ABSTRACT

Title of Thesis: SERVING UP HISTORY THROUGH PROTEIN ANALYSIS: AN INVESTIGATION OF THE SHELL (LA 20241) AND PECAN (LA 38597) SITES, NEW MEXICO

Chelsea Winter, Master of Professional Studies in Cultural Heritage Resource Management 2024

Thesis Directed By: Dr. Matthew Palus, Department of Anthropology

Poor faunal preservation in Southeast New Mexico (SENM) has left a gap in the archaeological record for this region. What plant and animal food resources were collected, processed, and/or consumed by the site's indigenous inhabitants in this area during the Archaic and Early Formative Periods? A way to fill that informational gap is with multidisciplinary analyses such as pollen, phytoliths, starch grains, and residues through the Fourier-transform infrared spectroscopy (FTIR) method. These analyses have been applied successfully in excavation projects in the Southeast New Mexico SENM region.

This study aims to investigate what plants and animals were processed at Archaic period to the Early Formative sites LA 20241 and LA 38597 through protein residue analysis. This region is quickly being consumed by the oil field industry and it is imperative that as much information about the area and its past peoples be gathered, before the history is erased forever. This thesis presents the methods, results, and findings from a protein residue analysis study using tools from these sites and demonstrates the use of protein residue analysis within this region.

Despite this being a rather costly process, a programmatic agreement established between agencies operating in the area can allow for higher budgets for cultural resource management work. Protein residue analysis is at least a three-day process that included extracting the proteins from the tools, creating the gels to run through the cross electrophoresis, pressing and drying, and lastly staining and drying the gels for reading the results. Thirty tools were tested using Cross-electrophoresis (CIEP) to find what tools reacted with which antisera (proteins) to the family level. The results present the range of reactions with the strongest positives being, chicken, mouse, yucca, and agave. The analysis presents the use and importance of all the resources identified in this study. This data allows us to know what plants and animals were processed at the shell (LA 20241) and the pecan (LA 38597) sites providing a broader glimpse into the lives of the people who thrived in this region. It also stands to be a useful technique to be applied in SENM answering broader research questions.

SERVING UP HISTORY THROUGH PROTEIN ANALYSIS: AN INVESTIGATION OF THE SHELL (LA 20241) AND PECAN (LA 38597) SITES, NEW MEXICO

by

Chelsea Winter

Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Professional
Studies in Cultural Heritage
Resource Management
2024

Advisory Committee:
Dr. Matthew M. Palus, Chair
Dr. Kathryn Lafrenz Samuels
Dr. Miguel Vilar
Dr. Lauren Cleeland

Acknowledgements

I owe thanks to many individuals whose help and efforts contributed to the process of my thesis. First, I offer my deepest gratitude to my thesis chair Dr. Matthew M. Palus whose patience and contributions were instrumental to the process. Dr. Linda Scott-Cummings who offered her lab in Boulder, Colorado and teachings of the methods for this entire study. Without her this thesis would not have been possible. Dr. Lauren Cleeland guided me by answering many questions throughout the process, and provided moral support every step of the way. Thank you to the remaining members of my committee Dr. Kathryn Lafrenz Samuels the director of the program and Dr. Miguel Vilar for your feedback and support. I would also like to thank my encouraging friends, family and colleagues who supported me throughout this process. Special thanks to my fiancé for his endless support and photographing the artifacts and scientific methods.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Research Question

Whispers of past civilizations are scattered across the landscape of Southeast New Mexico (SENM), as shown by the hundreds of archeological sites in this region. Poor faunal preservation in SENM has left a gap in the archaeological record for this region. What plant and animal food resources were collected, processed, and/or consumed by the site's indigenous inhabitants in this area during the Archaic and Early Formative Periods? This thesis presents data from two sites LA 20241 and LA 38597 using protein residue analysis on tools to discover what resources were collected, processed, and/or consumed by the people living at the sites. This research stands to expand the approaches used in SENM, by including protein residue analysis to assist in answering regional questions of subsistence and lifeways. When sites lack preserved faunal remains or coprolites, investigating ancient foodways requires more creative sleuthing. For example, projectile points, scrapers, unifaces, bifaces, choppers, and modified flakes are all tools examined in this study and used to process essential protein. Because the arid environmental conditions and dynamic sand substrate of SENM help preserve residue on these tools, I used protein residue analysis to help answer questions about food resources and sharpen our understanding of past lifeways.

Background

This research was inspired by a project and the client and project name will remain confidential throughout this study. When I arrived on the project in 2021, a large pipeline was going to be installed within the Bureau of Land Management (BLM) Carlsbad Field Office (CFO) region. To comply with Section 106 of the National Historic Preservation Act (NHPA), sites for inclusion on the National Register of Historic Places (NRHP) in this region are required to be either flagged and avoided, or mitigated. Although, during the last decade there has been an effort to reassess how CRM is being conducted in SENM. In 2002, the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory, sponsored a project that resulted improving existing CRM practices by "developing innovative, seamless, more systematic, and informative approaches to investigating archaeological resources" (Railey 2016:4).The BLM, the New Mexico Historic Preservation Division (the State Historic Preservation Office or SHPO), and the Advisory Council on Historic Preservation (ACHP) followed suit with these new changes and sponsored the Southeastern New Mexico Regional Research Designs and developed the Permian Basin Mitigation Program (PBMP). The memorandum of agreement that established the PBMP provided a new option for

> "oil and gas and other companies the choice to either participate in the PBMP or use the conventional Section 106 process. In choosing the PBMP, companies have been allowed to pay into a general fund that is managed by the BLM for research. The PBMP was extended in 2013 under a new programmatic agreement (PA) and was renewed for another 10-year period in 2016" (Railey 2016:4).

Sites LA 20241 and LA 38597 do not fall under the umbrella of the PA, but were guided by the regional research designs of the area. The portions of the sites in this study were within the pipeline's right of way (ROW) and were excavated. I was one of the few people who participated in nearly every step in the process of the mitigated sites, which included monitoring construction, excavation, in-lab analysis, and assisting in writing of the technical reports. While working with these sites, two stood out because they yielded the most tools, LA 20241 and LA 38597. An interdisciplinary approach was used in the analyses conducted at these sites, but other than projectile point identification, none involved the tools. Thus, my research question was developing, asking if there was a way to tell what these tools were used for.

My research question is explored by a technique called protein residue analysis. To my knowledge, cross-over electrophoresis (CIEP) has only been conducted once for SENM, perhaps due to cost or its limited research applications in contexts of regulatory compliance. Lipid residue analysis was conducted on one other tool in the region, but this technique is beyond the scope of this project. This study examines a selection of tools for proteins at sites LA 20241 and LA 38597 and the work that has been done to broaden their research potential in the wake of industrial development. The sites history and findings are summarized below.

LA 20241 (Shell Site)

LA 20241 has been visited six times since its first recording in 1979 by New Mexico Archeological Services. Originally it was recorded as a 16 x 95 m ephemeral camp affiliated with the Mogollon culture, containing an artifact assemblage comprised of a flaked stone and groundstone artifact scatter, pottery sherds (Carlsbad Brown type), two well-defined hearths, and burned caliche (NIMCRIS No. 15054;

Aylward 1979). In 2005, Lone Mountain Archeological Services revisited the site and found the site boundary to be much larger, measuring 320 x 190 m in size containing over 200 surface artifacts including debitage, flaked-stone tools, and groundstone (NMCRIS No. 92163; Travis et al. 2005). Temporally diagnostic points included one small triangular projectile point, similar to a Pueblo Side-notched Concave. Diagnostic pottery such as Chupadero Black-on-White, El Paso Brown, corrugated brown, Jornada Brown, and Mimbres Black-on-white were also identified. Two features were recorded, a 1 m in diameter burned caliche concentration and one 8 m in diameter stain (NMCRIS No. 92163; Travis et al. 2005). Lone Mountain Archaeological Services assigned the site to a Jornada Mogollon cultural affiliation, specifically the Late Pithouse to Late Pueblo period (AD 750–1400) and recommended the site eligible for NRHP listing under Criterion D. The BLM determined the site eligible and the Historic Preservation Division (HPD) concurred (HPD Log No. 75012).

According to the New Mexico Cultural Resource Information System (NMCRIS), a third visit was made by Archaeo-Physics LLC, but site information remained the same and the recording date is unknown (NMCRIS No. 130607). Geo-Marine later visited the site, but the recording date is also unknown (NMCRIS No. 142063). In May 2019, Southeastern Archeological Services (SEARCH) updated the site inventory data and observed more modern disturbances, including recreational vehicle use, camping, two-track roads used by ranchers for fence line access, and a new pipeline corridor to the east of the site (NMCRIS No. 143340; SEARCH 2019). The site contained subsurface cultural deposits and was located within the direct area of potential effect (APE) of their project with no feasible alternative route to avoid the site (NMCRIS No. 143340; SEARCH 2019). The State Historic Preservation Office (SHPO) determined the site eligible under Criteria D for nomination to the NRHP in September 2019 (HPD Log No:111090, 09/05/2019).

In 2022, a data recovery project was launched by SEARCH and TRC to mitigate the pipeline undertaking. The project involved total station mapping, surface artifact collection, hand excavation of units, shovel scraping, and mechanical scraping (NMCRIS No. 152240; SEARCH 2022). A total of 1,683 artifacts were collected and analyzed in the lab. Artifacts included lithic debitage, lithic tools, cores, groundstone, shell and ceramics. In addition to routine artifact analyses, collected materials were submitted for specialized analyses that included AMS radiocarbon dating, faunal and shell analyses, macrobotanical analysis, pollen, phytolith, FTIR analysis, starch analysis, lipid residue analyses, and petrographic analyses (Cleeland et al. 2023: 343). TRC submitted 25 charcoal samples to Beta-Analytic for AMS radiocarbon dating and findings suggest repeated use of the site from the Late Archaic period through the Late Formative period.

The lithic assemblage at Site LA 20241 is comprised by 1,304 pieces of debitage, 32 cores, 55 tools, and 102 pieces of groundstone, for a total of 1,492 artifacts. Among the tools were 15 bifaces, five choppers, a graver, a hammerstone, 14 flake tools, six projectile points or projectile point fragments, nine scrapers, and four unifaces. The groundstone assemblage include 31 indeterminate groundstone fragments, 15 manos or mano fragments, 52 metates or metate fragments, a polished stone and a pestle (Cleeland et al. 2023:375). Based on the lithic assemblage, the site was most likely a temporary campsite that was visited multiple times over a long period of time. This is the most common site type in the region (Railey 2016:219). The diagnostic projectile points found during the data recovery suggest different Late Archaic occupations spanning the period from approximately 1050 BC to AD 250 (Cleeland et al. 2023:376).

The projectile points suggest hunting was a secondary activity, as were lithic reduction and tool production (Cleeland et al. 2023:376). The groundstone in the assemblage, including manos, metates, and the pestle, and the identification of choppers and scrapers, are evidence for the procurement and processing of plants. According to SEARCH's (2023) analyses of the lithic assemblage, they hypothesized that this location served as a site for plant collection and at least preliminary processing when the relevant species were abundant and needed (Cleeland et al. 2023:376). SEARCH (2023) also hypothesized that, based on the lithic material and tool types, occupants of the site engaged in expedient hunting and tool manufacture while encamped.

The lithics are not the only part of the assemblage that point to plant procurement and processing as a primary activity. A selection of 52 sherds sampled from 86 ceramics collected by SEARCH and TRC were analyzed for form (Cleeland et al. 2023:377). It is suspected that all the ceramics in the sample were made within the Lincoln County Porphyry Belt, near Sierra Blanca or El Paso, Texas (Cleeland et al. 2023:390). Most of the ceramics collected are plain brownware materials with a few Red-Slipped Brownware, Corona, possibly Ochoa Corrugated brownware, traces of Jornada Black-on-brown, and Chupadero whiteware (Cleeland et al. 2023:390).

According to SEARCH (2023) the primary form of the ceramic vessels sampled are large jars that were likely used to transport and store water, and were possibly used in the cold or hot leaching of shinnery oak acorns, known to be an important food resource in the Pecos East dune environments. They may also have exported product to upland populations further to the west (Cleeland et al. 2023:391). The only faunal remains collected from the site were 103 shell fragments.

This site was named the "Shell site" not only for the abundance of shell it contained, but also for the discovery of a shell tool. Each shell was identified as Unionidae or the subclass Palaeoheterodonta, freshwater mussels with one fragment belonging to the Pecos pearly mussel (*Cyrtonaias tampicoensis*) (Cleeland et al. 2023:395). Five shell fragments exhibited cultural modification such as pry marks for opening the shell and flaking on the edge for cutting (Cleeland et al. 2023:395). Railey discusses in his research design, that there is a general lack of faunal remains in SENM, possibly due to poor preservation or lack of faunal processing at the sites (2016:199). He found that of a sample of 288 sites in the area only 25.3% of the sites contained any faunal remains (Railey 2016:199). Lipid analysis conducted at the site yielded some information on what was being processed at LA 20241.

Mary Malainey and Timothy Figol conducted lipid residue analysis of one piece of fire-cracked rock from LA 20241. They found "C18:0 residue" consistent with plants or large herbivore bone marrow. The higher levels of the residue's presence are consistent with preparation of animal products or tropical seed oils like sotol. The lower levels of the residue could come from plants such as prickly pear and Spanish Dagger, which are known to have low fat content residues (Cleeland et al.

2023:415). According to Malainey and Figol, “the sterol β-sitosterol indicates the presence of plant products” which supports an emphasis on the procurement and processing of plants (Cleeland et al. 2023:415). The findings at LA 38597 also contain many lines of evidence that support plants as a primary source of protein.

LA 38597 (Pecan Site)

LA 38597 has been visited seven times over the years since its first and second recording in 1982 by Agency for Conservation Archaeology Eastern New Mexico University (NMCRIS No. 437 and 10079; ENMU1982). It was first described as a 213 x 182 m extensive lithic scatter and campsite containing debitage, six hammerstones, four ceramics, 12 groundstone fragments, and two limestone slabs of unknown use (NMCRIS No. 437 and 10079; ENMU1982). The site was revisited in by Lone Mountain Archaeological Services in 2005 and the site inventory data was updated to match the current assemblage (NMCRIS No. 92163; Travis et al. 2005). APAC revisited the site in January 2013 and recorded it as 84 x 125 m campsite containing a total of 42 artifacts. The artifacts included 1 core, 1 tested cobble, 3 chipped stone tools, 32 core reduction flakes, 3 pieces of angular debris, a basin metate fragment and a second ground stone fragment of an undetermined origin (NMCRIS No. 125793; APAC 2013). A single shovel test revealed subsurface burned rock and charcoal at 15 cmbs within a feature (NMCRIS No. 125793; APAC 2013). It was revisited in March of that same year by Boone Archeological Services but was plotted inaccurately in the Archeological Records Management Section (ARMS), so the site was not updated (NMCRIS No.126743; Boone 2013). Boone updated the site in 2019 as a 102 x 104 m unspecified Jornada Mogollon site containing a total of 102 flaked lithic artifacts, groundstone tools, and pottery sherds, with two thermal features (NMCRIS No.143340; Boone 2013).

The most recent visit to the site in 2021proved the site to be eligible under criterion D and resulted in a data recovery investigation by SEARCH and TRC. The data recovery included shovel tests, test units, excavation blocks, mechanical trenches, and scraping areas. SEARCH collected a total of 6,790 artifacts and excavated 62 potential features from the portion of the site that was within their project area (Cleeland et al. 2023:106). Special analysis such as radiocarbon, optically stimulated luminesce (OSL), macrobotanical analysis, pollen, phytolith, starch, and lipid analysis were conducted for this excavation. Macrobotanical remains included charred plant tissue that indicated a brief occupation, but the pollen, phytolith and starch analysis recovered a large quantity of different plant types. Two pieces of fire-cracked rock (FCR) were sent for lipid analysis, but provided minimal results, due to the destruction on one FCR in transit and the other provided an insufficient amount of fatty acids for identification (Cleeland et al. 2023:364). Based on radiocarbon, OSL dates, five diagnostic projectile points and one diagnostic biface, LA 38597 was used repeatedly from the Middle Archaic through Early Formative periods. No dates from the site are associated with the Late Formative (Cleeland et al. 2023:295).

