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DIGGING DEEP INTO THE SUMMER ACTIVITIES AT BULL CREEK (34BV176): A LATE PALEOINDIAN SITE IN THE SOUTHERN PLAINS

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DIGGING DEEP INTO THE SUMMER ACTIVITIES AT BULL CREEK (34BV176):

A LATE PALEOINDIAN SITE IN THE SOUTHERN PLAINS

A THESIS APPROVED FOR THE

DEPARTMENT OF ANTHROPOLOGY

BY THE COMMITTEE CONSISTING OF:

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For Heather.

It’s not dinosaurs, but those were more your thing anyway.

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ABSTRACT

The Bull Creek site (34BV176), located along a tributary of the Beaver River in the Oklahoma Panhandle, belongs to a short list of late Paleoindian open-habitation camps. Events at Bull Creek are superimposed on one another. No clear refuse area (such as a midden, palimpsest, or dump) is evident, leaving the idea that the entirety of Bull Creek is in its' original context, abandoned on at least three separate occasions. To better understand the activities resulting in the artifactual and feature components of the archaeological record, I relied on the methods of ring analysis, the refit analysis of bone artifacts, animal protein residue and plant/starch analysis on lithic artifacts, 3D rendering, and experimental butchering. The spatial distribution of the remains from a single bison were plotted and investigated in relationship with other site materials, including a hearth, a lithic hammerstone/anvil couplet, and an isolated bone tool, resulting in the conclusion that site materials identify the animal butchering, animal processing, and plant processing around a central hearth feature.

CHAPTER ONE

Introduction

One of the basic principles of archaeology taught to students early on is that artifacts, features, ecofacts, and sites in general are composed of a people's refuse. Whether intentionally or unintentionally, these things are left behind never to be seen again. The previous statement can be deemed as common sense, but in truth, archaeological "refuse" is complicated. Questions regarding the sites which we study, such as the intentionality of leaving things behind, culturally perceived trash vs. abandoned objects, and scattered garbage vs. areas where artifacts were used daily arise (see Schiffer 1987).

Through the anthropological lense, refuse, or dump areas, are different than discrete activities areas where activities took place in the past. While different localities might have the same artifacts, they can answer different questions. Activity centers provide an in-depth view at everyday practices that are deeply ingrained within culture. While dump areas such as middens provide archaeologists with many more artifacts to analyze, the primary context of said artifacts is lost, limiting the information on task-specific activities that could have been gained. Site degradation augments the difficulty to assess if a locality within a site is representative of an activity or refuse. Preservation and artifact distribution are key determinants in the distinction of site types.

Bull Creek is a Late Paleoindian campsite in the southern high plains of the Oklahoma Panhandle (Figure 1-1). Previous work at Bull Creek (34BV176) has identified the site as an open-habitation camp with at least three occupations: one winter season occupation and two summer occupations (Bement, Carlson, and Carter 2022). The earliest summer occupation contains a myriad of task-specific artifacts, relating to the butchery of a single bison carcass, bone and stone tool manufacture, and cooking. Many artifacts appear concentrated around a hearth. I segregated the artifacts into groups that reflect the various activities represented in the overall assemblage. Research questions include: How many discrete activities are represented in the artifact and refuse materials in the summer occupation at Bull Creek? How are the artifacts from distinct activities distributed across the site? What kind of subsistence and resource acquisition is visible during the summer occupation? Is this different than what is previously known of other Paleoindian campsites? And finally, How does the context of a butchering and processing activity area illuminate the difference in Paleoindian acquisition strategies depending on season?

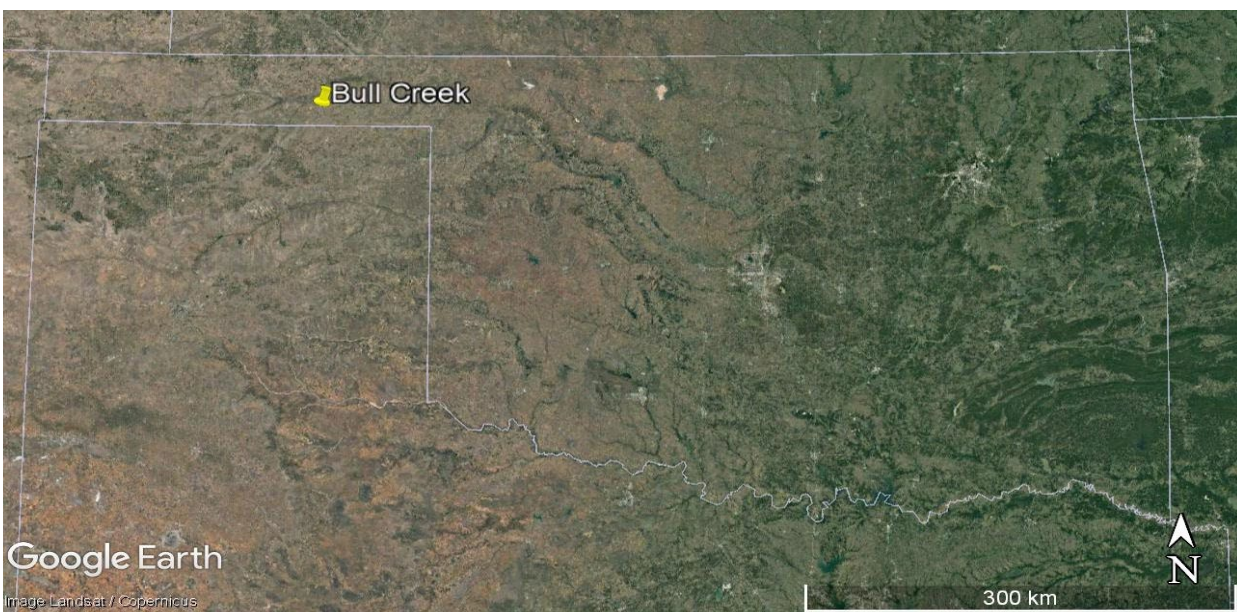


Figure 1-1. Satellite imagery showcasing the approximate location of Bull Creek (34BV176). Oklahoma border and surrounding states shown.

Chapter 2 introduces the theories and foundations that my research questions are founded upon. Chapter 3 summarizes the environmental context in which site activities took place and Chapter 4 provides a foundation of the people and cultures of the time. Chapter 5 outlines what previous research at Bull Creek has been established, with special attention given to areas pertinent to this work. Chapter 6 explains the analytical methods used within the scope of this project, while Chapter 7 discusses the results of the analyses. Finally, previously discussed theory and results are explored in Chapter 8 along with concluding statements.

CHAPTER TWO

Theory

Previous analyses of the Bull Creek site have applied aspects of landscape theory and cultural ecology through the lens of site catchment analysis (Larrick 2020). In this thesis, I am more interested in agency-based theories that link human activities, decision making, and site organization (Bamforth, 2022). Open air sites, including large camps like Bull Creek, are organized spaces without obvious natural boundaries. Instead, the boundaries are set by cultural patterns of population size, occupation duration, and seasonal or resource limitations (Carlson and Bement 2022).

The human-made structures and social constructs from the past can be distinguished at open air sites through the distribution and structure of activities. All social interaction requires the transmission of movement and communication across space. In the same sense, physical distance also affects social interaction throughout a camp, reflecting patterns of interaction, group integration, and discard (Lobo et al. 2022). In opposition to sites that have natural boundaries, the composition and location of activities is formed through cultural institutions (Carlson and Bement 2022). When thinking about activity areas archaeologically, considerations regarding the validity of said areas and discard patterns are necessary.

Archaeologists who study hunter-gatherers have long been parsing out the use of space at residential and non-residential archaeological sites by the type, concentration, and distribution of artifacts (Binford 1980). Early approaches to site patterning used a variety of theoretical and methodological techniques, though all mainly focused on statistical predictions (Carr 1984, Bamforth 2022). Bamforth suggests that the early work on hunter-gatherer site distribution rested on assumptions regarding archaeologically defined tool-types (2022). In other words, archaeologically prescribed tool types have a direct, culturally-tied function. When several tools arise together within a site, they must be used to carry out an activity. Such assumptions are still applied today and have led to the identification of discrete activity areas.

Activity areas can be defined as the portion of an archaeological site that can be ascribed to one activity such as animal butchering, plant processing, cooking, flintknapping, and more (Bamforth 1991, Binford 1979, O'Connell 1987). Discard patterns can range from a discrete area of abandoned debitage to large palimpsests. As such, site formation processes must be identified before significant relationships between artifacts and cultural phenomena can be made (Bement, Carlson, and Carter, 2022). Additionally, even further investigation is needed to determine if site artifacts, ecofacts, and features in association with each other are, in fact, discrete activity areas.

A second line of inquiry must be made when differentiating between refuse and an abandoned site, as the places where people do things and the places where archaeologists find the remnants of an activity are almost never the same (Schiffer 1987). Cultural activities associated with cleaning lead to differences in spatial patterning (Clark and Gingerich 2022, Heyman 2009). Sometimes refuse from a single activity is discarded into a discrete location; other times it is placed on top of previously discarded items, creating a palimpsest of activities.

Information is gained irrespective of whether an area is deemed an activity area or a discard area. Though it is true that cultural processes of cleaning refuse cause artifacts to be displaced from where they were used, the relationship of one artifact to another still produces valuable information. For example, in a midden deposit, artifacts are no longer situated in the location which they were originally used, yet conclusions are still made by studying the composition of the midden itself. The importance of context, then, is not dependent on what the de facto use once was, but of the relation to other artifacts discarded (or abandoned) with it.

The previous distinction is relevant at Bull Creek since it is an open-air site. Events at Bull Creek are superimposed on one another, merging the boundary of refuse vs. activity area. No clear refuse area (such as a midden, palimpsest or dump) is evident, leaving the idea that the entirety of Bull Creek was left in situ and abandoned on at least three separate occasions (Bement, Carlson, and Carter 2022). While this idea is speculative, it serves as a useful perspective when studying the range of activities at the site. Within this analogy information on camp structure and segregation of activities is possible.

According to Bement, Carlson, and Carter (2022), the over-arching research questions at Bull Creek are as follows: How did Late Paleoindian groups arrange activity areas at large camps, and how did the previous organization differ during various seasons of the year? To aid in answering overarching research questions at Bull Creek, this thesis will address the following questions: (1) What, if any, activity areas are discernable at Bull Creek? (2) How many activity areas are discernable? (3) Do the activities have to do with subsistence-related tasks? (4) What kind of subsistence is visible during the summer occupation? (5) Are summer occupation activities different than that of other seasons? (6) Do the results of the previous questions provide a different perspective on Paleoindian culture, namely modes of subsistence and camp organization?

My hypotheses for this thesis are that, (1) There are activity areas discernable, (2) at least 3 activity areas are visible, (3) some, but not all of the activities are related to subsistence, (4) there is a wide array of subsistence in the summer occupation with the inclusion of plant processing, and (5) summer occupation activities are similar to winter occupation activities.

Before continuing on with addressing the research questions forming the core of this work, it is important to establish the environmental and cultural milieu that forms the boundaries for our understanding of cultural adaptations.

CHAPTER THREE

Environmental Background

Modern Environment

The Bull Creek (34BV176) archaeological site is named after its location--the deeply stratified depositional landforms along Bull Creek, an 18 km long tributary of the larger Beaver River (or North Canadian River) in the Oklahoma panhandle. Geographically, the Oklahoma panhandle is in the southernmost area of the North American Great Plains and is further classified into the Southern High Plains (Holliday 1997, Johnson and Duchon 1995). The landscape of the Southern Plains was shaped by water flowing from the Rocky Mountains (Johnson 2008), resulting in highly variable topography as can be seen by the shift from Mesas in Cimarron County in the west to rolling Plains, flatlands, and playas in Beaver County (Doerr and Morris 1960, Johnson and Duchon 1995).

The closest town, and atmospheric weather station, to the archaeological research area is in Beaver, Oklahoma. According to the National Oceanic and Atmospheric Administration, within the last thirty years Beaver County has received an average of 2.5 inches (63.5 mm) of precipitation per month, with at least .5 inches (12.7 mm) of rain occurring year-round, and snow occurring solely in the fall and winter months (2021). Temperature in the area is seasonally highly variable with an average low of 17ºF (-8Cº) in the winter and a high of 94ºF (34Cº) midsummer. In addition, temperature fluctuates an average of 30ºF (26Cº) daily, with cold-temperate mornings and temperate-hot middays (NOAA, 2021).

Paleoenvironmental Reconstruction

Previous paleoenvironmental reconstructions of the southern High Plains strongly suggest that the modern environmental conditions are similar to those that occurred for most of the Holocene epoch (Bement et al. 2007, Johnson 1997). The following regional paleoclimatic reconstructions are based largely on depositional soil sequences, faunal remains, pollen analyses, carbon isotopes within buried soils, and fossilized plant material found in depositional layers within the Bull Creek Valley (Arouza et al. 2015). A reconstruction of the paleoenvironment allows contrasts and similarities to be drawn across time for this region.

Geology and Physiology

The geology of the research area is mostly composed of sediments that were deposited during the Pliocene and Pleistocene, with some modern deposition of fills currently taking place (Hofman et al. 1989). The subsurface geology is mainly comprised of Permian redbeds, the Ogallala Formation, and recent depositional sands. The Permian redbeds are the oldest of the three formations and include the Cloud Chief Formation (Brosowske and Bement 1998). This deposit is characterized as stacked sedimentary rocks that contains shale, dolomite, sandstone, and gypsum. Exposure of the Permian redbeds is common around river and stream passageways, especially along the Beaver River's tributaries, such as Bull Creek. The Ogallala Formation dominates the study area and is characterized by sand, silt, gravels, and calcium concentrations known as caliche. The formation varies widely in thickness due to extensive erosion in the area. Finally, the Ogallala formation is covered by recent alluvium that consists of sands, gravels, silts, and clay. When analyzed, these deposits can be separated into recent Pleistocene and Holocene ages that are derived from previous Ogallala formation deposits. The gravels of the Ogallala

Formation provide one of a limited number of local lithic raw material sources used by the Paleoindians of the region.

Terrace and overall sediment depositional processes in the Bull Creek record transitioned from fluvial to mostly aeolian deposition during the Holocene. In addition, some terrace deposits imply brief periods of extreme flooding in what appears to be a drought-dominated climate (Arouza et al. 2015).

Figure 3-1. Aerial photograph of the Bull Creek terrace, depicts stratigraphy and vegetation.

