sixteenth and eighteenth centuries. These documents are liberally cited in reference to the historical distribution of bison in the American Southwest. As these documents are so frequently cited and discussed, all observations of bison in Spanish colonial literature will not be repeated in this chapter in detail. Suffice to say that Pedro de Tovar and García López de Cárdenas did not mention encountering bison enroute from Zuni to the Hopi pueblos and the South Rim of the Grand Canyon in 1540 during the Coronado expedition (Hammond and Rey 1940). Additionally, Fathers Francisco Atanasio Domínguez and Silvestre Vélez de Escalante did not observe bison immediately north of the Grand Canyon through the

Arizona Strip in 1776 (Warner 1995).

Of importance here is Mead's (2002) rectification of an erroneous statement made in the Bison Management Team (2002) document: "The earliest written record of bison in Arizona is the sighting of a small herd in northern Arizona by a Spanish conquistador in the 1500s." As Mead (2002) explains, this error likely originated from a misinterpretation of events after Cárdenas returns from his expedition to the South Rim of the Grand Canyon. After leaving the Grand Canyon, Cárdenas mentions seeing bison. By this time, however, he had already returned to the Rio Grande Pueblos near Zuni. No known documents from the 1500s record observations of bison living in northern Arizona.

Reed (1955) points out, however, that in 1776, Father Tomás Garcés mentions being given wild *cibola* meat by the Havasupai while near the Little Colorado River (Coues 1900:403, 406). The Havasupai killed the bison themselves according to Garcés. What we cannot know from this journal entry, however, is where the Havasupai killed the bison. Additional uncertainty arises in interpreting the journal in regards to the terminology used by Spanish explorers in reference to bison. Spanish explorers called bison *vacas de Cibola* (cows of Cibola [Hodge 1937:109]) after 1540-1541, and later *cibola* until at least 1794 (Reed 1955). In 1776, it is possible that Garcés was referring to feral cattle (*B. taurus*), but it is interesting to note he used the term *cibola* not *vaca*. Since he did not mention actually seeing a bison, it is also possible that he either misunderstood what he was told or simply assumed the Havasupai killed the bison themselves.

Indigenous people in possession of bison hides were observed by Fray Marcos de

Niza in 1539 in Sonora, Mexico and along the San Pedro River through southeastern Arizona (Mead 2002; Reed 1955). This, however, cannot be taken as evidence of bison living in those regions. Bison hides were widely traded throughout the Southwest, and both groups of people told de Niza the hides were acquired from Cibola (Zuni).

Environmental Research

While presence-absence data as indicated in the paleontological, archaeological, and historical records can give valuable insight into the historical range distribution of bison in the Southwest, inferring spatiotemporal abundance of the species is inherently more complex. Conclusions based upon the foregoing research that bison were likely only ever present in the Southwest infrequently and in small, dispersed herds is called into question by the presence of introduced herds, such as in the House Rock Valley, that thrive in the modern day in regions beyond the known limits of their historical range.

To address this discrepancy, Truett (1996) compares factors of the modern and pre-Columbian ecosystems in an attempt to pinpoint what could have influenced changes in bison distribution and abundance prior to and after the arrival of Europeans. In this analysis, he addresses forage quality, predation, water availability, disease, and human hunting pressure. He concludes that 1) forage quantity and quality was better prehistorically than it is now, 2) although the installation of artificial water sources, such as catchments and wells, has substantially increased the availability of water in modern-day arid regions, bison are known to range miles from water and a scarcity of water alone may not limit bison distribution, 3) it is unlikely that non-human predators or disease eliminated bison herds prior to the arrival of Europeans, and 4) human hunting pressure

could have depleted bison populations, particularly if the herds were relatively small and isolated and concentrated around scarce water sources.

The scope of each treatment on the historical distribution of bison varies, but each generally addresses the topic on a large scale, and the actual skeletal elements and their taphonomic histories are rarely discussed. Although abundant evidence exists for the presence of bison during the Pleistocene in the Grand Canyon region, Holocene occurrences of the species are far rarer and found solely in archaeological sites. Deposits resulting from human behaviors introduce various possible interpretations to explain their occurrence. Therefore, the presentation of mere presence/absence data as recovered from archaeological sites insufficiently addresses the occurrence of bison in the pre-Columbian Southwest. Additionally, human hunting pressure as a reason why bison were absent when Europeans arrived is not supported by the available evidence from the Grand Canyon region or from any reported sites that occur outside the known historical range of bison.

Mead (2002), Reed (1955), Truett (1996), and Wolf (2013) seem to agree that if bison were present in the American Southwest during the Holocene, those populations were likely small and dispersed and wholly unlike the iconic image of bison herds blanketing the landscape as documented in the Plains during late Historic times. Additionally, their appearance may have only been intermittent; resulting from seasonal migrations that occasionally brought herds into marginal ranges or from small bachelor herds or stragglers that wandered into the region. The presence of sparse bison remains deposited as a result of natural death in southern Arizona supports this hypothesis.

However, the archaeological record is rarely explored in sufficient enough detail to further illuminate the patterns of scarcity and abundance which may provide additional insight into the distribution of *B. bison* prior to the arrival of Europeans.

CHAPTER 7: RESULTS

The paucity of bison remains in archaeological assemblages of the Southwest suggests that bison were very rarely, if ever, hunted by the many cultural groups throughout the region, but how do archaeofaunal assemblages within traditionally understood bison range to the north and east compare? Does a scarcity of bison remains outside of known distribution indicate long-distance exchange of goods, the occasional presence of bison in the region, or economic decisions made by people to only occasionally hunt bison that were regularly available in their environments? Bison are considered a high-ranked prey species because of the large amount of meat, marrow, and raw materials the animals provide, and it is expected that if bison were available to humans, they would be hunted. A sample of sites located inside known bison range to the north and east are used for comparison.

In order to evaluate the pre-Columbian distribution of bison in Grand Canyon National Park (GRCA), archaeological sites within known historical range are used to predict archaeological site types and faunal assemblage characteristics when bison inhabit ecosystems near human settlements. If there were native bison populations existing in the southern Colorado Plateau in the same densities as areas within traditionally understood historical range, then the same types of sites and faunal assemblages are anticipated. These expectations include: the presence of bison kill and carcass processing sites in the region, a relatively high frequency of bison specimens in habitation assemblages, bison representing the most frequently occurring artiodactyl in habitation assemblages, a high degree of skeletal completeness at habitations resulting from a greater proportion of the

carcass transported between kill/processing sites and habitation sites, and a variety of age groups with both males and females represented indicating breeding populations in the proximal site environment. If bison are non-native to the southern Colorado Plateau region, then there is expected to be no bison kill and carcass processing locations in the region, and if bison remains are present in habitation assemblages then expectations include extremely low relative frequencies of bison specimens and a low degree of skeletal completeness as the skeletal elements will likely reflect long-distance hunting or trade in highly valued portions of the animal.

The indigenous people who lived on the southern Colorado Plateau prior to intensified European settlement of the late 1800s exploited a diversity of fauna principally including various species of artiodactyls, lagomorphs, and rodents. Animals were used not only for food, but also for raw materials such as bone, antler, horn and hoof sheaths, hide, fur, and feathers. These materials could be constructed into tools, clothing, blankets, textiles, and objects of religious significance, among other items. Faunal remains, therefore, can represent a significant component of archaeological site assemblages and valuable tools for understanding material culture, subsistence practices, and the environments in which people lived.

The species of artiodactyls that dominate the archaeological record of the Grand Canyon and surrounding regions include bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*). Within GRCA, bighorn sheep tend to be the most abundant (Schwartz et al. 1980; Schwartz et al. 1981; Schwartz et al. 1979; Spurr and Cannon 2013; Yoshikawa 1986). In regions surrounding the Grand

Canyon, pronghorn dominate assemblages from sites in semi-arid grasslands such as found around Wupatki National Monument (Fortsas 1996; Huffer 2013; Lincoln 1961), while mule deer tend to occur more frequently in sites located in woodlands and forests such as those found around the San Francisco Peaks region (Blan 1997). Bison (*Bison bison*) are an exceptionally rare find. As an example, 536 archaeological sites in Arizona have faunal data entered into AZSite, but only 16 of those sites contain bison remains, representing just under three percent of all sites in the database.

Archaeological Contexts of Bison Remains in GRCA

Three possible bison bone specimens were identified from archaeological contexts in GRCA. All three elements were found at sites in the eastern Grand Canyon along the Colorado and Little Colorado River corridors (Figure 3). Two of those elements were recovered from AZ C:13:0010 (GC), and the other element was recovered from AZ C:13:0004 (GC).

AZ C:13:0004 (GC)

AZ C:13:0004 (GC), also known as Beamer's Cabin, is a multi-component site with Archaic (ca. 1500 B.C.), Formative to Late Prehistoric (ca. A.D. 775-1400 or later), and Historic (A.D. 1890-1892) occupations (Jones 1986). The site is located along the Little Colorado River near the confluence with the Colorado River. The historic component is Ben Beamer's cabin, masonry oven, and a bedrock mortar. The prehistoric component consists of a pictograph panel, a small rockshelter, and 10 subsurface fire pits and rock-lined hearths.

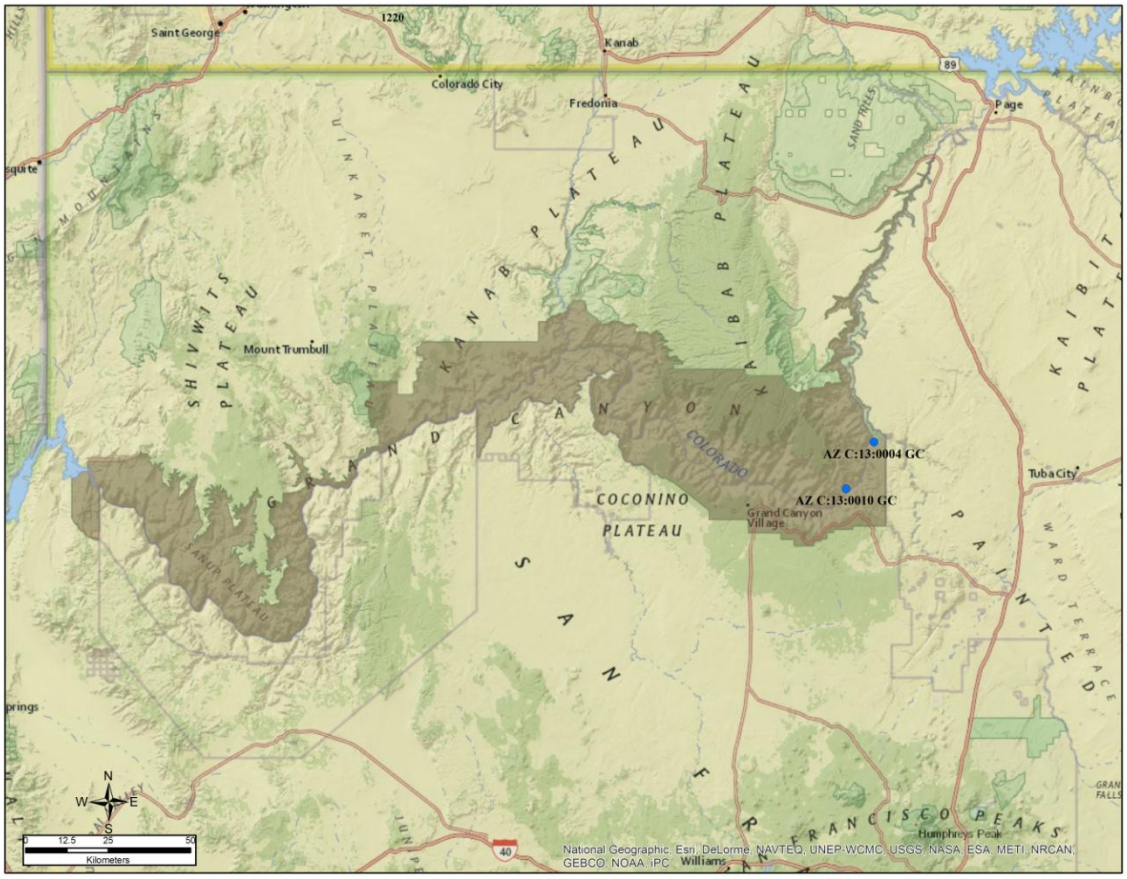

Figure 3. GRCA archaeological sites with possible bison remains.

One large ungulate bone specimen, identified as bison (*B. bison*) or elk (*Cervus elaphus*; GRCA Collections Database), was recovered from the excavation of a 2-m by 1- m test trench placed outside Beamer's Cabin (Jones 1986:Figure 4.17). Provenience information for this specimen indicates it was found from 0.00-0.10 m below present ground surface (mbpgs). This stratigraphic level is described as loose sandy silt containing Late Prehistoric period ceramics as well as abundant faunal bone attributed to the Historic period occupation of Ben Beamer's cabin based on the presence of domesticated sheep (*Ovis aries*) and goat (*Capra hircus*; Jones 1986:70-72).

The bison/elk element is a distal metapodial epiphysis fragment (GRCA Collections Database). The specimen is too weathered and fragmentary for confident species-level identification, but the size certainly indicates a large ungulate such as domestic cattle (*Bos taurus*), bison, or elk. Its stratigraphic association with domesticated sheep and goat, however, suggests it very likely could be cattle instead of bison or elk.

AZ C:13:0010 (GC)

AZ C:13:0010 (GC), also known as Furnace Flats, is a large multi-component habitation site located 7-10 m above and 20-70 m north of the Colorado River on an eroded alluvial terrace (Jones 1986). There is evidence of three occupations associated with Formative period Cohonina, Formative period Ancestral Puebloan, and Late Prehistoric period Hopi. Dates derived from various analyses span A.D. 641-1270 (GRCA Site Files).

Two possible bison bone specimens were recovered from this site. Both came from Structure 4, a large, coursed masonry room with 1.6-m high walls. This structure was buried under 1.7-2.0 m of culturally sterile eolian and colluvial overburden, and its walls were exposed in the side wall of an arroyo when it was first excavated by the Western Archaeological Conservation Center (WACC) in 1984 (Jones 1986). WACC excavated a 3-m by 1-m test trench inside the structure along the south wall beginning at the top of the structure wall at 2.00 mbpgs down to a clay floor at 3.04 mbpgs (Jones 1986:Figure 4.33). In 2007, Museum of Northern Arizona (MNA) and National Park Service (NPS) crews fully excavated the rest of the structure (Collette 2013).

The WACC and MNA/NPS excavations recovered a unique and abundant

assemblage of locally manufactured artifacts from Structure 4 (Collette 2013; Jones 1986). Breakdowns in local exchange networks toward the end of the Ancestral Puebloan occupation of the Grand Canyon (Effland et al. 1981) may have necessitated production of these items at the individual site level (Jones 1986). This assemblage had evidence of the production of stone pendants, ceramic and bone gaming pieces, and ceramic vessels during the later occupation (Collette 2013; Jones 1986). A cache of artifacts, interpreted as a possible calcite pendant production tool kit, was found in a sandy deposit 1 or 2 cm above floor level (Collette 2013).