The lithic assemblage at Site LA 38597 includes 6,222 pieces of debitage, 97 cores, 113 tools, and 143 pieces of groundstone, for a total of 6,575 artifacts. Tools include 25 bifaces, eight choppers, a chopper/hammerstone, a graver, 19 scrapers, six hammerstones, 14 unifaces, 11 projectile points, 26 modified flake tools, and nine utilized flakes. The groundstone category includes 143 artifacts: 85 indeterminate pieces, 26 metates, 31 manos, and one pestle (Cleeland et al. 2023:106). The diagnostic projectile points suggest occupations from as early as late Paleoindian (8100 BC–7600 BC) to Late Archaic/Early Formative (AD 150–AD 650). It is possible that the single late Paleoindian tool was repurposed, because the earliest AMS date collected was from the Middle Archaic between (2500-1900 BC) (Cleeland et al. 2023:295). Based on the derived dates this site was occupied over a long period of time. The large amount of groundstone in the assemblage, including 31 identified manos and 26 identified pieces of metates and the identification of nine choppers and 19 scrapers, support the emphasis of procuring and processing of plants (Cleeland et al. 2023:339). Conclusions drawn from the "lithic assemblage analysis shows this location likely served as a site for plant collection and at least preliminary processing when the relevant species were abundant and needed. Secondarily, occupants at the locality engaged in expedient hunting and tool manufacture while encamped" (Cleeland et al. 2023:339).

SEARCH recovered 88 ceramic sherds from Site LA 38597 and submitted them for attribute analysis. Michael Marshall conducted the ceramic analysis and found that based on the petrography, all the ceramic materials from the site are Plain brownware vessels of an Early Formative affinity (Cleeland et al. 2023:340). Many sherds analyzed were small and eroded, so a large percentage of the assemblage could not be classified by vessel form type. The identifiable forms include jars and bowls with bowls comprising a small percentage of the assemblage. Despite the low probability of faunal preservation on sites in SENM, five small unidentified mammal bones were collected from the site. These bone fragments are likely of modern origin and may not represent cultural activity. The shell assemblage consisted of 255 shell fragments of freshwater mussels. The fragments were identified as Pecos pearly mussel (*Cyrtonaias tampicoensis*) and freshwater mussel (*Palaeoheterodonta*) (Cleeland et al. 2023:379). One shell exhibited evidence of burning and two shells were culturally modified and suggests that the shells were locally procured and processed (Cleeland et al. 2023:380).

LA 38597 is named the "Pecan Site" due to the presence of *Carya* pollen, representing pecan or hickory in the microbotanical analysis conducted by Dr. Linda Scott-Cummings (Cleeland et al. 2023:365). Nineteen soil samples were submitted for pollen, phytolith analysis and Fourier-transform infrared spectroscopy (FTIR) spectrometry, finding a large range of local plants with the most interesting finding being the *Carya* pollen, the Genus including Hickory and related trees. Samples from three features contained *Carya* pollen (Cleeland et al. 2023:356). It is interesting because the presence of this pollen in the past in this region is considered rare to non-existent. Because Hickory is primarily found in the eastern half of North America the *Carya* at this site is likely pecan possibly from El Paso or San Saba where nut gather is well documented (Cleeland et al. 2023:376).

Thesis Outline

Following this chapter, Chapter Two discusses the setting and theoretical models used within the Permian Basin region as well as an overview of broad research designs that have been used within the region. One case study is presented, where protein residue analysis is used with in the study area. Chapter Three presents the cultural and historical background for the project. Chapter Four describes the methods used in protein residue analysis. Protein residue analysis is a technique that is applied to identify protein residues, both animal and plant, on archeological materials (Paleo Research Institute website). Twelve tools from site LA 20241 and 18 formal tools from site LA 38597 were tested against known proteins for the study area. Chapter Five presents the lab results from the protein residue analysis. It explains that the methods used only provide species of protein to the family level. Chapter Six provides an analysis of the results, inferring the most likely types of protein that were used/processed in the region. Chapter Seven summarizes my final thoughts on the study, along with future implications for protein residue analysis within the Cultural Resource Management (CRM) industry.

Chapter 2: Theoretical Background

Introduction

In Southeast New Mexico lies an area known as the Permian Basin and the district of the Carlsbad field office (CFO) (see Figure 1). This area has an abundance of archeological sites left by mobile hunter-gatherers and contains one of the richest concentrations of fossil fuels in the world (Railey 2016). With the rise in the oil industry, many sites have been identified by a series of surveys conducted to be in compliance with Section 106 under the National Historic Preservation Act (NHPA). The State of New Mexico has lots of Bureau of Land Management (BLM) areas and they were divided into districts. The southeastern district is supervised by the Carlsbad Field office (CFO). Located far west of the CFO region is Fort Bliss. It is a Military Reservation that covers more than 4,500 km^2 (Railey 2016:8). Fort Bliss lies within the Jornada Mogollon culture area, and has been performing archeological cultural resource management (CRM) work far longer than the CFO providing a theoretical framework for the Permian Basin. The first Permian Basin Research Design was created by Patrick Hogan for the CFO in 2006. This design was then updated and recreated by Railey in 2016. Sites LA 38597 and LA 20241 are within the Permian Basin Research Area and were recently excavated for a pipeline project by SEARCH and TRC. This chapter presents the relevant theories from the research designs by Hogan and Railey for the Permian Basin, based on Miller's Fort Bliss research design The summaries of these theories help to visualize the theoretical framework surrounding sites LA 385797 and LA 20241. It also presents the theories underlying protein residue analysis along with a case study from the region.

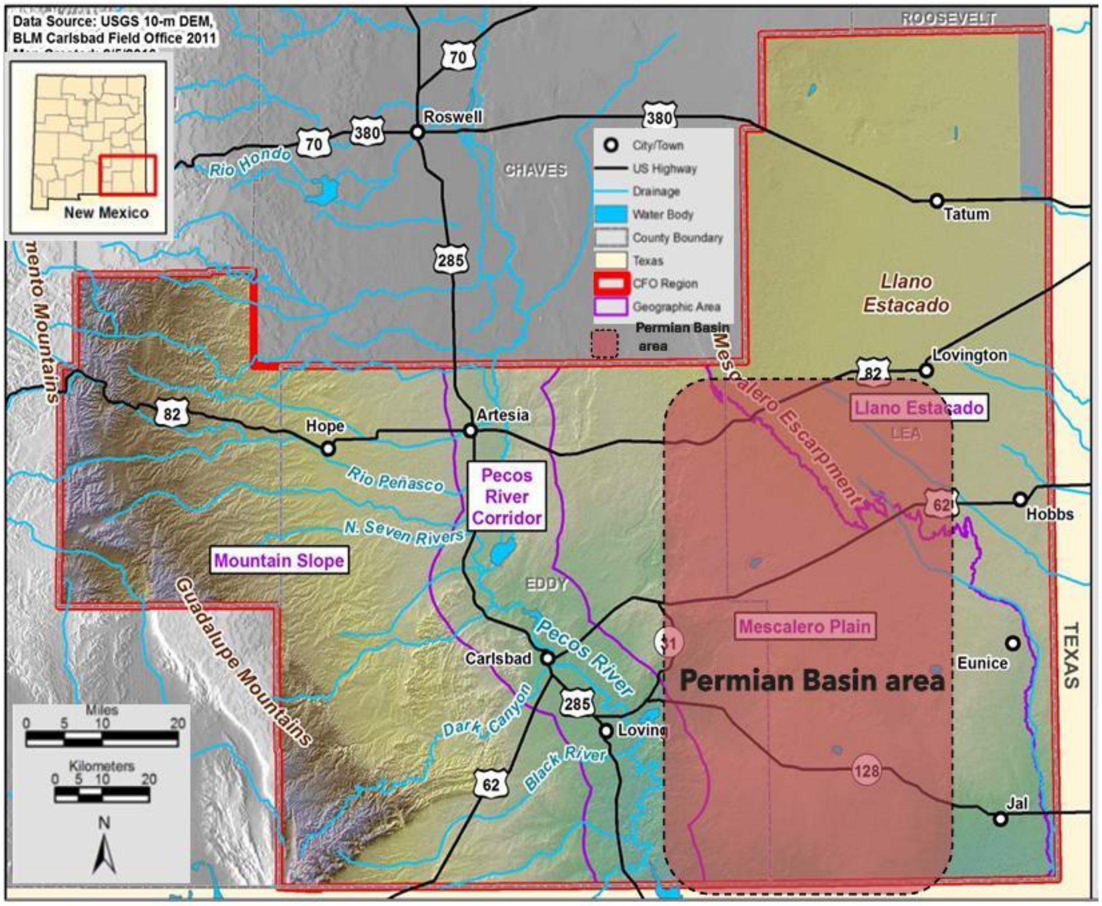

Figure 1 ***Error! Reference source not found.***

Regional Theoretical Models

Southeast New Mexico (SENM) is not known for its beauty or lush vegetation. It is an arid harsh landscape with many species of prickly vegetation and most recently an oil field. The Jornada Mogollon, Mescalero Apache, along with many other tribes did not view the landscape as we do. If we are to try to understand cultural values and beliefs through the lens of ethnographic and archeological study, then it's important to view the landscape as ancient humans did. They saw the land as fruitful with many resources. In 1868 John Carey Ceremony documented an Apache man saying, "There is food everywhere if one only knows where to find it." (Whitehead Flynn 2017:58). It was Franz Boas in 1877 who brought the idea of cultural relativism, though he did not coin the term, that states, “that all cultures are of equal value and need to be studied from a neutral point of view” (Glazer 1994). Boas argued that all humans view the world through their own culture shaped by specific histories associated with place and interactions with other human groups. Where currently, most people would see an empty desert in SENM, tribes of that area still see viable resources from which their ancestors thrived on. Following Boas’s work, Julian Steward, a prolific ethnographer, was interested in how environments influenced cultures. Contrary to Boasian thought, Lesile White later argued that it is not the viewpoint of the research, but the individual study of technology, sociology and ideological components of cultures.

This discussion introduces synthetic research frameworks that have been published and utilized by archeologists working in SENM over the last 20 years, which have shaped compliance-based work including the present studies. Myles Miller et al.(2009) authored a regional research framework that describes how Steward’s and White’s theories are applied at Fort Bliss, a military base in SENM with a significant role in shaping regional research programs. The guidance published by Fort Bliss cultural resources management (Miller 2009) helped to shape research on ancient Native American occupation in SENM, both on and off the base.

The most dominant ideology over the last forty years within the Jornada region, is processual archaeology and cultural ecology, for which Miller et al. (2009:4-2) explains the application and constraints of this theory. Miller (2009:4-4) refers to Steward (1968) when describing a culture's core and secondary elements; the core elements being technology, political, social, and religious orientations. It is these factors that contribute to a culture's adaptation to its physical environment while also directly being influenced by the environment (Miller et al. 2009). These core components were determined by interpersonal relationships, and similar environmental conditions would lead to equivalent technological advances among different cultures under comparable environmental pressures (Miller 2009:4-3). Secondary elements are not affected by environmental conditions but are created by diffusion and random invention, which obscure regularities among culture cores (Miller 2009:4-3). Steward's (1955) theory is that similar environments lead to similar cross-cultural cores, but Miller (2009) critiques that he does not incorporate social factors as part of the environment. Following these theories is Leslie White's (1959) concept of cultural evolution and energy capture, which describes that the more efficient technologies become in energy capture, it becomes the catalyst for change in social and ideological structures (Miller 2009:4-4).

These theories by Seward and White led to the development of the systems theory; which describes how the interactions between cultural subsystems and their effects can be described, and therefore, can explain the processes by which cultures evolved and changed (Miller 2009:4-4). With the combination of ecology, cultural evolution, and systems theory, archeologists can apply methods to look at archaeological patterns to explain culture change (Miller 20094-4). With the processual movement came new analytical and data collection methods, and a theory that shaped these methods was Binford's middle range research framework. As described by Pierce, "Middle-range theory can be seen as consisting of four components: 1) documentation of causal relations between relevant dynamics and observable statics; 2) recognition of signature patterns in static remains; 3) inference of past dynamics from observation of signature patterns in archaeological record; and, 4) evaluation of these inferences" (Pierce 1987:2). In other words, middle-range theory links human behavior and natural processes with archeological materials which Binford uses in his ethnographic research, linking observable data with unobservable, high-order inferences about causal relationships. The critiques of processualism are that it fails to account for natural and cultural pressures associated with social theory, and questions environmental determinism as a singular answer to why people make decisions. Miller (2009) concludes his discussion of processualism by noting that much of the Jornada research and Fort Bliss research has been under the influence of processualism and using models of settlement and subsistence organization that were developed in the 80s and early 90s.

Behavioral archeology resulted from the rise of processualism with Schiffer describing it in this way: "…the subject matter of archaeology is the relationship between human behavior and material culture in all times and places" (Schiffer 1976:4). More recently behavioral archaeology had looked at technology, design, and the life use of artifacts, while also taking into account behavioral factors (Miller 2009). It also has had a profound influence on work in the Fort Bliss and Jornada region, with the use of spatial analysis in hunter-gatherer site structure, as well as the effects of eolian environments on site formation processes (Miller 2009). Human behavioral ecology has goals "to construct complex, sophisticated models that predict the results of different behavioral trade-offs and to translate these into predictions that are testable with archaeological data" (Kelly 2000: 115). One theory that Miller

(2009) highlights is the optimal foraging theory which was spearheaded by Stephen and Kreb (1989). Miller (2009) explains that the theory proposes how an organism best forages under different conditions, and has been used in understanding the distribution of sites by Raven and Elston (1989).

Miller's (2009) final discussion on the use of theory in the Jornada Mogollon region, by Fort Bliss archeologists, discusses post-processual critiques. It is stated that post-processualism has a good argument faulting processualism for leaving out vital factors such as failure to incorporate individual agency and social relations, and mainly focusing on external environmental changes that cause culture change. Miller discusses the theory of individual agency and how it is capable of broader cultural changes but argues that it could be better applied to historical societies or historical documentation. Despite his critique, he also points out examples where agency has been successful, such as Whiteley's 1988 study of Hopi oral traditions, which describes cultural change through an individual's actions outside of environmental change (Miller 2009). One of Miller's closing statements beautifully summarizes his discussion of the mosaic of theories that he believes Fort Bliss should focus on by saying, "it is the dynamic interplay between environment, ecology, and human agency that perhaps best reveals the underlying processes of culture change and should thus be the focus of analysis" (Miller 2009:4-15).

Hogan's Research Design

Many archeological companies have searched for one theoretical model to be incorporated into a standard research design in SENM, and Patrick Hogan (2006) from the Office of Contract Archeology at University of New Mexico, focuses his research towards data gathering with sampling strategies and the use of subsistence modeling. His sampling strategy and use of models were to create a framework to guide future research. Hogan poses that the use of models is the best vehicle for maximizing the use of sites with limited data, and building associations between sites and environmental variables in the region. Hogan says that "modeling provides a mechanism for introducing dynamic explanatory concepts into the research" and that "modeling of subsistence strategies is based on optimal foraging theory and general hunter-gatherer theory" (2006:5-3). Optimal foraging theory was first applied in archeology by Robert Bettinger in his book, *Hunter-Gatherers: Archaeological and Evolutionary Theory* published in 1991. Optimal foraging theory is defined as, "feeding behaviors that maximize energy gain and minimizes energy expenditure" (Volsche & Hasnain 2022:283). Following this theory, is the hunter-gatherer theory that describes how reducing energy costs might pressure groups into moving closer to areas where resources are more abundant. Hogan (2006) proposes that the use of these diet-breadth models may be beneficial for exploring past subsistence strategies, that involve cost-benefit calculations, or return rates, based on: "1) the energy (calories) per unit obtainable from the resource; 2) search time – the energy and time expended in locating the resource, which is largely a function of its abundance in the foraging area; and 3) handling time –the energy and time expended in procuring and/or processing the resource." (Hogan 2006:23; Railey 2016b:262). In Railey's (2016a) research design he discusses how archeological models should be applied by acknowledging preference and risk factors. By incorporating human agency.