Soils

The Bull Creek soil complex is prominent on sloping terrace exposures and fairly uniform in thickness, geomorphology, and granule structure all along the 18 km length of the drainage (Arouza et al. 2015). The uniformity of the sediment throughout the valley indicates that soil deposition was consistent laterally on the terraces in the area. Beaver County has unique geological deposition due to its' geographical location, and the Bull Creek Valley is no different. The soils and bedrock beneath 34BV176 have distinctive characteristics that are almost exclusive to the valley itself. Soils typically have a very dark color, attributed primarily to high organic content, though manganese concentrations are also present (Arouza et al. 2015, Bement et al. 2007). Within these dark soils, there are often calcium carbonate concentrations (otherwise known as caliche) that can vary in size, shape, and hardness, from soft and sand-like to very hard and pebble to cobble-sized. Gastropods are the most common fossil found in deposits directly below the Bull Creek soils that hold cultural materials. In addition, there are ripple indices that indicate fluvial conditions within the soils, and available pollen data indicate a moisture-rich soil developed within a more humid environment during the pre-human Pleistocene than what is typical today.

There are three major and three minor soil series found in the Bull Creek Valley: Mansic, Woodward, and Carey soils amount to 79 percent of all soils found in the valley, while Glenrio, Mobeetie, Veal, Lincoln, Potter, and Spur soils are typically rare, comprising 21 percent of all soils in the area (NRCS, 2021).

The Mansic series are well-drained, moderately permeable soils that typically form in calcareous alluvium of Tertiary age (66 million-2.6 million years old) (NRCS, 2021). These soils are typically found on level to moderately steep ridges and hill slopes that are common in the Southern High Plains. Permeability of mansic soils is moderate due to its fine clay-loam consistency.

The Woodward series are also well-drained, moderately permeable soils but instead formed from weathered, Permian age Ogallala Formation (65 to 286 million years) red sandstone bedrock (NRCS, 2021). Woodward soils are typically found on the sloping interfluves, ridges, and hillsides of the rolling plains uplands. Native vegetation to the Woodward soils are little bluestem and grama grasses.

Carey soil series are deep, well-drained, permeable soils that form in silty and sandy Permian age (299 to 251 million years ago) sediments (NRCS, 2021). These soils are commonly observed on level to moderately sloping shoulders of dissected terraces in the uplands of the rolling red plains in the Bull Creek valley. Plants supported by Carey soils are blue grama, buffalograss, little bluestem, sand bluestem, switchgrass, and side oats grama.

Climate

Previous paleoenvironmental studies at Bull Creek (34BV176) in the Oklahoma Panhandle have yielded information necessary for reconstructing the past climate. The climate of the study area is highly variable throughout the year but is mainly characterized as continental (Johnson and Duchon 1995). The climate can be further described as dry and arid with highly variable precipitation patterns. In addition, temperature along the Bull Creek Valley changes rapidly with strong winds surging throughout most of the year, as is predicted to have been the case in the past. The combination of aridity, variable precipitation, and high winds produces high evapo-transpiration rates facilitating erosion and wind-blown sediment deposition.

Based on carbon-isotope ratios ($\delta 13C$) from buried soils, the height of drought conditions in the Bull Creek watershed occured in the middle Holocene (around 7 kya) and persisted to 3.7 kya (Bement 2007). The dry climate likely caused upland soil separation that resulted in the incised upland environment that persists today. In comparison, studies throughout the Great Plains note that continental drying was slow and persistent from 14 kya to 6 kya, with drought beginning at a midpoint of the North American midcontinent, and slowly expanding to encompass other areas (Williams et al. 2010, Arouza et al. 2015). The arid climate caused heavy aeolian deposition through high winds (Holliday 1995). A slightly wetter climate followed shortly after 3.7 kya at Bull Creek, indicating a shift to more mesic conditions allowing for more vegetation and a higher water table that allowed tributaries of the Beaver River to flow (Hall and Lintz 1984).

Flora and Fauna

Vegetation

The Bull Creek Valley is classified as part of the short-grass plains region in western Oklahoma. The region consists primarily of short grasses such as blue grama (*Bouteloua gracilis*), buffalograss (*Bulbilis dactyloides*), hairy grama *(Bouteloua hirsuta)*, side-oats grama, bluestem (*Andropogon scoparius*), Indian grass (*Sorghastrum nutans*), and sand sage (*Artemisia filifolia*) (Bement et al. 2007). Some areas are also abundant in yucca (*Yucca*), sand-hill plum (*Prunus angustifolia),* red cedar (*Juniperus sabina*), and cottonwood trees (*Populus*) (Figure 3-2). Overall, plants that are common in the area are customary within dry and windy environments.

Previous paleoenvironmental reconstructions were made possible through pollen analyses. Pollen samples taken from a profile at Bull Creek (34BV176) indicated a riparian community of walnut, cattails, and willow before the Younger Dryas (YD) transition (Bement et al. 2007, Arouza et al. 2015). After the YD transition, there is a reduced rate of plants in the high-spine Asteraceae family (such as aster, snakeweed, ragweed, and sumpweed) that suggests a shift to a much drier environment like the one seen today (Arouza et al. 2015).

Figure 3-2. Collage of different plants common to the Bull Creek Valley. From top to bottom, left to right: bluestem, hairy grama, sand sage, sand hill plum, blue grama, red cedar, Indian grass, buffalograss, cottonwood, and side oats grama.

Wildlife

Faunal distributions have changed considerably from the Pleistocene to modern times. The species living in the area today are mostly species that have adapted to arid or semi-arid conditions in the Great Plains. These animals include, but are not limited to, pronghorn, various species of deer, various species of rabbit, prairie dogs, squirrels, small rodents (gophers, mice, and rats), bison, box turtle, a myriad of migratory birds, and freshwater mollusks. Faunal life around the Bull Creek valley has consisted of various mammalian, amphibian, avian, reptilian, icthian, and molluscan species adapted to life on the Plains throughout the entirety of the Holocene (Bement et al. 2007b).

Though presence of Pleistocene megafauna is evident on the Southern High Plains (Dalquest 1977), evidence of human occupation and hunting during the period is scarce, apart from three sites: Blackwater Draw, Miami, and Domebo. From the Pleistocene extinction forward, there is a trend for large mammals to diminish in size, as is evident through the evolution of three bison subspecies (*Bison antiquus, Bison occidentalis, Bison bison*) (McDonald 1981). After the Pleistocene-Holocene transition, Bison became the only surviving megafauna, allowing them to dominate the area's resources. They continued to live as the largest land animal on the Plains for the next 13,000 years until they were brought to the edge of extinction by overhunting in the 1880s (Dary 1989). In addition to *Bison occidentalis* and *Bison antiquus*, there are 25 other animal species that have been identified at the Bull Creek site (34BV176) (Table 3-1). All of these animals, with the exception of *B. antiquus, B. occidentalis* and *Canis dirus*, are extant on the Southern High Plains today (Johnson 1987).

Table 3-1. Bull Creek Faunal Assemblage

	Taxa	Common Name	Habitat	Seasonal Availability
Mammals	*Bison antiquus*	Bison	lowland plains	Year-round depending on migratory route
	Bison occidentalis	Bison	lowland plains	Year-round depending on migratory route
	Cervus canadensis	Elk	forests and meadows	higher alt. in spring, woods in winter
	Odocoileus sp.	Deer	woods, open plains	Year-round, more active in spring
	Antilocapra americana	Pronghorn	high plains	Year-round, more active in spring
	Canis dirus	Canid cf. Dire Wolf	plains, woods, highlands	Year-round
	Canis sp.	Wolf-size	plains, woods, highlands	Year-round
	Canis latrans	Coyote-size	open plains	Year-round
	Taxidea taxus	Badger	open plains	less active in winter
	Lepus californicus	Jackrabbit	open plains	Year-round
	Sylvilagus floridanus	Cottontail Rabbit	open plains, shrubs	Year-round
	Cynomys ludovicianus	Black-Tailed Prairie Dog	open plains	Year-round
	Spermophilus sp.	Squirrel-size Mammal	undetermined	less active in winter
	Dipodomys sp.	Kangaroo Rat	arid plains, sandy soils	Year-round
	Neotoma albigula	Wood Rat	open plains, woods	Year-round
	Peromyscus maniculatus	Deer Mouse	open plains, woods	Year-round

	Microtus pinetorum	Vole	open plains	Year-round
	Scalopus aquaticus	Common (Eastern) Mole	open plains	Year-round, burrow deeper in winter
Birds	*Grus canadensis*	Sandhill Crane	open plains, near water	Year-round depending on migratory route
	Aves	Small Bird	undetermined	Year-round depending on migratory route
Reptiles	*Crotalus sp.*	Rattlesnake	open plains, rocky areas	less active in winter
	Undetermined	Non-pit Viper Snake	undetermined	undetermined
	Trachemys scripta	Slider Turtle	in / near streams	less active in winter
	Terrapene carolina	Box Turtle	open plains, near water	spring / summer
Amphibians	*Anura*	Frog/ Toad	open plains, near water	spring / summer
Fish	*Cyprinidae*	Minnow	streams, rivers	Year-round
Mollusks	*Lampsilis teres*	Freshwater Mussel	streams, rivers	Year-round, follow fish migrations
Gastropods	Undetermined	Snail	terrestrial, near water	spring / summer

CHAPTER FOUR

Cultural Background

The Great Plains physiographic region of North America was inhabited from the earliest times people came into the New World. Creating an all-encompassing cultural background for the entirety of the North American Plains is a large feat. Here, I focus on summarizing a cultural background that is relevant to the Late Paleoindian occupation of the Bull Creek site. To do so, I provide summaries of sites across the United States that have changed what was initially thought about Paleoindian groups. Specifically, I focus on campsites with one or more Paleoindian components in which diet, tool-use, and daily activities are easily recognizable. Paleoindian and Archaic time periods are discussed, though the Early Ceramic, Middle Ceramic, and Late Ceramic Periods are not covered here as they are Late Prehistoric in time and are not pertinent to the subject of this thesis. Every date mentioned within this work is calibrated.

The Paleoindian period is the earliest, clearly recognized, human occupation in the Southern Plains and includes widely accepted cultural traditions such as Clovis (13,100-12,900 B.P) and Folsom (11,000-9,000 B.P). There is now evidence for a Pre-Clovis culture, but this occupation is highly debated and current radiocarbon dates in Oklahoma are inconclusive. Generally, Pre-Clovis, Clovis, and Folsom groups are highly organized, residentially-mobile, and egalitarian hunter-gatherer groups (Hofman et al. 1989).

The first people to leave an indisputable trace in the Southern Plains is the Clovis occupation that dates to about 13,100 B.P. (Waters and Stafford 2007). The Clovis culture was first identified at the Blackwater Draw site in New Mexico (Hester 1972) where large fluted projectile points were found in association with the skeletal remains of mammoths and bison.

Since that discovery, Clovis projectile points have been found associated with other large mammal remains, including in Oklahoma at the Domebo mammoth kill in Caddo County (Leonhardy 1966) and the Jake Bluff large-scale arroyo trap bison kill in Harper County (Bement and Carter 2010). The mass extinctions of the Pleistocene megafauna occurred during the Clovis era. Bison, however, did not go extinct and hunters shifted from hunting very large game to a specialization in bison procurement (Bement 1999, 2003). Key Clovis sites in the Southern Plains include Jake Bluff, Domebo, Blackwater Draw, Gault, and Miami, another mammoth kill site.

A specialization in bison hunting extended to the Folsom complex. Folsom points are characterized by their smaller size and fluted midsection. Key Folsom sites in Oklahoma and the surrounding area include the Folsom type site in New Mexico (Meltzer 2006), Lipscomb bison kill in the Texas Panhandle (Hofman et al. 1989b), Waugh bison kill and small camp in Oklahoma (Hill and Hofman 1997), and the large-scale arroyo bison kill sites of Cooper and Badger Hole in Harper County, Oklahoma (Bement 1999; Bement et al. 2012).

After the Folsom complex, tool typologies and archaeological cultures split regionally, eventually diversifying further during the Archaic. The following sites have Paleoindian and/or Archaic stratigraphic components and provide a background against which to compare Bull Creek.

Meadowcroft

The Meadowcroft Rockshelter was one of the first locations to present data that differed from the accepted model of Paleoindian big game hunters. The site is located in Washington County, Pennsylvania inside a rockshelter overlooking Cross Creek, a small tributary of the Ohio

River (Adovasio et al. 1978). The rockshelter is a natural overhang made of sandstone that once protected its inhabitants from outside forces.

The shelter was rediscovered after its abandonment by Albert Miller in 1955. Miller failed to report the site to archaeologists for almost twenty years; he decided to contact Dr. James Adovasio in the early 1970's (Adovasio et al. 1999). Adovasio and his team conducted excavations from 1975 to 1979, with additional University of Pittsburgh field schools taking place until 1989.

Excavations yielded more than 20,000 artifacts from several occupations. Artifact types found include debitage, bifaces, Miller projectile points, lamellar blades, altered animal bones, plant materials, pottery, one hearth, and even quickly perishable goods such as sandals, fragments of basketry, and wooden implements. Burned materials from the hearth yielded radiocarbon dates as early as 19,000 BP, though the formal range for the earliest occupation is 19,000-16,000 BP (Adovasio, Donahue, and Stuckenrath 1990). The dates for early occupation in the rockshelter have been highly debated for the past 40 years but counterarguments have been disproven by Adovasio and his team (Adovasio et al. 1999).

The unparalleled preservation at Meadowcroft has permitted researchers to collect plant and animal remains extensively. From this author's understanding, not all animal remains in the cave were the result of human occupations. Due to this, only bones with cutmarks have been taken into account when discussing the diet of the Paleoindian groups at the locale. According to Adovasio, the diet of the individuals in the lower two occupations (the two Paleoindian occupations) consisted of foraged plants and seeds and small mammals only; no large animal bones with cutmarks have been found in those occupations to date (2010).

Paisley Caves

This site in south-central Oregon consists of four caves located in the Summer Lake basin. The Paisley Caves are carved into a ridge of Miocene and Pliocene era basalts and contain proof that deems the caves one of the oldest sites in North America (Hudson et al. 2021).

The caves were first studied by anthropologist Luther Cressman in 1938 (Smith et al. 2020), where he made the first major discoveries such as a pair of sandals. Paisley Caves have since continued to be studied, with another major project beginning at the turn of the century. Since 2002, there has been an ongoing archaeological project at the Paisley Caves. From this project, the most striking evidence surfaced in 2007 and was published in 2008: human coprolites dating to 14,300 BP (Gilbert et al. 2008).