The assemblage of materials recovered from Structure 4 also includes the two possible bison elements: fragments of a palatine bone from a cranium and fragments of a femur. The palatine fragments were identified and reported by Yoshikawa (1986) as indeterminate bison or cattle (*Bison* sp. or *B. taurus*). They were recovered from the 1-m by 3-m excavation unit inside Structure 4 along the south wall. Considering how deeply buried this structure was, the palatine specimen most likely belongs to bison. This structure was probably buried long before cattle were introduced to the Southwest. The precise stratigraphic context of the bovid specimen within Structure 4, however, is unknown. The femur was identified and reported by Spurr and Cannon (2013). It is the distal portion of a left femur of an adult bison (*B. bison*), including the nearly complete distal articular surface and a small portion of the diaphysis. The bison femur was found within the 10 cm of culturally sterile sand deposited above floor level, and it was situated in the room's southwest corner.

Taphonomic Interpretations of Archaeological Bison Remains in GRCA

Ascertaining the taphonomic history of skeletal elements is imperative since a variety of mechanisms may be responsible for influencing the assemblage of faunal remains present in an archaeological site. Various natural and cultural processes act on an animal carcass between death, deposition, and scientific discovery (Lyman 1994; Reitz and Wing 2008). Traces of these processes may be present on the bone surface providing clues from which to identify the taphonomic mechanisms involved. Hypothetically, the faunal remains recovered from archaeological sites in the Grand Canyon could have been deposited as a result of 1) natural death of the animal at the site, 2) fluvial transport, 3) transport by other animals, and 4) procurement by humans. A discussion of each of these mechanisms is provided to reveal the taphonomic history of archaeological bison remains in GRCA sites.

Natural Death of a Bison in the Inner Canyon

Substantial evidence for the existence of bison in the Grand Canyon at any time during the Pleistocene or Holocene is lacking. Bison dung deposits found in seven sandstone rock alcoves in Glen Canyon National Recreation Area (Mead and Agenbroad 1992) signify the occurrence of bison at the those alcoves during the Pleistocene. Only five relatively small specimens (a tooth, horn fragment, keratin hoof fragment, carpal, and acetabulum fragment) of Pleistocene-aged bison or possible bison remains were recovered from caves in GRCA (Emslie 1988; Harington 1984; Mead and Agenbroad 1992). These particular elements were likely carried into these cliff-face caves by other animals such as raptors or packrats, but where and how these animals acquired the bison

remains cannot be determined with the available evidence.

Mead (2002) argues that the presence of a bison keratin hoof fragment in Stanton's Cave that lacks taphonomic traces of digestion, breakage, pecking by raptors, or battering and warping due to fluvial transport is an indicator that a bison wandered into the Marble Gorge during the Pleistocene. This assumes that the mechanism of transport always leaves a visible taphonomic effect on the bone or keratin surface, which is not a reliable assumption (Lyman 1994:185-187). It is unlikely that bison ever inhabited the extremely steep inner canyon - their skeletal structure is not designed for the rugged topography (Mead 2002). Based on the available evidence, it is more likely that a bison carcass was transported downriver from elsewhere, and the remains either washed into the caves or were carried in by scavengers and rodents. Further, the aforementioned remains are all Pleistocene in age. There is even less evidence to support the occurrence of bison living either in GRCA or Glen Canyon National Recreation Area during the Holocene.

Fluvial Transportation of Bison Remains

As mentioned above, bison remains could have been transported down the Colorado or Little Colorado Rivers from elsewhere and naturally deposited in fluvial sediments at archaeological sites in the Grand Canyon. Prior to the construction of Glen Canyon Dam, the Colorado River regularly flooded, carrying and depositing immense loads of sediment as a result. Fluvial action can leave distinctive patterns of damage on the exterior surfaces of bone and keratin. Expected traces of fluvial transport include striations resulting from sedimentary abrasion which are often, though not always, visible

to the naked eye (Fisher 1995; Lyman 1994). No bone surface striations were visible with the naked eye or under magnification with a loupe upon re-inspection of the palatine fragments and metapodial, and Yoshikawa (1986) and Spurr and Cannon (2013) reported no striations on the palatine fragments and femur. However, as stated previously, taphonomic mechanisms may not always leave visible traces. Therefore, the stratigraphic contexts of the remains should also be considered.

Furnace Flats (AZ C:13:0010 [GC]) is located on a triangular-shaped landform along the toeslope of a Dox Sandstone cliff (Collette 2013). This landform is on the outer bend of the river as the river turns southwest after a relatively straight east-west stretch. The geomorphic position of this landform is not conducive to the deposition of fluvial sediments. As a result, fluvial deposits do not dominate the stratigraphy at Furnace Flats like most other sites along the river corridor. Deposits are instead primarily colluvium derived from the Dox Formation cliffs interfingered with cultural layers and rarer eolian and fluvial deposits. The overall geomorphology of AZ C:13:0010 (GC) does not favor the scenario of river transport and deposition of bison remains.

Since the roof of Structure 4 at Furnace Flats was removed sometime after the room ceased to be occupied but before the site as a whole was abandoned, the structure was left open to the deposition of natural sediments and cultural refuse (Collette 2013). The deposition of intramural stratigraphy primarily occurred by means of slopewash, wind-blown sand, and the intentional dumping of trash into the room. Although the precise depositional context of the palatine fragments is unknown, it is likely they eroded into the structure from nearby, were thrown into the structure by people as trash, or were

intentionally placed in the structure for other reasons. The femur fragment was located within culturally sterile sand very close to the structure floor. It was likely intentionally placed or disposed of in the structure very shortly after the room was vacated.

The strata documented at Beamer's Cabin (AZ C:13:0004 [GC]) consist of alluvial gravels and sandy silt that aggraded throughout the site's occupation (Jones 1986). The large ungulate specimen was recovered from younger deposits composed of very loose sandy silt within 10 cm of the modern ground surface. This cultural deposit was composed of Late Prehistoric (A.D. 1250- 1540) ceramics and the remains of domesticated taxa, and therefore likely resulted from Late Prehistoric and Late Historic trash dumping and not with fluvial deposition.

Animal Transportation of Bison Remains

Animals are responsible for dispersing, accumulating, modifying, and destroying significant quantities of bone. Carnivores, raptors, and rodents disarticulate, scatter, and remove elements of a carcass as well as introduce bone to and remove bone from archaeological sites (Reitz and Wing 2008). Many different animals often chew or consume bone.

Modifications to bone surfaces resulting from animals include gnaw marks, crenulation of broken bone ends, punctures, salivary rounding, digestive corrosion, and fracture (Fisher 1995; Lyman 1994; Reitz and Wing 2008). No bone surface modifications resulting from animals were observed upon re-inspection of the palatine fragments and metapodial, and none were reported by Yoshikawa (1986) and Spurr and Cannon (2013) on the palatine fragments and femur. Therefore, the role that animals

played in bringing bison bone into the site cannot be assessed. Since animals also removed bone from sites, and it is possible that at one time there were more bison elements present but were scavenged and removed from the site location.

Human Procurement of Bison

There is no substantial evidence to support the presence of bison regularly living in the Grand Canyon, the fluvial deposition of bison remains, or the introduction of bison elements into archaeological sites by scavengers in the inner canyon. The proveniences of the palatine and femur fragments inside a deeply buried structure at AZ C:13:0010 (GC) and the distal metapodial fragment in trash deposits at AZ C:13:0004 (GC) indicates these specimens are likely the result of human procurement. However, there are no bone surface modifications on any of the specimens to indicate butchering, burning, tool use wear, or bone tool manufacture to further validate this.

The bison elements at AZ C:13:0010 (GC) are not typical of trade goods. Traded bison elements might include bone or horn sheath constructed into tools, foot elements left attached to bison hides, keratinous hoof portions used as tinklers, or portions having potential religious or ceremonial significance such as horn cores. If bison meat was traded into the Grand Canyon region from elsewhere, it would have been deboned and jerked at carcass processing locations (e.g. Catlin 1965; Denig 1930; Weltfish 1965), which would result in very few or no elements represented at habitation sites. If a bison was hunted by the site's inhabitants, only a small percentage of the skeletal elements were brought back to the site. Where the bison was hunted cannot be precisely determined; however, for large-sized taxa such as bison, as distance increases between

kill site and habitation site, the proportion of elements transported decreases (Bunn et al. 1988; O'Connell et al. 1988, 1990). The type and paucity of remains in GRCA assemblages, therefore, may indicate bison were killed some distance from the site and only high utility carcass portions of hindquarter meat, marrow, organ, or bone desired for raw material were brought back. Alternatively, although these elements are not typical of traded items, it is plausible people traded for them as raw material for the construction of gaming pieces or other tools.

The possible bison element recovered from AZ C:13:0004 (GC) may in fact be cattle given its spatial association with the remains of domesticated species such as sheep and goat. In 1890-1892 when Beamer's Cabin was occupied, bison were already close to extinction as a result of over-exploitation, and there were no herds, privately owned or otherwise, in Arizona at that time. Native Merriam's elk (*C. elaphus merriami*) were extirpated from Arizona at this time as well, and Rocky Mountain elk (*C. elaphus nelsoni*) were not reintroduced to the Mogollon region of Arizona until the 1930's (Hoffmeister 1986). The stratigraphic context of this specimen also contained Late Prehistoric ceramics, however, and the possibility that it is bison must still be considered.

Inter-site Comparisons

The occurrence of bison remains in GRCA archaeological sites lacking taphonomic indicators of natural deposition and occurring within cultural contexts suggests a bison or portions thereof were procured by humans. The elements represented are not typical of trade goods, and therefore the animal may have been hunted by Grand Canyon residents. The types of sites associated with bison remains and the relative

abundance, skeletal completeness, and demography of bison at habitation sites across the entire geographic study region are reviewed to place the GRCA remains in a broader context of bison assemblages across the Southwest.

Site Types

For this study, archaeological sites with bison remains are generally categorized as artifact caches, bison kill and carcass processing sites, and habitations (Figure 4; Table 1). Holocene-aged paleontological bison remains are also included in Figure 4 to facilitate visualization of naturally occurring, non-cultural bison finds as they relate in space to cultural remains. Site types associated with bison remains were identified to understand the contexts in which the species is found and to determine if there are site types unique to regions in or out of historical range. Bison occur at habitation sites across the entire study region. Bison kill and processing sites, however, are only found within known historical range.

Bison kill and carcass processing sites are indicated by a concentration of bison remains with evidence of butchering. The remains may be associated with lithic tools and tool- making debitage and indications of temporary encampment. Large-sized game species such as bison are typically field butchered, and low utility carcass portions may be left behind at the site resulting in differential representation of skeletal elements (Binford 1978, 1981; O'Connell et al. 1988, 1990; Perkins and Daly 1968). A variety of age groups and both males and females are likely if the site occurs within range of breeding populations. These sites are evidence of the presence of bison in proximity to the site location since people would not transport such a large animal in its entirety far

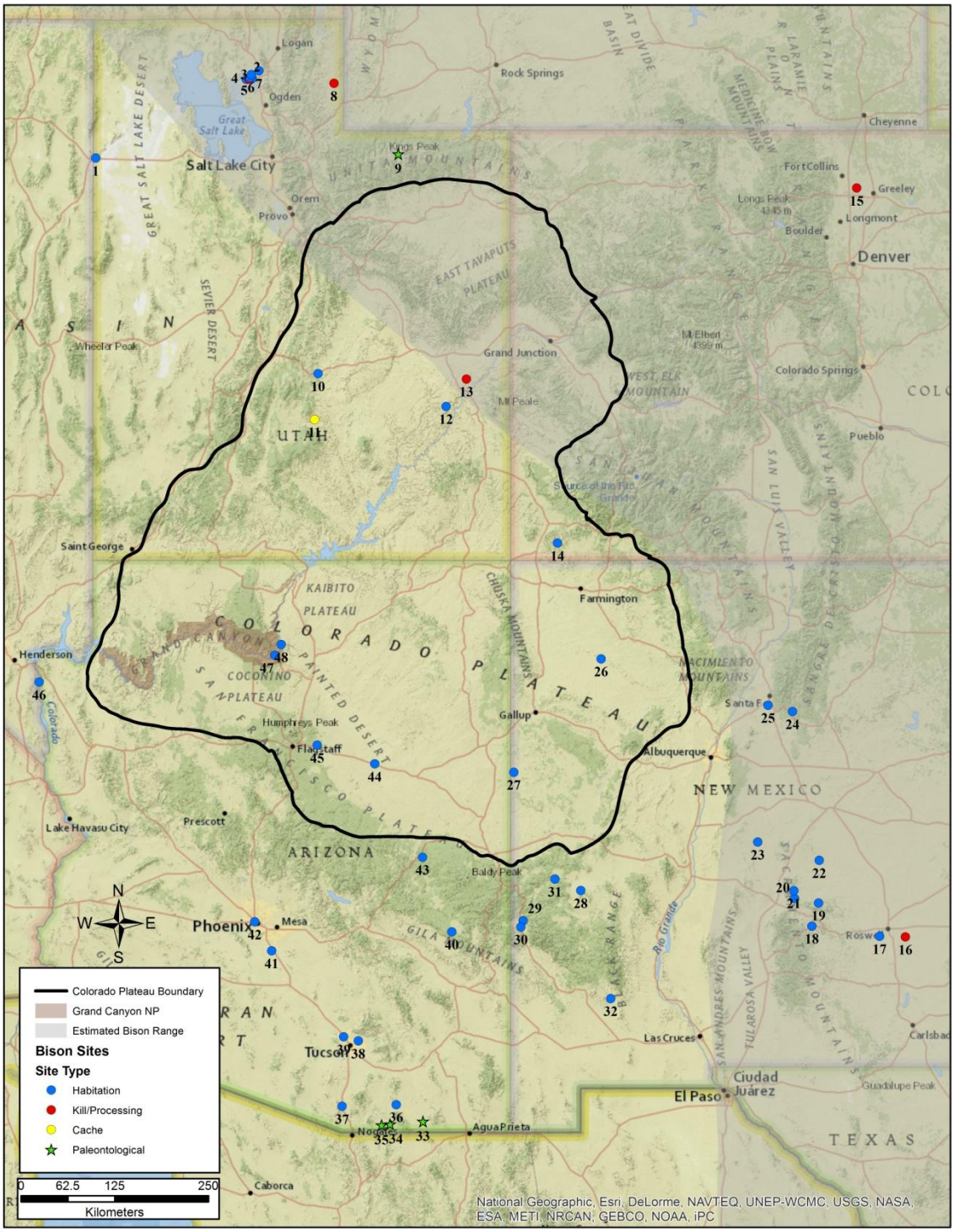

Figure 4. Holocene paleontological and archaeological sites containing bison remains.