Railey's Research Design

In a more recent publication of the Permian Basin Research Design by Jim Railey (2016a), the framework of these models is respected, but the faults in these models are also discussed. Diet-breadth models assume that people would "maximize the cost/return benefit while moving across the landscape and utilizing its food resources", although Railey (2016:262) points out that this is often applied to hunter-gatherers. It is noted that Hogan does mention the challenges of the lack of subsistence evidence gathered from the sites of the region, but Railey (2016a:262) argues that "he did not consider this limitation fatal to the construction of diet-breadth models, which are based on data from potentially available foods in the natural environment" (2016a:262). Railey (2016a) also argues that diet-breadth models must be constructed carefully and consider other factors such as the effects of economies of scope and scale; the benefits of long-term storage; and the potential use of such plant foods as high-prestige foods , alcoholic liquids, and importance in ritual activities. These models also fail to factor in the role that risk applies in resource procurement, which is a vital factor in the Southwest due to the low probability of rain (Railey 2016a). Diet-breath models also do not account for foods that are culturally favored such as delicacies, or the importance they might have in ceremonial contexts (Railey 2016a). Railey cites (Bird et al. 2001) saying that, "the rare and/or costly nature of delicacies often worked to enhance their social value—a case of costly signaling in which foragers may acquire or distribute foods in ways that do not maximize return rates " Railey (2016a:264).

In contrast to Hogan's (2006) and Miller’s (2009) approaches for how research standards should be conducted in the Jornada Mogollon region, Railey (2016) suggests a narrower focus on theory. He discusses the theoretical concept of human agency (both individual and collective) under the assertion that humans are active participants in their lives and they react, act, and interact with the resources and constraints imposed by their environment and society (Cleeland et al. 2023). According to Cleeland et al., “this approach takes into account the history of the person or group, generational knowledge, and ritual, political, and social factors, among others, in how any given person or group may handle stressors” (Cleeland 2023:46). Railey (2016) applies other theoretical models when looking at settlement-subsistence strategies. These models show that with an increase in site materials, there is a collating increase in diversity in hunter-gatherer camps. He also discussed that artifact assemblages can provide information on site function (Railey 2016). One way to examine tool use through protein residue analysis.

Protein Residue Analysis and Settlement-Subsistence Studies

Protein residue analysis is a technique used to identify proteins preserved on artifacts. The technique was developed by forensic scientist Culliford (1964) and later modified for use in archeology by Newman and Julig (1989). This technique is further discussed in the Methods chapter. The key theories behind the success of protein residue analysis are the preservation, molecular stability, and specificality of proteins. Proteins are relatively stable molecules and according to Hyland et al. (1990:105) “...proteins can remain relatively stable for many years under a variety of environmental and depositional regimes.” Proteins are composed of amino acids, which can form complex and stable structures. These sturdy structures can sometimes resist degradation better than other biological molecules like DNA or lipids. This stability makes proteins good candidates for analysis in ancient samples (Collins 2000:778). The last concept that makes this type of analysis successful is the simple fact that different organisms produce unique proteins. This method only produces species specific levels of detail, but it can still contribute to reconstructing ancient biodiversity. Analyzing ancient proteins can provide information about the diet, health, and lifestyle of past peoples. For example, proteins extracted from dental calculus can reveal dietary habits such as in Linda Scott-Cummings 2001 paper "Dental Calculus and Dietary Variability: A Comparison of Multiregional Prehistoric and Historic Samples." Protein residue analysis has been used in archeological contexts all over the world, including the specific area of SENM. Railey (2016:192) poses that protein residue analysis "offers vague and confusing results" but also used this method to support subsistence behaviors on site LA 43257 (Railey 2015).

In June 2015, SWCA environmental consultants conducted a data recovery at LA 43257 (X miles from LA 20241 and X miles from LA 38597). It was conducted for the Zia II Natural Gas Pipeline in Eddy County, New Mexico. LA 43257 is a large multicomponent with a large prehistoric component and a small historic component (Railey, 2015:57). As with LA 20241 and LA 38597, LA 43257 is situated among coppice dunes within desert scrubland. LA 43257 was originally recorded in 1970 by LCAS and most recently by SWCA for the data recovery. SWCA (Railey, 2015) documented the site as a 468 × 417 m (1,536 × 1,368 feet) site containing eleven features and over 100 artifacts including flaked lithic debitage and tools, ground stone, ceramic sherds, burned caliche, burned sandstone, and unburned sandstone that may have been ground. Two projectile points indicated a Late formative prehistoric occupation of the site. The historic component composed of six pieces of sun-colored amethyst (SCA) glass observed during the survey (Railey 2015). During this project, Railey wanted to know not only basic questions about the chronological age(s) of the site's archaeological remains, subsistence information, assemblage patterning, etc., but also how basic information from this site relates to broader patterns at local and regional scales of analysis. Like most sites in the area, LA 43275 had very limited faunal remains within the site, so direct evidence of animal subsistence was not available. In order to fill this data gap, protein residue analysis was used.

Three projectile points from LA 43275 were analyzed by Dr. Cameron Walker at Archaeological Investigations Northwest, Inc. using Cross-over immunoelectrophoresis (CIEP). The protein residue was extracted from the artifacts and tested against antisera from known animals, then placed in a gel, and then exposed to an electric current that causes the proteins to flow together (Walker appendix B 2014). The result is the antigen-antibody reaction that can be seen after the gel is stained. The projectile points extracted proteins, were tested against bovine, deer, goat and human antigens. One projectile point tested positive for goat, and was confirmed by repeat testing. According to Dr. Walker, the goat positive is most likely related to bighorn sheep or mountain goat. According to Railey (2015) LA 43275 is far from the Guadeloupe and Sacramento Mountains, and it is unknown if the goats roamed east of the Pecos River during prehistoric times. This could speak to the seasonal rounds that the Jornada Mogollon may have made.

Theoretical Summary

This review of theories used in the Permian Basin region stands to guide the interpretations of protein residue results from LA 38597 and LA 20241. Though Hogan's models stand as a good framework from which to build upon, it leaves out important factors such as social dynamics and risk of procurement. Miller's research design synthesizes a broader use of theories of the Jornada Mogollon region of Fort Bliss. Railey (2016) focuses on three theories of ecological/demographics, social/structural, and Darwinian theories of cultural evolution. As seen with Railey's Red Tank Project, protein residue analysis is a powerful tool for reconstructing the biological and cultural aspects of past life. It relies on the stability, specificity, and identifiable nature of proteins, combined with advanced analytical techniques, to provide detailed insights into ancient peoples and their environments. Applying protein residue analysis in SENM will add another line of evidence to support a better image of ancient lifeways.

Chapter 3: Cultural and Historical Background

Introduction

This Chapter presents the chronological framework of SENM that is utilized in every report, along with the importance of plant use throughout time. The chronological framework of the CFO region in SENM is shown in (Table 1). For the purposes of this research only sites LA 20241 and LA 38597 temporal cultural affiliations will be presented. These cultural contexts for these sites are the Archaic period (6000 to 500 B.C) and the Early to Late formative periods (A.D 500 to 1450). According to Railey (2016:53), during the Middle Archaic to Late formative periods there is an increase of sites in the CFO region, and LA 20241 and LA 38597 falls within those periods. These time periods coincided with the Late Holocene wet period and the Medieval warm period before the Little Ice Age. The Archaic tradition is between the Paleoindian tradition and AD 500 where ceramics begin to appear (Railey 2016). Dating this period used to rely heavily on projectile point types, but with radiocarbon dates it is no longer the primary source. The Archaic tradition is broken up into three periods in the region: Early Archaic (6000–3200 B.C.), Middle Archaic (3200–1800 B.C.), and Late Archaic (1800 B.C.–A.D. 500) (Railey 2016). For this chapter I am going to separate the cultural historical framework by lifeways and plant use similarly to Railey in his chapter of 'Plant utilization in Southeastern New Mexico' (Whitehead & Flynn 2017:28). Changes in the climate within the individual cultural periods will be discussed because plant use is part of a cycle and as environments change so do ecosystems. These changes cause human cultures to change as well (Railey 2017:25).

Table 1 Chronological Framework for the CFO Region (Derived from Jim Railey 2016:20)

Tradition	Period	Time span
Historic Euro-American		A.D. 1865–present
Post-Formative Native American		A.D. 1450–present
Formative	Late	A.D. 1100–1450
	Early	A.D. 500–1100
Archaic	Late	1800 B.C.–A.D. 500
	Middle	3200–1800 B.C .
	Early	6000–3200 B.C.
Paleoindian	Plano	9800–7000 B.C.
	Folsom	10,800–9800 B.C.
	Clovis	11,500–10,800 B.C.

Holocene Foragers (6500 B.C to A.D. 1100): Archaic to Early Formative

Both LA 20241 and LA 38597 have associated dates from the Archaic period to the Early Formative. Traditionally, Paleoindians have been viewed as big game hunters, but due to limited sites associated with this time period in SENM, the importance of plant use is unknown (Whitehead & Flynn 2017:29-30). Mobile hunter gathering continued from the Paleoindian period, but a shift occurred towards resource diversification, or a "diffuse" economy (Judge 1982:49). The people of the Archaic tradition subsisted on a variety of plants and the modern suite of Plains' fauna (Cleeland et al. 2023). Based on Search's report and other sites in the region, Archaic populations most likely primarily depended on plant foods, a seasonally mobile settlement pattern, and a flexible social structure in which group size and composition varied in response to changing economic opportunities (Cleeland et al. 2023). Regions with consistent seasonal availability and distribution of essential plant resources were revisited as part of yearly migration (Judge 1982:49). The increased reliance on plant foods during the Archaic period is evident from the higher occurrence of grinding tools. Both LA 20241 and LA 38597 have an abundance of ground stone recovered from the excavations.

Archeological evidence in the surrounding areas of the sites show that many plant foods were collected, processed, stored and eaten (Whitehead & Flynn 2017:32). For Sites LA 20241 and LA 38597 starch, pollen, phytolith, and Fourier Transform Infrared Spectroscopy (FTIR) analyses were conducted. At LA 20241 a variety of plant starch, pollen and phytoliths were observed from the mano and metate washes. The starch analyses from soils samples found Maize (zea mays)(Cleeland et al. 2023). The researcher Linda Perry suggests the grain was brought in along with other starchy grains as a food resource (Cleeland 2023:74). In contrast to other parts of New Mexico, the Archaic sites in (SENM) have not provided clear evidence of an early agricultural subsistence base, and were dependent on wild plants and animals (Whitehead & Flynn 2017:31).

Proceeding the Paleoindian Period, the climate became warmer and drier. The Early Archaic period falls mostly or entirely within the Altithermal, an exceptionally dry interval that led to a drastic reduction of available surface water (Railey 2016:70 and Cleeland et al. 2023). These conditions dominated the area beginning around 5000 B.C., and lasted until sometime between 3000 and 2000 B.C. (i.e., into the Middle Archaic period) (Cleeland et al. 2023). Because springs, marshes, and playa lakes east of the Pecos River likely dried up during the Altithermal, water wells were likely dug in areas with shallow subsurface water, such as at Blackwater Draw Locality I (Evans 1951; Green 1962; Hester 1972; Warnica 1966), Mustang Springs in west Texas (Meltzer and Collins 1987), and at Rattlesnake Draw (Railey 2016:23; Smith et al. 1966). Hunter-gatherers then tended to sacrifice foraging efficiency in favor of keeping their camps close to scarce water sources (Railey 2016:23). This foraging strategy meant more distant journeys from camps and not abandoning the camps until their local resources are depleted before moving to a new resource location (see Railey 2016 :71-72 and Cleeland et al. 2023). LA 20241 and LA 38597 both show repeated use overtime and align with this narrative.

The primary large game that was hunted during this time was deer, pronghorn, bighorn sheep, and bison (when they were present) (Whitehead & Flynn 2017:31). They used the atlatl made from oak species, wrapped with yucca fibers (Whitehead & Flynn 2017:31) until it was replaced by the bow and arrow where small thin projectile points were used. According to (Whitehead & Flynn 2017:31), there was evidence found west of Roswell that bows were made from mountain mahogany, juniper, and Gambel's oak. Archaic rock shelter occupations also provide evidence that small arrows were also made of wood and cane from Phramites grass, however, arrows were not always tipped with points, long hardwood sticks were also sharpened at the ends (Railey 2017:31). As we know, organic tools do not preserve well out in the open exposed to the elements, so it was not surprising when no organic tools were discovered on the excavations at LA 202041 and LA 38597.

In order to look at plant use during different cultural historical traditions, it is important that archeologists use paleoethnobotany. Whitehead defines this field as, "...a synthesis of techniques and methods archeologists have either invented themselves or borrowed from other fields…merging botany, ethnography, and archeology into one interpretive framework" (2017:65-68). Sites in the area provide evidence of plant use, including seeds of wild grasses and weeds like dropseed grass, wild barley, and sunflower, as well as yucca root, agave hearts, and prickly pear buds (Whitehead & Flynn 2017:32). Mano and metates were used to grind up starchy and oily seeds to make flour from native plants (Whitehead & Flynn 2017:32). The seeds were also roasted and not burned for better storing and digestibility (Whitehead & Flynn 2017:32). Mesquite is a local plant that can be seen all over the current landscape of SENM, but it also played a vital role in the lives of Holocene hunter-gatherers. The mesquite wood was used for firewood, and wooden mortars were made from their stumps. The mesquite pods were crushed up with stone pestles and made a sticky paste. It is hypothesized that acorns from shinnery oak, and cattail roots were also processed with mortar and pestles, but there is very little direct evidence in SENM (Whitehead & Flynn 2017:32).

During the interval 3000–2000 BC it became wetter and cooler creating more sources of reliable surface water and vegetation became more readily available. A significant number of Middle Archaic-period sites across the upland areas, desert basin floors and plains located at greater distances from rivers and larger playa lakes began to appear in the archeological record (Railey 2016:25). A broad-spectrum subsistence economy was well established, as indicated by the recovery of seeds and roots that required extensive processing for consumption. This is further supported by the presence of groundstone milling implements, cooking pits, and burned rock (Huckell 1996:336–342; Mallouf 1985; Miller and Kenmotsu 2004:224–225). Archaeologists in the area call these large cooking pits "ring middens" because after they are abandoned, they look like large rings of rock, typically with a dark depression in the center. In my experience the rocks are 5 to 8 cm in size and the size of the midden is based on how much it has been eroded or the extent of its use. These middens were used repeatedly sometimes over centuries (Whitehead & Flynn 2017:34).

Hot-rock cooking and a broad-spectrum subsistence base were established during the Early Archaic period in west Texas (Dering 1999; Mallouf 1985; Miller and Kenmotsu 2004:220–221; Railey 2016b:22; Turpin 1994:70). They are also known as "earth ovens." This method of cooking, called pit baking, it involves piling hot rocks and ash to cook food. Both meat and plant foods were cooked in these ovens such as roots, tubers, cholla buds, cactus pads and agave. The food was cooked over a period of hours or even days, tightly wrapped up with leaves, grass, textiles, to retain oils and grease for added flavor and nutrition (Whitehead & Flynn 2017:32). One of the more popular items to cook in these burned rock middens are agave hearts. In some well-preserved ovens, remains of agave hearts have been found inside along with agave knives (Whitehead & Flynn 2017:34). These types of features are found east of the Pecos River in the Guadalupe Mountains and its foothills, miles from LA 38597 and LA 20241. Today that area receives more water and has more opportunities for firewood along with areas where agave continues to grow.

The Late Archaic period continued with wetter and cooler conditions from the Middle Archaic and accumulated surface water (Railey 2016a:74). The widespread abundance of freshwater mussel shells at many sites suggests that perennial aquatic habitats once existed along many drainages in the region, which are now only seasonally aquatic (Railey 2016a:74). At LA 20241 103 freshwater muscle shell fragments were recovered, and five of them had evidence of tool use or reworking. At LA 38597 there were more artifacts overall, and 255 shell fragments were recovered (Cleeland et al 2023). Two important effects came from the climatic conditions:1) a sharp increase in population density, resulting in a higher site density, and 2) new foraging opportunities for hunter-gatherers that allowed for more widespread use of the landscape through residential mobility. Overall sites in the region contained an increased number of projectile points reflecting an increase in hunting. With greater population there is a significant increase in the number of thermal features reported, and correspondingly available radiometric dates for the Late Archaic period (Railey 2016:75).