According to researchers, more than 60 coprolites were collected, from which 280 radiocarbon dates were obtained roughly yielding the date above (Gilbert et al. 2008, Jenkins et al. 2012, Taylor, Bryant, and Jenkins 2020, Hudson et al. 2021, Smith et al. 2020). The corpolites were subjected to DNA analysis, in which they found no possible contamination. Furthermore, the six oldest coprolite samples had six markers only known in the Native American population today (Gilbert et al. 2008). Further coprolite analysis revealed that the inhabitants of the caves were omnivorous, cementing that the coprolites were of human origin. Additional evidence of humans was the presence of a lined hearth feature. Finally, the samples identified a varied diet of foraged plants and seeds, small mammals, and even insects (Taylor, Bryant, and Jenkins 2020). Such findings support theories that Paleoindian groups' diets did not necessarily always consist of big game such as mammoth, bison, and deer.

Gault

Gault is a stratified, multicomponent site in central Texas in the physiographic region of the Edwards Plateau (Lassen 2015, Collins 2007). The site itself lies along an exposed vein of the Edwards Limestone Formation along Buttermilk creek, where chert and fresh water are abundant, making the area a coveted habitat for thousands of years (Waters et al. 2011).

The first formal excavations at Gault began in 1929 and were headed by J.E. Pierce from the University of Texas. Pierce was interested in the Archaic rock midden that was visible on the surface, though the crew began to uncover Paleoindian artifacts shortly after excavations began ("Gault School: History", accessed 08/2022). From 1929 to present day, various researchers have uncovered artifacts ascribed to periodic occupations from Early Archaic, Late Prehistoric, and an extensive sequence of Paleoindian components. The Paleoindian components at Gault include technologies ascribed to Pre-Clovis, Clovis, Folsom, Wilson, Cody, Golondrina-Barber, St. Mary's Hall, and Angostura (Collins 2007). Animal remains and stone tools have been recovered from every Paleoindian component at Gault.

Collins reveals that the inhabitants of Gault have a more generalized subsistence than what was originally thought of for Paleoindian groups (2007). Individuals foraged and hunted a wide array of resources. Faunal evidence has proven that big game only accounts for a small percentage of the diet and is instead part of a very large array of small, medium-sized, and large animals (Cannon and Meltzer 2004, Collins 2007). Faunal remains are also indicative that mammals are not the only part of the diet which also consisted of plenty of fish, amphibians, reptiles, and birds. Evidence of plant processing is not mentioned in detail within Gault publications.

Debra L. Friedkin

The Debra L. Friedkin site is a stratified, multicomponent deposit along Buttermilk Creek some 275 meters downstream from Gault. Much like Gault, Friedkin has occupations from Pre-Clovis to Late Prehistoric dating from 15,500-1,800 BP respectively (Waters et al. 2011). The dating at this site was conducted with optical stimulated luminescence in opposition to radiocarbon dating (Waters et al 2018). According to researchers, Gault appears to be solely a workshop while Friedkin has been interpreted as a campsite (Waters et al. 2011, Waters et al. 2018). Evidence from Friedkin suggests that habitants ate large and small animals and foraged local plants.

Barger Gulch

Barger Gulch is a tributary of the Colorado River in Grand County, Colorado. The stream flows from south to north and has cut deeply through the Miocene bedrock in the area, exposing veins of Troublesome Formation chert, a desired material for flintknapping. Barger Gulch appears to have been an inviting oasis in the past, with 11 Paleoindian sites recorded along it's 4-mile stretch (Surovell 2022). Modern vegetation in the area includes plants such as sagebrush, short grasses, and junipers, much like the Bull Creek Valley.

Of the 11 sites, the areas that are dated have a range of 12,900-10,000 BP (Surovell 2022) that is consistent with middle to late Paleoindian cultures. In fact, artifacts span most well-known Paleoindian cultures, with the curious exception of Clovis. The earliest artifacts found fit within the Clovis era yet are technologically different. From these sites, Folsom materials comprise the majority of collected artifacts, and are the main component of Barger Gulch (Surovell, 2022). As previously mentioned, Troublesome Formation chert is a local material that was readily available for the making of stone tools; the chert dominates the Folsom assemblage at the sites along Barger Gulch.

Of the 11 sites that have been documented on the 4-mile stretch of the Barger Gulch tributary, only Locality B has been studied and excavated extensively, yielding most of the data known about the area. Locality B is a Folsom campsite that has been dated to around 12,760 BP (Surovell 2022). Due to the extremely large amount of artifacts collected from this area (more than 75,000, without accounting for plant and animal remains), researchers have concluded that Locale B was once a winter campsite of extended duration. This site once again shows a less-mobile model for Paleoindian groups (Surovell 2022).

In addition to the previous conclusion, Surovell was able to study the differences between indoor and outdoor spaces at Locality B. There were four hearths in the area; three of them inside home structures. Surovell used statistical modeling and traditional archaeological methods to deduce that the hearths were activity centers, whether inside or outside, but that those activities differed depending on the location. For example, the hearth located on the outside of the home had large primary flakes surrounding it, while the indoor hearths only had small to medium-sized debitage, indicating that initial flaking happened outside while the final touches and resharpening of tools occurred inside the home (Surovell 2022). By utilizing a traditional and ethnographic theory on hearth patterning, Surovell was able to deduce that certain activities only happen in culturally prescribed areas of a site.

The previous sites have provided a framework in which Bull Creek can now be discussed. Like the Paisley Caves, Gault, Friedkin, and Barger Gulch, Bull Creek contradicts outdated assumptions about Paleoindian hunter-gatherers. More specifically, it widens the door on the concept that Paleoindian groups were not always highly-mobile big game hunters.

Because of the multicomponent occupations of the previously discussed sites and Bull Creek, archaeologists are now able to compare these sites to the more predominant hunting/kill sites that were once thought to be the archetype. In the next chapter, the background of previous excavations, findings, and analysis of Bull Creek is discussed.

CHAPTER FIVE

Site Overview

The Bull Creek site contains at least three stratified late Paleoindian components (Figure 5-1) dating from 11,000 to 9,800 BP (Bement et al. 2017). In this chapter I provide a history of investigations of the site and review each of these components. In brief, current research indicates that these different components represent activities at different seasons: a clear winter component (Component II, dated 10,685 +/- 50 BP) and an extensive summer component (Component III, dated 10,407 +/- 60 BP). Seasonality of components is determined through the analysis of developmental stages of faunal material. Winter component activities involved a specialization in bison hunting and processing. The summer component has a broad acquisition of at least 26 different animal resources, including bison, small and medium-sized mammals, reptiles, amphibians, birds, and mollusks. Previous research at Bull Creek has established the local environmental, geologic, and cultural content for the area (Arouza et al. 2016; Bement et al. 2007; and Carlson et al. 2017). Though the taxa have been previously identified, there are further analyses to be performed on the zooarchaeological finds, including taphonomy and ascertainment of evidence for processing for food and tool manufacture and micro residue analysis of other artifact classes found in context with animal resources.

(right).

Figure 5-1. Photograph of Bull Creek's stratigraphic sequence with radiocarbon dates (right).

Of the three components at Bull Creek, the top two components (II and III) have the densest artifact concentration thus far. These two components contain artifacts that indicate that the upper (III) of the two strata was a summertime occupation dominated by taxa only available to the inhabitants during the warmer months, while the lower component (II) was occupied during the wintertime when bison fetuses were available (Larrick 2020). According to Larrick, bison dominate the faunal assemblage in the wintertime occupation, while a much broader spectrum of animals is represented in the summertime occupation (2020). Although differences in subsistence resources between the two strata exist, the fact that both are found on the same site suggests that an extensive seasonal round and a residentially mobile lifestyle was not necessary for every Paleoindian group. It is likely that the same (or closely related) Paleoindian Plains groups had a distinct home range that they were very familiar with and exploited throughout the year.

During the 2019 field season, 12 1x1 meter units were excavated, resulting in 128 plotted artifacts. Of these artifacts, 78 were various lithic implements (debitage, bifacial tools, 1 core), 6 were charcoal samples, and 45 were bone and burned bone artifacts (with the exception of one xenacanthid shark tooth). Previous excavations amassed thousands of mapped artifacts and eleven postholes within approximately a dozen activity areas. To aid the reader, I will describe each stratigraphic component of the Paleoindian occupations (there is an Archaic occupation that is not included here), beginning with Component I, the lowest and thus oldest of the Paleoindian layers, and then proceeding upwards through the layers to Component IV, the youngest Paleoindian stratigraphic layer. Here, I will mainly give an overview of work that has been previously done by Bement and colleagues to provide a better understanding of where my thesis work fits into the larger research objectives at Bull Creek.

Figure 5-2. Excavation block B.

Component I

The first sign of Component I at Bull Creek occurred between 2007 and 2008 when Dr. Bement observed large bison ribs eroding out of a terrace. Bement then decided to conduct controlled excavations along the east side of the Bull Creek terrace in 2009. Subsequently, a second excavation block was opened along the west side of the terrace, leaving a trench in between blocks. Eventually, bison bones were found eroding out of the trench, so a 1x1-meter test unit was excavated. Excavations in this area in 2016 yielded a total of 47 bison bones and bone fragments, one turtle carapace fragment, and a single utilized flake made of translucent brown silicious chert. The bison bones consisted mainly of ribs and thoracic vertebrae; the minimum number of individuals was later estimated at three animals. One of the thoracic vertebrae had a maximum length of 55 cm, perhaps belonging to an extinct form of bison (*Bison antiquus* or *Bison occidentalis*), which is consistent with site stratigraphical sequence. The sole flake recovered was coated in calcium carbonate, though color suggests that it was sourced from the Edwards Plateau.

Researchers have attempted to get radiocarbon dates from animal bones found in this component on four different occasions and have been unsuccessful due to the poor collagen preservation in this older deposit. Bement and colleagues have identified this stratum as Component I due to a Clovis projectile point that was found eroding out of the southern wall of the site location. In lieu of a continued attempts to date bones out of this deposit, a maximum age of 11,660 BP was obtained by radiocarbon dating organic matter from the sediments surrounding the artifacts studied (Larrick 2021).

Component II

Component II is situated under Component III and is comprised of a soil layer of very fine to fine sandy loam, being very apparent throughout the entirety of the West Trench. This stratigraphic layer yielded around 1150 animal bones and bone fragments along with 143 lithic artifacts. Unlike other components, Component II had a large concentration of bison bones, with an MNI of seven adult bison and five bison fetuses. The bison fetuses have been identified as representing development to five or six months, leading researchers to conclude that Component II must indicate winter kills, assuming that the reproductive cycle of the excavated bison is the same as modern populations (Bement et al. 2022, Larrick 2020). Other finds within Component II include one hearth that has a 45 cm diameter and Alibates chert debitage.

The large assemblage of bison remains displays evidence of a variety of techniques for animal bone processing. For example, a large number of appendicular skeletal elements, such a limbs, have green fractures, indicating that they were broken relatively soon after the animal's death, perhaps for the extraction of bone marrow (Larrick 2021). Additionally, many bones show cutmarks- evidence of meat procurement. There is only one cranium recovered from Component II. This bison skull's frontal, parietal, and temporal bones were bashed, indicating the removal of brain matter from the braincase. The removal of brain matter was perhaps done for the purpose of hide-tanning, as seen ethnographically in later Plains groups (Frink and Weedman, 2005).

Finally, one hearth was excavated within this component. The hearth did not contain any charcoal and was devoid of any other artifacts in the immediate associated area. Instead, this hearth was characterized by charred sediments measuring 45 cm in diameter and having a 10 cm depth. Additionally, the hearth's periphery contained both burned and non-burned bones and Alibates debitage (Bement et al. 2022).

Component III

Component III is the topmost stratigraphic layer, sitting 0-25 cm above Component II. On average this layer sits about 10-15 centimeters above the previous component. To-date, a total of approximately 1856 animal bone elements from at least 28 distinct taxa have been recovered from this occupational level, though only 44 of those were excavated and plotted in 2019. Of those 28 taxa, two are identified at the level of class, one to the order, one to the family, four to the genus, eighteen to the species, and two to the sub-species (Table 3-1). The presence of neonatal bison in this component, in addition to the presence of deer fawn and cold-blooded reptilian species, indicates a late spring- summer occupation (Bement et al. 2022). While the majority of bones present are *Bison occidentalis*, the high number of other animal species at a Paleoindian campsite is surprising, given assumptions about the narrow diet breadth and big-game focus of this time period. What is even more striking is that Bull Creek's Component III adds more knowledge to the growing body of literature describing Paleoindian groups as not only big-game hunters but instead to be participants of a highly-varied diet when game is unavailable or conditions for big-game are not favorable (see Cannon and Meltzer 2008, Hill 2007, and McDonough et al. 2022). Perhaps the most intriguing part of this phenomenon is the distinction that has been made by Bement and others of a broad-spectrum diet visible in the summer while big-game hunting is indicated in the winter.

Like the diverse faunal assemblage, there is a wide variety of tool types in this component. Among them are an Alibates scraper, many utilized Alibates and Dakota Quartzite flakes, and at least three instances in which large bison bones were purposefully fractured to make several types of bone tools (needles, butchering tools). The lithic materials present mostly consist of secondary flaking debris/debitage of primarily Dakota Quartzite, but also Alibates chert for tool manufacture. According to Bement et al. (2022), 89% of the lithic materials procured are made of Dakota Quartzite, while 11% is Alibates, with the exception of Feature 2019-1. Peculiar within this assemblage is the incidence of two fragments of the same obsidian channel flake that had been utilized as a knife. The obsidian was sourced to the Jemez Mountains region of New Mexico and it is the only piece of this material found at Bull Creek (Bement et al. 2020).

Previous work at Bull Creek has identified at least 11 activity areas (Larrick 2021), including ten post-holes, six hearths, and two bison butchering features (one of which is the focus of this thesis). This thesis focuses on the densest of the two bison butchering features, which showcases the harvest of one bison's muscle tissues and skin from the axial skeleton and ribs. From the butchered bones, only one cutmark was observed by Larrick (2021) on the occipital condyle of the cranium associated with Feature 2016-1. A radiocarbon assay dates this feature to 9,267 BP. Dakota Quartzite flakes were found in association with feature 2016-1, perhaps the tools used by an agent to butcher the animal. Known as Feature 2018-1, two large cobbles exhibiting use-wear were excavated three meters east of the bison butchering activity area. The hammerstone-anvil pair was surrounded by spirally-fractured appendicular bison elements. The spiral fractures present on these limb bones were perhaps caused by the butcher's need to extract bone marrow with the hammerstone and anvil. One of the bones recovered from Feature 2018-1 was later identified as fragment of a bison metapodial, made possible by the discovery of the distal-end of a metacarpal in which the metapodial shaft refit. In addition to all bison bones previously mentioned, two scapulae were uncovered within Component III on the southeasternmost excavation units. The two right scapulae blades were intentionally broken, perhaps for the manufacture of bone tools such as the three possible bone needles previously documented in Larrick (2021). The scapulae's difference in size dictate that one came from a large bison, most likely a bull, while the other was extracted from a smaller individual, most likely a juvenile.