Table 1. Holocene paleontological and archaeological sites containing bison remains.		
Figure 4 #	Site	Reference
UTAH		
1	Danger Cave	Grayson 1988; Jennings 1957
2	Bear River No. 1	Aikens 1966; Pendergast 1961
3	Bear River No. 2	Aikens 1967
4	Bear River No. 3	Shields and Dalley 1978
5	Levee Site	Fry and Dalley 1979
6	Knoll Site	Fry and Dalley 1979
7	Orbit Inn	Simms and Heath 1990
8	Woodruff Bison Kill	Shields 1978
9	Ashley NF Bison Skull	Cannon 2004
10	Snake Rock	Aikens 1967
11	Capitol Reef Bison Hide Shields	Loendorf and Conner 1993
12	45SA8502, Canyonlands NP	Osborn 1995
13	Bison Alcove, Arches NP	Mead et al. 1991
COLORADO		
14	Site 34, Mesa Verde NP	O'Bryan 1950
15	Kaplan-Hoover Bison Bone Bed	Todd et al. 2001
NEW MEXICO		
16	Garnsey Site	Speth and Parry 1980
17	Bloom Mound	Driver 1985
18	Bonnell	Driver 1985, 1990
19	Block Lookout	Driver 1985, 1990
20	Phillips	Driver 1985, 1990
21	Robinson	Driver 1990
22	Hiner	Driver 1985, 1990
23	Gran Quivira	Haynes 1981; Vivian 1964
24	Pecos Pueblo	Kidder 1932
25	Arroyo Hondo Pueblo	Lang and Harris 1984
26	Chetro Ketl	Brand et al. 1937:64
27	Hawikuh	Hodge 1920; Smith et al. 1966
28	Bat Cave	Dick 1965
29	Turkey Foot Ridge	Martin and Rinaldo 1950
30	Mogollon Village	Haury 1936
31	Tularosa Cave	Hough 1914; Lyon 1907
32	Swartz Ruin	Cosgrove and Cosgrove 1932
ARIZONA		
33	Murray Springs	Agenbroad and Haynes 1975
34	San Rafael Ranch State Park	Mead and Dryer 2001
35	San Rafael Valley	Mead and Johnson 2004

Table 1. Holocene paleontological and archaeological sites containing bison remains.		
36	Babocomari Village	DiPeso 1951
37	Tubac Presidio	Shenk and Teague 1975
38	University Indian Ruin	Guo-Qin 1983
39	Sunset Mesa Ruin	FaunAZ
40	W:9:69, W:10:47, 50 Point of Pines	Gifford 1957, 1980; Stein 1962, 1963
41	Snaketown	Haury 1938
42	Las Colinas	Johnson 1981
43	Bear Ruin	Haury 1940
44	Homol'ovi I and Kiva 903	LaMotta 2006
45	Winona/Ridge Ruin	McGregor 1941
46	Catclaw Cave	Wright 1954
47	AZ C:13:0010 (GC)	Yoshikawa 1986; Spurr and Cannon 2013
48	AZ C:13:0004 (GC)	GRCA Collections Database

from the kill site. No Holocene-aged bison kill or carcass processing sites outside of the known historical range were identified.

Not surprisingly, habitation sites with bison remains occur across the entire geographic study region. Unfortunately, most publications do not correlate faunal remains to their intra-site provenience, particularly for ubiquitous taxa, which precludes the identification of fine-scale stratigraphic associations in the contexts of finds. It can be assumed that at sites with abundant bison remains, the specimens were likely found in a variety of contexts including, but not limited to, refuse areas. The same appears to be true for bison found at sites outside of known distribution, thus creating no patterns connecting the hypothesized rarity of the species in the site environment to special treatment by people. Bison remains were found in many different contexts including buried with human cremations, buried in cremation areas, deposited in kiva and habitation structures, left in cooking features, and disposed of in refuse areas. These

contexts indicate bison were probably both consumed and treated with some degree of reverence.

In GRCA, the two bison elements at C:13:0010 (GC) were recovered from a single habitation structure (Spurr and Cannon 2013; Yoshikawa 1986). One of these elements, the distal portion of a femur, was found in the floor fill in proximity to a specialized tool kit. Numerous pendants and ceramic and bone gaming pieces in various stages of production were recovered from the intramural fill (Collette 2013; Jones 1986). Unfortunately, there are no bone surface modifications on either bison element from this site, and their association with this specialized tool kit is circumstantial. It is possible the femur fragment was desirable as a raw material for constructing gaming pieces or tools, but bone from other more readily available large-sized taxa, such as deer and bighorn, could also have been used.

Only a few publications for sites outside of the Grand Canyon region mention the provenience of bison remains. At Homol'ovi I, an unfused distal femur fragment was recovered from a structure, and a dark brown patina indicates it may have been used as a flesher (LaMotta 2006). A fused distal femur fragment was also recovered from Kiva 903 at Homol'ovi, but further information on the intramural context of this find was not located. Four horn cores, other miscellaneous cranial elements, and a fragment of a humerus were found at Snaketown, and the horn cores were recovered from a cremation, a house floor, and in trash deposits (Haury 1938). At Babocomari, a bison burial was found in a cremation area (DiPeso 1951). The carcass was a disarticulated concentration of the head, legs, and ribs. Some of the elements were burned, cracked, and painted. An

intentional burial such as this indicates some level of special significance to the animal. However, an unspecified number of bison remains were also recovered from a house floor, an outdoor cooking pit, and were commonly found in trash fill, indicating that, although the species may have held special significance, it probably also contributed to human diet.

Cache is the term employed here to refer to isolated artifacts deposited in caves, perhaps for religious purposes, unassociated with evidence of other human activity. One cache located outside of known distribution in Utah includes three decorated bison hide shields found in a cave just east of Capitol Reef National Park in 1925 (Loendorf and Conner 1993). Reed (1955) mentions Basketmaker-era bison hair belts found in a cave in northeastern Arizona by E.H. Morris, although a report on this find could not be located, and Reed (1955) may have mistakenly been referring to dog hair belts found in the Prayer Rock District by Morris (Morris 1980). Other discoveries in Utah include a cache of buffalo-hide moccasins and a drum cover discovered on Promontory Point (Boren 1998). An artifact constructed of a bison horn sheath was located in a cave with bison remains at Bison Alcove in Arches National Park (Mead et al. 1991). It is unknown whether the horn sheath belonged to the individual bison found there, and it is uncertain whether that animal was killed by people or died of natural causes. The skeletal elements represented may indicate human procurement based on the differential representation of low-utility carcass portions found in samples recovered from the site.

What is important to note here is that these items were constructed of hide, hair, and horn sheaths, and these body portions are not proof of bison living in the local

environment at the time of the artifact's placement by humans. Bison hide was widely traded throughout the southwest (Creel 1991; Riley 1975), and other items such as horn cores and sheaths and bone tools may have been traded as well (see Spielmann 1983 for bison bone tool trade in New Mexico). As an example, Fray Marcos de Niza saw bison hides in Sonora in 1539 on the San Pedro River in southern Arizona, and he was informed the hides were acquired from the Zuni pueblos (Allen 1974:126 [1876]). Likewise, the Havasupai obtained bison skins from the Hopi (Spier 1928), and the Southern Paiute obtained bison robes from the Ute (Kelly 1964:90).

Number of Identified Specimens of Bison

NISP is used to compare the relative abundance of bison between habitation sites and determine how abundance changes across the study region relative to known historical bison range. It is predicted that the relative abundance of bison at habitation sites will correlate to distance from known historical bison range. Habitation sites located within bison range will have the highest relative abundance, and sites located farthest from bison range will have the lowest relative abundance. Two regions within and on the margins of known bison range with well-documented faunal assemblages are used for inter-assemblage comparisons with sites located outside of bison distribution (Figure 5; Table 2). These include several sites located northeast of the Great Salt Lake in Utah and sites in the Sierra Blanca region of southeastern New Mexico.

The Great Salt Lake is located on the northeastern edge of the Great Basin, which lies west of the Colorado Plateau and covers western Utah. Northeastern Utah overlaps with known bison distribution, and Mormon settlers were known to kill bison in this

Figure 5. Bison NISP at habitation sites.

Table 2. Absolute and relative frequencies of artiodactyls at habitation sites.

	Figure 4 #	Site	Bison		Other[1]		Total
			NISP	%	NISP	%	NISP
UTAH							
In[2]	3	Bear River No. 2[3]	1,220	38.3	11	0.3	3,189
	4	Bear River No. 3[3]	632	15.3	10	0.2	4,125
	5	Levee[3]	624	20.4	15	0.5	3,057
	6	Knoll[3]	54	17.4	7	2.3	310
	7	Orbit Inn[3]	29	2.7	121	1.1	10,614
Out	1	Danger Cave	11	0.3	435	12.0	3,628
	10	Snake Rock Village	1	<0.1	661	24.3	2,723
	12	45SA8502, Canyonlands NP	8	2.8	171	60.6	282
ARIZONA							
Out	46	Catclaw Cave	1	-	-	-	-
	48	AZ C:13:0004 (GC)	1	0.1	59	6.6	899
	47	AZ C:13:0010 (GC)	2	<0.1	90	2.9	3,121
	44	Homol'ovi I[4]	1	<0.1	321	1.4	23,334
	43	Bear Ruin	1	-	-	-	-
	42	Las Colinas	2	0.2	52	5.6	922
	41	Snaketown	7+	-	-	-	-
	40	AZ W:10:47, 50 Point of Pines	10+	-	-	-	-
	38	University Indian Ruin	10	0.3	494	15.0	3,304
	39	Sunset Mesa Ruin	1	1.3	2	2.5	80
NEW MEXICO							
Out	29	Turkey Foot Ridge	2	-	-	-	-
	27	Hawikuh	8+	-	-	-	-
	28	Bat Cave	1,047	~65.4	~400	~25.0	~1,600
	31	Tularosa Cave	7	-	-	-	-
In	23	Gran Quivira, House A	7	3.8	76	41.5	183
	20	Phillips	32	1.1	433	15.0	2,889
	22	Hiner	6	2.1	53	18.3	289
	19	Block Lookout	22	2.9	78	10.1	770
	18	Bonnell	47	0.8	234	4.0	5,826
	17	Bloom Mound	9	8.7	8	7.7	104

[1]Deer (*Odocoileus* sp.), pronghorn (*Antilocapra americana*), and bighorn (*Ovis canadensis*); [2]In or out of defined bison range (Figure 5); [3]NISP taken from reanalysis reported in Lupo and Schmitt 1997; [4]Figure 5 also includes 1 bison element from Kiva 903 at Homol'ovi; Dash (-) indicates data not available.

region prior to 1840 (Hornaday 2002 [1889]). Bison remains are typically abundant at archaeological sites located in this region (Aikens 1966, 1967; Fry and Dalley 1979; Pendergast 1961; Shields and Dalley 1978; Simms and Heath 1990). The relative abundance of bison at most of these sites is between 15 and 38 percent of the total faunal assemblage, while all other artiodactyl species combined represent only two percent or less (Table 2)

Not all sites in this region have high numbers of bison remains, however, and this has been attributed to spatiotemporal fluctuations in bison populations, which became scarcer after A.D.1300 in the Great Salt Lake region (Lupo and Schmitt 1997). Sites such as Orbit Inn and Knoll contain only small quantities of bison, and two sites not included in this study, 42Wb32 and Injun Creek, contain no bison remains at all. Lupo and Schmitt (1997) compared these with 34 additional sites in the region and observed that Late Prehistoric period faunal assemblages have much lower proportions of bison remains compared to earlier Fremont sites, which denotes a decline in available bison populations that persisted until historic contact.

The Sierra Blanca region of southeastern New Mexico lies between the Rio Grande and Pecos Rivers. This region is variably considered to be either in or out of bison range in different publications (Allen 1974 [1876]; Bailey 1935; McDonald 1981; McHugh 1972; Olsen 1960). The entire region between the Pecos and Rio Grande Rivers throughout New Mexico is perhaps best characterized as marginal bison range as the animals are well-documented in the adjacent plains to the east, and herds likely ranged in the lowland areas of central New Mexico at least intermittently. In this region, the

relative abundances of bison are low and highly variable representing between one and nine percent of the total faunal assemblages, whereas other artiodactyl species average slightly higher and range between four and 18 percent (Table 2).

Trade in bison products between Plains groups and central New Mexico pueblos, such as Pecos and Gran Quivira, is well documented archaeologically and historically. Plains hunters traded bison meat, fat, marrow, and hides for corn, ceramics, obsidian, and cotton on an annual basis (Baugh 1984; Carter 1997; Snow 1981; Spielmann 1983; Wilcox 1984); a practice which intensified after the arrival of the Spanish (Spielmann 1983). The sites in the Rio Grande drainage, however, typically have less than one percent relative abundance of bison (Driver 1990) reflecting the trade of deboned meat. The Sierra Blanca region of southern New Mexico does not appear to have engaged in prolific trade with Plains groups (Driver 1990); however Driver (1990) argues that circumstantial evidence suggests the inhabitants of Peñasco, Bonnell, Robinson, Phillips, Hiner, and Block Lookout likely obtained their bison meat through trade with people inhabiting the Pecos Valley to the east. Sites in the Sierra Blanca region contain significant quantities of bison but the animal is rarely the most frequently occurring species in the assemblage (Table 2). Sites in the Pecos Valley east of Sierra Blanca, on the other hand, contain abundant quantities of bison. This, and evidence of bison kill sites (e.g. Garnsey), indicates that people in the Pecos Valley lived well within traditional bison distribution.

Bison represents the most frequently occurring artiodactyl in sites located securely within bison range, such as those northeast of the Great Salt Lake of Utah and in

the Pecos Valley of extreme southeastern New Mexico, while the relative abundance of bison at sites in the Sierra Blanca region on the margin of bison range are highly variable and considerably less than the absolute and relative abundances of other artiodactyl species (Table 2). The bison remains in these regions contrast starkly with most sites located outside bison distribution. Bat Cave represents the most striking exception, and other minor exceptions are Hawikuh in western New Mexico; Point of Pines, University Indian Ruin, and Snaketown in southeastern Arizona; and Canyonlands and Danger Cave in Utah (Figure 5; Table 2).

If bison at least occasionally ranged into southwestern New Mexico and southeastern Arizona, as evidenced by the quantity of bone identified at Bat Cave and the presence of Holocene-aged paleontological finds at Murray Springs (Agenbroad and Haynes 1975), San Rafael Ranch State Park (Mead and Dryer 2001), and in the San Rafael Valley (Mead and Johnson 2004), then slightly higher quantities of bison remains than expected at Point of Pines (NISP=10+), University Indian Ruin (NISP=10), Snaketown (NISP=7+), and Babocomari (bison burial and unspecified number of bones from various proveniences) are not surprising. Likewise, Danger Cave (NISP=11) and Canyonlands (NISP=8) appear to be on the margin of bison range in Utah, and people were likely in a position to trade bison meat and goods, obtain bison directly on long-distance hunting forays, or have occasional access to bison herds that migrated beyond traditional range limits within proximity of habitation sites.

Greater than half of the sites outside bison distribution only have 1-2 specimens representing less than one percent of the total faunal assemblages while the remainder,

with the exception of Bat Cave, only have up to 10 specimens (Table 2). This raises questions regarding why so few bison remains are located at these sites and how they got there, whether through trade or direct procurement. In order to determine this, the skeletal elements represented are assessed and compared to sites within bison distribution.

Skeletal Element Representation of Bison

The skeletal elements represented in a site assemblage can be reflections of carcass transportation decisions between kill/processing site and habitation site and the context of transport (as food or other desired goods). Large mammals such as bison would be field butchered, and selected high utility carcass portions would be brought back to a habitation site. A high degree of skeletal completeness is expected for sites within bison range where distance between kill site and habitation site is presumably low, which would allow hunters to return with more portions of the animal. A low degree of skeletal completeness is expected for sites located far from known bison range where bison goods were either traded or bison were hunted long distances from the habitation site.

Most habitation sites in bison range in northeastern Utah have all, or nearly all, skeletal elements represented (Table 3), signifying the availability of bison in the environs of the site and short distances between kill/processing locations and habitations. In fact, Bear River No. 1, a carcass processing site with the remains of a small herd of bison, is located among these habitations clustered around the Great Salt Lake. The exception is Orbit Inn, which, as discussed in the previous section, is evidence of the declining bison populations in the Late Prehistoric period of the Great Salt Lake region

Table 3. Bison elements represented at habitation sites and demographic data (when available).