Before radiocarbon dating was popular, projectile point typology was the most common way to date sites. Stemmed projectile points types like Irwin-Williams' (1973, 1979) Jay and Bajada types of the Oshara tradition and Uvalde and similar types identified in central and west Texas (Miller and Kenmotsu 2004:220; Prewitt 1981; Turpin 1994:70; Weir 1976) are associated with Early Archaic components (Railey 2016a:75). During the Middle Archaic period, projectile point styles diversified both within and between regions. Points featured either contracted stems with flat, rounded, or pointed bases, or expanded stems with concave bases (Miller and Kenmotsu 2004:225; Railey 2015:24). The diagnostic projectile points were predominantly expanded stem forms with varying blade shapes, which might or might not have pronounced shoulders (e.g., Miller and Kenmotsu 2004:7-11). Other styles, such as bifurcated base and straight-stem forms, were also present (Mallouf 2005:226) (Railey 2015:25).

Both LA 38597 and LA 20241 have the full suite of artifacts that are typical for their temporal cultural affiliation. Eleven projectile points were recovered from LA 38597 and are described in (Table 2). Six diagnostic projectile points were recovered from LA 20241, one of which is a corner-notched fragment only and was too fragmented to be typed. The five diagnostic points date to the Late Archaic and Early Formative periods (Turner and Hester 1993) and include one Datil type that dates 1600 BC–AD 300; one Carlsbad type that dates to 1,050 BC–AD 350; one Hueco type that dates to 1050 BC–AD 250; one Marcos type that dates to 600 BC–AD 200; and one Ahumada Expanding Stem type that dates to AD 750–900 (Railey 2026a). Combined, the diagnostic lithics range in manufacture date approximately from 1600 BC (Datil points) to AD 1100 (Ahumada Expanding Stem). These points indicate site occupation during the Late Archaic and Early Formative (Cleeland et al. 2023).

Table 2 Summary of projectile points from LA 38597 (table is attributed to SEARCH and TRC)

Lab No.	Type	Temporal Affiliation	Cultural Period	Material	Condition	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)
T42-8-1	Medial/base fragment	9800-7000 BC	Late Paleo	Chert	Broken	31.78	21.22	5.88	5.1
MT-4	Agate Basin	8550–7350 BC	Late Paleo	Chert	Complete	48.16	21.7	8.71	8.04
T92-7-1	Langtry-Arenosa	2500–1000 BC	Middle to Late Archaic	Chert	Broken	37.33	27.55	5.97	5.12
T167-8-2	Langtry-Arenosa	2500–1000 BC	Middle to Late Archaic	Chert	Complete	33.71	24.68	6.6	3.92
MT-11	En Medio	800 BC–AD 400	Late Archaic	Chert	Complete	22.02	18.92	4.2	1.57

T53-7-2	Figueroa-like	1200 BC–AD 700	Late Archaic-Early Formative	Chert	Broken	33.3	22.83	5.95	4.03
T33-6-2	Tip only	N/A	N/A	Chert	Broken	6.57	5.62	2.33	0.2
T105-5-1	Tip only	N/A	N/A	Chert	Broken	13.95	10.83	4.31	0.68
T207-4-2	Tip only	N/A	N/A	Chert	Broken	9.83	10.03	2.85	0.3
T225-4-1	Tip only	N/A	N/A	Chalcedony	Broken	16.6	13.79	3.54	0.3
F31-0-3	Tip only	N/A	N/A	Chert	Broken	11.15	8.3	2.12	0.21

The Early Formative period (AD 500–1150) is represented by the appearance of pottery and bow and arrow technology. This drastic shift in technology is inferred from a sharp reduction in the size of projectile points, which occurs across most of sub-boreal North America around A.D. 500–600 (Railey 2015:32). In the Southwest and Southern Plains, the earliest arrow points are characterized by strong shoulders, and corner-notched or stemmed forms. At well-dated sites in the Hondo Valley of the Sierra Blanca highlands (Campbell and Railey 2008; Railey 2010a), the earliest arrow points have shouldered, recurved blades similar to the Bonham and Homan types in northeast Texas (Turner and Hester 1993:202, 219). These are soon followed by straight-bladed points with tanged shoulders and corner notching. These latter forms, resembling the Scallorn type of the Plains (Turner and Hester 1993:230) and the Trujillo and Dolores types in northern New Mexico (Justice 2002; Turnbow 1997:202–205), persist throughout the Early Formative period and into the early Late Formative period. (Railey 2015:32).

During this time period in the CFO region, there is currently a lack of evidence of permanent structures, and Late Archaic hunter-gatherers most likely used brush huts similar to wickiups seen in the American west during historic times (Whitehead & Flynn 2017:36) (cf. Binford 1990; Kelly 1995:139–140) (Railey

2015:32). Archaeologists continue to observe a large number of thermal features at Early Formative sites, possibly suggesting a continued emphasis on plant foods. With more soil samples being gathered from sites in this region, we can begin to find botanical remains of various wild plants, including Chenopodiums (goosefoot), wild barley, yucca root, and others are common occurrences (e.g., Acklen and Railey 2001; Brown 2011; Condon et al. 2008; Lord and Reynolds 1985; Railey 2011; Simpson 2004, 2010a, 2010b), along with succulents processed in burned-rock middens in the western portion of the CFO region (Jones et al. 2010). There is some microbotanical evidence that maize was present at this time, but currently there is a complete lack of domesticates in macrobotanical assemblages in securely dated, pre-Late Formative contexts. This indicates that farming was not practiced across most of the CFO region during Early Formative times (Railey 2015:32). However, to the northwest of the CFO region on the eastern slope of the Sierra Blanca highlands there is well documented evidence of maize based farming beginning in the Late Archaic and throughout the Early Formative (Campbell and Railey 2008). (Railey 2015:32).

During the Early Formative period, the Medieval Climatic Anomaly (AD 800/900–1350) brought a dry period that impacted people in western North America (Jones et al. 1999). The worst drought occurred from AD 940–1040, followed by a very wet period from AD 1040–1120 (Grissino-Mayer et al. 1997; Railey 2016:33). A significant decrease in radiometrically dated thermal features during the latter part of the Early Formative period may indicate a population decline, as shown by fewer campsites. Populations on the Mescalero Plain appear to have established more permanent settlements near reliable water sources, such as large playas and drainages with nearby escarpments, ridges, or hills (Railey 2015;Railey 2016:33;Cleeland 2023) According to Railey's Permian Basin Research Design (PBRD), precipitation levels increased again toward the end of the Early Formative, unfortunately, the damage apparently was already done, and the response to the period of severe drought may have facilitated some fundamental changes in cultural adaptations that took hold during the Late Formative period. (Railey 2015:36).

Village Farmers and Their contemporaries (A.D. 1100-1450): Late Formative

The occupation at site LA 20241 extended into the Late Formative, according to the radiocarbon dates. The Late Formative (AD 1100–1450) marked the appearance of Chupadero Black-on-White pottery as the hallmark for the period, along with Several glaze wares and polychromes occurring after AD 1300 (Railey 2016:30; Cleeland et al. 2023). Arrow point morphology changed from corner-notched arrow point styles with strong shoulders to side-notched arrow points with wide, squared, or concave bases and weak shoulders. These forms are usually referred to as Harrell, Desert Side-notched, Washita, or Pueblo Side-notched (Justice 2002; Speth 2004; Turnbow 1997; Turner and Hester 1993). Unnotched triangular points such as the Fresno type, are rare in the SENM but do occur in small numbers (Railey 2016:37)(Railey 2015:36)(Cleeland et al. 2023). These points correspond to the use of the recurved bow, which is a much more powerful hunting tool than a simpler self-bow (Railey plant book 40).

According to Railey (2015:7) substantially occupied "villages" were established by A.D 1300 across much of the CFO region, as part of a widespread pattern of greater sedentism across the southeastern Great Plains and Jornada

Mogollon region. Climatic conditions fluctuated frequently between wet periods and drought (Grissino-Mayer et al. 1997; Johnson and Holliday 2004:292; Polyak and Asmerom 2001). (Railey 2015:41). At sites dating to this period there is an abundance of artifacts, bones and plant remains. Late Formative houses include pit houses and room blocks. An excellent example of these is documented at the Merchant site in Lea County (Miller et al. 2016:147). Farming became in important part of sedentary life at large structural sites such as the Merchant site, but in the southern parts of SENM it is hypothesized that a highly mobile society still persisted (Railey 2017:40). In A.D 1200 a trade system was developed between the people on the High Plains and Pueblo-based peoples to the West, but it is unclear when the people of SENM participated in this system (Railey 2017:41).

The use of plants has clearly been essential for survival as well as being culturally significant throughout time for the people of SENM. There are many ways to look at plant use as an archaeologist. By collecting soil samples, we can look at macrobotanicals, and microbotanicals. Among the microbotanicals is pollen, starch, phytoliths, and plant proteins. The next chapter will review the methods used in extracting and identifying proteins from tools located at sites LA 20241 and LA 38597. These methods were conducted and guided in a lab in Denver, Colorado provided by Dr. Linda Scott Cummings.

Chapter 4: Methods

Introduction

This chapter discusses the methods used to process 41 samples obtained from 30 flaked stone tools for protein residue analysis. The tools were loaned to the laboratory of the Paleo Research Institute in Boulder, Colorado from the TRC laboratory, and were collected during the fieldwork conducted at sites LA 20241 and LA 38597 by SEARCH and TRC in 2021. SEARCH and TRC used the same collection methods throughout both excavations. All artifacts were systematically excavated, and bagged and labeled with exact provenience. Special analyses were conducted on the artifacts, but no testing of any kind was performed on the flaked-stone tools that were collected, prior to the current study. LA 38597 had 90 flaked stone tools collected and 18 tools were selected for protein analysis. At LA 20241, 55 flaked stone tools were collected, but 12 flaked stone tools were tested for proteins in this study. (see Table 4 and Table 5 for sample lists). Tools were selected with specific parameters, but were also chosen at random to avoid biases. Protein residue analysis is conducted with a series of steps in a matter of three days. The first step is to extract the proteins off the tools. The next step is creating the agarose gels and wells for the antisera and extracted solutions to go into. Gels are made two at a time. After pipetting the solutions into the proper wells, the gels then go into the electrophoresis tank. The gels are then pressed and placed into NaCl solution overnight. Day 2 the gels are pressed, rinsed and left to air dry overnight. The third and final day the dried gels are stained, rinsed, destained, and left to dry for the reading of the results. Before these steps can be put into motion tools need to be selected for this type of analysis.

Tools for this study were selected based on use ware, probability of proteins remaining in the grooves of the tool edges, and variety. Throughout examination of the tools, the selections exhibited heavy use ware that consisted of dull or heavily reworked edges. None of the tools selected were from within features, because the heat would have destroyed any remaining proteins. Surface and subsurface tools were selected to test if there were any remaining proteins on the surface tools verses the subsurface tools. It was also important for the study to have tool variety such as choppers, scrapers and a utilized flake to see if any residue remained and if so, what could different tool types tell us about site subsistence. Formal projectile points were selected in anticipation that the solution would have a positive reaction with animal protein. A total of 41 samples were recovered and tested from this subset of 30 formal tools, due to some artifacts having the tip and haft tested separately. Protein residue analysis involves many steps, and utilizes Cross-over electrophoresis, following procedures are implemented at the Paleo Research Institute in Boulder Colorado.

Methods Background

Cross-over electrophoresis (CIEP) uses an electric field to move the sample extract and antiserum through an agarose gel medium (National Institute of Justice, 2023). Forensic CIEP methods were developed at the Royal Canadian Mounted Police Serology Laboratory, Ottawa and the Centre of Forensic Sciences, Toronto (Culliford's 1964; 1971). The methods were later modified by Newman and Julig (1989) for use on archaeological materials from a stratified boreal forest site.

Following Dr. Richard Marlar's counsel from the Thrombosis Research Laboratory, the United States Veterans Administration Medical Center, Denver, and the Health Sciences Center, University of Colorado, the Paleo Research Institute implemented adjustments to the method. Other methods such as, enzyme-linked immunosorbent assay (ELISA) and radioimmunoassay (RIA) have been utilized in archeological investigations but, the CIEP test exhibits exceptional sensitivity, capable of detecting as little as 10^{-8} grams of protein (Culliford 1964:1093). Because of the sensitivity of the tests, it is important to test 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.

Successful identification of proteins from lithic artifacts relies on the biological activity of those proteins (Hyland et al. 1990:105) and the recovery method. This method is based on an antigen-antibody reaction, where a known antibody (immunoglobulin) is used to detect an unknown antigen (Bog-Hansen 1990) . According to Newman, “the principle of this method is that all animals produce antibodies that recognize and bind with foreign proteins (antigens) as part of the body's defense system” (Newman,1989:120). None of the tools were tested against human proteins, because they were collected in the field and photographed with ungloved hands, introducing the risk of contamination by touch.

Step 1

The first step to this process is to extract the proteins from the artifacts. The lithics were washed using 0.5–1.0 ml of solution containing 0.02 M Tris hydrochloride, 0.5 M sodium chloride, and 0.5% Triton X-100 (Tris/NaCl/Triton).

This solution is abrasive enough to extract the protein from the tool, without damaging the protein. While in solution, the artifacts were placed in an ultrasonic bath for 30 minutes, on a rotating mixer for 30 minutes, back into an ultrasonic bath for an additional 30 minutes, and once again onto a rotating mixer for an additional 30 minutes (Figures 2-5). The sonication vibrations and rotations gently pull the proteins off the tool. When removed from the ultrasonic bath, artifacts were rinsed using a small amount of reverse osmosis de-ionized (RODI) water to recover all of the protein wash solution. The extracted solution was then pipetted into a tube and promptly refrigerated to keep the proteins from breaking down. Some projectile points and large knives were selected for tip and haft sampling, to see if different proteins were identified. The same process was used, but tips and hafts were isolated during sonication (see Figures).

Figure 2 Ultrasonic bath (Used with permission from Michael Stork)

Figure 3 Rotating mixer (Used with permission from Michael Stork)

Figure 4 Ultrasonic bath for bases of artifacts (Used with permission from Michael Stork)

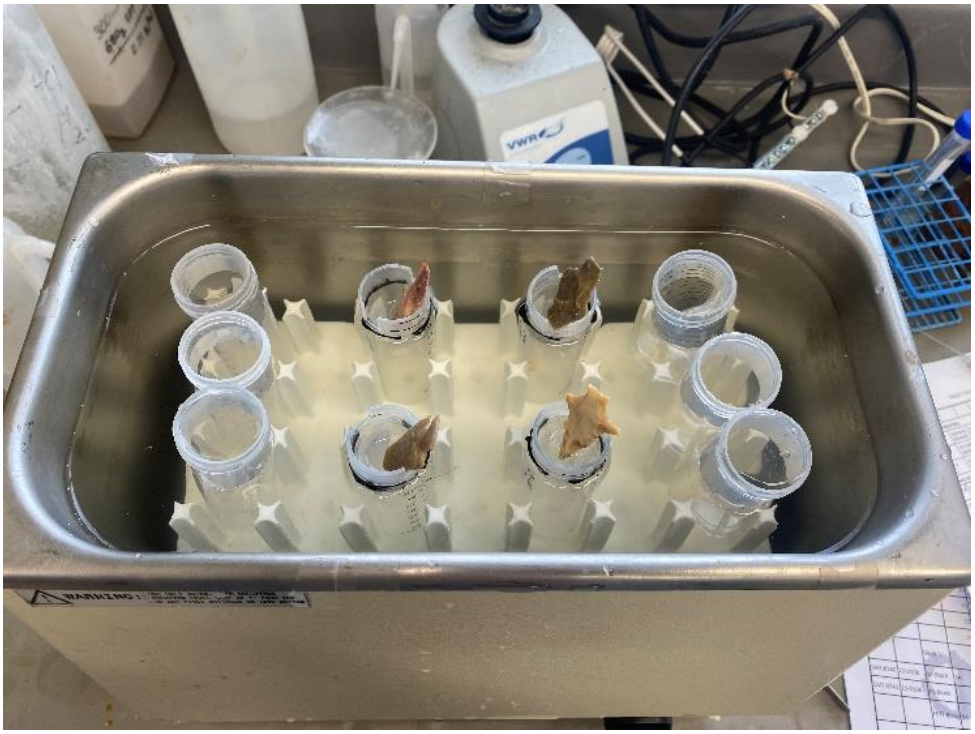

Figure 5 Ultrasonic bath for tips of artifacts (Used with permission from Michael Stork)

For larger artifacts this process was modified. Only one chopper tool (SF110) 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 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. No sediment control accompanied the chopper tool sample.