Six of the eleven activity areas are hearths located in the southern area of the excavation trench. Though most of this area was heavily eroded through fluvial or wind erosion, the presence of the hearths was identified by clearly defined basins, or depressions, of dark stained sediments comparable to burned earth around rock middens. In addition to burned earth, several hearths were further identified by the presence of scattered charcoal and tiny fragments of burned bone.

Finally, eleven post-holes, all measuring 8-10 cm across and 6-10 cm deep, were documented in Component III; four postholes were excavated in 2018 and 2019 while the remaining six were excavated during previous years. All postholes were directly associated with a hearth (Figure 5-3). The association of posthole groupings with at least one hearth suggests the construction of small shelters in which a hearth was used for warmth, cooking, and heat-treatment for stone tool manufacture. Other post holes may represent wind breaks, drying racks, or cooking supports.

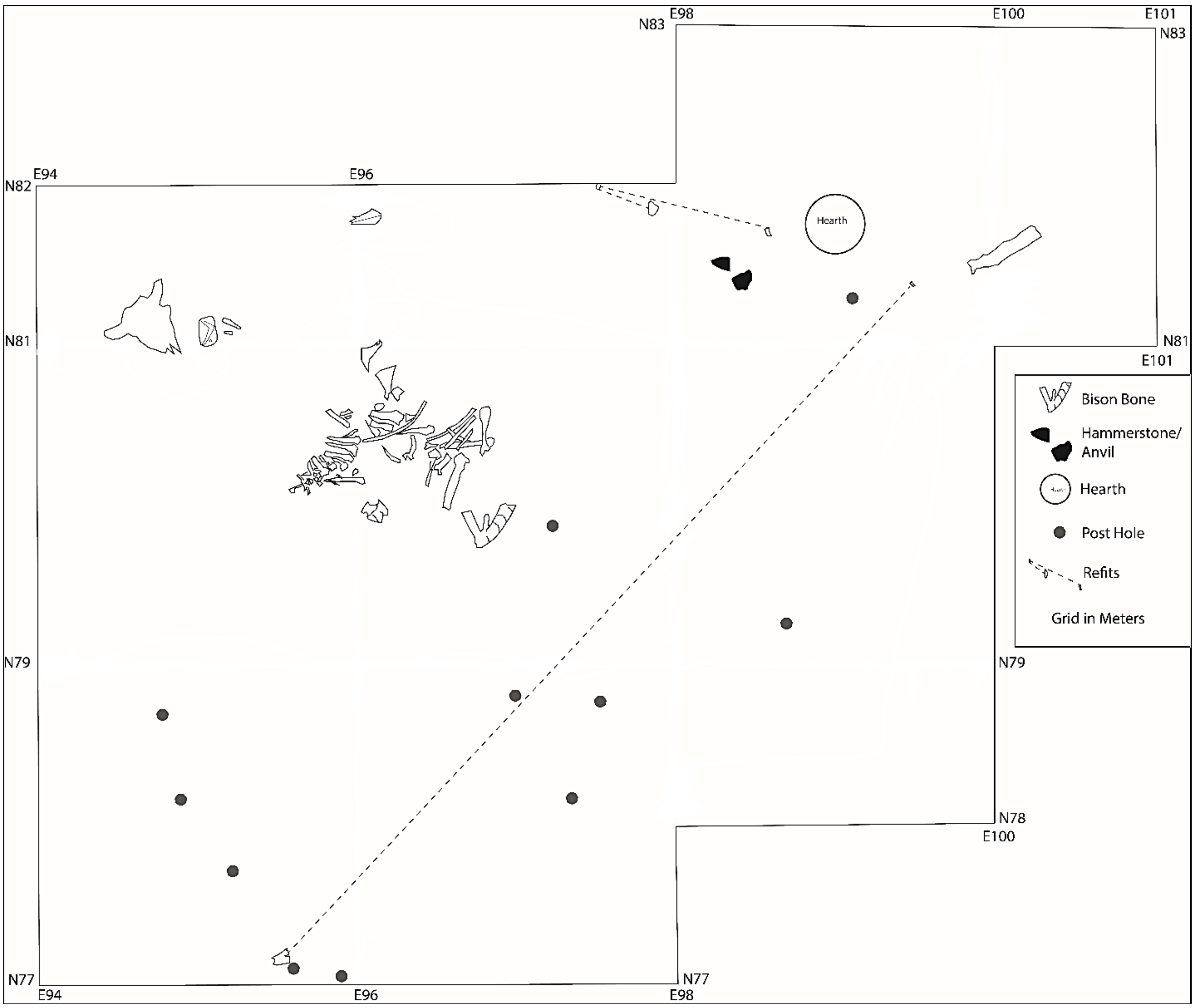


Figure 5-3. Site map with plotted research material.

Component IV

Component IV was identified during excavations within the West Trench in 2017. Component IV is situated within a thin layer of sandy loam that overlays Component III. The only artifacts in this layer are a bison pelvis, sesamoid, and cranium. The smashed bison cranium yielded a date of 9085 BP, while materials from Component III date to 9267 BP, yielding a 182-year difference between components. Additional excavation is needed to determine the extent and content of the Component IV occupation. To aid in the identification of component IV, radiocarbon dating of the bison pelvis was undertaken, yielding a date of 9092 BP, suggesting a likely connection to the activities in Component IV.

CHAPTER SIX

Methods

The research described here is concerned with the earliest known summer occupation at the Bull Creek campsite, known as Component III as defined in Bement et al. (2022) and Larrick (2021). Within this stratum, there are discard areas and features aligned with activities including heating/cooking, animal butchering/bone processing, possible bone tool manufacturing, lithic reduction, and lithic tool rejuvenation (Bement et al. 2022). To better understand the activities resulting in the artifactual and feature components of the archaeological record, I relied on the methods of spatial patterning through a ring analysis, refit analyses of bone artifacts, animal protein residue and plant/starch analysis on lithic artifacts, 3D rendering, and experimental butchering.

The methods employed include the taxonomic identification of faunal remains to identify the genera and species that have not yet been analyzed from the 2019 excavations. The taxonomic identification was achieved through a thorough analysis of bone length, width, height, and diameter. Identification of faunal remains was further supported by the comparative faunal collection available for study at the Oklahoma Archaeological Survey. I also assessed taphonomic history of the bone materials, including breakage due to weathering, carnivore gnawing, rodent gnawing, root etching, freeze fractures, sediment abrasion, trampling, and crushing (Lyman 1994). Included in the taphonomic analysis, human interaction with the faunal remains such as butchering and processing (seen as cut marks and spiral fractures on bone) was recorded to further interpret human-animal interactions.

Documentation of cultural processes included use of a Dinolite system to image and measure suspected butchering marks. Within this system, marks are imaged to scale and then measured digitally under low magnification, usually 10x. The scaled images documented the placement of measurements on the bone. Measurements for each individual occurrence were entered into an Excel database to facilitate further descriptive analysis and comparison.

Extra effort was expended to document the shape and size of a suspected expedient bone tool created and used for the butchering of the bison axial skeleton. First the bone was 3D imaged using photogrammetry provided in the Agisoft Metashape Pro system with the help of Kristi Wyatt in the OU Libraries Innovation at The Edge Laboratory. Once the 3D imaging was completed, a full-size plastic duplicate of the bone was made on a 3D printer. This 3D duplicate was then used to form a cast of the bit end in clay. The clay cast was filled with silicon and, once cured, transected to provide cross-sectional slices of the bit that were then compared visually as well as metrically to marks documented on the bison axial skeletal remains of Feature 2016-1.

In addition to traditional zooarchaeological methods, I have employed counter immunoelectrophoretic (CIEP) residue analysis (with the help of the PaleoResearch Institute) to assist in the identification of animal species that are represented in a processing feature that contains the hammerstone and anvil pair (BN1871 and BN1872). Both artifacts were washed with buffer and detergent solutions that remove antigens from the artifact surface. Subsequently the recovered artifacts were placed in an ultrasonic bath that aided in the recovery of plant and animal proteins (Cummings 2021-023; Appendix B). After this process, the solution recovered from BN1872 was processed through standard agarose gel electrophoresis (for the blood residue analysis only). The previous analysis was employed to possibly expand the taxonomic variation at the site and anchor which of the 26 buried animals were being processed at Bull Creek as well as possibly identifying a new species at the site.

A final line of methodology follows Henry's ring analysis for spatial patterning (2012). Henry (2012) proposed that a ring analysis centered on a hearth could help discern between areas of direct activity and those of discard, in essence identifying both within a single space. A ring analysis relies on the patterning of artifacts and encircling a site feature, generally a hearth. Three concentric zones are identified by rings. The first ring, labeled the drop zone, is immediately around the hearth edges and contains the highest concentration of artifacts if the hearth is the center of an activity area. The second ring, the squat zone, represents where the occupant(s) sat while performing the tasks represented in the drop zone. As such, the squat zone contains far fewer artifacts than the drop zone. The final zone, which is located furthest from the center, is the toss zone. The toss zone is a discard area where larger tools and residues are discarded. The largest objects would be removed the furthest from the hearth-centered activities.

By using various lines of inquiry, the research questions outlined in Chapter 2 will be answered in the following chapters.

CHAPTER SEVEN

Results

The zooarchaeological and lithic remains associated with the dismemberment and processing of a bison carcass (Feature 2016-1) unearthed during the 2016 through 2019 excavations at the Bull Creek site are analyzed. The skeletal remains of a single animal that consists of both articulated and disjointed axial elements provides the unique opportunity to investigate the butchering sequence of this single animal. The spatial distribution of the remains from this animal were plotted and investigated in relationship with other site materials, including a hearth, a lithic hammerstone/anvil couplet, and an isolated bone tool (Figure 7-1 below). Protein residue, pollen, and starch analyses were conducted on the hammerstone/anvil couplet found in relationship with the hearth mentioned previously.

Animal protein residue and plant/starch analysis of these two lithic objects supplement information gained from standard zooarchaeological analyses including taphonomic, metric, element, age, sexing, and cutmark/processing mark analyses. Residue analysis on the lithic assemblage associated with bison remains both solidify theories about bison butchering practices and attempt to identify species utilization not represented in the archaeological record. These approaches allow a more reliable estimate of seasonal variance in subsistence specialization to be made. By answering these research questions, new data that is relevant to Plains archaeology and zooarchaeology is acquired.

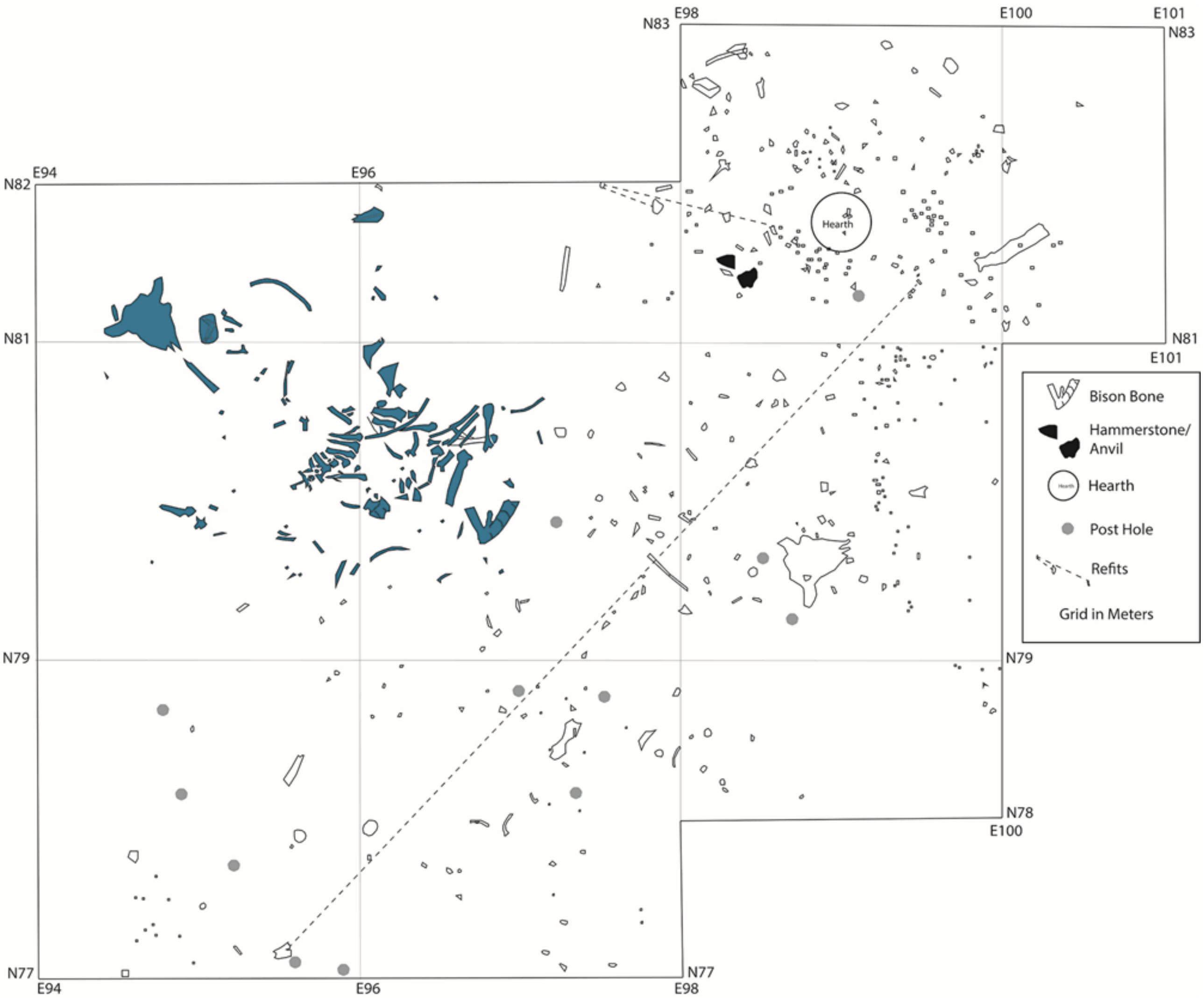
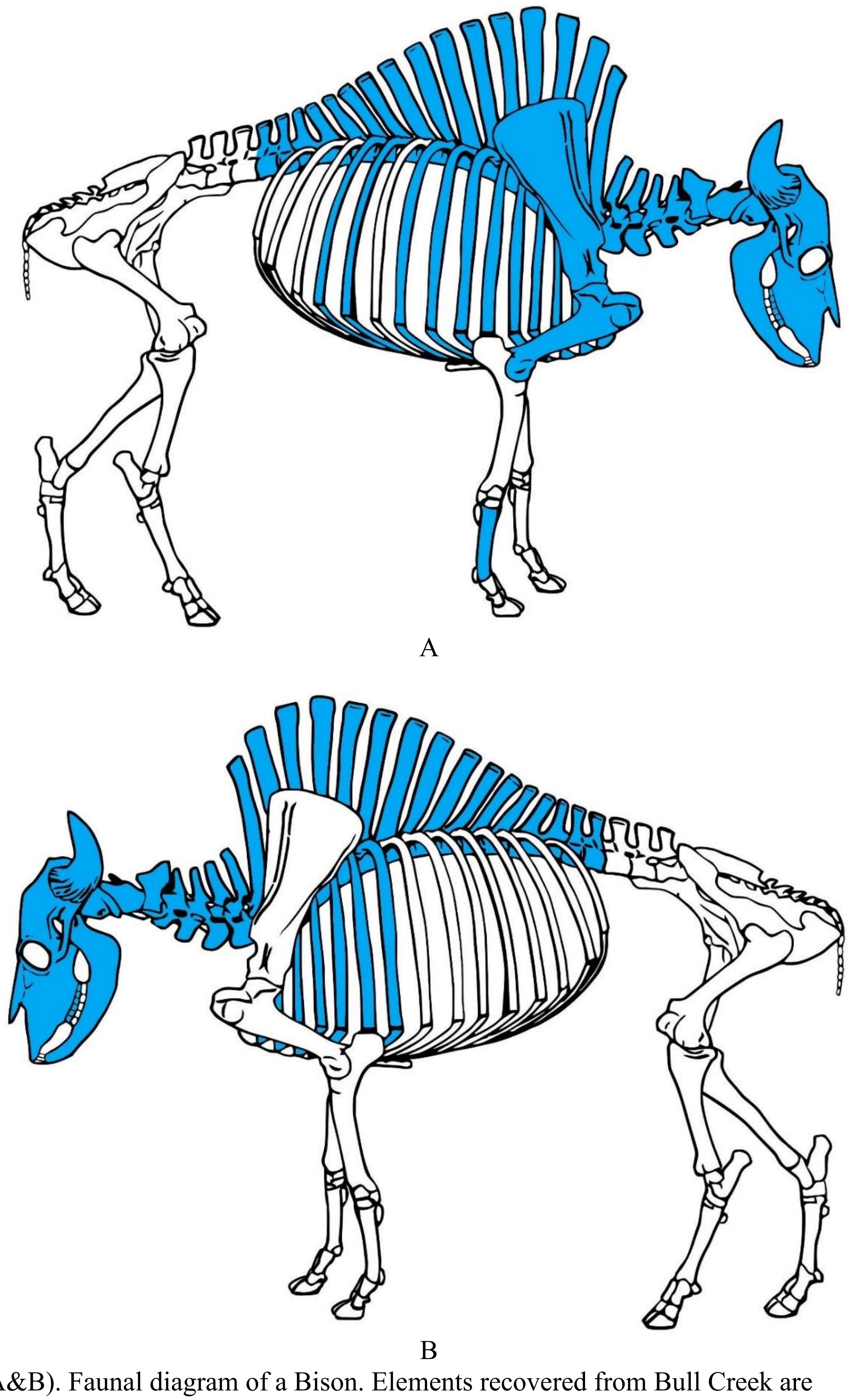