	Figure 4 #	Site	Elements (n) and Demographics Represented
UTAH			
In[2]	3	Bear River No. 2[1]	All elements represented, all age groups represented.
	4	Bear River No. 3[1]	Nearly all elements represented, all age groups represented.
	5	Levee[1]	All elements represented, only adults and neonates represented.
	6	Knoll[1]	Most elements represented, only adults represented.
	7	Orbit Inn[1]	Cranium (100), lumbar vertebra (16), proximal radius/ulna (50), tarsal (10), phalanx (75); only adults represented.
Out	1	Danger Cave	Teeth (2), carpal (2), innominate (1), metatarsal (1), metapodial (1), phalanx (4)
	12	45SA8502, Canyonlands NP	Metacarpal (2), unspecified (6)
ARIZONA			
Out	46	Catclaw Cave	Horn core (1)
	48	AZ C:13:0004 (GC)	Metapodial distal epiphysis fragment (1)
	47	AZ C:13:0010 (GC)	Palatine (1), fused distal femur fragment (1)
	44	Homol'ovi I, Kiva 903	Unfused distal femur fragment/possible flesher (1), fused distal femur fragment (1)
	43	Bear Ruin	Mandible (1)
	42	Las Colinas	Either a tibia or a radius (contradictory information in Johnson [1981]), innominate fragment (1)
	41	Snaketown	Horn core (1 burnt and with a cremation, 1 on a house floor, 2 in trash), lower first molar (1), ear bones (?), and the end of a humerus (1)
	40	AZ W:10:47 and 50, Point of Pines	Scapula (2), 3rd phalanx (2), 7th cervical vertebra (1), thoracic vertebra (4+), lumbar vertebra (1)
	38	University Indian Ruin	Ulna fragment (1), mandible fragment (1), and tooth fragment (8)
	36	Babocomari Village	Burial (head, legs, and ribs), unspecified bones from a house floor and outdoor cooking pit
NEW MEXICO			

Table 3. Bison elements represented at habitation sites and demographic data (when available).

Out	27	Hawikuh	Rib (6), innominate fragment (1), hyoid (1). This does not represent everything found. Additional finds were described only as "few odd bones" (Smith 1966:231)
	28	Bat Cave	All body portions represented.
	31	Tularosa Cave	Permanent premolar (1), rib fragment (1), distal metatarsal (1), proximal metacarpal (1), horn (1), skin on the sole of a sandal (1), cord twisted from hair (1)
In	23	Gran Quivira, House A	Rib fragment (2); femur head (1); tibia fragment (1); carpal (2); phalanx (1)
	20	Phillips	Mandible (1); vertebra (14); rib (11); metacarpal (1); femur (1); tibia (4)
	22	Hiner	Vertebrae (1); scapula (2); humerus (1); femur (1); tibia (1)
	19	Block Lookout	Humerus (9); ulna (2); femur (8); tibia (3)
	18	Bonnell	Vertebra (19); rib (13); humerus (5); radius (1); femur (5); tibia (4)
	17	Bloom Mound	Humerus (2); radius (1); ulna (1); innominate (2); patella (1); tibia (2)

[1]Age data taken from reanalysis reported in Lupo and Schmitt 1997; [2]In or out of defined bison range (Figure 5).

(Lupo and Schmitt 1997) that likely necessitated a shift in subsistence patterns, which included relying more on other species of artiodactyl, traveling farther to hunt bison, or obtaining bison goods in trade. The skeletal elements represented at this site (Table 3) suggest that crania and hides were the principal products brought back to the site; crania contained brains used to tan hides, and lower limb elements were frequently left attached to the hides during transport. If the distance from kill/processing and habitation sites was great, the bison meat may have been made into jerky for transport, resulting in the lack of other body portions represented.

Skeletal element data from the Sierra Blanca region of southeastern New Mexico,

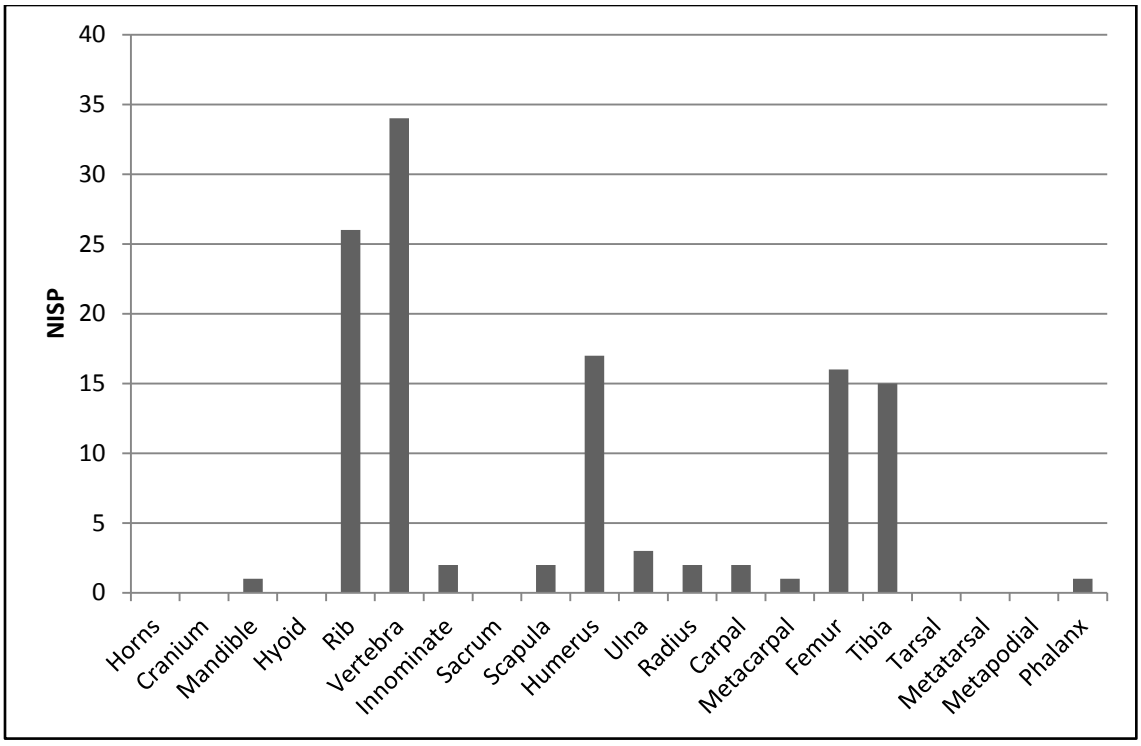

Table 4. Skeletal elements represented at sites in the Sierra Blanca Region of New Mexico.

located on the edge of bison distribution, shows differential representation of body portions (Tables 3 and 4). Adding in the faunal specimens from unidentified large ungulates (Driver 1990:Table 1), which are most likely bison since no other large ungulate species were positively identified at the sites, shows evidence for the selective transport of high value carcass portions such as the rib cage, the hump, marrow bones, and tenderloin, likely over long distances through hunting or trade with Plains groups (Driver 1990).

All body portions are represented at Bat Cave (Table 3) further substantiating the presence of bison in southwestern New Mexico approximately A.D.225±250 (Dick 1965), and three Holocene-aged paleontological sites dating between A.D. 1440-1640

provide evidence of bison in southeastern Arizona during the Late Prehistoric and Protohistoric periods (Agenbroad and Haynes 1975; Mead and Dryer 2001; Mead and Johnson 2004). Further, a bison burial at Babocomari Village (DiPeso 1951) in addition to an unspecified number of bison remains from a structure and cooking pit contexts indicates inhabitants at this site had at least occasional access to bison nearby.

Unfortunately, the paucity of other archaeological remains found outside bison distribution hinders confident interpretations of the skeletal portions represented. The patterning of elements is more evenly distributed in these assemblages (Table 5) than in the Sierra Blanca region (Table 4). Slightly higher numbers of horns cores, ribs,

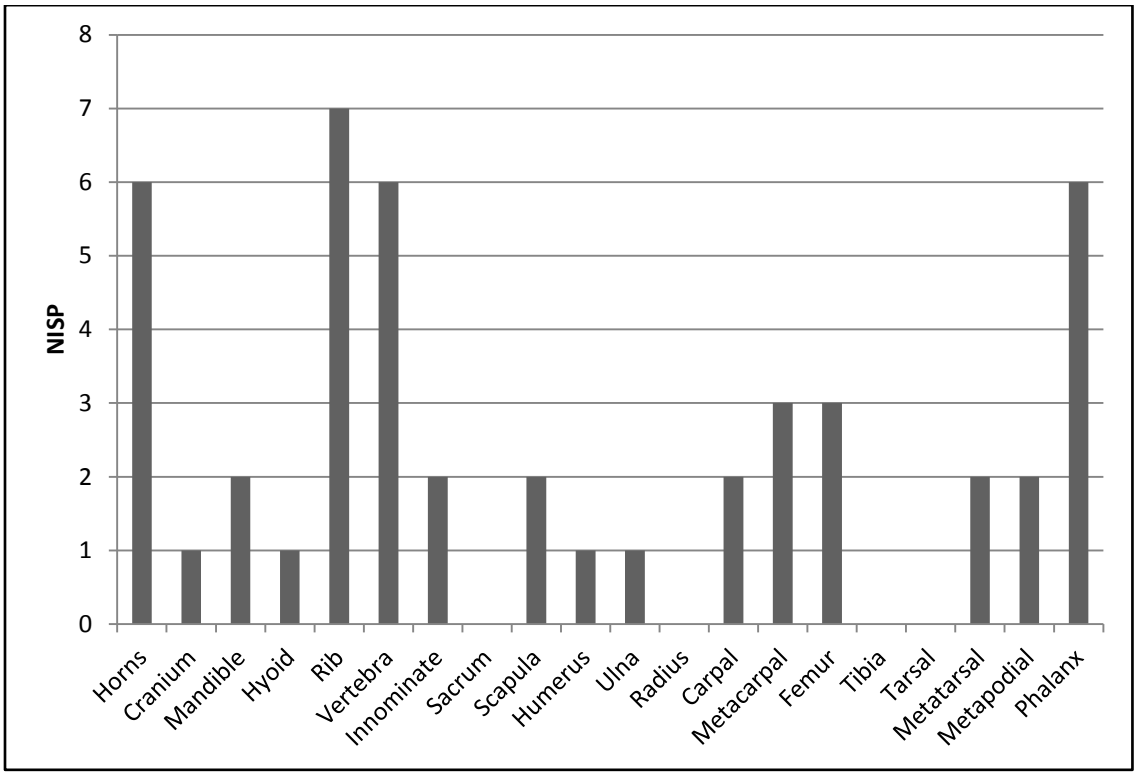

Table 5. Skeletal elements represented at sites outside bison range in Arizona, New Mexico, and Utah.

vertebrae, distal femora, metapodials, and phalanges may indicate trade items (e.g. horn cores for possible religious use, metapodials for tools, phalanges left attached to hides) or preferential transport of valued meat portions (rib meat, hump meat, and marrow bones).

Relatively few skeletal elements are represented at Hawikuh (Table 3), a pueblo of the Cíbola-Zuni region, however the site's status as a major trade center located along established and well-used east-west and north-south trade routes is well documented (Riley 1975). Widely traded items such as turquoise from central New Mexico, bison hides from the Great Plains, parrots and macaws from extreme southern Arizona and Mexico, and shell and coral from the Gulf of California, among other non-local goods, were abundantly traded into the Ancestral Puebloan region including the pueblos of Zuni. The presence of a few skeletal elements at Hawikuh, therefore, is not surprising, and the elements represented (ribs, pelvis, and hyoid) may reflect the receipt of high value carcass portions (rib meat, hindquarter, and tongue) during trade with Plains groups. Alternatively, if bison intermittently ranged beyond the limits of the Great Plains, other cultural groups or the inhabitants of Zuni themselves may have occasionally encountered small, dispersed populations of bison. In either scenario, the skeletal elements represented indicate the bison were procured at a significant distance from the site and only high value portions were brought back.

Spielmann (1983:261) noted horn cores found in possible ceremonial rooms at two historic pueblos and one prehistoric pueblo in north-central New Mexico pueblos. These elements may have been desired as ritual paraphernalia and acquired through trade or on long-distance hunting trips to the Great Plains. Horn cores are present at Snaketown

in central Arizona, Catclaw Cave along the Lower Colorado River, and Tularosa Cave in southwest New Mexico (Table 3), and these elements may have been traded (as was probably the case at Catclaw Cave) or brought back to the site from long-distance hunts.

Demographics

The presence of different age groups and sexes in an archaeological faunal assemblage suggests the presence of breeding populations that were at least intermittently indigenous to an area, whereas the presence of only adult animals in a faunal assemblage may represent the exploitation of solitary animals or mature bull groups. Seasonality affects herd size and composition and may be responsible for the demographics observed in the archaeofaunal assemblage, and hunters may make decisions to target specific a specific age or sex (Speth 1983). Due to these factors, demographic data is a less reliable indicator of bison herd characteristics in the site environment. However, it is expected that the persistent presence of only adult animals in a single site assemblage or across multiple sites in an entire region may indicate that people only had access to far-ranging bull herds or solitary animals that moved beyond the traditional migration limits of matriarchal and mixed herds. Therefore it is anticipated that habitation sites within bison range will have multiple age groups and both sexes represented, whereas sites outside bison range may have only adults or males represented.

Habitation sites within bison range in northeastern Utah, such as Bear River Nos. 1, 2, and 3 and the Levee site are comprised of a combination of adults, juveniles, and neonates suggesting the presence of breeding populations of bison in the Great Salt Lake region. The presence of only adult animals at two sites in northeastern Utah, Knoll and

Orbit Inn, is attributed to fluctuating bison populations in the Great Salt Lake during Fremont occupation of the region that resulted in a retraction of bison populations (Lupo and Schmitt 1997). Unfortunately, the bison remains from archaeological sites outside of known bison range are too sparse and the published reports often too vague to determine if only adults were exploited. The presence of a pregnant bison cow at Murray Springs, however, is evidence of a breeding population within 1 or 2 days range of southeastern Arizona in A.D. 1610 (Agenbroad and Haynes 1975).

Kroeber (1935) documents that the Hualapai people rarely saw bison in their country. Only a few animals were ever known to straggle now and then into Hualapai lands. This could represent evidence of solitary bulls ranging near the southwestern region of the Grand Canyon. Father Tomás Garcés mentions being given wild *cibola* meat while visiting Havasupai near the Little Colorado River in 1776 (Coues 1900:403, 406). He claimed the Hualapai killed the animal themselves. This also could be evidence of a straggler or bull group wandering into Havasupai territory southeast of the Grand Canyon. This is conjectural, of course, but given the paucity of bison remains in the archaeological record of the region, this seems a reasonable explanation for the rare sightings and remains of bison in southern Colorado Plateau country.

CHAPTER 8: SUMMARY AND MANAGEMENT IMPLICATIONS

> These last animals [buffaloes] are now so numerous that from an eminence we discovered more than we had ever seen before at one time; and if it be not impossible to calculate the moving multitude, which darkened the whole plains, we are convinced that twenty thousand would be no exaggerated number [Lewis and Clark; quoted in Hornaday 2002:389 (1889)].

Historical images of bison blanketing the landscape of America are iconic but uncharacteristic of bison populations through time and the species' entire geographic range. Temporal and spatial fluctuations of bison populations are documented for northern regions of the American West and the Great Basin (Butler 1978; Grayson 2011; Lupo and Schmitt 1997; McDonald 1981; Van Vuran 1987; Van Vuren and Bray 1986), and the preponderance of evidence from historic-era observations, ethnographic accounts, and archaeofaunal remains suggests that bison were present in the Southwest but in comparatively small numbers and perhaps only sporadically.