Controlling for Contamination

The initial phase involves testing all residue washes obtained from artifacts and sediment controls (if available) against pre-immune goat serum (serum derived from an animal not exposed to immunization). This screening is conducted to identify any instances of non-specific or indiscriminate protein binding. All of the artifact washes tested negative against pre-immune serum (Newman and Julig 1989:126). Sediment controls are essential to address the potential for false positives caused by compounds in sediments, such as chlorophyll, bacteria, and metal cations (e.g., manganese, copper, and iron oxide) (Evershed et al. 1996), or proteins from modern animal activity, like feces and urine. These contaminants may originate from the sampled location or may be introduced as airborne material. Therefore, sediment control samples, from the same provenience as the artifact, are recommended to eliminate potential false positives. Although, associated soil samples are not required for testing artifact washes against the available antisera. No sediment control samples accompanied these lithics. The soil samples collected from the sites were destroyed during the flotation process. The sample solutions were centrifuged to remove sediments and recover the solution with protein, which was decanted into new microcentrifuge tubes.

Tested Antisera

The samples were also tested against prepared animal and plant antisera that correlates to the artifact's origin. The tools were tested against (Table 3) list of antisera. Appropriate positive and negative controls were run for each antiserum. The blood of an animal for which the antiserum tests positively constitute the positive control, while negative controls use the serum of the type of animal in which the antiserum was raised, either rabbit or goat (Newman 1989:126). This is done to help minimize the occurrence of false positives. The anti-serum and the solution extracted from the samples, along with the controls, are pipetted into a prepared gel.

Table 3 List of Antisera Used in testing Artifacts from Site LA 20241 and LA 38597

ANTISERUM	POSSIBLE RESULTS
MAMMALS:	
Bear	Ursidae (bear family) - *Ursus americana* (black bear), *Ursus arctos* (brown bear and grizzly bear), *Ursus maritimus* (polar bear)
Bison	*Bison* sp. (bison) - *Bison occidentalis* (prehistoric bison), *Bison* (plains bison), *Bison athabascae* (mountain or wood bison); *Bos sp.* (cow), domestic bovids
Bovine	*Bos* sp. (cow), domestic bovids, *Bison* sp. (bison)
Cat	Felidae (cat family) - *Felis concolor* (mountain lion, cougar), *Felis rufus/Lynx rufus* (bobcat), *Felis catus* (domestic cat), and other wild cat species
Deer	Cervidae (deer family) - *Odocoileus hemionus* (mule deer or black-tailed deer), *Odocoileus virginianus* (white-tailed deer), *Cervus canadensis* (elk, wapiti), *Alces alces* (moose), *Rangifer* (caribou)
Dog	Canidae (dog family - coyote, wolf, fox, domestics), *Canis latrans* (coyote), *Canis lupus* (gray wolf), *Canis rufus* (red wolf), *Urocyon cinereoargenteus* (gray fox), *Urocyon littoralis* (island fox), *Vulpes vulpes* (red fox), *Vulpes macrotis* (kit fox), *Vulpes velox* (swift fox), *Canis familiaris* (domestic dog)
Goat	*Antilocapra americana* (pronghorn); *Oreamnos americanus* (mountain goat), *Capra hircus* (domestic goat)
Guinea pig	*Castor* sp. (beaver); *Erethizon dorsatum* (porcupine); Sciuridae (rodent family including tree and ground squirrels, flying squirrels, chipmunks, prairie dogs, and marmots/woodchucks) - *Tamias striatus* (eastern chipmunk), *Marmota monax* (woodchuck), *Sciurus carolinensis* (gray squirrel), *Sciurus nigra* (fox squirrel), *Tamiasciurus hudsonicus* (red squirrel), *Glaucomys* sp. (flying squirrel), *Ammospermophilus leucurus* (whitetail antelope squirrel), *Spermophilus* sp./*Citellus* sp. (ground squirrel), *Sciurus griseus* (western gray squirrel); Caviidae (cavy family) - *Cavia porcellus* (guinea pig)

Table 3 List of Antisera Used in testing Artifacts from Site LA 20241 and LA 38597	
ANTISERUM	POSSIBLE RESULTS
Mouse	Members of Cricetidae (family of New World rats and mice, hamsters, and gerbils), and Members of Murinae (Old World rats and mice family)
Pig	Suidae (pig family) - *Sus scrofa* (domestic pig and wild pig/boar, peccary)
Rabbit	Leporidae (rabbit and jackrabbits/hare family) - *Sylvilagus floridanus* (Eastern cottontail), *Sylvilagus aquaticus* (swamp rabbit or cane-cutter rabbit), *Sylvilagus bachmani* (brush rabbit), *Sylvilagus audubonii* (desert cottontail), *Sylvilagus nuttallii* (mountain cottontail), *Sylvilagus transitionalis* (New England cottontail), *Oryctolagus cuniculus* (European rabbit), *Lepus californicus* (black-tailed jackrabbit), *Lepus townsendii* (white-tailed jackrabbit), *Lepus americanus* (snowshoe hare), *Lepus capensis* (European hare)
Rat	Members of Cricetidae (family of New World rats and mice, hamsters, and gerbils), and Members of Murinae (Old World rats and mice family)
Sheep	*Ovis canadensis* (bighorn sheep), *Ovis aries* (domestic sheep)
BIRDS:	
Chicken	Phasianidae (bird family including chicken, ptarmigan, pheasant, partridge and quail) - *Colinus virginianus* (common bobwhite), *Tympanuchus* (prairie chicken), *Callipepla californica/Laphortyx californicus* (California quail), *Callipepla gambelii/Lophortyx gambelii* (Gambel's quail), *Oreortyx pictus* (mountain quail); Tetraonidae (grouse family) - *Centrocercus urophasianus* (sage grouse), *Bonasa umbellus* (ruffed grouse); domestic chicken
Turkey	Phasianidae (bird family including pheasants, partridges, junglefowl, quail, peafowl, and chickens), *Meleagris gallopavo* (wild turkey), and domestic turkey; Anatidae (duck, geese, and swan family)
FISH:	
American Eel	Anguillidae (freshwater eel family) - *Anguilla rostrata* (American eel)
Atlantic Croaker	Perciformes order (Spiny-rayed [percoid] fishes)
Catfish	Ictaluridae (catfish family), Cyprinidae (carp and minnow family), Catostomidae (sucker family)
Striped Bass	Perciformes order (Spiny-rayed [percoid] fish); Percichthyidae (temperate bass), Centrarchidae (sunfish), Percidae (perch), Cottidae

Table 3 List of Antisera Used in testing Artifacts from Site LA 20241 and LA 38597	
ANTISERUM	POSSIBLE RESULTS
	(sculpin family), Kyphosidae (sea chubs), Embiotocidae (surfperch and seaperch family), Clinidae (clinids family), Stichaeidae (pricklebacks family), Gobiidae (gobies family), Scombridae (mackerel family), Scorpaenidae (scorpionfish family), Agonidae (poacher family)
Trout	Salmonidae (trout and salmon family) - *Oncorhynchus* (salmon), *Salmo* (trout), *Salvelinus fontinalis* (brook trout), *Salvelinas namaycush* (lake trout), *Coregonus clupeaformis* (lake whitefish), *Prosopium cylindraceum* (round whitefish), *Thymallus arcticus* (arctic grayling), *Oncorhynchus mykiss* (rainbow trout), *Salmo salar* (Atlantic salmon), *Salmo trutta* (brown trout)
INSECTS:	
Grasshopper	Unknown specificity, but would likely cross-react with many insects in the order Orthoptera, which includes grasshoppers, crickets, and locusts
PLANTS:	
Acorn	Acorn
Agave	Agave, yucca, camas, aloe, & all members of the agave and lily families
Yucca	Yucca, agave, camas, aloe, & all members of the agave and lily families

<u>*Step 2*</u>

Agarose gel poured onto GelBond® film acts as the medium for CIEP (Newman). 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 (Figure 6). The anodic (-) left well contained the antiserum while the cathodic (+) right well held the artifact's protein extraction (the antigen)(Newman 1989:122-133). The pipetting of the samples is a very delicate process and must be kept uncontaminated by changing out the pipette tips after every sample (Figure 7). The samples were electrophoresed in Barbital buffer (pH 8.6) for 45 minutes at 130 V to drive the antigens and antibodies toward each other (Figure 8). The gels are then placed overnight, into a 1 M NaCl bath to remove extraneous proteins from the gel (Figure 9). The next morning the gels were pressed for 10 minutes, rinsed with RODI water for an hour, and then pressed for an additional 10 minutes (Figure 10 and Figure 11). This sequence removes extraneous water and provides a rinse to remove the NaCl. The gels were then air dried, before being stained (Figure 12).

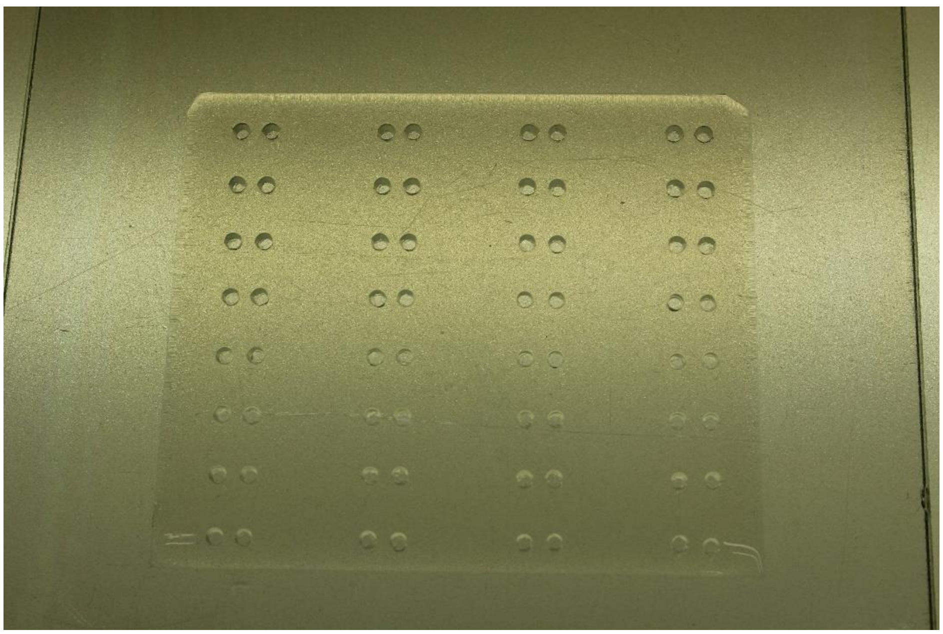

Figure 6 Photo of gel bond with punched wells (Used with permission from Michael Stork)

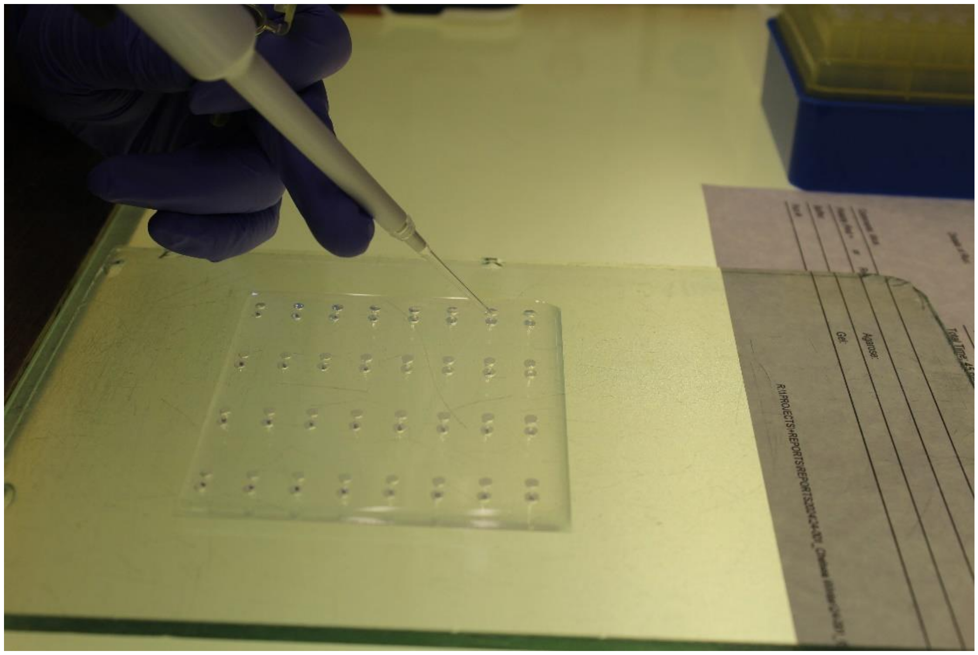

Figure 7 Photo of loading the gels with Antisera (Used with permission from Michael Stork)

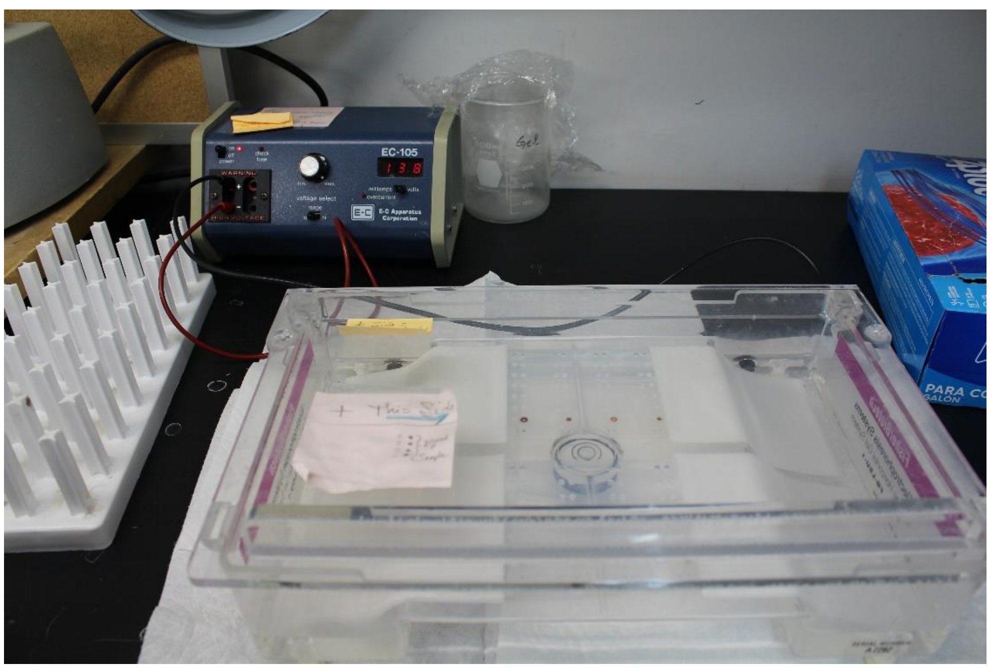

Figure 8 Photo of gels in the electrophoresis tank (Used with permission from Michael Stork)

Figure 9 Gels in the salt bath overnight (Used with permission from Michael Stork)

Figure 10 The gels being pressed (Used with permission from Michael Stork)

Figure 11 Rinsing the gels (Used with permission from Michael Stork)

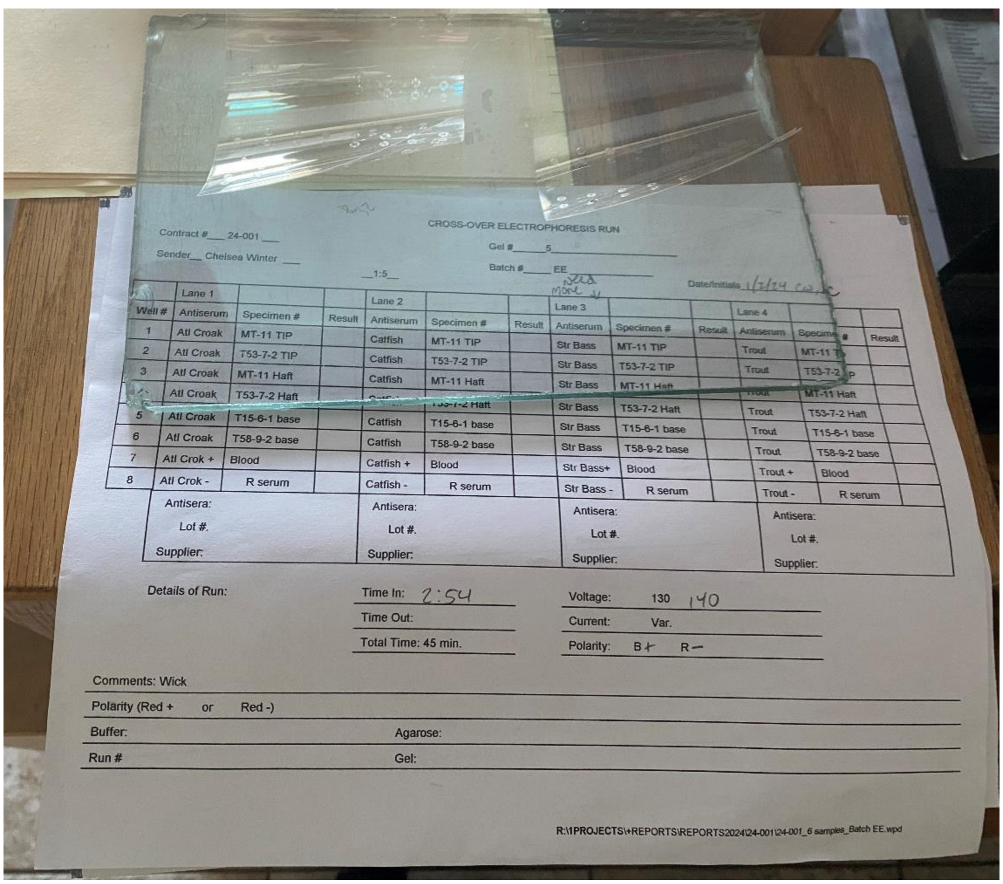

Figure 12 Photo of the dried gels (Used with permission from Michael Stork)

Step 3

According to Newman (1989:124), if the sample contains protein corresponding to the species antiserum, then a line of precipitate will form between the two wells. Coomassie Blue stain was used to make the line of precipitation easier to see. When a positive reaction was obtained between the artifact wash (antigen) and an antiserum at the 1:5 dilution, the antigen from the artifact was retested using dilute antiserum at a concentration of 1:10. Retests are performed when the original test did not yield conclusive reactions or there was a positive reaction. Retests distinguish between true and false positives, identifying a true positive when they replicate the initial positive reaction and when that reaction is not observed in the accompanying soil control sample. As stated above, soil samples were not available for control sample testing.