Figure 7-1. Site map of Bull Creek Area B with plotted artifacts.

Analysis of Bison Remains

Bison remains are not scarce at the site. The focus of this thesis is a bison axial skeleton that displays distinctive butchering marks. The axial skeleton includes the cranium, mandibles, hyoid, all cervical vertebrae, all thoracic vertebrae, first and second lumbar vertebrae, and 10 right side and 6 left side ribs (Figures 7-2, 7-3, 7-4). There are no bone duplicates, and while it is not completely certain, it is likely that the disarticulated skull, atlas, hyoid, and mandibular portions belong to the same individual as the articulated axial skeleton. Additionally, atlas and axis diameters are 46.4 mm and 39.2 mm respectively, indicating they re-articulate well.

Figure 7-2. Bison remains in situ.



A

B

Figure 7-3 (A&B). Faunal diagram of a Bison. Elements recovered from Bull Creek are highlighted in Blue. Diagrams depict right (A) and left (B) sides respectively.

Skull (BN1190) was found together with an atlas vertebra (BN 1188) and two hyoids. The back of the skull, including the occipital condyles had been removed, exposing the brain case. No evidence could be found to suggest the type of tool used during this process. The edges of the hole were badly fractured, although radiating fracture lines suggest this task was performed while the skull was fresh. This action suggests the brain had been removed for further processing or perhaps for tanning the hide. The proximity of the atlas vertebra to the cranium suggests the skull and atlas were removed as a unit when severed from the carcass. Butchering punctures are observable on the atlas vertebra, but due to its fractured state, are unmeasurable.

The partial left (BN103) and complete right (BN250) greater hyoids were found in the vicinity of the cranium. None of the other hyoid bones were found. No butchering marks were observed on the hyoids although their separation from their normal skeletal position and fracturing of one suggests intentional removal, possibly in association with removal of the tongue.

Fractured mandibular ascending rami sections were found between the skull and the axial cluster. Both mandibles display helical fracture edges at the ascending ramus/horizontal ramus juncture, although distinctive blow marks were not visible. Only the ascending rami were found. No mandibular teeth or tooth fragments were associated with either ramus.

The third through seventh cervical vertebrae were found together in an articulated sequence, as were the sixth thoracic through second lumbar vertebrae (Figure 7-4), with some rib heads still articulated to the thoracic vertebrae.

Figure 7-4. Photograph of articulated bison remains. T6 through L2 (left) C3 through C7 (right).

Butchering Marks

No cutmarks typical of butchering with a stone tool were documented. One possibillity for the lack of cutmarks on the carcass is that a stone tool was not used in the butchering process. A second possibility is that the animal was butchered with more skill and thus did not leave marks on the bone. Regardless on which possibility is more likely, the butchering process differs from previously documented butchering sequences in the northern portion of the site. Here, the winter occupants utilized lithic tools to remove the periosteum from long bones prior to fracturing the bones for marrow removal, leaving many cutmarks (Bement, Carlson, and Carter 2022).

Close inspection of the vertebrae and some rib sections found distinctive impact or blow marks. All marks were measured and the shape of the mark noted. Individual marks ranged in size from 7 mm to 19.4 mm long and 5.9 mm to 14.4 mm wide. Some marks included multiple impacts. Marks made by a single blow or impact share a very distinctive morphology. The indentation is crescent shaped with a smooth, convex margin opposite an angular concave edge (Figure 7-5, 7-6).

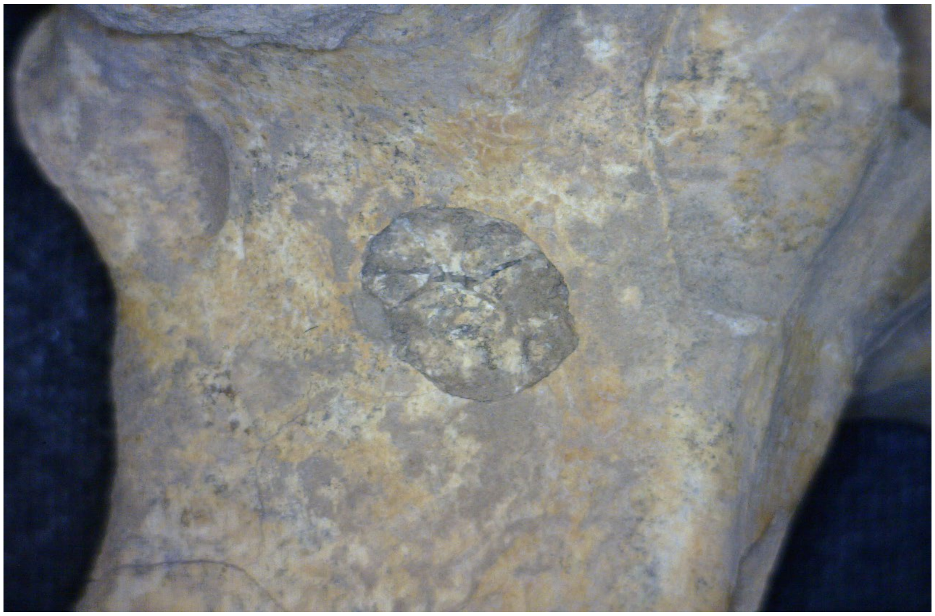


Figure 7-5. Indentation on axial element T2.

Figure 7-6. A composite blow on axial element T14.

Accompanying the indentations are short radiating fractures. Taken together with the smooth edges of the blowmarks, the radiating fractures suggest the bones were fresh when impacted. Marks were found on both sides of the axial elements, yielding a total of 40 blow marks.

Table 7-1. Minimum Number of Visible Blows

Bone Number	Element	# blows on right side	# blows on left side	Total blows
1010	C2	2	5	7
962A	C3	0	1	1
945A	C4	0	0	0
945B	C5	0	2	2
945C	C6	0	1	1
945D	C7	0	1	1
954	T1	1	1	2
986	T2	0	1	1
991	T3	0	0	0
960	T4	0	0	0
1009	T5	0	0	0
963B	T6	1	0	1
987B	T7	1	2	3
962B	T8	0	0	0
1140A	T9	2	1	3
1140B	T10	2	2	4
1140C	T11	2	1	3
1140D	T12	0	2	2
1140E	T13	0	1	1
1140F	T14	2	2	4
1140G	L1	1	2	3
1140H	L2	1	0	1
			TOTAL	40

Table 7-2. Length and Width of Blows on Axial Skeleton

Bone Number	Element	Length (mm)	Width (mm)
1010	C2	11.3	8.8
		12.5	6.2
		10.1	9.4
		10.8	8.8
		14	9.8
962A	C3	15.2	13.5
945B	C5	11	8.3
		17.5	14.4
945C	C6	14.9	8.1
945D	C7	15.6	9.5
954	T1	23.7	10.5
		19.4	12.4
986	T2	15.2	11.5
963B	T6	14.2	10.9
987B	T7	7	5.9
		9.2	8.2
		14.2	9.7
1140A	T9	10.2	9.8
1140B	T10	9.4	7.5
		11.7	10.3
1140C	T11	12.8	8.6
		7.1	6
1140D	T12	11.2	10.6
1140E	T13	10.8	8.6
1140G	L1	9.4	8

* while there are at least 40 visible blows, some are unavailable for measurement since some segments of the axial skeleton remain encased in foam

The morphology of the indentations suggest that the impactor had a bit end that was convex on one side and angular on the other (Figure 7-7, 7-8). Expedient bone tools fashioned by the helically fractured leg bones have been found at Paleoindian bison butchery sites, such as at Lubbock Lake in Texas and Cooper in Oklahoma, describe such a bit end (Johnson 1987, Johnson and Bement 2009). At Cooper, a Folsom bison kill site, a spirally fractured metapodial exhibited a bit end with one smooth convex surface formed by the exterior cortical surface of the shaft and an angular edge formed by intersecting helical fractures on the interior marrow cavity. Similar butchering marks on vertebrae at Cooper resulted from a reconstructed butchering sequence where the hide was cut down along the back and laid open on either side of the carcass by Bement and his team (Bement 2010). Once the hide was removed, an expediently fashioned bone tool similar to the one found at Bull Creek was held in the hand and used as a cleaver to separate the muscle masses from along the dorsal spines of the thoracic vertebra. Chopping in a pickaxe motion, the chopper slides along the bone until it encounters the body of the vertebra. The excessive force required to separate the meat from the dorsal spine hits with full force onto the vertebra body, sometimes causing a dent or impact (as seen on the Bull Creek specimens). One of the Cooper vertebrae from the middle kill level had the bone bit end from such a tool embedded in the vertebral body (Johnson and Bement 2009).

Metacarpal Tool

While analyzing the Bull Creek materials, researchers identified a metacarpal that had been fractured, leaving a sharp bit projection along the shaft on the distal end (Figure 7-7, 7-9). It was hypothesized that such a tool might have produced the marks on the axial elements. To test this hypothesis, I replicated the use of the metacarpal specimen. A three-dimensional replica of the metacarpal rendered in plastic after 3D scanning was inserted into clay to obtain a negative imprint of the bit end (Figure 7-8). The replica indent was then filled with silicone caulking and allowed to cure. Then the replica silica-filled indentation was transversely sliced to obtain cross-sectional views of the tool bit and indentation at differing distances from the bit end. The cross-sections were then compared metrically and visually to the impacts displayed on the bison bones. The results support the hypothesis that this bone tool or one like it was used to help butcher this animal.

Figure 7-7. Bison occidentalis metapodial in situ.

Figure 7-8. 3-D Rendering and silicone mold of metapodial tool used for data collection.

Comparison of tool marks to blow marks

To further assess the likelihood that this tool was used to butcher this axial skeleton, I assessed the excavated remains for additional data. The first line of inquiry relied on 19 measurements taken with a Dino-Lite Digital Microscope. Twelve measurements are from the axial skeleton, three from the right scapula, and three from the silicon slices seen above (Tables 7-1, 7-2, Figure 7-7). These measurements were then plotted to ensure that tool bit measurements and bone fractures were similar enough to continue testing. The measurements acquired from the tool bit fit within the twelve measurements taken from the axial skeleton fractures, indicating that there is a high likelihood that the metapodial was used to butcher the bison carcass. The measurements of the blows on the scapula are irregular, and thus, another tool was used.