This characterization of bison populations was stated previously by other researchers (Mead 2002; Reed 1955; Truett 1996; Wolff 2013), yet the occasional discovery of the animal in the Southwest's archaeological record fuels continuing reanalysis of its historical range. Movement of the House Rock Valley bison herd in Arizona from the House Rock Valley Wildlife Area on National Forest land to the Kaibab Plateau on Grand Canyon National Park (GRCA) land has elicited inquiries from wildlife managers regarding the significance of paleontological and archaeological finds to determinations of the species' status as native or nonnative to the southern Colorado Plateau. It is the intent of this investigation to move beyond discussions presenting mere

presence/absence lists of bison finds and provide a zooarchaeological interpretation to address the complexity inherent in the formation of site assemblages. The archaeological record is, admittedly, only a snapshot of past environments. Assemblages are constructed by various cultural and non-cultural taphonomic mechanisms that act on faunal collections from death of the animals through the scientific investigative process. This complex taphonomic history blurs the snapshot, which is why it is imperative that discussions of the historical range of a species as evidenced in prehistoric records be placed within appropriate paleontological or zooarchaeological interpretive frameworks.

What is known about the faunal resources exploited by people of the southern Colorado Plateau prior to European colonization is based on a substantial amount of accumulated faunal data from numerous archaeological sites excavated throughout the region. Deer (*Odocoileus* sp.), pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), jackrabbits (*Lepus* sp.), cottontails (*Sylvilagus* sp.), and various rodents, among a few other lesser exploited taxa, contributed substantially to human diet. Bison (*Bison bison*), on the other hand, are very rarely present in Holocene archaeofaunal assemblages. Based on corroborating evidence from historic, ethnographic, and archaeological records, this is more likely a factor of availability than it is of choice on the part of pre-Columbian human hunters.

To date, only three possible bison specimens are documented from Holocene archaeological contexts in GRCA. The elements recovered from the inner canyon sites are not indicative of typical trade goods, and there is no substantial evidence linking these elements to non-cultural taphonomic depositional mechanisms such as fluvial or animal

transport. Given the exceptionally rugged topography, it is improbable that bison inhabited the inner Grand Canyon at any time during the Pleistocene and Holocene, although it is possible that bison infrequently wandered into the inner canyon along traversable routes, perhaps in search of water, or occupied either rim. It is more likely, based on the available evidence, that a bison was hunted by the site's inhabitants, yet the paucity of remains and the elements represented suggests it was procured some distance from the site. How far and where the animal was likely captured cannot be determined, and this evidence still does not adequately illuminate historical bison range in the Southwest.

In order to further assess the availability of bison to pre-Columbian human hunters in the southern Colorado Plateau region, a sample of sites to the north and east within and on the margins of known historical bison range were used for an inter-assemblage comparison with sites located out of bison range. Indicators of bison living in proximity to human settlements are 1) the presence of bison kill and processing sites in the immediate region, 2) a high relative abundance of bison occurring as the most frequent artiodactyl species, 3) a high degree of skeletal completeness, and 4) a diversity of age groups and both males and females represented. Regions northeast of the Great Salt Lake in Utah and on the western edge of the Plains in easternmost New Mexico contain such sites and site assemblages.

People living on the margins of bison range such as in the Sierra Blanca region of southeastern New Mexico could have obtained bison through long distance hunting trips, trade with groups within range, or occasional access to herds that migrated beyond

traditional distribution. Indicators of these mechanisms of procurement are 1) modest but highly variable relative abundances of bison among site assemblages, 2) bison rarely as the most frequently occurring artiodactyl species, and 3) a differential representation of skeletal elements indicating the selection of high utility carcass portions for long-distance transport.

Human settlements outside known historic range likely acquired bison in the same manners as those in marginal range, but the bison specimens represented contrast with sites within range even more starkly. These sites have exceptionally low relative abundances of bison (<0.1%), which are never the most frequently occurring artiodactyl species. A very low number of skeletal elements represented is also characteristic. The wide variety of elements present at all sites combined (Tables 5 and 7) and the contexts of finds (e.g. animal burial, human cremation, kiva, habitation structure, cooking features, refuse areas) do not produce any patterns from which to draw a single interpretation (e.g. only trade goods such as hide, ritually significant elements, or selective transport of valued meat portions). Rather, there is a seemingly random assortment of skeletal portions with only slightly higher numbers of certain elements that may represent traded non-edible products (e.g. hide, horn, and tools) and selective transport of high value meat and marrow portions (e.g. rib meat, hump meat, marrow bones.

The question that remains is what does this mean for the fate of the House Rock Valley bison herd that now resides within GRCA? Paleontological evidence proves bison were in the region of Glen Canyon National Recreation Area during the Pleistocene (Mead and Agenbroad 1992), and sparse remains found in GRCA caves may be evidence

of bison in the Grand Canyon during that time as well (Emslie 1987, 1988; Harington 1984). However, conservation and restoration scientists are not generally seeking to recreate Pleistocene environments. The targeted environmental reference condition is typically the pre-Columbian Holocene, and the evidence of bison on the southern Colorado Plateau during this time is limited and circumstantial.

There are no known Holocene-aged paleontological bison remains in GRCA (Mead 2002), and only two, perhaps three, specimens are known from archaeological proveniences (GRCA Collections Database; Spurr and Cannon 2013; Yoshikawa 1986). Yet when the GRCA finds are placed within the context of the entire Southwest, a somewhat even distribution of low-abundance finds occurring outside of traditionally known bison range emerges (Figures 4 and 5; also see Grayson 2011; Wolff 2013). Based on the sites reviewed herein, these finds cannot be explained away as strictly trade goods, and the possibility remains that bison were available to human hunters in regions of the Southwest typically considered outside range. The declining relative abundances and skeletal completeness of bison at sites located at great distances from the known bison range implies increasingly smaller population numbers that were infrequently available to human hunters.

Today, the House Rock Valley bison herd occupies a relatively small geographic area (the Kaibab Plateau and House Rock Valley) year round. Prior to habitat fragmentation resulting from urbanization, geopolitical divisions of land, and human hunting pressure, bison migrated hundreds of miles between summer and winter ranges. If bison were present in the Southwest during the Holocene, as the evidence suggests,

they likely roamed intermittently as small herds or loan males in and out of the region, perhaps in response to harsh winters in more northern climes or widespread climate changes and fluctuations in the availability of water and forage. This scenario, however, is not equivalent to a full-time resident population. The House Rock Valley bison herd currently inhabits a roughly 50-mile by 30-mile area, and their potential migratory range in the region is constrained by nearly 300 miles of rugged canyon to the east and south; over-grazed and drought-impacted high desert grasslands to the north, west, and east; and urban environments and other man-made impediments to movement to the north. In addition, natural large predators, which were nearly eradicated in the early 1900s, are too few to adequately mitigate herd size, and hunters cannot take game on National Park Service land. The data presented here cannot judge the carrying capacity of GRCA ecosystems to support bison herds. Continuing research structured to account for the possibility of bison in archaeological site assemblages throughout the Southwest is needed to refine our knowledge. Based on what is currently known, it is unlikely that the pre-Columbian bison populations in the region were equivalent to a full-time resident, large-sized herd as exists within the confines of the Arizona Strip today.

Attempts to characterize bison populations in the Southwest ultimately generate more questions than answers, but this provides directions for future zooarchaeological research. First, a reanalysis of assemblages collected from older excavations is needed since zooarchaeological analytical standards have changed considerably over the years, and frequently only lists, and perhaps counts, of taxa represented were provided in older project reports. Further, a reanalysis of specimens labeled *Bison/Bos*, unidentified

ungulate, or unidentified artiodactyl is warranted since bison remains may have been overlooked in previously analyzed assemblages if the faunal analyst did not consider bison a native species or an exotic trade good in their study region. Second, future analysts need to consider the possibility that bison may be present in faunal assemblages outside traditionally understood range, and if remains are found, an explication of the temporal and spatial contexts and interpretation of remains should be included in reporting to contribute to discussions on bison range in the Southwest and economic trade networks. Finally, if bison are identified in archaeological assemblages, correlation should be drawn, when possible, to other stratified sites in the study region with bison remains in an attempt to gain temporal control on the occurrence of bison and potential fluctuations in historical range.

DNA analysis to determine genetic integrity may ultimately decide the fate of the House Rock Valley bison herd that was crossbred with cattle over a hundred years ago (Minard 2003). Should bison be considered a native species to GRCA, then the herd's genetic integrity must conform with the *Department of Interior Federal Herd Standard-Draft Document, DIO Bison Working Group 2003* (Leslie 2003). If the House Rock valley bison are permitted to stay as a native species and genetically pure herd, the archaeological evidence suggests herd numbers would need to be controlled to more closely mimic hypothesized pre-Columbian population numbers and distribution and accommodate for the lack of natural predators. Further, 150 years of intensive grazing, wildfire suppression, and the most recent drought have transformed the modern Arizona Strip landscape, producing environmental conditions unlike those under which bison

formerly ranged. While bison may in fact be native, the prospective long-term sustainability of a self-sufficient herd under modern conditions in an exceptionally arid landscape may, in the end, be the question that needs addressed.

REFERENCES

Abbott, Lon, and Terri Cook
2004 *Hiking the Grand Canyon's Geology*. The Mountaineers Books, Seattle.

Agenbroad, Larry D., and C. Vance Haynes
1975 *Bison bison* Remains at Murray Springs, Arizona. *Kiva* 40:309-313.

Agenbroad, Larry D., and India S. Hesse
2004 Megafauna, Paleoindians, Petroglyphs, and Pictographs of the Colorado Plateau. In *The Settlement of the American Continents: A Multidisciplinary Approach to Human Biogeography*, edited by C. Michael Barton, Geoffrey A. Clark, David R. Yesner, and Georges A. Pearson, pp. 189-195. The University of Arizona Press, Tucson.

Ahlstrom, Richard V.N.
1986 Tree-Ring Dating the Cohonina. Manuscript on file, Department of Anthropology, University of Arizona, and SWCA, Inc., Environmental Consultants, Tucson.

Ahlstrom, Richard V.N., David E. Purcell, Mark Zyniecki, Dennis A. Gilpin, Virginia L. Newton
1993 *An Archaeological Overview of Grand Canyon National Park*. SWCA Archaeological Report No. 93-92. SWCA Environmental Consultants, Flagstaff. Submitted to National Park Service, Grand Canyon National Park.

Aikens, C. Melvin
1966 *Fremont-Promontory-Plains Relationships*. Anthropological Papers No. 82. University of Utah Press, Salt Lake City.

1967 *Excavations at Snake Rock Village and the Bear River No. 2 Site*. Anthropological Papers No. 87. University of Utah Press, Salt Lake City.

Allen, Joel A.
1974 [1876] *The American Bisons Living and Extinct*. Arno Press, New York.

Anderson, Michael F.
1998 *Living at the Edge: Explorers, Exploiters and Settlers of the Grand Canyon Region*. Grand Canyon Association, Grand Canyon, Arizona.

2000 *Polishing the Jewel: An Administrative History of Grand Canyon National Park*. Grand Canyon Association, Grand Canyon, Arizona.

Arizona Game and Fish Department
2013 2013-14 Arizona Hunting Regulations. Arizona Game and Fish Department, Phoenix.

Axtell, Robert L., Joshua M. Epstein, Jeffrey S. Dean, George J. Gumerman, Alan C. Swedlund, Jason Harburger, Shubha Chakravarty, Ross Hammond, Jon Parker, and Miles Parker
2002 Population Growth and Collapse in a Multiagent Model of the Kayenta Anasazi in Long House Valley. *Proceedings of the National Academy of Science* 99:7275-7279.

Bailey, Vernon
1935 *Mammals of the Grand Canyon Region*. Natural History Bulletin No. 1. Grand Canyon Natural History Association, Grand Canyon, Arizona.

Banfield, Alexander W.F.
1974 *The Mammals of Canada*. University of Toronto Press, Toronto.

Baugh, Timothy G.
1984 Southern Plains Societies and Eastern Frontier Pueblo Exchange during the Protohistoric Period. In *Collected Papers in Honor of Harry L. Hadlock,* edited by Nancy C. Fox, pp. 141-155. Papers of the Archaeological Society of New Mexico No. 9. Albuquerque.

Benedict, James B.
1979 Getting Away from It All: Man, Mountains and the Two Drought Altithermal. *Southwestern Lore* 45:1-12.

Berg, Adam M., Stewart Deats, Doug Drake, Joshua S. Edwards, Dennis Gilpin, Jim Hasbargen, Michael O'Hara, and Gordon F.M. Rakita
2003 *Prehistoric Occupation of the Confluence Valley Between the Vermilion Cliffs and Short Creek: Investigation of 16 Sites for the Hildale Wastewater Treatment Facility, Hildale, Utah, and Colorado City, Arizona*. SWCA Environmental Consultants, Flagstaff.

Berry, Claudia F., and Michael S. Berry
1986 Chronological and Conceptual Models of the Southwestern Archaic. In *Anthropology of the Desert West: Essays in Honor of Jesse D. Jennings,* edited by Carol J. Condie and Don D. Fowler, pp. 253-327. Anthropological Papers No. 110. University of Utah Press, Salt Lake City.

Binford, Lewis R.
1978 *Nunamiut Ethnoarchaeology*. Academic Press, New York.

1981 *Bones: Ancient Men and Modern Myths*. Academic Press, New York.

Bison Management Team
2002 *Bison Management Plan*. Arizona Game and Fish Department, Phoenix.

Blan, Linda M.
1997 Sinagua Subsistence Behavior: Inferences Derived from Faunal Analysis at Elden Pueblo. Unpublished Master's thesis, Department of Anthropology, Northern Arizona University, Flagstaff.

Boren, Ray
1998 Buffalo: Exploring the Legacy. Electronic document, http://www.deseretnews.com/article/632450/Buffalo-Exploring-the-legacy.html?pg=all, accessed September 14, 2013.

Bradley, Ronna J.
1993 Marine Shell Exchange in Northwest Mexico and the Southwest. In *The American Southwest and Mesoamerica: Systems of Prehistoric Exchange*, edited by Jonathon E. Ericson and Timothy G. Baugh, pp. 121-151. Plenum Press, New York.

Brand, Donald D., Florence M. Hawley, and Frank C. Hibben
1937 *Tseh So, A Small House Ruin, Chaco Canyon, New Mexico*. Anthropological Series Vol. 2, No. 2. University of New Mexico Press, Albuquerque.

Broughton, Jack M.
2004 Pristine Benchmarks and Indigenous Conservation? Implications from California Zooarchaeology. In *The Future from the Past: Archaeozoology in Wildlife Conservation and Heritage Management,* edited by Roel C.G.M. Lauwerier and Ina Plug, pp. 6-18. Oxbow Books, Oxford.

Brown, Christopher L., and Carl E. Gustafson
1979 *A Key to Postcranial Skeletal Remains of Cattle/Bison, Elk, and Horse*. Reports of Investigations No. 57. Laboratory of Anthropology, Washington State University, Pullman.

Bunn, Henry T., Laurence E. Bartram, and Ellen M. Kroll
1988 Variability in Bone Assemblage Formation from Hadza Hunting, Scavenging, and Carcass Processing. *Journal of Anthropological Archaeology* 7:412-457.