All positive results were recorded and read from the gels by the author and reviewed and confirmed by Linda Scott-Cummings. 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.

These methods were presented to show the reader how the samples were selected, where protein residue methods derived from, and an explanation of the process. When choosing tools for this process it was important to try and anticipate which tools would still have remaining proteins. This method was created by many different scientists to help answer questions about the past. The use of CIEP has made it possible to identify ancient proteins so that archeologists can use this method to help piece together the past. The next chapter will review the results of these methods.

Chapter 5: Results

Introduction

Twelve tools from site LA 20241 and 18 formal tools from site LA 38597 were subjected to extraction of proteins, for protein residue analysis (Table 2 and Table 3). Five samples from LA 20241 had proteins extracted separately from their tip and haft, which creates two separate samples for one tool. Six tools from LA 38597 had tip and haft proteins extracted separately. Many archaeological samples fail to produce the clear vertical lines of precipitation seen with positive blood-based controls due to different environmental conditions, varying rates of protein degradation, and lack of present proteins. The different patterns of precipitation lines and reaction strengths have been categorized by Linda Scott-Cummings, based on her experience applying these techniques. All of the recorded reactions for these samples follow her definitions of positive, very weak positives, probable positives, questionable positives, and negative reactions.

Table 4 LA 20241 Artifacts Tested

No.	Artifact No.	Portion Tested	Tool Type
1	SF110	Whole	Chopper
2	SF115	Tip and haft	Projectile point
3	SF125	Whole	Scraper
4	SF135	Tip and haft	Projectile point
5	SF138	Whole	Scraper
6	F44-1-1	Whole	Modified flake
7	T47-10-1	Tip and haft	Projectile point

8	T54-4-1	Tip and haft	Projectile point
9	T158-1-2	Whole	Scraper
10	T197-1-1	Whole	Biface
11	STP48	Tip and haft	Projectile point
12	SC-1	Whole	Projectile point

Table 5 LA 38597 Artifacts Tested

No.	**Artifact No.**	**Portion Tested**	**Tool Type**
1	MT-11	Tip and base	Projectile point
2	MT4	Whole	Projectile point
3	T120-3-2.1	Whole	Scraper
4	T131-4-2.1	Whole	Biface
5	T133-4-2	Whole	Uniface
6	T15-6-1	Tip and base	Biface
7	T156-3-1	Whole	Scraper
8	T167-8-2	Whole	Projectile point
9	T186-5-2	Whole	Scraper
10	T188-4-1	Whole	Biface
11	T65-4-2	Whole	Uniface
12	T92-7-1	Whole	Projectile point
13	T96-5-1	Tip and base	Biface
14	T96-5-2	Tip and base	Biface
15	T42-8-1	Whole	Biface

16	T53-7-2	Tip and base	Projectile point
17	T58-9-2	Tip and base	Biface
18	T63-5-1.1	Whole	Scraper

Positives

According to Scott Cummings (2018:4), “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.” All of the tools that tested positive for proteins came from site LA 38597. Tools (T42-8-1, T188-4-1, T156-3-1.1, T96-5-1 (tip), T96-5-2 (tip), T58-9-2 (tip) tested positive against chicken (Phasianidae), mouse (Cricetidae), Agave and yucca antisera. All of these tools were excavated in different units across the site (Table 4). Tool T42-8-1 is a medial section of a biface with an intricate oblique flaking pattern (Figure 7), and tested positive against the chicken antiserum. This sample produced such a strong positive reaction that it was not retested for confirmation. T-188-4-1 (Figure 10) is a broken biface and tested positive for mouse. The sample was only tested once against the mouse antiserum. T156-3-1.1 is a complete scraper (Figure 9) and it tested positive for yucca. The first run of testing for this sample had inconclusive results, but the second test returned positive for yucca. T96-5-1 is a large biface (Figure 8), and the tip and base were tested separately, only the tip returned a strong positive for Agave. The tip extraction was tested four times. The first test showed a cloud and a curved precipitate line indicating a probable positive. The second and third tests were inconclusive showing two horizontal lines and a probable positive, and the last test was positive.

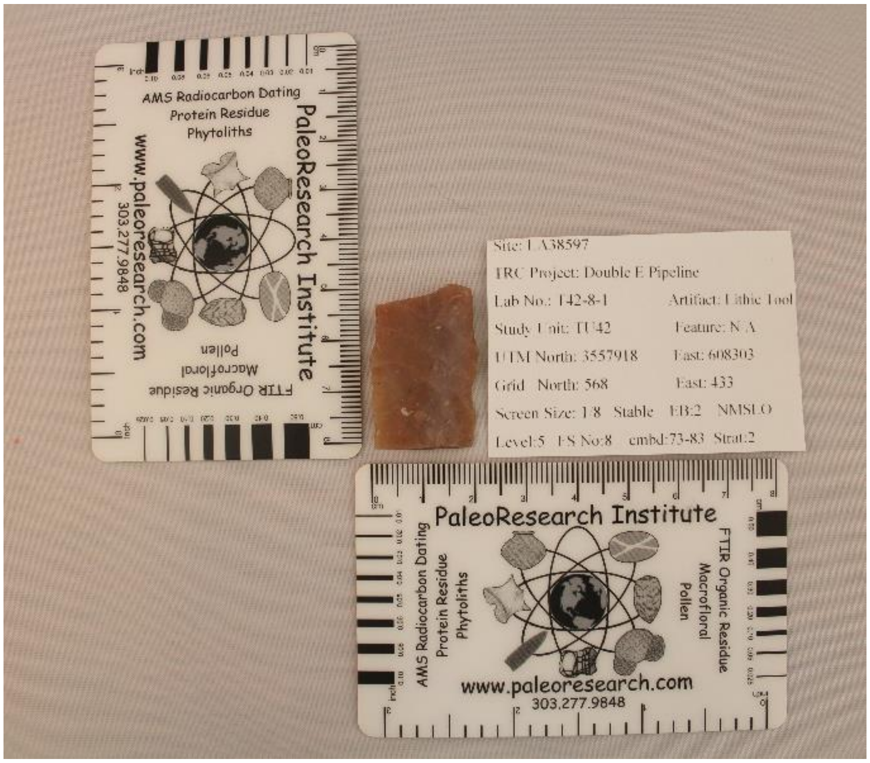

Figure 13 T42-8-1 (Used with permission from Michael Stork)

Figure 14 T96-5-1 (Used with permission from Michael Stork)

Figure 15 T156-3-1.1 (Used with permission from Michael Stork)

Figure 16 T188-4-1 (Used with permission from Michael Stork)

Tool T96-5-2 (Figure 11) is a complete biface and the tip and haft were extracted separately, with only the tip testing positive for Agave. This sample was tested against agave twice and both times the reaction produced a strong positive. T58-9-2 is also a complete biface (Figure12) and the tip and haft were extracted separately. The tip was tested against Agave three times with the last result producing a positive reaction.

Figure 17 T96-5-2 (Used with permission from Michael Stork)

Figure 18 T58-9-2 (Used with permission from Michael Stork)

<u>*Weak or very weak Positives*</u>

Not all reactions have a definite positive or negative reaction. Sometimes a weak or very weak positive is produced. A "very weak positive" demonstrates a faint precipitation line. This suggests presence of deteriorated proteins similar to the antiserum animal or plant's family or order (Cummings, 2018, p. 4). Three tools from LA 38597 and two tools from LA 20241 yielded weak or very weak positive results. The first tools presented are from LA 38597. Tool T58-9-2 (see Figure 12), haft also produced a very weak positive for yucca. This is the only weak or very weak reaction that was tested twice. The first result was negative and the second was a very weak positive. The remainder of the weak positives were not retested for further investigation. T63-5-1 (Figure 13) is a scraper with one serrated edge, and it produced a weak positive for catfish. T167-8-2 is a complete projectile point (Figure 14) that had a weak positive reaction to grasshopper.

Figure 19 T63-5-1 (Used with permission from Michael Stork)

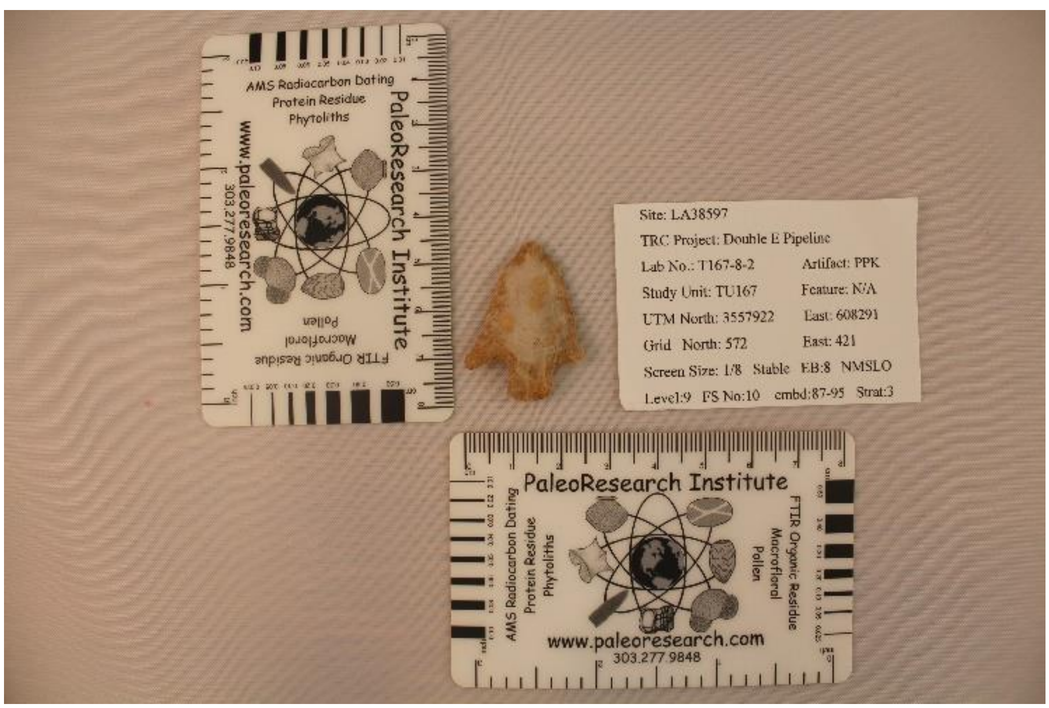

Figure 20 T167-8-2 (Used with permission from Michael Stork)

From LA 20241 T197-1-1 (Figure 15) is a broken biface that reacted to deer with a weak positive. The last very weak reaction was to agave, from tool SF 115 haft, (Figure 16) a broken projectile point.

Figure 21 T197-1-1 (Used with permission from Michael Stork)

Figure 22 SF 115 (Used with permission from Michael Stork)

<u>*Probable Positives*</u>

If the samples produce a curved or fuzzy precipitate line the reaction is defined as a probable positive. “Probable positive” samples produce a fuzzy precipitation line or curved concentrated cloud of stain during testing. These reactions suggest the presence of degraded proteins related to the animal represented by the antiserum. However, this reaction cannot be assigned as a definitive positive” (Cummings, 2018:4). There is a total of six probable positives, five from site LA 38597 and one from LA 20241. Starting with LA 38597, tools T133-4-2.1, and T120-3-2.1, produced a probable positive reading for grasshopper and yucca (Figures 17 and 18). T156-3-1.1 (see above Figure 15) extraction reacted with grasshopper. Tool

T188-4-1 (see above Figure 16) tested as a probable positive for yucca. The one outlier of the group of probable positives from site LA 38597 is the base of tool T96-5-1 (see above Figure 14 T96-5-1) that reacted with the antiserum for Atlantic croaker. The extraction for this tool was tested three times, with the first reading have a probable positive reaction, the second was negative and the third was a probable positive reaction. For site LA 204241 the only tool that had a probable positive is the tip of tool T47-10-1 (Figure 19) and the reaction was with the deer antisera.