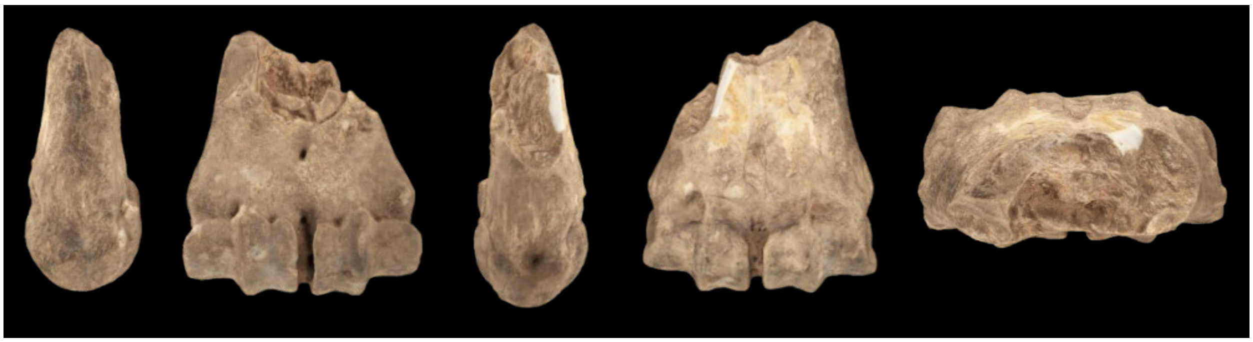


Figure 7-9. Views of metapodial tool from various angles.

The second line of inquiry relies on conclusions of Johnson and Bement (2009) that the tool responsible for similar marks was expediently manufactured by spirally fracturing the midshaft of a metapodial (metacarpal or metatarsal). To fracture the midshaft of a metapodial to obtain the right shape bit end requires a hammerstone and anvil. A hammerstone/anvil couplet was uncovered at Bull Creek in 2018.

To ascertain if this hammerstone/anvil couplet could have produced the metacarpal tool, I searched the Bull Creek database to see if any bison shaft fragments had been identified in the vicinity. One small piece of bison shaft (BN1948) had been identified as a possible refit for the metacarpal. The distal metacarpal (BN1800) refits with bone fragment (BN1948). A distance of 5.8 meters separates the two pieces (Figure 7-10).

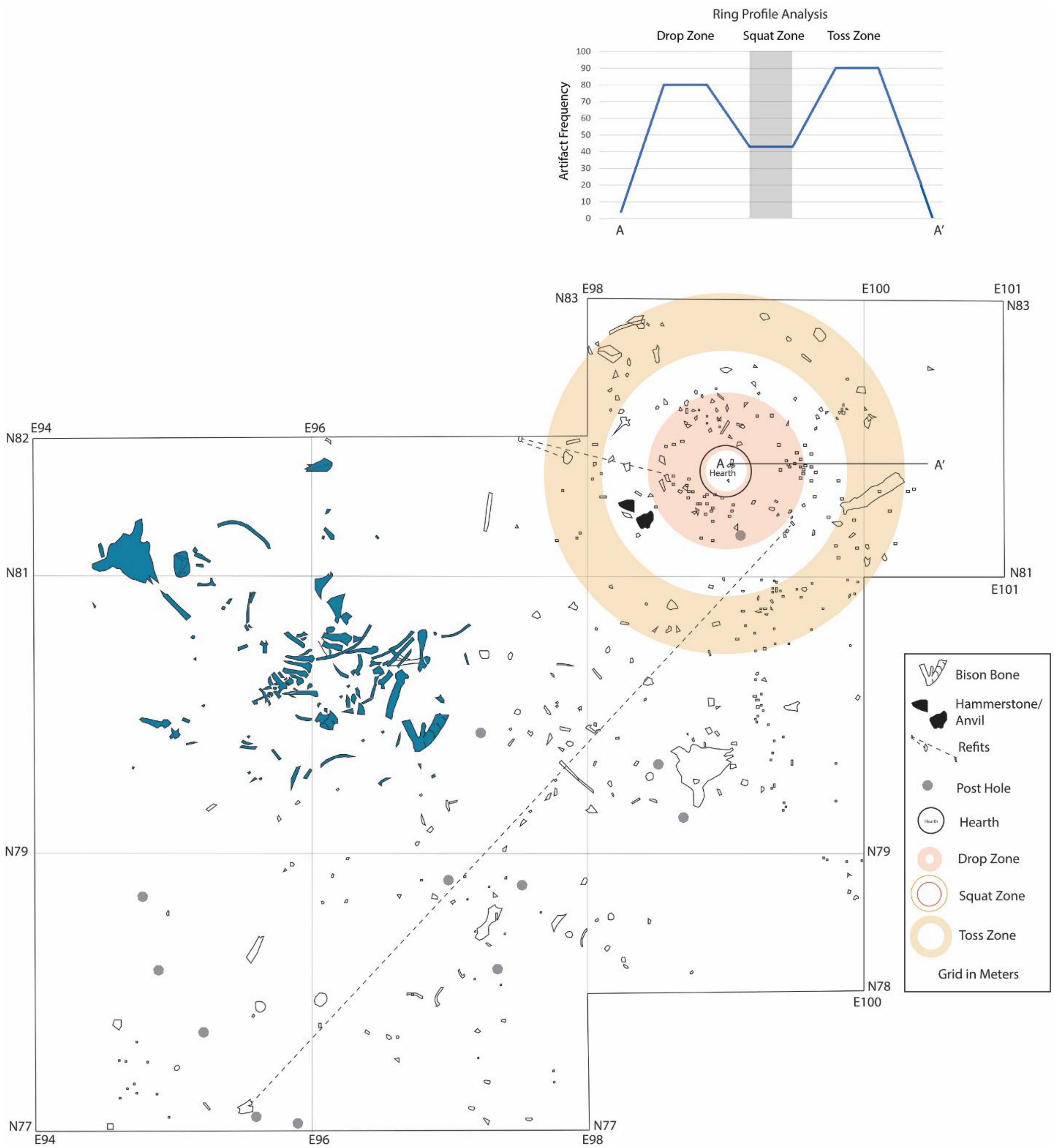


Figure 7-10. Plan map of artifact distribution with hearth drop and toss zones included.

The only permanent feature within my research area is hearth 19-1 depicted above (Figure 7-10). A simple ring analysis as is detailed by Henry (2012) shows that all artifacts were found within 5 meters of the center of the hearth. The largest concentration of artifacts by far occurs within 1 meter of the hearth in all directions. The hammerstone/anvil pair are placed within the squat zone (Henry 2012) where a person would be seated. Larger, and perhaps more bothersome artifacts that might be seen as refuse, are found in the outskirts of the hearth. Interestingly, the metapodial tool is almost five meters away from the hearth, while the butchered bison elements are placed closer.

A third line of inquiry was to determine if there was evidence that the hammerstone/anvil was, in fact, used to break bison bone. To accomplish this, I enlisted PaleoResearch Labs, Golden, Colorado for protein residue analysis (Cummings 21-023; Appendix B).

Animal protein residue analysis

The anvil/hammerstone (Sample/ Bone number 1872) was tested against multiple animal antisera at the PaleoResearch Institute in Colorado. Of all the antisera tested, there was a very weak positive result for bovine antisera (Cummings 21-023; Appendix B). Bovine antisera signals the presence of bison or cattle protein. The result could not be replicated, probably due to the degradation of blood proteins due to the age of the site and the open air exposure of the area.

Experimental Butchering

Having ascertained through refit analysis and protein residue analysis that the hammerstone/anvil may have been used to break the metacarpal, thereby forming the expedient tool, the next step was to better understand how and why the tool was used on the axial segment of the bison carcass. To better understand the manufacture and use aspects of this expedient tool, I devised an experiment to make and use of this type of tool and then compare the results to the archaeological evidence from Bull Creek.

Bones were acquired from a butcher shop in Woodward, OK. We began by attempting to make a tool out of a radius/ulna midsection that had been fused. To accomplish this, the radius/ulna midsection was placed on the ground and struck multiple times with a large hammerstone weighing 1/5 kg. The radius/ulna did not fracture. The next step was to place the bone on an anvil and repeat striking it with the hammerstone. This time the bone fractured. Since the bone was previously sawed, we were only able to create a straight fracture long the bone's midline. The bone was then split, and a section of the radius was hit repeatedly until we achieved a sharp endpoint. The sharp radius bone tool was then used in conjunction with the 1.5 kg hammerstone/ percussor to mimic the vertebrae and rib fracture pattern from Bull Creek. Researchers also attempted direct percussion with the radius tool and were unsuccessful. Even with issues due to the sawed ends of the radius, there was one very successful recreation of the Bull Creek butchering sequence (Figure 7-11). By recreating a similar bone tool, it became easier to understand the process of using such a tool to butcher an animal. While it took brute force to create a fracture pattern like the one seen on the metapodial, it was more expedient than finding raw material and fracturing it until a large and sharp enough flake was manufactured. In addition, the radius kept a sharp edge even after repeated blows to other bones.

Figure 7-11. Successful experimental radius fracture.

Plant Processing

To test the possibility that the hammerstone/anvil had been used to process plant remains, I also had PaleoResearch Labs check for pollen and starch remains. The possibility that Bull Creek inhabitants processed plant remains on-site was raised when charred seeds of goosefoot, amaranth, sedge, and possibly nightshade were obtained from flotation analysis of sediment from a hearth located east of the hammerstone/anvil couplet (Bement et al. 2019). A hammerstone and anvil pair was used to obtain plant and starch presence from the research area. Sample/bone number 1871 was washed to recover pollen and starch, and Sample 1872S was sent as the soil sample. The pollen signature obtained from the sediment control sample is very different from the pollen signatures published previously (Cummings and Varney 2010). Unlike previously, Low-spine Asteraceae pollen significantly dominated the record, indicating that marsh elder plants were abundant in the area. Not uncommon to the area, Amaranthaceae, High-Spine Asteraceae, and Poaceae pollens indictate plants from the goosefoot family. Plants from this family (goosefoot, sunflowers, and grasses) are still native to the area and their presence is not uncommon. Finally, the sediment sample showed small quantities of Pine trees, sagebrush, members of the chicory tribe of the sunflower family, Mormon tea, and globemallow; these are also common to the area and were previously reported on in Cummings and Varney (2010).

The hammerstone/anvil (BN1871) sample was washed to recover pollen and starches. As is common in Paleoindian sites, preservation of pollen and starches is rare. Nonetheless, 6 pollen and a small amount of microscopic charcoal and lenticular starch grains were found. The six pollen and starches observed were one High-spine Asteraceae, one Poaceae, one lenticular starch, and three pieces of microscopic charcoal. As mentioned previously, the high-spine Asteraceae and the poacaea represent sunflowers and grasses, respectively. Lenticular starches are typically produced in seeds from grasses such as barley grass, wildrye, and western wheatgrass (Cummings 21-023; Appendix B). Grasses commonly found in the Bull Creek valley include blue grama, buffalograss, hairy grama, side-oats grama, bluestem, Indian grass, and sandsage. While it is possible that the grasses in the natural environment left their mark on BN1871, the presence of lenticular starches preserved on the hammerstone's surface suggests the processing of grasses/ grains through crushing and grinding.

Activities identified by this analysis are bison butchery, bone tool manufacture, hearth use and possible plant processing. Though the following are not the main concern of this thesis, the presence of debitage suggests lithic tool production, and the presence of post-holes suggest the construction of a shelter, as well as possible hide-processing (as was outline by Larrick 2021).

CHAPTER EIGHT

Discussion and Conclusion

The likelihood that an expedient tool made on a metapodial was used at Bull Creek was ascertained by analyzing the blow marks observed on the axial skeletal elements, comparing them to the morphology of the bit end of a possible expedient tool manufactured with hammerstone and anvil and experimentally replicating the manufacture and use of a similar tool. Prior to the manufacture and use of this tool, the bison had to have been killed and transported to the Bull Creek site.

The distribution of skeletal elements at Bull Creek suggests this bison was transported to the site in pieces. One parcel probably consisted of the cranium, atlas, hyoid, and mandibles. A second parcel probably consisted of the vertebral column from the axis (2nd cervical) through the 2nd lumbar and associated ribcage. The rear end of the animal posterior of the 3rd lumbar and including the pelvic girdle and tail was not found. Appendicular segments of all four legs are not present, but probably were brought back separately and then processed further for marrow acquisition.

This possible segmentation of the bison fits the pattern of segmentation documented at the penecontemporaneous Ravenscroft bison kill site where carcasses were cut into fore and aft axial portions, sometimes with hind legs attached to the pelvis; complete front leg sections; and cranial units (Muhammad 2017). The similarity between the Bull Creek bison segmentation documented here and the broader pattern of bison primary segmentation at the Ravenscroft bison kill suggests that butchers at both sites followed similar practices, possibly suggestive of shared traditions that reflect social group boundaries.

The spatial distribution of the remains from a single bison were plotted and investigated in relationship with a hearth, a lithic hammerstone/anvil couplet, and an isolated bone tool, resulting in the conclusion that site materials identify a distinct focus of activities. As mentioned in Chapter 2, discard patterns are often predicated on a perceived length of stay at a site and also on the qualities of materials being processed at the site. The only permanent feature or site furniture within my research sphere was hearth 19-1. Using this hearth as an anchor point, all artifacts were found within a radius of five meters (Figure 7-10). The greatest density of artifacts occur within one meter of the hearth and consist of the majority of lithic flaking debris, the hammerstone/anvil couplet, and refit of spirally fractured bison bone, including pieces of the metacarpal butchering tool. The working or bit end of the metacarpal butchering tool was found some 5 meters away from the hearth and hammerstone/anvil. Midway between the hearth and metacarpal tool is the concentration of bones of the butchered bison axial segment. Whether because of smell or the attraction of flies, it probably is no accident that the residue of butchering a bison is located at distance from the hearth.

The butchering of the bison reflects use of a single type of butchering tool, that of a bone tool. Whether one or more such tools was employed is difficult to say. It is also not known how many people were involved in butchering the bison. The paucity of other artifact types, including stone flaking debris, suggests that the bison butchering area was its own use/discard area, while a palimpsest of activities accompanies the vicinity of the hearth.

Were these activities carried out in the vicinity where the artifacts were found or were they discarded to another location? Performing a simple ring profile analysis of plotted artifacts for the Bull Creek III occupation allowed the significance of the placement of study materials to become apparent. The drop zone was found to contain small artifacts alongside the hearth, and the toss zone contained larger artifacts discarded at distance from the hearth (Figure 7-10). The results of a ring profile analysis that plots artifact frequency against the tripartite zone designations (drop, squat, toss) describe a Type I profile where the toss zone is dominant (Figure 7-10). The Type I profile suggests this hearth at the Bull Creek site was a focal point for a diverse array of domestic activities, including the activities, in this case, related to the creation of an expedient tool.

The results of the pollen analysis performed on the sediment sample submitted with the hammerstone/anvil pair as a control for protein residue analysis (BN1872S, where S= soil), and starch analysis on the anvil (BN1871), indicate plant processing was also performed adjacent to the hearth. Further evidence that plants were processed is provided by the recovery of charred goosefoot, amaranth, sedge, and possibly nightshade from hearth sediment (Bement et al. 2021).