Butler, Robert B.
1978 Bison Hunting in the Desert West Before 1800: The Paleoecological Potential and Archaeological Reality. In *Bison Procurement and Utilization: A Symposium*, edited by Leslie B. Davis and M. Wilson, pp. 106-112. Plains Anthropological Memoir 14(2).

Cannon, Kenneth P.
2004 The Analysis of Late Holocene Bison Skull from the Ashley National Forest, Utah. Midwest Archaeological Center. Submitted to the Ashley National Forest, Report No. AS-04-1010, Vernal, Utah.

Cannon, Michael D., and David J. Meltzer
2004 Early Paleoindian Foraging: Examining the Faunal Evidence for Large Mammal Specialization and Regional Variability in Prey Choice. *Quaternary Science Reviews* 23:1955-1987.

Carpenter, Mary C.
2003 Late Pleistocene Aves, Chiroptera, Perissodactyla, and Artiodactyla from Rampart Cave, Grand Canyon, Arizona. Unpublished Master's thesis, Quaternary Sciences Department, Northern Arizona University, Flagstaff.

Carter, William
1997 Bison, Corn, and Power: Plains-New Mexico Exchange in the Sixteenth and Early Seventeenth Centuries. *Heritage of the Great Plains* 30(1): 20-32.

Cartledge, Thomas R.
1979 Cohonina Adaptation to the Coconino Plateau: A Re-evaluation. *Kiva* 44:297-317.

Castleton, Kenneth Bitner
1984 *Petroglyphs and Pictographs of Utah*. Occasional Publications No. 4. Utah Museum of Natural History, Salt Lake City.

Catlin, George
1965 *Letters and Notes on the Manners, Customs, and Conditions of North American Indians*. Ross and Haines, Minneapolis.

Christensen, Don D.
2004 *Cohonina Rock Art in the Williams District, Kaibab National Forest, Arizona.* Archaeoimagery, Costa Mesa. Submitted to Kaibab National Forest. Copy available from Grand Canyon National Park.

2007 Preformative and Early Formative Rock Art of the Kanab Creek Wilderness Area, Arizona. *American Indian Rock Art* 33: 127-144.

Christensen, Don D., and Jerry Dickey
2006 *Beyond the Rim: An Overview of Rock Art on the South Rim of the Grand Canyon National Park and the Tusayan District of the Kaibab National Forest, Arizona*. Archaeoimagery, Costa Mesa, California. Submitted to Grand Canyon National Park. Copy available from Grand Canyon National Park.

2007 *An Overview of Rock Art on the Kanab and Kaibab Plateaus, Northern Arizona*. Archaeoimagery, Costa Mesa, California. Submitted to Kaibab National Forest, Grand Canyon National Park, and Bureau of Land Management, Arizona Strip District. Copy available from Grand Canyon National Park.

Christensen, Don D., Jerry Dickey, and Steven M. Freers
2013 *Rock Art of the Grand Canyon Region*. Sunbelt Publications, San Diego.

Cole, Kenneth, and Jim I. Mead
1981 Late Quaternary Animal Remains from Packrat Middens in the Eastern Grand Canyon, Arizona. *Journal of the Arizona-Nevada Academy of Science* 16:24-25.

Collette, Jim
2013 AZ C:13:0010 (Furnace Flats). In *The River Corridor Archaeology Project Synthetic Report: Excavations of Nine Colorado River Sites 2007-2009, Grand Canyon National Park*, edited by Theodore L. Neff, Kimberly Spurr, Jim Collette, and Mick Robbins. Draft submitted to Grand Canyon National Park.

Coltrain, Joan Brenner, and Steven W. Leavitt
2002 Climate and Diet in Fremont Prehistory: Economic Variability and Abandonment of Maize Agriculture in the Great Salt Lake Basin. *American Antiquity* 67:453-485.

Cosgrove, H.S., and C.B. Cosgrove
1932 *The Swartz Ruin: A Typical Mimbres Site in Southwestern New Mexico. Report of the Mimbres Valley Expedition Seasons of 1924-1927*. Papers of the Peabody Museum of American Archaeology and Ethnology Vol. 15, No. 1. Harvard University, Cambridge

Coues, Elliott
1900 *On The Trail of a Spanish Pioneer: The Diary and Itinerary of Francisco Garcés (Missionary Priest) in His Travels Through Sonora, Arizona, and California, 1775-1776*. Francis P. Harper, New York.

Creel, Darrell
1991 Bison Hides in Late Prehistoric Exchange in the Southern Plains. *American Antiquity* 56:40-49.

Crumley, Carole L.
1994 *Historical Ecology: Cultural Knowledge and Changing Landscapes*. School of American Research Press, Santa Fe.

Danz, Harold P.
1997 *Of Bison and Man: From the Annals of a Bison Yesterday to a Refreshing Outcome from Human Involvement with America's Most Valiant Beasts*. University Press of Colorado, Niwot, Colorado.

Dary, David A.
1974 *The Buffalo Book: The Full Saga of the American Animal*. The Swallow Press, Chicago.

Dean, Jeffrey S.
1988 Dendrochronology and Paleoenvironmental Reconstruction on the Colorado Plateau. In *The Anasazi in a Changing Environment*, edited by George J. Gumerman, pp. 119-167. Cambridge University Press, Cambridge.

2012 Trees, Time, and Environment. In *Hisat'sinom: Ancient Peoples in a Land without Water*, edited by Christian E. Downum, pp. 35-42. School for Advanced Research Press, Santa Fe.

Dean, Jeffrey S., Robert C. Euler, George J. Gumerman, Fred Plot, Richard H. Hevly, and Thor N.V. Karlstrom
1985 Human Behavior, Demography, and Paleoenvironment on the Colorado Plateaus. *American Antiquity* 50:537-554.

Dean, Jeffrey S., and William J. Robinson
1977 *Dendroclimatic Variability in the American Southwest A.D. 680 to 1970*. Laboratory of Tree-Ring Research, University of Arizona, Tucson. Prepared for the Department of the Interior National Park Service, Southwest Paleoclimate Contract No. CX-1595-5-0241.

1978 *Expanded Tree-Ring Chronologies for the Southwestern United States*. Laboratory of Tree-Ring Research, University of Arizona, Tucson.

1979 Computer Cartography and the Reconstruction of Dendroclimatic Variability in the American Southwest, A.D. 680 to 1970. In *Computer Graphics in Archaeology: Statistical Cartographic Applications to Spatial Analysis in Archaeological Contexts*, edited by Steadman Upham, pp. 79-94. Anthropological Research Papers No. 15. Arizona State University, Tempe.

Denevan, William M.
1992 The Pristine Myth: The Landscape of the Americas in 1492. *Annals of the Association of American Geographers* 82:369-385.

Denig, EdwinT.
1930 Indian Tribes of the Upper Missouri. *Bureau of American Ethnology Bulletin* No. 46:375-628. Government Printing Office, Washington, D.C.

deSaussure, Raymond E.
1956 Remains of the California Condor in Arizona Caves. *Plateau* 29:44-45.

Dick, Herbert W.
1965 *Bat Cave*. Monograph No. 7. School of American Research Press, Santa Fe.

DiPeso, Charles C.
1951 *The Babocomari Village Site on the Babocomari River, Southeastern Arizona*. The Amerind Foundation, Dragoon, Arizona.

Dongoske, Kurt
2009 *Dissenting Report on the Technical Working Groups Recommendation Concerning the FY 2010 & 2011 Work Plan and Budget for the Glen Canyon Dam Adaptive Management Program*. Pueblo of Zuni, New Mexico.

Driver, Jonathan C.
1985 *Zooarchaeology of Six Prehistoric Sites in the Sierra Blanca Region, New Mexico*. Research Reports in Archaeology Contribution 12, Technical Reports Number 17. Museum of Anthropology, University of Michigan, Ann Arbor.

1990 Bison Assemblages from the Sierra Blanca Region, Southeastern New Mexico. *Kiva* 55:245-263.

Effland, Richard W., Anne Trinkle Jones, and Robert C. Euler
1981 *The Archaeology of Powell Plateau: Regional Interpretation of Grand Canyon*. Monograph No. 3. Grand Canyon Natural History Association, Grand Canyon, Arizona.

Emslie, Steven D.
1987 Age and Diet of Fossil California Condors in Grand Canyon, Arizona. *Science* 237:768-770.

1988 Vertebrate Paleontology and Taphonomy of Caves in Grand Canyon, Arizona. *National Geographic Research* 4:128-142.

Emslie, Steven D., Robert C. Euler, and Jim I. Mead
1987 A Desert Culture Shrine in Grand Canyon, Arizona, and the Role of Split-twig Figurines. *National Geographic Research* 3:511-516.

Emslie, Steven D., Jim I. Mead, and Larry Coats
1995 Split-Twig Figurines in Grand Canyon, Arizona. New Discoveries and Interpretations. *Kiva* 61:145-173.

Etnier, Michael A.
2002 Occurrences of Guadalupe Fur Seals (*Arctocephalus townsendi*) on the Washington Coast over the Past 500 Years. *Marine Mammal Science* 18:551-557.

Euler, Robert C.
1967 The Canyon Dwellers. *American West* 4(2):22-27, 67-71.

1974 Future Archaeological Research in the Grand Canyon. *Plateau* 46:139-148.

Euler, Robert C. (editor)
1984 *The Archaeology, Geology, and Paleobiology of Stanton's Cave, Grand Canyon National Park, Arizona*. Monograph No. 6. Grand Canyon Natural History Association, Grand Canyon, Arizona.

Euler, Robert C., George Gumerman, Thor N.V. Karlstrom, Jeffrey S. Dean, and Richard H. Hevly
1979 The Colorado Plateaus: Culture Dynamics and Paleoenvironment. *Science* 205:1089-1101.

Euler, Robert C., and Alan P. Olsen
1965 Split-Twig Figurines from Northern Arizona: New Radiocarbon Dates. *Science* 148:368-369.

Fairley, Helen C.
1989 Culture History. In *Man, Models, and Management: An Overview of the Archaeology of the Arizona Strip and the Management of Its Cultural Resources*, edited by Jeffrey Altschul and Helen C. Fairley. Submitted to the USDA Forest Service, Kaibab National Forest, and the USDI Bureau of Land Management, Arizona Strip District, Contract No. 53-8371-6-0054. Statistical Research, Tucson.

2003 *Changing River: Time, Culture, and the Transformation of Landscape in the Grand Canyon, A Regional Research Design for the Study of Cultural Resources along the Colorado River in Lower Glen Canyon and Grand Canyon National Park, Arizona*. Technical Series 79. Statistical Research, Inc. Tucson.

Fairly, Helen C., Peter W. Bungart, Christopher M. Coder, Jim Huffman, Terry L. Samples, Janet R. Balsom
1994 *The Grand Canyon River Corridor Survey Project: Archaeological Survey along the Colorado River between Glen Canyon Dam and Separation Canyon. Grand Canyon National Park, Arizona*. National Park Service, Department of the Interior Cooperative Agreement No. 9AA-40-07920.

Feldhamer, George A., Bruce C. Thompson, Joseph A. Chapman (editors)
2003 Wild Mammals of North America: Biology, Management, and Conservation. 2nd ed. The Johns Hopkins University Press, Baltimore.

Ferguson, T.J., and E. Richard Hart
1985 *A Zuni Atlas*. University of Oklahoma Press, Norman.

Ferring, C. Reid, and Scott A. Ellias
2001 *The Archaeology and Paleoecology of the Aubrey Clovis Site (41DN479), Denton County, Texas*. Center for Environmental Archaeology, Department of Geography, University of North Texas, Denton.

Fisher, John W.
1995 Bone Surface Modifications in Zooarchaeology. *Journal of Archaeological Method and Theory* 2:7-69.

Fortsas, Konstantino N.
1996 Artiodactyl Procurement at Wupatki Pueblo: Emphasis on *Antilocapra americana*, the Pronghorn Antelope. Unpublished Master's thesis, Department of Anthropology, Northern Arizona University, Flagstaff.

Fry, Gary F., and Gardiner F. Dalley
1979 *The Levee Site and the Knoll Site*. Anthropological Papers No. 100. University of Utah Press, Salt Lake City.

Garretson, Martin S.
1938 *The American Bison: The Story of Its Extermination as a Wild Species and Its Restoration under Federal Protection*. New York Zoological Society, New York.

Geib, Phil R.
1996 *Glen Canyon Revisited*. Anthropological Papers No. 119. University of Utah Press, Salt Lake City.

Geib, Phil R., Jim H. Collette, and Kimberly Spurr
2001 *Kaibabitsinüngwü: An Archaeological Sample Survey of the Kaiporawits Plateau*. Cultural Resource Series No. 25, Grand Staircase-Escalante National Monument Special Publication No. 1. Bureau of Land Management, Salt Lake City.

Gifford, James C.
1957 *Archaeological Exploration in Caves of the Point of Pines Region Arizona*. Anthropological Papers No. 36. University of Arizona Press, Tucson.

1980 *Archaeological Exploration in Caves of the Point of Pines Region Arizona*. Unpublished Master's thesis, Department of Anthropology, University of Arizona, Tucson.

Gilpin, Dennis
1994 Lukachukai and Salina Springs: Late Archaic/Early Basketmaker Habitation Sites in the Chinle Valley, Northeastern Arizona. *Kiva* 60:203-218.

Gipson, Philip S., Warren B. Ballard, and Ronald M. Nowak
1998 Famous North American Wolves and the Credibility of Early Wildlife Literature. *Wildlife Society Bulletin* 26:808-816.

Gou-Qin, Qi
1983 The Analysis of Faunal Remains from the University Indian Ruin. *Kiva* 49(1-2):81-103.

Grahame, John D., and Thomas D. Sisk (editors)
2002 Canyons, Cultures, and Environmental Change: An Introduction to the Land-Use History of the Colorado Plateau. Electronic document, http://www.cpluhna.nau.edu, accessed 10/30/2013.

Grayson, Donald K.
1984 *Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas*. Academic Press, Orlando.

1988 *Danger Cave, Last Supper Cave, and Hanging Rock Shelter: The Faunas*. Anthropological Papers Vol. 66, Part 1. The American Museum of Natural History, New York.

2011 *Great Basin: A Natural Prehistory*. University of California Press, Berkeley.

Grayson, Donald K., and David J. Meltzer
2002 Clovis Hunting and Large Mammal Extinction: A Critical Review of the Evidence. *Journal of World Prehistory* 16:313-359.

Gumerman, George J. (editor)
1988 The Anasazi in a Changing Environment. Cambridge University Press, Cambridge.

Haines, Francis
1975 *The Buffalo*. Thomas Y. Crowell Company, New York.

Hammond, George P., and Agapito Rey
1940 *Narratives of the Coronado Expedition 1540-1542*. University of New Mexico Press, Albuquerque.

Hanson, Jeffrey R.
1984 Bison Ecology in the Northern Plains and a Reconstruction of Bison Patterns for the North Dakota Region. *Plains Anthropologist* 29:93-113.

Hargrave, Lyndon L.
1938 Results of a Study of the Cohonina Branch of the Patayan Culture in 1938. *Museum Plateau* 11:43-50.

Harrington, C.R.
1972 Extinct Animals of Rampart Cave. *Canadian Geographical Journal* 85:178-183.

1984 Ungulate Remains from Stanton's Cave: An Identification List. In *The Archaeology, Geology, and Paleobiology of Stanton's Cave, Grand Canyon National Park, Arizona*, edited by Robert C. Euler, pp. 67-75. Monograph No. 6. Grand Canyon Natural History Association, Grand Canyon, Arizona.