Figure 23 T133-4-2.1 (Used with permission from Michael Stork)

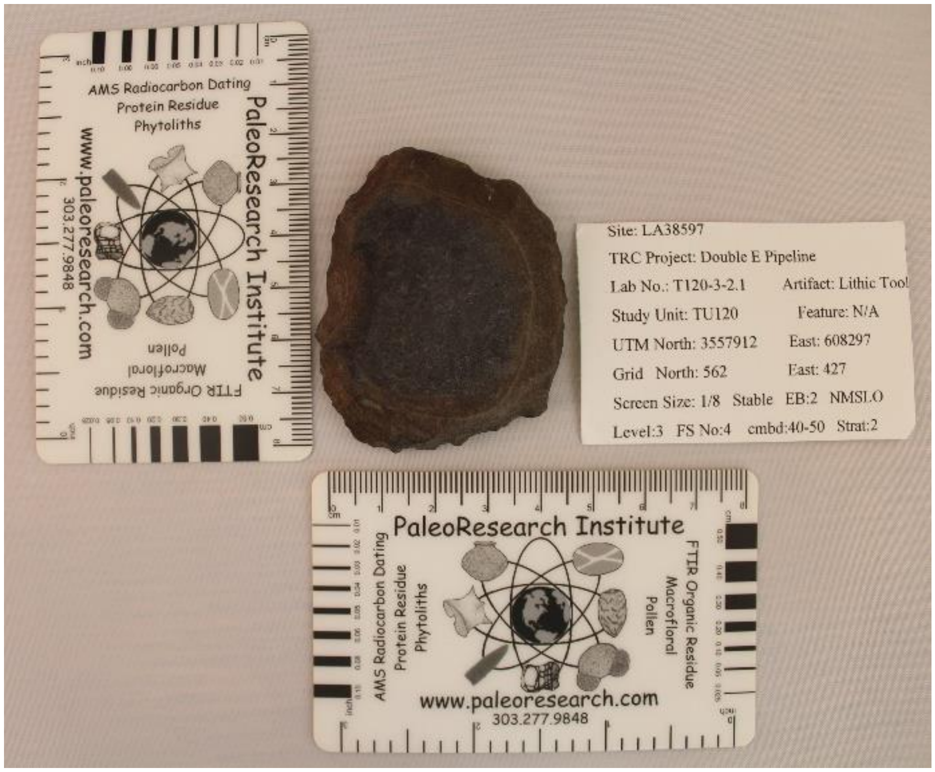

Figure 24 T120-3-2.1 (Used with permission from Michael Stork)

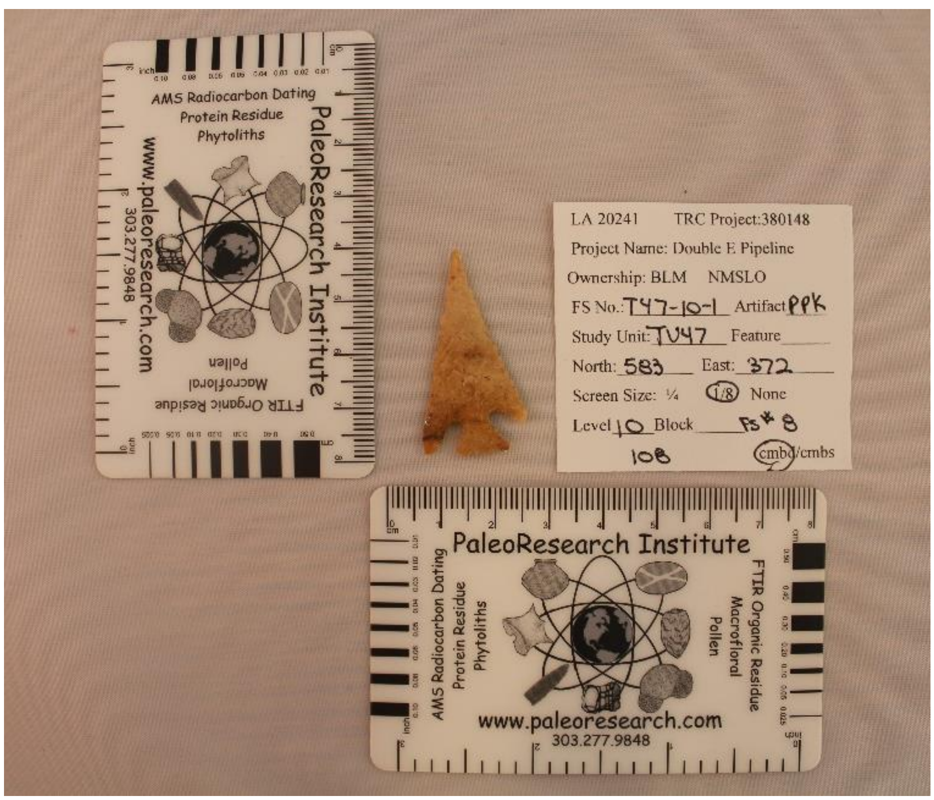

Figure 25 T47-10-1 (Used with permission from Michael Stork)

Questionable positives and Negatives

"Reactions lacking vertical precipitation lines, such as a dense cloud of stain concentrated between the anodic and cathodic wells, are recorded as "questionable positives." These results suggest the sample washes contain proteins, but do not definitively identify their presence" (Cummings, 2018:4). All of the reactions that produced dense clouds were identified as negative or were retested and proven negative. There were no questionable positives in this study by the definition provided. According to Scott-Cummings, when "there is no visible reaction, the sample is categorized as "negative," indicating the absence of proteins related to animals represented by the antiserum in the sample wash." The remaining samples were categorized as negative for the tested antisera (Table 6). All of the reactions were recorded during testing to better guide retesting.

Table 6 Negative results

Sample No.	**Description**	**Site, Test unit**	**Dilution for all antisera**	**Results**
SF110	Scraper	LA 20241, Surface	1:5	Negative
SF125	Scraper	LA 20241, Surface	1:5	Negative
SF135	Projectile point	LA 20241, Surface	1:5	Negative
SF138	Scraper	LA 20241, Surface	1:5	Negative
F44-1-1	Modified flake	LA 20241, Feature 44	1:5	Negative
T54-4-1	Projectile point	LA 20241, TU 54	1:5	Negative
T158-1-2	Scraper	LA 20241, TU 158	1:5	Negative
STP48	Projectile point	LA 20241, Shovel test 48	1:5	Negative

SC-1	Projectile point	LA 20241, Scrape 1	1:5	Negative
MT-11	Projectile point	LA 38597, Mechanical trench	1:5	Negative
MT4	Projectile point	LA 38597, Mechanical trench 4	1:5	Negative
T131-4-2.1	Biface	LA 38597, TU 131	1:5	Negative
T15-6-1	Biface	LA 38597, TU 15	1:5	Negative
T186-5-2	Scraper	LA 38597, TU 186	1:5	Negative
T65-4-2	Uniface	LA 38597, TU 65	1:5	Negative
T92-7-1	Projectile point	LA 38597, TU 92	1:5	Negative
T53-7-2	Projectile point	LA 38597, TU 53	1:5	Negative

Summary of Results

Overall, 17 artifacts yielded positive results from the CEIP process, ranging from strongly positive reactions of the antisera to weak and only probably positive reactions. Summary data for all positive results are presented in Table 6, below. Due to time constraints, some samples were not retested for confirmation of results, and are preserved for future research. When analyzing these results, it is important to remember that the antisera only provide us the family of the species, so a positive for chicken, for example, could be a variety of any Phasianidae (bird family including chicken, ptarmigan, pheasant, partridge and quail). Another item of note is that there were no corresponding soil samples to test for contamination. These tests only show if protein is present, not when the tool was exposed to the protein. There is a good possibility that the proteins in the soil may have been represented in the data set. The analysis chapter will discuss the potential protein uses, and reasons why particular proteins were discovered on different tool types.

Table 7 Positive Results

Sample No.	**Description**	**Site, Test unit**	**Dilution**	**Positive result (Antiserum Type)**	**Reaction Strength**
T42-8-1	Biface (broken)	LA 38597, TU 42	1:5	Chicken	Positive
T188-4-1	Biface (broken)	LA 38597, TU 188	1:5	Mouse	Positive
T156-3-1.1	Scraper	LA 38597, TU 156	1:5	Yucca	Positive
T96-5-1 tip	Biface	LA 38597, TU 96	1:5	Agave	Positive
T96-5-2 tip	Biface	LA 38597, TU 96	1:5	Agave	Positive
T58-9-2 tip	Biface	LA 38597, TU 58	1:5	Agave	Positive
T58-9-2 base	Biface	LA 38597, TU 58	1:5	Yucca	Very weak positive
T63-5-1	Scraper/knife ?	LA 38597, TU 63	1:5	Catfish	Weak positive
T197-1-1	Biface	LA 20241, TU 197	1:5	Deer	Weak positive
T167-8-2	Projectile point	LA 38597, TU 167	1:5	Grasshopper	Weak positive
SF 115 base	Projectile point	LA 20241, Surface	1:5	Agave	Very weak positive
T156-3-1.1	Scraper	LA 38597, TU 156	1:5	Grasshopper	Probable positive
T133-4-2.1	Uniface	LA 38597, TU 133	1:5	Yucca, Grasshopper	Probable positive
T188-4-1	Biface	LA 38597, TU 188	1:5	Yucca	Probable positive
T120-3-2.1	Scraper	LA 38597, TU 120	1:5	Yucca, Grasshopper	Probable positive
T47-10-1 tip	Projectile point	LA 20241, TU 47	1:5	Deer	Probable positive
T96-5-1 base	Biface	LA 38597, TU 96	1:5	Atlantic croaker	Probable positive

Chapter 6: Analysis of Results

Introduction

The results of this study alone can be confusing, but with proper background research and cultural context they become more tangible. This chapter interprets the corresponding results with the most likely of species options that are historically present in the region. The tools from sites LA 20241 and LA 38597 were not tested against all available proteins, but a select group of proteins that would be likely to exist or previously exist in the region of SENM. The complete list of antisera that the tools were tested with can be found in methods in (Table 3). The antisera list presented in (Table 8) represents the antisera that positively reacted with the samples and the corresponding possible origins of the proteins. These results have provided a valuable glimpse of an ancient lifestyle. This way of life and its knowledge only remains in the oral traditions of its descendants, and in archeological evidence.

Table 8 Antisera list with positive reactions

Antiserum	Possible Results
Deer	Cervidae (deer family) - *Odocoileus hemionus* (mule deer or black-tailed deer), *Odocoileus virginianus* (white-tailed deer), *Cervus canadensis* (elk, wapiti), *Alces alces* (moose), *Rangifer* (caribou)
Mouse	Members of Cricetidae (family of New World rats and mice, hamsters, and gerbils), and Members of Murinae (Old World rats and mice family)
Chicken	Phasianidae (bird family including chicken, ptarmigan, pheasant, partridge and quail) - *Colinus virginianus* (common bobwhite), *Tympanuchus* (prairie chicken), *Callipepla californica/Laphortyx californicus* (California quail), *Callipepla gambelii/Lophortyx gambelii* (Gambel's quail), *Oreortyx pictus* (mountain quail); Tetraonidae (grouse family) - *Centrocercus urophasianus* (sage grouse), *Bonasa umbellus* (ruffed grouse); domestic chicken
Atlantic Croaker	Perciformes order (Spiny-rayed [percoid] fishes)

Catfish	Ictaluridae (catfish family), Cyprinidae (carp and minnow family), Catostomidae (sucker family)
Grasshopper	Unknown specificity, but would likely cross-react with many insects in the order Orthoptera, which includes grasshoppers, crickets, and locusts
Agave	Agave, yucca, camas, aloe, & all members of the agave and lily families
Yucca	Yucca, agave, camas, aloe, & all members of the agave and lily families

Chicken (Phasianidae)

One of the first positive reactions that appeared during testing was from the chicken antisera and tool T42-8-1, a biface. This tool is determined to be from the Late Paleoindian period, based on its oblique parallel faking pattern and high-quality chert material (Cleeland et al.2023). The occupation of Site LA 38597 is not dated that early. There are many different species that fall within the Phasianidae family, so the most likely birds will be discussed. The lesser Prairie chicken is on the endangered species list and its habitat is known to be in the region of SENM. The bird's habitat has been destroyed by industrial development in conjunction with climate change. It is unlikely to see Prairie chicken in the area today, but it is possible they were in the area during the site's occupation. Quail is the most likely species to have met their demise by this tool.

According to Cummings and Kováčik (2013:37) four species of quail are known in the area: Montezuma quail, Bobwhite quail, Scaled quail, and Gamble's quail. Only Bobwhite quail and Scaled quail are currently in the area (Kemees et al., 2008:5). During a micro floral, phytolith, and starch analysis on radiocarbon samples for the Permian Basin in New Mexico, Cummings and Kováčik (2013) found a synergistic relationship with the distribution of whitemouth dayflower (*Commelina erecta*), quail, and human occupation. She poses that it is probable that the hearths that people left crated a viable spot for plants to thrive, when the vegetation increased it created a winter habitat for the quail. It is probable that the increased number of quail on the landscape attracted people during the winter months to enrich their diet. *Commelina erecta* seed phytoliths were in sediments from four features at site LA 38597 (Cleeland et al. 2023:360). It was speculated in the report that quail was processed at LA 38597 because of the presence of the whitemouth dayflower, but without faunal materials it is impossible to prove (Cleeland et al. 2023:365). The data from this study supports the inference that Phasianidae (most likely quail) was processed at this site, conceivably for dietary and other purposes.

Agave (Agavaceae)

Three tools (T96-5-1 tip, T96-5-2 tip, T58-9-2 tip) from site LA 38597 tested positive for Agave, yucca, camas, aloe, all members of the agave and lily families. Since there is dense ethnographic and scientific evidence of the importance of Agave, the use of mescal agave will be discussed. All three of these tools are categorized as bifaces, made from silicified sandstone (Cleeland et al. 2023). They are worked on both sides, but do not have sharp lateral edges. During the preliminary examination of these tools, it was noted that the lateral edges were not sharp, so the tips and bases were tested for proteins. It was hypothesized that since the lateral edges were not the "working edges" that the tip and base of the tools may have been used instead. The size and similar appearance of the bifaces supported their identification as agave knives. New Mexico Office of Archaeological Studies OAS's 128 project discusses agave knives which were claimed to have been used for processing yucca, agave, and Sotol (Wiseman 2014:480–498). According to Railey (2016:198), the agave knives are more commonly found than direct evidence of burned agave fragments remaining in hearths or middens, however they have been observed west of the Pecos River. Agave or mescal agave (Agavaceae) with the Apache name *naa'da*, is used for its roots, stems, and hearts (Mescalero Apache THPO). In Bryant's (1974:413) study of coprolites from within the Permian Basin, agave was one of the most common flowers found to have been eaten. Ethnographically, the crowns of the agave would have been dug out during spring or summer months, with three-foot digging sticks cut from oak. The leaves would then be trimmed off, leaving the heart of the plant for roasting for several days, to finally be eaten, possibly with pinon or sumac berries. The leaves of the mescal are used to promote the healing of burns, and can be stripped to be made into ties for ceremonies (Mescalero Apache THPO n.d). The spike at the tips of the leave can be peeled off with an attached strand to make and instant needle and thread (Mescalero Apache THPO n.d).

Tools T96-5-1 and T96-5-2, respectively identified as bifaces, were found together, in what may be a cache. According to Cleeland et al. (2023) "the two bifaces were at the same depth as Feature 29 in TU 96 and were found in situ, one lying over the other, with signs of calcium carbonate formation on their abutting surfaces. They represent a cache or, more likely accidental loss" (Cleeland 2019:186). With all of the evidence gathered from the excavation, and what is known about the peoples of that time in this region, we know that site LA 38597 had repeated use as part of the seasonal rounds. It is not inconceivable that they cached these tools, with the intention of returning.

Deer (Cervidae)

The type of deer that inhabit this area are mule or black-tailed deer (*Odocoileus hemionus)* (Brown and Lowe 1994:178)(Cleeland 2023:16). Deer have been present in this area since the Late Pleistocene (26,000-11,700 BP) (Cleeland 2023:16-19). Mule deer is reported to be hunted in the fall with great respect, and the most important game animal for Mescalero subsistence (Brown et al. 2010:40). Two tools from LA 20241 reacted with deer antiserum. Biface fragment T197-1-1 exhibited a weak positive reaction, and projectile point T47-10-1 tip showed an even weaker sign of the protein with a probable positive reaction. No deer faunal remains were collected during the excavation, or noted in previous recordings. In Railey's (2016:199) study examining 288 excavated sites in the area, only 25.3% contained faunal remains, and nine sites contained deer faunal remains. This includes the Merchant site where deer and other ungulates were suggested to be hunted for frequently (Miller 2013, Railey 2016:206). "Deer constituted the largest percentage of meat in the Mescalero diet, or at least this was the case once the Mescalero had been largely excluded from the high plains by the Comanche" (Railey 2016:211). With archeological evidence and results from the protein residue analysis, these tools were mostly likely used for shooting/spearing, and processing deer at or near site LA 20241.

Catfish (Ictaluridae) and Atlantic Croaker (Perciforms)

As seen in Table 7 Atlantic Croaker antiserum translates to Perciformes order (Spiny-rayed [percoid] fishes) and Catfish antiserum could potentially be Ictaluridae (catfish family), Cyprinidae (carp and minnow family), and/or Catostomidae (sucker family). This creates a large range of possibilities that could have been fished from the Pecos River. Instead of discussing each possible species, the presence of fish in the SENM archeological record will be discussed. As demonstrated by the abundance of shell at LA 20241, it is known that freshwater mollusks were of exceptional importance (Cleeland, Railey 2016:203). "Today the Pecos River provides the main, if not only, habitat for freshwater mussels in the CFO region, and east of the river there are no surviving aquatic habitats suitable for mussels" (Railey 2016:203). Faunal remains are rare in the SENM generally, and fish bones are only present at one archeological site in SENM. However, during a data recovery at Rascal Rabbit site, 30 km east of the Pecos River, a complete ceramic bowl was found containing evidence of fish (Boggess 2018). Several analyses were conducted on the bowl including petrography, lipid residue analysis, and Fourier Transform Infrared Spectroscopy (FTIR). The Lipid residue and FTIR analysis concluded that fish had been cooked inside that bowl (Boggess 2018). The only reported fish remains in the CFO is at site LA X29D34, near the Pecos River (Railey 2016:205). Sample T63-5-1 base reacted with the catfish antiserum, providing a weak positive result. This sample was only tested once and should be retested for confirmation during any future research. Sample T96-5-1 base was tested three times with varying results. The first test precipitated a probable positive reaction, second a negative, and third a probable positive reaction. These results provide probable evidence that fish was processed at site LA 38597.