The butchered remains of the bison axial skeleton may or may not be an intact butchering activity area. In general, the distance away from the hearth is consistent with the expectation that large materials would be discarded furthest away and this also fits for removing malodorous and pest-infested materials from main activity areas.

The research questions formulated for this project were as follows: (1) What, if any, activity areas are discernable at Bull Creek? (2) How many activity areas are discernable? (3) Do the activities have to do with subsistence-related tasks? (4) What kind of subsistence is visible during the summer occupation? (5) Are summer occupation activities different than that of other seasons? (6) Do the results of the previous questions provide a different perspective on Paleoindian culture, namely modes of subsistence and camp organization?

Through these pages, it has been proven that (1) activity areas are discernable at Bull Creek. Particularly, (2) there are 3 activity areas in the immediate vicinity of the site materials studied within this thesis, though more have been identified in other areas of the site (see Larrick 2021 for more information). (3) All of the activities detected in Chapter 7 are related to subsistence in one way or another, whether it be by direct association, i.e. the butchering of a carcass and processing of plant materials, or by indirect affiliation through tool manufacture. (4) The most apparent subsistence activity during the summer occupation is that of one bison, though the presence of 25 other taxa and pollen/ starches of plants that are not native to the area warrant more research. (5) Summer occupation activities are different than that of other seasons at Bull Creek as was seen in Chapter five which detailed some of the data available from the winter occupations. Finally, (6) the results of the previous questions do provide a different perspective on Paleoindian culture in that they illuminate that the summer component at Bull Creek showcases a variety of practices at the site. Taken together, the analysis of the butchering of the bison axial and the analysis of hearthside artifacts shows that the Bull Creek site is the result of a wide diversity of activities typical of summer occupations of a group following a broad-spectrum subsistence adaptation. This situation is in stark contrast to the winter occupation at Bull Creek which targets many bison from a large-scale kill event.

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APPENDIX A

Pollen Diagram

This pollen diagram showcases the results acquired by the PaleoResearch Institute for project 21-023. The results below were discussed throughout this work.

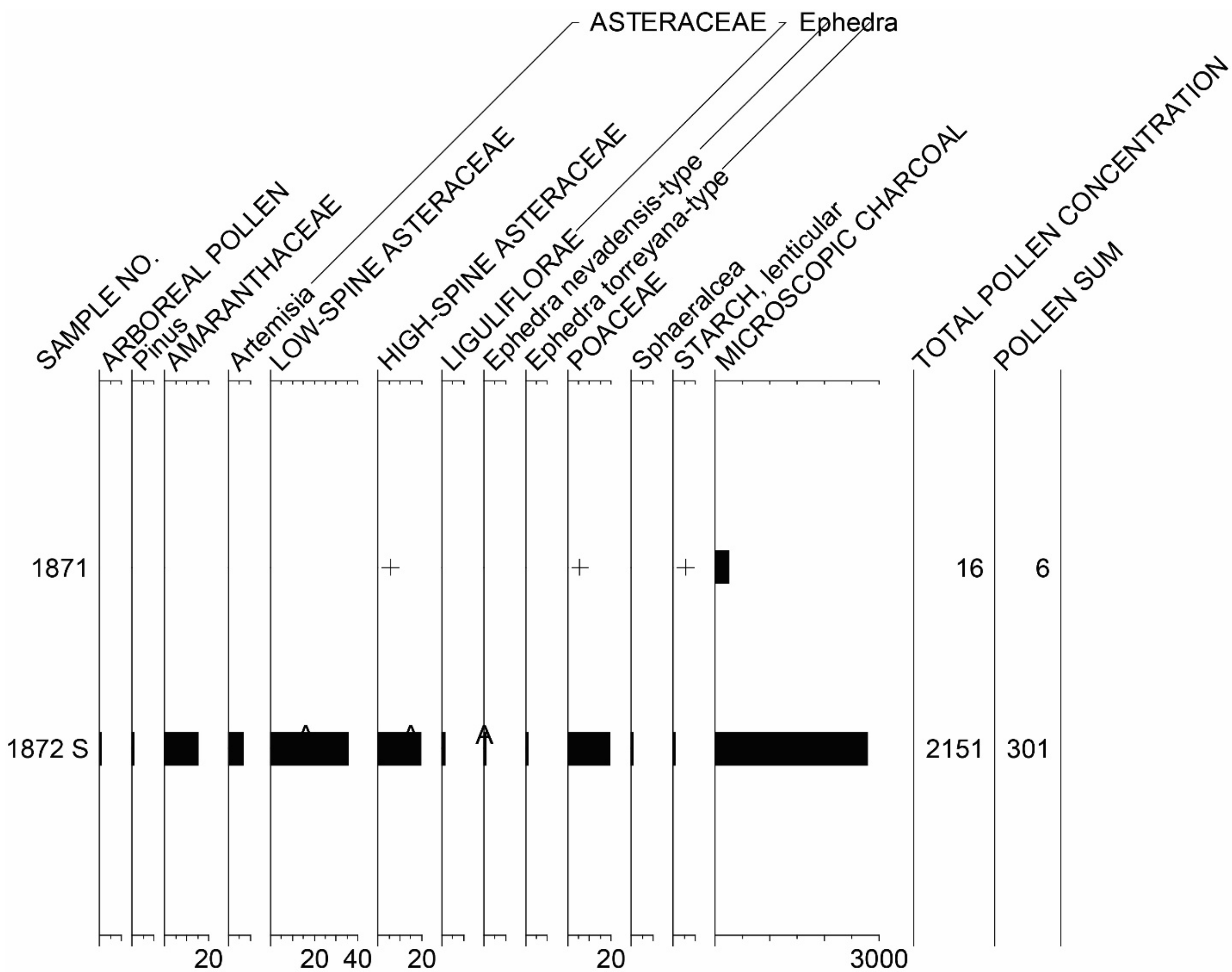

FIGURE 1. POLLEN DIAGRAM FOR ... 21-023X.TGX

APPENDIX B

Paleoresearch Institute Results

POLLEN, STARCH, AND PROTEIN ANALYSIS OF SAMPLES FROM
THE BULL CREEK SITE (34BV176), OKLAHOMA

By

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PaleoResearch Institute Technical Report 2021-023

Prepared for

Oklahoma Archeological Survey
Norman, OK

October 2021

INTRODUCTION

The Bull Creek site (34BV176) is situated within the short grass prairie biome on a cut bank that is in a meander of Bull Creek located in the High Plains physiographic region of western Beaver County, Oklahoma. The Bull Creek floodplain supports trees that include elm (*Ulmus*), cottonwood (*Celtis*), and hackberry (*Celtis*). The stratigraphic sediments, including buried paleosols, date from 13,210 RCYBP to the present. Two rocks and one sediment sample were recovered from the lower summer occupation area that has been previously radiocarbon dated to between 10,233–10,299 CAL yrs. BP (9,139 ± 21 RCYBP).

METHODS

Pollen and Starch

Sediments often present unique challenges for pollen preservation and recovery, meaning that larger samples are required for land sediments than for pollen recovery from lake sediments or peat bogs. Groundstone or rock washes and sediment samples receive much of the same processing. This section first describes recovery of the wash from one of the rocks, then describes the first steps in processing sediment samples.

The rock was rinsed using tap water and gentle hand pressure, which functions to remove modern contaminants. A small portion of the rock was tested with dilute (10%) hydrochloric acid (HCl) to detect the presence of any calcium carbonates; yielding a slight reaction, which was followed by rinsing the entire rock surface with dilute HCl. Then, the ground surfaces were washed with a 0.5% Triton X–100 solution to recover pollen and starch grains. The surface was scrubbed with an ultrasonic toothbrush and rinsed thoroughly with reverse osmosis deionized (RODI) water. The washed area was measured. Each sample then was sieved through 250–micron mesh to eliminate any large particles that might have been released during the washing process. This pollen-rich organic fraction was rinsed, then HF and acetolysis treatments described below.

A chemical extraction technique based on heavy liquid flotation is the standard preparation technique used in this laboratory for recovering pollen grains from sediments. This particular process was developed for extracting pollen from soils where the ratio of pollen to inorganic material is relatively low. It is important to recognize that it is not the repetition of specific and individual steps in the laboratory, but rather mastery of the concepts of extraction and how the desired result is best achieved, given different sediment matrices, that results in successful recovery of pollen for analysis.

Our pollen extraction method retains starch granules when they are present. Starch granules are a plant's mechanism for storing carbohydrates. Starches occur in numerous seeds, as well as in starchy roots and tubers. The primary categories of starches include the following: with or without visible hila, hilum centric or eccentric, hila patterns (dot, cracked, elongated), and shape of starch (angular, ellipse, circular, or lenticular). Some of these starch categories are typical of specific plants, while others are more common and tend to occur in many different types of plants.

Hydrochloric acid (10%) was used to remove calcium carbonates present in the sediment samples, after which, they were screened through 250–micron mesh. Multiple water rinses, employing Stoke's Law for settling time, were completed to return the sample to a neutral pH. A small quantity of sodium hexametaphosphate was used to suspend clay-sized particles prior to additional rinsing using Stoke's Law. This process was repeated with ethylenediaminetetraacetic acid (EDTA), which removes clay, soluble organics, and iron. Finally, the samples were freeze-dried under vacuum.

Once dry, the samples were mixed with sodium polytungstate (SPT), at a density of 1.8 g/ml, and centrifuged to separate the organic material including pollen and starch, which floats, from the inorganic remains and silica, which do not float. The light fraction was recovered and the process was repeated as many times as necessary. This pollen-rich organic fraction was rinsed, then all samples received a short (25 minute) treatment in hot hydrofluoric acid to remove remaining inorganic particles. The samples were acetylated for 10 minutes to remove extraneous organic matter. The samples were rinsed with RODI water to neutral. Following this, a few drops of potassium hydroxide (KOH) were added to each sample, which was then stained lightly with safranin. Due to the presence of minute organic debris, the sediment sample was centrifuged at high speeds for short intervals to remove this debris for better viewing.

A light microscope was used to count the pollen at a magnification of 500x. Pollen preservation was relatively good. Comparative reference material collected at the Intermountain Herbarium at Utah State University and the University of Colorado Herbarium was used to identify the pollen to the family, genus, and species level, where possible. The microscope slide was scanned using cross-polar illumination to search for starches after the count was completed.

Pollen aggregates were recorded during pollen identification. Aggregates are clumps of a single type of pollen and may be interpreted to represent either pollen dispersal over short distances or the introduction of portions of the plant represented into an archaeological setting. The aggregates were included in the pollen counts as single grains, as is customary. An "A" next to the pollen frequency on the percentage pollen diagram notes the presence of aggregates. A plus sign (+) on the pollen diagram indicates that pollen was observed, in spite of the fact that pollen was not present in a sufficient concentration to obtain a full count. The percentage pollen diagram was produced using Tilia Version 2.1.1. Total pollen concentrations were calculated in Tilia using the quantity of sample processed in cubic centimeters (cc), the quantity of exotics (spores) added to the sample, the quantity of exotics counted, and the total pollen counted and expressed as pollen per cc of sediment.

Protein Residue

Successful identification of proteins from lithic materials relies on the biological activity of those proteins (Hyland et al. 1990:105) and recovery method. Protein residue analysis for lithic artifacts used counter immunoelectrophoresis (CIEP). We note that both cross-over and counter are used in the literature to describe this type of immunoelectrophoresis. This method is based on an antigen-antibody reaction, where a known antibody (immunoglobulin) is used to detect an unknown antigen (Bog-Hansen 1990).

Culliford's (1964; 1971) forensic CIEP methods used at the Royal Canadian Mounted Police Serology Laboratory, Ottawa, and the Centre of Forensic Sciences, Toronto, were modified by Newman and Julig (1989) for use on archaeological materials. Subsequently, PaleoResearch Institute enacted changes following the advice of Dr. Richard Marlar of the Thrombosis Research Laboratory, VA Medical Center, Denver, and the Health Sciences Center, University of Colorado. Although several different protein detection methods have been employed in archaeological analyses, including enzyme-linked immunosorbent assay (ELISA) and radioimmunoassay (RIA), the CIEP test is demonstrated to be extremely sensitive, with the detection of 10^{-8} g of protein possible (Culliford 1964:1092). Testing unknowns against non-immunized animal serum screens for the presence of reactive proteins that bind indiscriminately with numerous antisera, but are not species, genera, family, or group specific. Sediment controls are necessary to address the potential for false positives caused by compounds in sediments, including chlorophyll; bacteria; and metal cations, i.e. manganese, copper and iron oxide (Evershed et al. 1996); or proteins from modern animal activity, such as feces and urine.

The rock was washed using a sonicating toothbrush with a new head and 1.5 ml of a Tris/NaCl/Triton solution (0.02M Tris hydrochloride, 0.5M sodium chloride, and 0.5% Triton X-100). The artifact and toothbrush head were rinsed with reverse osmosis de-ionized (RODI) water to recover all of the protein wash solution. The solution recovered was centrifuged using a short-duration spin (10 seconds at 3000 rpm) to remove sediments, then was decanted into a Centriprep–10 centrifugal concentrator. The concentrator is equipped with a 10,000 molecular weight cut-off membrane that removes most of the water and small fragments of proteins (with molecular weights less than 10,000), concentrating the larger proteins in the remaining 1 ml of solution.

Wash solutions were centrifuged to remove sediments and recover the solution, which was decanted into new microcentrifuge tubes. Centriprep–10 centrifugal concentrators containing a 10,000 molecular weight cut-off membrane were used for larger samples. The concentrator removes most of the water and small fragments of proteins (with molecular weights less than 10,000), collecting the larger proteins in the remaining 1 ml of solution. In addition, a control sample was tested because sediments contain compounds, such as bacteria and animal urine and/or feces, causing false positive results. These contaminants may originate in the sampled location or be introduced as air-borne material. One half gram of sediment associated with each artifact was added to 1 ml Tris/NaCl/Triton solution, and then refrigerated for several days prior to testing.

The first step tests the residue wash extracted from artifact and the sediment control against pre-immune goat serum (serum from a non-immunized animal) to screen for the presence of non-specific, indiscriminate binding of proteins. The artifact wash tested negative against pre-immune serum. Next, the sample was tested against prepared animal and plant antisera obtained from a variety of commercial and private sources. Appropriate positive and negative controls were run for each antiserum. The blood of an animal for which the antiserum tests positively constitutes the positive control, while negative controls use the serum of the type of animal in which the antiserum was raised, either rabbit or goat.