Haury, Emil W.
1936 The Mogollon Culture of Southwestern New Mexico. Medallion Papers No. XX. Gila Pueblo, Globe, Arizona.

1938 Food. In *Excavations at Snaketown: Material Culture*, edited by Harold S. Gladwin, Emil W. Haury, E.B. Sayles, and Nora Gladwin, pp. 156-158. Medallion Papers No. 25. Gila Pueblo, Globe, Arizona.

1940 *Excavations in the Forestdale Valley, East-Central Arizona*. Social Science Bulletin No. 12. University of Arizona, Tucson.

Haury, Emil W., Ernst Antevs, and John F. Lance
1953 Artifacts with Mammoth Remains, Naco, Arizona. *American Antiquity* 19:1-24.

Haury, Emil W., E.B. Sayles, and William W. Wasley
1959 The Lehner Mammoth Site, Southeastern Arizona. *American Antiquity* 25:2-30.

Hayes, Alden C.
1981 *Contributions to Gran Quivira Archaeology, Gran Quivira National Monument, New Mexico*. Publications in Archaeology No. 17. U.S. Department of the Interior, National Park Service, Washington, D.C.

Haynes, C. Vance, Jr., and Bruce B. Huckell (editors)
2007 *Murray Springs: A Clovis Site with Multiple Activity Areas in the San Pedro Valley, Arizona*. Anthropological Papers Number 71. University of Arizona Press, Tucson.

Haynes, Gary
2002 *The Early Settlement of America: The Clovis Era*. Cambridge University Press, Cambridge.

Hedquist, Saul L.
2012 Exotic Goods in the Sierra Sin Agua. In *Hisat'sinom: Ancient Peoples in a Land without Water*, edited by Christian E. Downum, pp. 140-148. School for Advanced Research Press, Santa Fe.

Heid, J.J.
1982 Settlement Patterns on Little Creek Mountain. *Western Anasazi Reports* 3:87-179.

Hodge, Frederick Webb
1920 *Hawikuh Bonework*. Indian Notes and Monographs Vol. 3, No. 3. Museum of the American Indian, Heye Foundation, New York.

1937 *History of Hawikuh*. Ward Ritchie Press, Los Angeles, California.

Hoffmeister, Donald F.
1986 *Mammals of Arizona*. University of Arizona Press, Tucson.

Hollenshead, Marci
2007 *Exploration of Paleoindian and Early Archaic in the Greater Grand Canyon Region: Recent Evidence from Grand Canyon and Implications for Prehistoric Land Use*. Department of Biological Sciences, Northern Arizona University. Submitted to Grand Canyon National Park, Arizona.

Horn, Lyle H., Reid A. Bryson, and William P. Lowry
1957 *An Objective Precipitation Climatology of the United States*. University of Wisconsin Department of Meteorology, Madison, Wisconsin. U.S.A.F. Contract AF 19 (604) 992.

Hornaday, William T.
2002 [1889] *The Extermination of the American Bison*. Smithsonian Institution, Washington, D.C.

Hough, Walter
1914 *Culture of the Ancient Pueblos of the Upper Gila River Region, New Mexico and Arizona*. Smithsonian Institution United States National Museum Bulletin 87. Government Printing Office, Washington, D.C.

Huffer, Donelle J.
2013 *An Analysis of Faunal Remains from Wupatki National Monument, Arizona*. Arizona State Museum, University of Arizona, Tucson. Submitted to the National Park Service. Copies available from Flagstaff Area Monuments.

Hunter, Malcolm, Jr.
1996 Benchmarks for Managing Ecosystems: Are Human Activities Natural? *Conservation Biology* 10:695-697.

Iberall, Eleanora R.
1972 Paleoecological Studies from Fecal Pellets: Stanton's Cave, Grand Canyon, Arizona. Master's thesis, Department of Geosciences, University of Arizona, Tucson.

Jennings, Jesse D.
1957 *Danger Cave*. Anthropological Papers No. 27. University of Utah Press, Salt Lake.

Jennings, Jesse D. (editor)
1980 *Cowboy Cave*. Anthropological Papers No. 104. University of Utah Press, Salt Lake City.

Johnson, Paul C.
1981 Mammalian Remains from Las Colinas. In *The 1968 Excavations at Mound 8 Las Colinas Ruins Group, Phoenix, Arizona*, edited by Laurens C. Hammack and Alan P. Sullivan, pp.277-282. Archaeological Series No. 154. Arizona State Museum University of Arizona, Tucson.

Jones, Anne Trinkle
1986 *A Cross Section of Grand Canyon Archaeology: Excavations at Five Sites along the Colorado River*. Publications in Anthropology No. 28. Western Archaeological and Conservation Center, National Park Service, Tucson.

Kay, Charles E., and Randy T. Simmons (editors)
2002 *Wilderness and Political Ecology: Aboriginal Influences and the Original State of Nature*. The University of Utah Press, Salt Lake City.

Kelly, Isabel T.
1964 *Southern Paiute Ethnography*. Anthropological Papers No. 69, Glen Canyon Series No. 21. University of Utah Press, Salt Lake City.

Kelly, Robert L., and Lawrence C. Todd
1988 Coming into the Country: Early Paleoindian Hunting and Mobility. *American Antiquity* 53:231-244.

Kidder, A.V.
1932 *Artifacts of Pecos*. Papers of the Southwestern Expedition 6. Phillips Academy, Andover.

Krech, Shepard, III
1999 *The Ecological Indian: Myth and History*. W.W. Norton and Company, New York.

Kroeber, A.L. (editor)
1935 *Walapai Ethnography*. Memoirs of the American Anthropological Association, Contributions from the Laboratory of Anthropology, I. American Anthropological Association, Menasha, Wisconsin.

LaMotta, Vincent Michael
2006 Zooarchaeology and Chronology of Homol'ovi I and Other Pueblo IV Period Sites in the Central Little Colorado River Valley, Northern Arizona. Unpublished Ph.D. dissertation, Department of Anthropology, University of Arizona, Tucson.

Landres, Peter B.
1992 Temporal Scale Perspectives in Managing Biological Diversity. *Transactions of the North American Wildlife and Natural Resource Conference* 57:292-307.

Lang, Richard W., and Arthur H. Harris
1984 *The Faunal Remains from Arroyo Hondo Pueblo, New Mexico: A Study in Short-term Subsistence Change*. Arroyo Hondo Archaeological Series Vol. 5. School of American Research Press, Santa Fe.

Larson, Daniel O., and Joel Michaelsen
1990 Impacts of Climatic Variability and Population Growth on Virgin Branch Anasazi Cultural Developments. *American Antiquity* 55:227-249.

Lauwerier, Roel C.G.M., and Ina Plug (editors)
2004 *The Future from the Past: Archaeozoology in Wildlife Conservation and Heritage Management.* Oxbow Books, Oxford.

Lawrence, Barbara
1951a *Part II: Post-cranial Skeletal Characteristics of Deer, Pronghorn, and Sheep-goat with Notes on Bos and Bison*. Papers of the Peabody Museum of American Archaeology and Ethnology Vol. 35, No. 3. Harvard University, Cambridge.

1951b *Part I: Mammals Found at the Awatovi Site*. Papers of the Peabody Museum of American Archaeology and Ethnology Vol. 35, No. 3. Harvard University, Cambridge.

Leslie, Elaine F.
2003 Capture Operations Plan for North Rim Bison. NPS Biological Resource Management Division and Grand Canyon National Park. Manuscript on file, Grand Canyon National Park Research Library, Grand Canyon, Arizona.

Library of Congress
2002 The Evolution of the Conservation Movement 1850-1920. Electronic document. http://memory.loc.gov/ammem/amrvhtml/, accessed October 23, 2013.

Lincoln, Edward P.
1961 *A Comparative Study of Present and Past Mammalian Fauna of the Sunset Crater and Wupatki Areas of Northern Arizona*. Unpublished Master's thesis, Department of Zoology, University of Arizona, Tucson.

Lindsay, Alexander. J., J.R. Ambler, M.A. Stein, and P.M. Hobler
1968 *Survey and Excavations North and East of Navajo Mountain, Utah, 1959-1962*. Bulletin 45, Glen Canyon Series 8. Museum of Northern Arizona, Flagstaff.

Loendorf, Lawrence L., and Stuart W. Conner
1993 The Pectoral Shields and the Shield-Bearing Warrior Rock Art Motif. *Journal of California and Great Basin Anthropology* 15:216-224.

Long, Paul V.
1966 *Archaeological Excavations in Lower Glen Canyon, Utah, 1959-1960*. Bulletin 45, Glen Canyon Series 8. Museum of Northern Arizona, Flagstaff.

Lott, Dale F.
2002 *American Bison, A Natural History*. University of California Press, Berkeley.

Lupo, Karen D., and Dave N. Schmitt
1997 On Late Holocene Variability in Bison Populations in the Northeastern Great Basin. *Journal of California and Great Basin Anthropology* 19:50-69.

Lyman, R. Lee
1994 *Vertebrate Taphonomy*. Cambridge University Press, Cambridge.

1996 Applied Zooarchaeology: The Relevance of Faunal Analysis to Wildlife Management. *World Archaeology* 28:110-125.

2006 Paleozoology in the Service of Conservation Biology. *Evolutionary Anthropology* 15:11-19.

Lyman, R. Lee, and Kenneth P. Cannon (editors)
2004 *Zooarchaeology and Conservation Biology*. University of Utah Press, Salt Lake City.

Lyon, Marcus Ward, Jr.
1907 Mammal Remains from Two Prehistoric Village Sites in New Mexico and Arizona. *United States National Museum Proceedings* 31:647-649.

McDonald, Jerry N.
1981 *North American Bison: Their Classification and Evolution*. University of California Press, Berkeley.

McFadden. Douglas A.
2000 Formative Chronology and Site Distribution on the Grand Staircase-Escalante National Monument (Draft). Unpublished manuscript on file at the Grand Staircase-Escalante National Monument Headquarters, Kanab, Utah.

McGregor, John C.
1941 *Winona and Ridge Ruin Part I: Architecture and Material Culture*. Bulletin 18. Museum of Northern Arizona, Flagstaff.

1951 *The Cohonina Culture of Northwestern Arizona*. The University of Illinois Press, Urbana.

McHugh, Tom
1972 *The Time of the Buffalo*. Alfred A. Knopf, New York.

McNett, Charles W., Jr. (editor)
1985 *Shawnee Minisink: A Stratified Paleoindian-Archaic Site in the Upper Delaware Valley of Pennsylvania*. Academic Press, Orlando.

Malotki, Ekkehart, and Henry D. Wallace
2011 Columbian Mammoth Petroglyphs from the San Juan River Near Bluff, Utah, United States. *Rock Art Research* 28:143-152.

Malotki, Ekkehart, and Donald E. Weaver
2002 *Stone Chisel and Yucca Brush: Colorado Plateau Rock Art*. Kiva Publishing, Walnut, California.

Martin, Paul S., and John B. Rinaldo
1950 *Turkey Foot Ridge Site: A Mogollon Village, Pine Lawn Valley, Western New Mexico*. Fieldiana: Anthropology Vol. 38, No. 2. Chicago Natural History Museum Press, Chicago.

Martin, Paul S., Bruno E. Sables, and Dick Shutler
1961 Rampart Cave Coprolite and Ecology of the Shasta Ground Sloth. *American Journal of Science* 259:102-127.

Mead, Jim I.
1981 The Last 30,000 Years of Faunal History within the Grand Canyon, Arizona. *Quaternary Research* 15:311-326.

1983 Harrington's Extinct Mountain Goat (*Oreamnos harringtoni*) and Its Environment in the Grand Canyon, Arizona. Ph.D. dissertation, Department of Geosciences, University of Arizona, Tucson.

2002 *Bison of the Grand Canyon Region, Arizona: An Overview Assessment*. Laboratory of Quaternary Paleontology, Northern Arizona University, Flagstaff. Submitted to the Grand Canyon National Park. Manuscript on file at the Grand Canyon National Park Research Library.

Mead, Jim I., and Larry D. Agenbroad
1992 Isotope Dating of Pleistocene Dung Deposits from the Colorado Plateau, Arizona and Utah. *Radiocarbon* 34:1-19.

Mead, Jim I., Arturo Baez, Sandra L. Swift, Mary C. Carpenter, Marci Hollenshead, Nicholas J. Czaplewski, David W. Steadman, Jordon Bright, Joaquin Arroyo-Cabrales
2006 Tropical Marsh and Savannah of the Late Pleistocene in Northeastern Sonora, Mexico. *The Southwest Naturalist* 51:226-239.

Mead, Jim I., Larry L. Coats, and Blaine W. Schubert
2003 Late Pleistocene Faunas from Caves in the Eastern Grand Canyon, Arizona. In *Ice Age Cave Fauna of North America*, edited by Blaine Schubert, Jim I. Mead, and Russell Wm. Graham. Indiana University Press, Bloomington, Illinois.

Mead, Jim I., and Harold D. Dyer
2001 *Vertebrate and Invertebrate Paleontological Remains: San Rafael Ranch State Park, Arizona State Parks*. Laboratory of Quaternary Paleontology Quarternary Sciences Program, Northern Arizona University, Flagstaff, Arizona.

Mead, Jim I., and Catherine B. Johnson
2004 Bison and Bos from Protohistoric and Historic Localities in the San Rafael Valley, Arizona. *Kiva* 70:183-193.

Mead, Jim I., and Arthur M. Phillips
1981 The Late Pleistocene and Holocene Fauna and Flora of Vulture Cave, Grand Canyon, Arizona. *The Southwestern Naturalist* 26:257-288.

Mead, Jim I., Saxon E. Sharpe, and Larry D. Agenbroad
1991 Holocene Bison from Arches National Park, Southeastern Utah. *Great Basin Naturalist* 51:336-342.

Meagher, Mary
1986 Bison bison. *American Society of Mammalogists* 266:1–8.

Meagher, Mary, and Margaret E. Meyer
2007 On the Origin of Brucellosis in Bison of Yellowstone National Park: A Review. *Conservation Biology* 8:645-653.

Meltzer, David J.
1993 Is There a Clovis Adaptation? In *From Kostenki to Clovis: Upper Paleolithic-Paleo-Indian Adaptations*, edited by Olga Soffer and N.D. Praslov, pp. 293-310. Plenum Press, New York.

2002 What Do You Do When No One's Been There Before?: Thoughts on the Exploration and Colonization of New Lands. In *The First Americans: The Pleistocene Colonization of the New World*, edited by Nina G. Jablonski, pp. 27-58. Memoirs of the California Academy of Sciences 27. University of California Press, San Francisco.

2004 Modeling the Initial Colonization of the Americas: Issues of Scale, Demography, and Landscape Learning. In *The Settlement of the American Continents: A Multidisciplinary Approach to Human Biogeography*, edited by C. Michael Barton, Geoffrey A. Clark, David R. Yesner, and Goerges A. Pearson, pp. 123-137. University of Arizona Press, Tucson.

Merriam, C. Hart, and L. Steineger
1890 *Results of a Biological Survey of the San Francisco Mountain Region and the Desert of the Little Colorado, Arizona*. North American Fauna Report 3. U.S. Department of Agriculture, Division of Ornithology and Mammalia, Washington D.C.

Miller, L.
1960 Condor Remains from Rampart Cave, Arizona. *Condor* 62:70.

Minard, Anne
2003 Unwelcomed Bison May Face a DNA Test. *Science* 299:1835.