Agarose gel poured onto GelBond® film acts as the medium for CIEP. Four columns of paired wells (2 mm in diameter separated by 3 mm of gel) organized in a series of eight rows were punched into the gel. The anodic (-) well contained the antiserum while the cathodic (+) well held the artifact's protein extraction (the antigen). The sample was electrophoresed in

Barbital buffer (pH 8.6) for 45 minutes at 130 V to drive the antigens and antibodies toward each other. Overnight, a 1 M NaCl bath removed extraneous proteins from the gel. The next morning the gel was pressed for 10 minutes, rinsed with RODI water for an hour, and then pressed for an additional 10 minutes to remove extraneous water and provide a rinse to remove the NaCl. Gels were air dried.

A positive reaction appears as a vertical line of precipitation between the two wells. Coomassie Blue stain was used to make the line of precipitation easier to see. A recorded "positive" result displays a clear vertical precipitation line between the antiserum and the sample (antigen), indicating the sample wash contained proteins related to the animal represented by the antiserum, or a member of its family group/order. A "very weak positive" demonstrates a faint precipitation line. This suggests presence of deteriorated proteins similar to the antiserum animal's family or order. When a positive reaction was obtained between the artifact wash (antigen) and an antiserum at the 1:5 dilution, the soil control was tested using dilute (1:5) antiserum. Retests distinguish between true and false positives when that reaction is not observed in the accompanying soil control sample. Positive reactions obtained using dilute (1:5) antisera were reported.

Identification of animals represented by positive results is usually made to the family level. All mammalian species share serum protein antigenic determinations (epitopes or sites on the surface of an antigen molecule to which the antibody binds); therefore, some cross-reactions occur between closely and sometimes distantly related animals (Gaensslen 1983:241). Examples of closely related reactivity include bovine antiserum reacting with bison blood, as well as deer antiserum reacting with other members of the Cervidae (deer) family, such as elk and moose. Positive reactions between distantly related (at the order level) animals include guinea pig antiserum reacting with squirrel blood. This similarity in epitopes (binding sites) is the reason that all labs test their antisera against the blood of many animals, not simply the one to which the antiserum was created. This testing builds lists of animals whose blood is recognized by each antiserum.

PROTEIN RESIDUE REVIEW

Proteins preserved on stone tools of considerable age have been detected by researchers using CIEP at unrelated institutions (Gerlach et al. 1996; Hogberg et al. 2009; Kooyman et al. 2001; Seeman et al. 2008; Yost and Cummings 2008). For example, Gerlach et al. (1996) reported 45 positive reactions obtained on 40 of the 130 stone tools tested from an early North American Paleoindian site (ca. 11,200–10,800 years BP). In an archaeological context, an antigen is the unknown protein adhering to an artifact after exposure. Although ancient proteins break down into small fragments over time, antibodies can recognize small regions of antigens (Marlar et al. 1995). Sensabaugh, Wilson, and Kirk (1971:566) demonstrate that proteins undergo chemical and physical modification, breaking down into smaller molecules (polydispersing), and contributing to high molecular weight aggregates of dried blood's insoluble fraction. Hyland et al. (1990:105) hypothesized "protein molecules may be conjoined with fatty tissues, resulting in an insoluble complex" resistant to water's disintegrative properties. Although the mechanism for protein preservation is not fully understood, proteins demonstrate a remarkable ability "to retain a level of biological activity over a long period of time" (Hyland, et al. 1990:106). They also demonstrate an affinity for adhering to silica (Marlar, et al. 1995), which likely assists with preservation.

ETHNOZOOARCHAEOLOGICAL REVIEW

Ethnographically documented animal uses suggest possible or even probable prehistoric animal exploitation. Records of widespread historic animal utilization may demonstrate continuation of prehistoric practices into the historic era, acknowledging the likelihood that European contact affected hunting and animal use practices, resulting in loss of indigenous knowledge. A wide breadth of ethnographic sources, both inside and outside the study area, was consulted to permit a more exhaustive review of potential human and animal interactions. Ethnographic literature serves only as a guide, not as conclusive evidence of resources' occurrences or specific uses. When compared with archaeological materials (artifacts and features), protein residues are interpreted as use indicators. We provide the following ethnozooarchaeological background to discuss animals identified through protein residue analysis.

Bovidae (Cattle, Sheep, and Goat Family)

The family Bovidae includes ungulate, ruminant mammals with unbranched horns that grow on all males and sometimes females. Although Bovidae are located primarily in the Old World, bison (*Bison*), goat (*Oreamnos*), sheep (*Ovis*), and muskox (*Ovibos*) are present in North America.

Bison bison **(Bison)**

Bison (*Bison*) were an exceptionally important animal for Native American peoples of the plains and woodland prairies. Bison meat supplied a major portion of the diet and shaped hunting customs and food habits for Plains peoples (DeMallie 2001:6).Bisons' migratory behaviors contributed to the semi- to fully nomadic lifestyle for dependent peoples.

Before tribes acquired horses, bison hunting required nearly full tribal cooperation. One hunting technique was the "surround method" (Dary 1989:56; DeMallie 2001:6). People encircled the herd, and after a prearranged signal from the hunt leader, they began running in circles and yelling. The running, shouting people moved toward the herd, making the circle increasingly smaller. Once close enough, people threw lances and shot arrows at the animals. At other times, after surrounding a herd with fire, Native Americans waited at an open end, killing bison as they tried to escape the fire (DeMallie 2001:6). The "impounding" method involved construction of a strong rock and/or wood corral (Dary 1989:56). Once driven inside, people killed bison using lances and arrows. Often, corrals were reused.

Alternatively, Native Americans used a bison jump or *piskun,* to stampede a herd of bison over a cliff. If any animals survived the fall, they were killed by hunters below. Many northern Plains peoples and those in the foothills of the northern Rocky Mountains used bison jumps. From northern Wyoming through Montana into Alberta and Saskatchewan at least 100 jumps are still visible (Dary 1989:57-59).

Cut and sun-dried, smoked, or salted bison meat kept for several months without spoiling. Also, dried meat was made into pemmican. Tallow and grease were preserved for winter use, and bones and horns provided materials for tools and weapons (Ahler et al. 1991:36). Dried bones and hooves were boiled to make glue. Bison sinew was used for thread and ropes; while hides were used for a variety of products included clothing (garments and shoes), utilitarian items (blankets and cooking vessels), housing (tipi coverings), and even boats. In areas of scarce tree growth, bison droppings (buffalo chips) were used as fuel because they burn easily when dry, providing a hot fire with little smoke. In addition, bison chips were stacked as temporary markers (Dary 1989; Wallis 1947:10-12; Whitaker 1980:664-667).

ETHNOBOTANIC REVIEW

Archaeological studies reference ethnographically documented plant uses as indicators of possible, or even probable, plant uses in pre-Columbian times. Ethnobotany, the study of the relationship between people and plants, provides information regarding both broad and specific historic exploitation of numerous plants. Although plant uses differ between cultures and change over time, similar use documented among multiple cultures or culture areas indicates an increased likelihood that the plant was used similarly in the past. We consulted a broad range of ethnographic sources both inside and outside the study area to provide a more exhaustive review of potential plant uses. Ethnographic sources document numerous instances of historic plant use enduring from the past. In particular, pre-Columbian medicinal plant use often persisted well into the historical period. An estimated 17.1% of the world's flora comprise medicinally important plants (Chandra and Rawat 2015:124). Unfortunately, due to changes in subsistence practices and European food introduction, a loss of plant knowledge likely occurred. The ethnobotanic literature serves only as a guide for potential uses in pre-Columbian times, not as conclusive proof of those uses. When compared with the material culture (artifacts and features) recovered by the archaeologists, pollen and starch can become use indicators. We provide the following ethnobotanic background to discuss plants identified during macrofloral analysis.

Native Plants

Poaceae (Grass Family)

Poaceae (grass family), one of the largest and most economically important families of plants, grow in all climates, though local conditions determine their abundance. Cereals, grown worldwide, have been a staple in diets for thousands of years. Cereals and all grass seeds contain an incomplete protein complex and often are eaten with legumes to provide a complete protein complex that contains all the essential amino acids (Couplan 1998:464).

Native Americans typically used a seed beater and burden basket when collecting caryopsis (seeds) (Ebeling 1986:183, 195; Grant 1978:517). When present, grass awns (hairs) were singed off by exposing the seeds to flame. Depending on species, grass seeds ripen from spring to fall (Kirk 1975:189; Pohl 1954:131-132), providing stable food source available over many months. Grains were parched and ground into meal for making mush, bread, flour, and cake (Ebeling 1986:195-198; Kirk 1975:177-189).

Lenticular starch grains are attributed to large-seeded grasses such as wheatgrass, ryegrass, and barleygrass, all of which are members of the festucoid or cool season grass group.

DISCUSSION AND CONCLUSIONS

The Bull Creek Site (34BV176) is situated near a meander of Bull Creek, which is a tributary of the Beaver River. Previous pollen analysis of stratigraphic samples provided an environmental interpretation for this site and area (Cummings and Varney, 2010). This stratigraphic pollen record provides control information against which the pollen signatures from the rock and accompanying sediment sample may be compared.

Two rocks surrounded by fragmented bison and other animal bones were recovered in close proximity to a thermal feature that had been discovered in earlier stages of this site's excavation (Table 1). This occupation has been previously dated, yielding a radiocarbon age of 10,233–10,299 CAL yrs. BP (9,139 ± 21 RCYBP). These rock samples were submitted for pollen and starch analysis (Sample 1871)(Table 2) and protein residue analysis (Sample 1872). The sediment sample (1872S) was submitted for pollen analysis and provided the soil control for the protein analysis.

The rock (Sample 1872) was tested multiple times against available antisera (Table 3). Of the multiple analyses, a very weak positive for bovine was observed once; however, in the subsequent test, the positive result could not be recreated. Over time, degradation renders proteins unrecognizable by antisera at greater dilutions and eventually by all antisera. Failure to obtain an interpretable positive reaction can result from numerous processes including degradation of proteins over time, the stone having been associated in some way with animals or plants not represented by the tested antisera, the stone being subject to a process that could have removed the proteins, or use of the stone in association with behaviors other than those detectible using CIEP. The failure to obtain a replicate of the original positive is likely the result of this type of degradation, given the age of the site.

The pollen signature obtained from the sediment control sample (1872S) is significantly different from the pollen signatures reported previously (Cummings and Varney 2010). In this sample, Low-spine Asteraceae pollen dominated the record, indicating that marsh elder or similar plants grew abundantly in this area, suggesting the sediment was moist and likely located adjacent to Bull Creek. Moderate quantities of Amaranthaceae, High-spine Asteraceae, and Poaceae pollen indicate local vegetation also included plants in the goosefoot family, such as goosefoot, members of the sunflower family, and grasses. These plants are compatible with marsh elder and are expected to be part of the mesic vegetation community. Small quantities of *Pinus*, *Artemisia*, Liguliflorae, *Ephedra nevadensis*, *E. torreyana*, and *Sphaeralcea* represent pine trees, sagebrush, members of the chicory tribe of the sunflower family, two different species of ephedra or Mormon tea, and globemallow. The large quantity of Low-spine Asteraceae pollen, indicating marsh elder, combined with the presence of Liguliflorae pollen suggest mesic sediments in this area.

Finally, the rock was washed to recover pollen and starches (Sample 1871). Only six pollen, including High-spine Asteraceae and Poaceae, representing plants in the sunflower and grass families, were observed. This sample also contained a relatively small quantity of microscopic charcoal and lenticular starch. These lenticular starches are typically produced in seeds from cool season grasses that produce large seeds such as little barley grass (*Hordeum*), wildrye (*Elymus*), or western wheatgrass (*Pascopyron smithii* syn. *Agropyron smithii*). Recovery of this starch suggests cooking grasses, whether the seeds were parched or a paste was made prior to cooking. Total pollen concentration is calculated as 16 pollen/cm^2 of washed surface.

The combined pollen and protein residue analyses of two rocks suggest that they came in contact with bison proteins and also ground grass seeds that probably were processed in this area.

TABLE 1
PROVENIENCE DATA FOR SAMPLES FROM THE BULL CREEK SITE (34BV176)

Sample No.	Provenience/Description	Analysis
1871	Two rocks, recovered side-by-side in the lower summer occupation at the site, 9139 ± 21 RCYBP. Surrounded by fragmented bison and other animal bones.	Pollen/Starch
1872		Protein
1872S	Sediment	Pollen, Protein control

TABLE 2
POLLEN TYPES OBSERVED IN SAMPLES FROM THE BULL CREEK SITE (34BV176)

Scientific Name	Common Name
ARBOREAL POLLEN:	
Pinus	Pine
NON-ARBOREAL POLLEN:	
Amaranthaceae	Amaranth family (now includes Chenopodiaceae, these two families were combined based on genetic testing and the pollen category "Cheno-ams")
Asteraceae:	Sunflower family
Artemisia	Sagebrush
Low-spine	Includes ragweed, cocklebur, sumpweed
High-spine	Includes aster, rabbitbrush, snakeweed, sunflower, etc.
Liguliflorae	Chicory tribe, includes dandelion and chicory
Ephedra nevadensis-type (includes *E. clokeyi, E. coryi, E. funera, E. viridis, E. californica, E. nevadensis,* and *E. aspera*)	Ephedra, Jointfir, Mormon tea
Ephedra torreyana-type (includes *E. torreyana*, *E. trifurca*, and *E. antisyphilitica*)	Ephedra, jointfir, Mormon tea
Poaceae	Grass family
Sphaeralcea	Globemallow
STARCHES:	
Lenticular starch	Typical of starches produced by grass seeds such as those from wheat grass (*Agropyron*), ryegrass (*Elymus*), or barley grass (*Hordeum*)
OTHER:	
Microscopic charcoal	Microscopic charcoal fragments
Total pollen concentration	Quantity of pollen per cubic centimeter (cc) of sediment

TABLE 3
PROTEIN ANALYSIS RESULTS FOR ARTIFACTS FROM THE BULL CREEK SITE (34BV176)

Sample No.	Description	Antiserum	Results	Possible Animal(s) Represented
1872	Rock recovered in the lower summer occupation, 9139 ± 21 RCYBP. Surrounded by fragmented bison and other animal bones.	Bovine	Very Weak Positive	*Bos* sp. (Cow), Domestic bovids, *Bison* sp. (Bison)

Genus and species of animal or fish listed for each family or order group do not comprise an exhaustive list. Instead, they are examples of animal or fish that react positively to the antiserum listed. Reactions are observed at more general levels that genus, meaning that all species of a genus will have the same reaction potential.

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