Minnis, Paul E., Michael E. Whalen, Jane H. Kelley, and Joe D. Stewart
1993 Prehistoric Macaw Breeding in the North American Southwest. *American Antiquity* 58:270-276.

Moffitt, Linda R., Steven A. Moffitt, Amy Horn-Wilson, and Anne Trinkle Jones
1998 *The Light Rail Corridor Project Mitigation Plan.* Report #98-07. National Park Service, Grand Canyon National Park.

Montgomery, Ross G., Watson Smith, and John Otis Brew
1949 *Franciscan Awatovi: the Excavation and Conjectural Reconstruction of a 17th-century Spanish Mission Establishment at a Hopi Town in Northeastern Arizona*. Papers of the Peabody Museum of Archaeology and Ethnology Vol. 36, Reports of the Awatovi Expedition No. 3. Harvard University, Cambridge.

Morris, Elizabeth A.
1980 *Basketmaker Caves in the Prayer Rock District, Northeastern Arizona*. Anthropological Papers No. 35. University of Arizona Press, Tucson.

Montgomery, Ross Gordon, Watson Smith, and John Otis Brew
1949 *Franciscan Awatovi: The Excavation and Conjectural Reconstruction of a 17th-century Spanish Mission Establishment at a Hopi Indian Town in Northeastern Arizona*. Reports of the Awatovi Expedition Report No. 4. Peabody Museum, Harvard University, Cambridge.

Nabhan, Gary P., Marcelle Coder, and Susan J. Smith
2004 *Woodlands in Crisis: A Legacy of Lost Biodiversity on the Colorado Plateau*. Occasional Papers No. 2. Ralph M. Bilby Research Center, Northern Arizona University, Flagstaff.

National Park Service
2006 Management Policies 2006. Department of the Interior, Government Printing Office, Washington, D.C.

Nowak, Ronald M.
1991 *Walker's Mammals of the World,* Vol. II. 5th ed. Johns Hopkins University Press, Baltimore.

O'Bryan, Deric
1950 Excavations in Mesa Verde National Park, 1947-1948. Medallion Papers No. 39. Gila Pueblo, Globe, Arizona.

O'Connell, James F., Kristen Hawkes, and Nicholas Blurton Jones
1988 Hadza Hunting, Butchering, and Bone Transport and Their Archaeological Implications. *Journal of Anthropological Research* 44:112-162.

1990 Reanalysis of Large Mammal Body Part Transport among the Hadza. *Journal of Archaeological Science* 17:301-316.

Olsen, Stanley J.
1960 Post-Cranial Skeletal Characteristics of *Bison* and *Bos*. Papers of the Peabody Museum of Archaeology and Ethnology Vol. 35, No. 4. Harvard University, Cambridge.

1978 The Faunal Analysis. In *Bones from Awatovi, Northeastern Arizona*. Reports of the Awatovi Expedition Report No. 11. Papers of the Peabody Museum of Archaeology and Ethnology, Vol. 70, No. 1 and 2. Harvard University, Cambridge.

Osborn, Alan J.
1995 *Aboriginal Adaptations on the Colorado Plateau: A View from the Island-in-the-Sky, Canyonlands National Park, Utah*. Midwest Archaeological Center Occasional Studies in Anthropology No. 33, USDOI, NPS, Lincoln, Nebraska. Produced for the Rocky Mountain Region, National Park Service.

Parmalee, Paul W.
1969 California Condor and Other Birds from Stanton's Cave, Arizona. *Journal of the Arizona-Nevada Academy of Science* 5:204-206.

Pavao-Zuckerman, Barnet, Rick Karl, and John F. Chamblee
2011 FaunAZ: Arizona's Archaeofaunal Index. *The SAA Archaeological Record* 11(1):33-36.

Pearson, Nancy E.
2008 *Archaeological Data Recovery at the Rim of the Grand Canyon: Shoshone Point, Grand Canyon National Park, Arizona*. Publications in Anthropology 103. Western Archaeological and Conservation Center, Tucson.

Pendergast, David
1961 Excavations at the Bear River Site, Box Elder County, Utah. *Utah Archaeology Newsletter* 7(2):14-18.

Perkins, Dexter, and Patricia Daly
1968 A Hunter's Village in Neolithic Turkey. *Scientific American* 219(5):96-106.

Phillips, A.M., and Thomas R. Van Devender
1974 Pleistocene Packrat Middens from the Lower Grand Canyon of Arizona. *Journal of the Arizona-Nevada Academy of Science* 9:117-119.

Redman, Charles L.
1999 *Human Impacts on Ancient Environments*. The University of Arizona Press, Tucson.

Reed, Erik K.
1952 The Myth of Montezuma's Bison and the Type Locality of the Species. *Journal of Mammology* 33:390-392.

1955 Bison Beyond the Pecos. *The Texas Journal of Science* 7:130-135.

Reimondo, Evan L.
2012 Ecological Impacts and Management Implications of Introduced Bison in the Grand Canyon Region. Unpublished Master's thesis, School of Earth Sciences and Environmental Sustainability, Northern Arizona University, Flagstaff.

Reitz, Elizabeth J., and Elizabeth S. Wing
2008 *Zooarchaeology*. 2nd ed. Cambridge University Press, Cambridge.

Riley, Carrol L.
1975 The Road to Hawikuh: Trade and Trade Routes to Cibola-Zuni during Late Prehistoric and Early Historic Times. *Kiva* 41:137-159.

Roe, Frank G.
1970 *The North American Buffalo: A Critical Study of the Species in its Wild State*. 2nd ed. University of Toronto Press, Toronto.

Rose, Martin R.
1989 Present and Past Environmental Conditions. In *Man, Models, and Management: An Overview of The Archaeology of The Arizona Strip and The Management of Its Cultural Resources*, edited by Jeffrey H. Altschul and Helen C. Fairley, pp. 7-52. Submitted to the USDA Forest Service, Kaibab National Forest, and the USDI Bureau of Land Management, Arizona Strip District, Contract No. 53-8371-6-0054. Statistical Research, Tucson.

Schroedl, Alan R.
1977 The Grand Canyon Figurine Complex. *American Antiquity* 42:254-265.

1988 *Cultural Resource Investigations on the Kaibab Plateau, Northern Arizona: The Highway 67 Data Recovery Project*. P-III Associates, Salt Lake City. Submitted to the West Region Interagency Archaeological Services Branch, USDI National Park Service, San Francisco.

Schwartz, Douglas W.
1989 *On the Edge of Splendor: Exploring Grand Canyon's Human Past*. The School of American Research Press, Santa Fe.

Schwartz, Douglas W., Richard C. Chapman, and Jane Kepp
1980 *Archaeology of the Grand Canyon: Unkar Delta*. Grand Canyon Archaeological Series Vol. 2. School of American Research Press, Santa Fe.

Schwartz, Douglas W., Jane Kepp, and Richard C. Chapman
1981 *Archaeology of the Grand Canyon: The Walhalla Plateau*. Grand Canyon Archaeological Series Vol. 3. School of American Research Press, Santa Fe.

Schwartz, Douglas W., Arthur L. Lange, and Raymond deSaussure
1958 Split Twig Figurines in the Grand Canyon. *American Antiquity* 23:264-275.

Schwartz, Douglas W., Michael P. Marshall, and Jane Kepp
1979 *Archaeology of the Grand Canyon: The Bright Angel Site*. Grand Canyon Archaeological Series Volume 1. School of American Research Press, Santa Fe.

Schwinning, S., Jayne Belnap, David R. Bowling, and James R. Ehleringer
2008 Sensitivity of the Colorado Plateau to Change: Climate, Ecosystems, and Society. *Ecology and Society* 13(2):28. Electronic document, http://www.ecologyandsociety.org/vol13/iss2/art28/, accessed May 1, 2012.

Shields, Wayne F.
1978 The Woodruff Bison Kill. Miscellaneous Paper No. 21. In *Miscellaneous Collected Papers 19-24*, edited by Jesse D. Jennings, pp. 43-54. University of Utah Press, Salt Lake City.

Shields, Wayne F., and Gardiner F. Dalley
1978 The Bear River No. 3 Site. Miscellaneous Paper No. 22. *In Miscellaneous Collected Papers 19-24*, edited by Jesse D. Jennings, pp. 55-99. University of Utah Press, Salt Lake City.

Simms, Steven R., and Katherine Heath
1990 Site Structure of the Orbit Inn: An Application of Ethnoarchaeology. *American Antiquity* 55:797-813.

Sluyter, Andrew
2001 Colonialism and Landscape in the Americas: Material/conceptual Transformation and Continuing Consequences. *Annals of the Association of American Geographers* 91:410-428.

Smiley, Francis E.
1994 The Agricultural Transition in the Northern Southwest: Patterns in Current Chronometric Data. *Kiva* 60:165-189.

2002 The First Black Mesa Farmers: The White Dog and Lolomai Phases. In *Prehistoric Culture Change on the Colorado Plateau: Ten Thousand Years on Black Mesa*, edited by Shirley Powell and Francis E. Smiley, pp. 37-65. University of Arizona Press, Tucson.

Smith, Howard V.
1956 The Climate of Arizona. *Arizona Agricultural Experiment Station Bulletin* 279:1-99.

Smith, Watson, Richard B. Woodbury, Nathalie F.S. Woodbury
1966 *The Excavation of Hawikuh by Frederick Webb Hodge: Report of the Hendricks-Hodge Expedition 1917-1923*. Contributions from the Museum of the American Indian, Heye Foundation, Vol. 20, New York.

Snow, David H.
1981 Protohistoric Rio Grande Pueblo Economies: A Review of Trends. In *The Protohistoric Period in the North American Southwest A.D. 1450-1700*, edited by David R. Wilcox and W. Bruce Masse, pp. 354-377. Arizona State University Anthropological Research Papers No. 24, Tempe.

Speth, John D.
1983 *Bison Kills and Bone Counts*. University of Chicago Press, Chicago.

Speth, John D., and William J. Parry
1980 *Late Prehistoric Bison Procurement in Southeastern New Mexico: The 1978 Season at the Garnsey Site (LA-18399)*. Research Reports in Archaeology Contribution 7, Technical Reports No 12. Museum of Anthropology, University of Michigan, Ann Arbor.

Spielmann, Katherine A.
1983 Late Prehistoric Exchange Between the Southwest and Southern Plains. *Plains Anthropologist* 28:257-272.

Spier, Leslie
1928 *Havasupai Ethnography*. Anthropological Papers Vol. 29, Part 3. American Museum of Natural History, New York City.

Spurr, Kimberly, and Kenneth P. Cannon
2013 Analysis of Faunal Remains. In *The River Corridor Archaeology Project Synthetic Report: Excavations of Nine Colorado River Sites 2007-2009, Grand Canyon National Park,* edited by Theodore L. Neff, Kimberly Spurr, Jim Collette, and Mick Robbins. Museum of Northern Arizona. Draft submitted to Grand Canyon National Park.

Stein, Walter T.
1962 Mammals from Archaeological Sites, Point of Pines, Arizona. Unpublished Master's thesis, Department of Anthropology, University of Arizona, Tucson.

1963 Mammal Remains from Archaeological Sites in the Point of Pines Region, Arizona. *American Antiquity* 29:213-220.

Talbot, Richard K.
1990 Virgin Anasazi Architecture: Toward a Broader Perspective. *Utah Archaeology* 3:19-41.

Thompson, Richard A., and Georgia Beth Thompson
1978 *The Little Jug Site: 1976 and 1977*. Southern Utah State College, Cedar City.

Todd, Lawrence C., David C. Jones, Robert S. Walker, Paul C. Burnett, and Jeffrey Eighmy
2001 Late Archaic Bison Hunters in Northern Colorado:1997-1999 Excavations at the Kaplan-Hoover Bison Bonebed (5LR3953). *Plains Anthropologist* 46:125-147.

Truett, Joe
1996 Bison and Elk in the American Southwest: In Search of the Pristine. *Environmental Management* 20:195-206.

U.S. Fish and Wildlife Service
1990 *Humpback Chub Recovery Plan*. U.S. Fish and Wildlife Service, Denver.

2002 *Humpback Chub (Gila cypha) Recovery Goals: Amendment and Supplement to the Humpback Chub Recovery Plan*. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver.

Van Vuren, Dick
1987 Bison West of the Rocky Mountains: An Alternative Explanation. *Northwest Science* 61(2):65-69.

Van Vuren, Dick, and Martin P. Bray
1986 Population Dynamics of Bison in the Henry Mountains, Utah. *Journal of Mammology* 67:503-511.

Vivian, Gordon
1964 *Gran Quivira : Excavations in a 17th-Century Jumano Pueblo*. Archeological Research Series No. 8. National Park Service, U.S. Department of the Interior, Washington, D.C.

Walling, Barbara A., Richard A. Thompson, Gardiner F. Dalley, and Dennis G. Weder
1986 *Excavations at Quail Creek*. Cultural Resource Series 20. Bureau of Land Management, Utah State Office, Salt Lake City.

Warner, Ted J. (editor)
1995 *The Dominguez-Escalante Journal: Their Expedition Through Colorado, Utah, Arizona, and New Mexico in 1776*. University of Utah Press, Salt Lake City, Utah.

Weaver, Donald E.
1984 *Images on Stone: The Prehistoric Rock Art of the Colorado Plateau*. The Plateau 55.

Weltfish, Gene
1965 *The Lost Universe: Pawnee Life and Culture*. University of Nebraska Press, Lincoln.

Wilcox, David R.
1984 Multi-ethnic Division of Labor in the Protohistoric Southwest. In *Collected Papers in Honor of Harry L. Hadlock*, edited by Nancy C. Fox, pp. 141-155. Papers of the Archaeological Society of New Mexico No. 9, Albuquerque.

Wilson, Robert W.
1942 *Preliminary Study of the Fauna of Rampart Cave*. Carnegie Institution of Washington, Washington, D.C.

Winship, George P.
1896 *The Coronado Expedition, 1540-1542*. Bureau of American Ethnology Annual Report, Part 2. Smithsonian Institution, Washington, D.C.

Wolf, David
2005 Decision to call bison non-native is arbitrary. Electronic document, http://azdailysun.com/%E2%80%A6/article_3a33e12f-b461-5ee3-877d-011986623b5e.html?print=1, accessed April 23, 2012.

Wolff, Sarah E.
2013 Home on the Range: Biogeographic Distribution of Bison in Arizona. *PalArch's Journal of Vertebrate Paleontology* 10(4):1-11.

Wolverton, Steve, and R. Lee Lyman (editors)
2012 *Conservation Biology and Applied Zooarchaeology*. The University of Arizona Press, Tucson.

Wright, Barton A.
1954 Excavation of Catclaw Cave, Lower Colorado River. Unpublished Master's thesis, Department of Anthropology, University of Arizona, Tucson.

Yates, Bonnie C., and Ernest L. Lundelius, Jr.
2001 Vertebrate Faunal Remains from the Aubrey Clovis Site. In *The Archaeology and Paleoecology of the Aubrey Clovis Site (41DN479) Denton County, Texas*, by C. Reid Ferring, pp. 103-119. Center for Environmental Archaeology, Department of Geography, University of North Texas, Denton.

Yoshikawa, L. Keiko
1986 Faunal Analysis of Five Grand Canyon Sites. In *A Cross Section of Grand Canyon Archaeology: Excavations at Five Sites along the Colorado River*, edited by Anne Trinkle Jones, pp. 201-253. Western Archaeological and Conservation Center, National Park Service, U.S. Department of the Interior, Tucson.