Yucca

Five samples from LA 38597 tested positive for Yucca which includes agave, camas, aloe, and all members of the agave and lily families. The samples' reactions ranged from positive to probable positive. There are four species of yucca that grow in the region (*baccata, campestris, elata, torreyi*) but only the Plains yucca (campestris) grows directly around site LA 38597 (William& Floyd 2017:280). When examining plant use and remains in the archeological record in SENM, researchers have to look to rock shelters and caves in the area. Caves are known to archeologists as a prime location for preservation of perishable artifacts such as plant materials. It was not until 1978 that an excavation at Granado Cave used modern archeological methods, and provided the best example of perishable materials in the region (William & Floyd, 2017;39). It is reported that, "yucca is most commonly used for textiles, sandals, cordage, and mats, along with other succulents such as sotol and beargrass" (William & Floyd 2017:39). Site LA 38597 contained an abundance of thermal features and groundstone implements suggesting a reliance on plant foods including wild barley, yucca root, mesquite bean, sotol, and agave (Cleeland et al 2023:34). Due to the abundance of yucca in the area, and lack of comparative soil samples to compare, contamination is a possibility such that the positive precipitate reactions are detecting modern yucca proteins. However, the tools that had a reaction with the yucca antisera, could all have been feasibly used to, cut, chop, or strip yucca leaves for food, sandals, matts, baskets, medicine or ceremonial purposes.

Mouse (Cricetidae)

One broken biface T188-4-1 tested positive for mouse antisera and corresponds to the members of Cricetidae family and Murinae (see Table 7). This tool was only tested once, due to time constraints and the strong positive reaction. Non-cultural rodent activity on sites in the SENM are extremely common. Their burrows often disturb artifacts, contaminate the site contexts, and leave small mammal skeletal remains behind (Cleeland et al. 2023:74). Railey (2016:203) reports that unidentified small mammal remains are reported from 33 sites within the SENM, possibly fragmentary rabbit remains, but also include the fragmented bones of rodents. He notes that many of the bones are natural occurrences that are unrelated to human activity. Soil samples from site LA 38597 were analyzed and found an abundance of rodent feces in every sample (Cleeland 2023:75). Despite the strong possibility of contamination, there is evidence that rodents were a part of ancient diet. In Bryant's (1974:415) study of the coprolites, small mammals of the rodent class were found to have been consumed with prickly pear flower along with wild onion bulbs, and monocot fibers (similar to cattail stems). Although it is possible that this tool had processed a kangaroo rat, packrat, or mouse, it is more probable that this tool was contaminated. Another contaminant present in many of the soils samples at site LA 38597 are insect remains.

Grasshopper

Four tools reacted with the grasshopper antiserum from site LA 38597, with one weak positive and three probable positives. Tool T167-8-2 is a projectile point that provided the weak positive reaction. Tools T156-3-1.1 and T120-3-2.1 are scrapers, and T133-4-2.1 is a uniface. Tools T133-4-2.1 and T120-3-2.1 also reacted with the yucca antiserum. None of these tools would have been used to capture or process grasshoppers. According to LA 38597 report, 21 flotation samples were submitted for paleoethnobotanical analysis and all samples contained "abundant indicators of chronic and intense biological disturbance, mostly insects" (Cleeland et al. 2023:349). Despite the insect contamination of these tools, grasshoppers were most likely on the menu. Three coprolite samples from site 41VV162 contained 6-25% grasshopper and one sample contained between 26-50% grasshopper based upon total volume (Bryant 1974:414). According to Reinhard, (2000:127) grasshoppers are the most common prehistoric dietary insect. (Cleeland et al.2023:413).

Contamination may have played a minor role in the results of this study, but overall, the tools accurately reflect the types of plants and animals processed at sites LA 20241 and LA 38597. The archaeological record in southeastern New Mexico (SENM) and corresponding site reports further support these findings. During their seasonal rounds of plant collection, Late Archaic to Late Formative people acted as naturalists, with an intimate knowledge of when and where to find the plants essential for their survival. The disturbed land they left behind may have created environments favorable for plant growth, attracting quail, which could later be exploited. The Texas coprolite study identified the primary diet as including the flowers of Yucca, Agave, and Sotol (Bryant 1974). While gathering plants, it is likely that quail, deer, rodents, and grasshoppers were also encountered and processed as supplemental food sources.

Chapter 7: Conclusions

This study sought out to answer the question of, what food resources were processed at sites LA 20241 and LA 38597. With the analyses from the excavations at sites LA 20241 and LA 38587, coupled with the protein residue analysis, enough data was produced to show some of the plants and animals that were processed at these sites. The successful excavations at these sites were a product of BLM compliance with National, State, and agency regulations, so that impacts to portions of the sites within the project right-of-way would be mitigated via data recovery, within specified research frameworks discussed in this thesis. Because of the thorough synthesis of this data new questions can be asked. Can the methods of this study be more regularly applied in SENM? The potential for future research from this study may answer these questions. What is the cultural significance of these resources identified at these sites? If protein residue analysis can be applied to more Late Formative sites in the region, then even more specific questions could be answered. All of the collections from these sites are currently located in the Museum of Indian Arts and Culture in Santa Fe, New Mexico. With the guidance of, Dr. Linda Scott-Cummings at the Paleo Research institute, I was able to test protein-containing residues from select artifacts against proteins known to the area.

This study revealed that chicken (*Phasianidae*), mouse (*Cricetidae*), yucca, and agave families produced the strongest positive reactions for six of the tools tested. It is probable that the reaction with the chicken antisera was most likely related to quail, due to their history and current presence in the region. The mouse protein is likely to have been a product of contamination, but may express exploitation and processing of rodents in the area. Yucca and Agave have a documented importance in this area, due to their versatile and ceremonial purposes. These results, paired with the excavation analyses, support a primarily plant diet with hunting or trapping as a secondary activity. These results have made a broader impact on the region's research questions and possibly CRM practices.

The PBRD states that one of the primary objectives is to conduct additional excavations at Late Formative "Village" sites "to recover subsistence remains, chronometrically datable materials, and other important information" from those type of sites (Railey 2016:339). This protein residue analysis study did contribute to the gathering of subsistence remains from two different sites in SENM. It showed that eight of the samples from LA 38597 had yucca and agave protein residue identified on them and four samples yielding animal or fish protein residue. At LA 20241 only three samples positively reacted with the antisera, two being from the deer (Cervidae) family and one reaction to Agave. As discussed in Chapter 1, due to typical soil conditions faunal remains are not commonly found in sites in SENM. Protein residue analysis assists in filling that void in the archeological record to illustrate what plants and animals were processed at sites.

These methods can potentially be utilized in the future to continue to add to the archeological record in the CFO region. As science and technology evolve, so does cost efficiency. Protein residue analysis technology may not be as costly in a few short years. Dr. Reuther (2006) presents an improved radioimmunoassay (pRIA) technique that is so sensitive and accurate for identifying proteins that residues can be identified to genus. It may be possible that the solutions that have been extracted and curated for this study could be used in the future to identify the species to the genus level. With advancements in DNA technology, it could be possible to identify individual animals. These techniques can only be utilized with the cooperation and support of the BLM and CRM agencies..

This study was not conducted without its challenges. Protein residue analysis only provides proteins to the family level and not the genus. This alone places limitations on the study. While it is likely that quail was processed at LA 38597 and not domestic chicken, it can still not be proven through this process alone. The catfish (Ictaluridae) and Atlantic croaker (Perciformes) antisera that positively reacted with two tools from LA 38597 most likely came from species that live in the Pecos River or one of its tributaries, but without more archaeological evidence or advancement in technology, it can’t be proven. This study also faced issues with post-field laboratory processes. In order to eliminate the possibility of contamination such as, rodent or insect proteins in the surrounding soils of the tools, soil samples are needed for testing. Over 200 soil samples were collected for both site LA 20241 and LA 38597, and unfortunately none of it was saved for future research. The soil samples were either expended for flotation, or screened for recovery of macrobotanical remains. In the future it would be best to save at least part of each soil sample. This oversight was most likely due to time restrictions and pressures in the laboratory, and it suggests the general need for greater coordination between specialized analyses and circumspect management of such processes. The inability to test soil samples from the sites does not invalidate the results of this thesis, but leaves some questions unable to be answered with available data.

This study required extensive travel time, many lab hours learning the process, and each sample required about three days to produce results. The steps to protein residue analysis requires time and patience. As discussed in the presentation of results for this thesis, the reactions to the antisera varied in strength. Due to time and resource constraints, not all of the positive results were able to be retested for confirmation. If this study continued it would be a priority to re-test the samples that produced a weak or probable positive reaction. All of the sample solutions are curated and frozen at the Paleo Research Institute for future research. Only one sample (T65-4-2, uniface) ran out of solution during the testing process.

The CRM industry attempts to focus on the client's project and what is required to complete it, while also being answerable for archeological research frameworks for the region. With the pressure to get projects complete in an efficient manner, while following state and BLM regulations, sometimes the science takes a backseat. The soil samples being completely destroyed for other analyses is a perfect example of that. However, the Permian Basin Mitigation Program (PBMP) has established a cohesive research design for all CRM companies working within the CFO region of SENM to use as a guide in answering regional research questions and additional funding to support that research. This regulatory tool has encouraged improved systematic scientific methods for the CFO region and has supported the efforts of the pursuit of archeological data. Despite the challenges this study faced, an interdisciplinary approach taken by SEARCH and TRC led to the success of this research. All of the analyses conducted during the excavations support the findings of this study that plants were the primary diet with hunting or trapping as a secondary activity. Now we know archeologists can apply protein residue analysis to use as supporting evidence in this region. The samples extracted from this study can be used in future research to investigate the species identified to the genus level. In order to assist studies in the future, it is important to always be thinking of future research potential of materials collected from an excavation. With the knowledge gained from this study, it is my hope that protein residue analysis be considered as a useful technique in the region of SENM and acknowledged during the analyses of mitigated artifacts.

Bibliography

Acklen, John C., and Jim A. Railey (editors)
2001 Final Report for Testing and Data Recovery at Five Sites Near Carlsbad, New Mexico. TRC Mariah Associates Inc., Albuquerque.

Binford.
1980. "Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation." *American Antiquity* 3-20.

Bird, Rebecca Bliege, Eric Alden Smith, and Douglas W. Bird
2001 The Hunting Handicap: Costly Signaling in Human Foraging Strategies. Behavioral Ecology and Sociobiology. DOI 10.1007/s002650100338.

Bog-Hansen, T. C.
1990 Immunoelectrophoresis. In Gel Electrophoresis of Proteins, edited by D. Rickwood, and B.D. Hames, pp. 273-300. Oxford University Press, Oxford.

Brown, Marie E. (editor)
2011 The Boot Hill Site (LA 32229): An Oasis in the Desert, Eddy County, New Mexico. TRC, Albuquerque.

Bryant, Vaughn M. Jr.
1974. *Prehistoric Diet in Southwest Texas: The Coprolite Evidence*. American Antiquity, Vol. 39, No. 3 (Jul., 1974), 407-420.

Campbell, Kirsten, and Jim A. Railey (editors)
2008 Archaeology of the Hondo Valley, Lincoln County, New Mexico: Archaeological Investigations Along US 70 from Ruidoso Downs to Riverside. New Mexico Department of Transportation, Cultural Resource Technical Series 2006-1. SWCA Environmental Consultants and Parsons Brinckerhoff, Albuquerque.

Cleeland Lauren, Kathryn Parker-Hutzel, Leeanne Mahoney, Chelsea Winter, Chris Clement, and Howard Higgins.
2023. "Results of Data Recovery At Site LA 38597 For the Double E Pipeline Project, Eddy County, New Mexico." Austin.

Cleeland Lauren, Kathryn Parker-Hutzel, Leeanne Mahoney, Chelsea Winter, Chris Clement, and Howard Higgins.
2023. "Results of Data Recovery At Site LA 20241 For the Double E Pipeline Project, Eddy County, New Mexico." Austin.

Collins, M. J., & Riley, M. S.
2000. "Proteins in a post-genomic era: The biology and preservation of ancient proteins." *Journal of Archaeological Science*, 27(9), 777-784.

Condon, Peter C., David D. Kuehn, Linda Scott Cummings, Maria Hroncich, Lillian M. Ponce, Nancy Komulaine, and Willi Hermann
2008 Archaeological Testing and Data Recovery Recommendations for 16 Prehistoric Sites, Bear Grass Draw, Eddy County, New Mexico. TRC, El Paso.

Craig, O. E.
2000. The survival and detection of proteins on archaeological potsherds. PhD Newcastle-upon-Tyne.

Culliford
1971 The Examination and Typing of Bloodstains in the Crime Laboratory. United States Department of Justice, U.S. Government Printing Office, Stock 2700-0083, Washington, D.C.

Cummings, L. S.
2018. Protein Residue Analysis of Metal Weaponry from Site 28ME363 Possibly Associated with the Revolutionary War Battle of Princeton, Mercer County, New Jersey. Golden Colorado.

Dering, J. Phil
1999 Earth Oven Plant Processing in Archaic Period Economies: An Example from a Semi-arid Savannah in South-Central North America. American Antiquity 64(4):659–674.

D. W. Ingersoll, J. E. Yellen, and W. Macdonald. 1977. *Experimental Archaeology*. New York: Columbia University Press.

Evans, Glen
1951 Prehistoric Wells in Eastern New Mexico. American Antiquity 17:1–9.

Evershed, Richard, Connie Kolman, Noreen Tuross, and Mel Wachowiak
1996 Residue Analysis: How You Can Do It and How Much It Will Cost. Copies available from A Workshop Presented at the 61st Annual Meeting of the Society for American Archaeology, New Orleans, Louisiana.

Gaensslen, R. E.
1983 Sourcebook in Forensic Serology, Immunology, and Biochemistry. United States Department of Justice, Washington, D.C.

Gould, R.A. 1978. *Explorations in Ethnoarchaeology*. Albuquerque: University of New Mexico Press.

Green, F.E.
1962 Additional Notes on Prehistoric Wells at the Clovis Site. American Antiquity 28:230–234.

Grissino-Mayer, Henri D., C.H. Baisan, and T.W. Swetnam

1997 A 1,373 Year Reconstruction of Annual Precipitation for the Southern Rio Grande Basin. Report submitted to the Directorate of Environment, Natural Resources Division, Fort Bliss, Texas, for the Legacy Program.

Hasnain, Shelly Volsche and Annemarie. 2022. *Introduction to Evolution & Human Behavior An Anthropological and Comparative* . Boise: Creative Commons Attribution NonCommercial ShareAlike. Introduction to Evolution & Human Behavior – Simple Book Publishing

Heilen, Phillip O. Leckman and Michael.
2023. "Our Checkered Past Sites, Landsacapes, Trails, and Trsansect-Recording Unit Survey." In *Advances in Archaeological Practice*, by F. Kirk Halford and Dayna M. Ables, 11-28. Cambridge University Press.

Hester, Thomas R., and Robert F. Heizer
1972 Problems in the Functional Interpretation of Artifacts: Scraper Planes from Mitla and Yagul, Oaxaca. In University of California Archaeological Facility Papers No. 14, pp. 109–110. Department of Anthropology, University of California at Los Angeles, Los Angeles.

Hogan, Patrick. 2006. *Southeasten New Mexico Regional Research Design and Cultural Resourse Management Strategy.* Santa Fe: Office of Contract Archaeology.

Huckell, Bruce B.
1996 The Archaic Prehistory of the North American Southwest. Journal of World Prehistory 10(3):305–373.

Hyland, D. C., J. M. Tersak, J. M. Adovasio, and M. I. Siegel
1990 Identification of the Species of Origin of Residual Blood on Lithic Material. American Antiquity 55(1):104-111.

Irwin-Williams, Cynthia
1973 The Oshara Tradition: Origins of Anasazi Culture. Eastern New Mexico University Contributions in Anthropology 5. Portales. 1979 Post-Pleistocene Archeology, 7000–2000 B.C. In Handbook of North American Indians, Vol. 9: Southwest, edited by Alfonso A. Ortiz, pp. 31–42. Smithsonian Institution, Washington, D.C.

Jones, Terry L., Gary M. Brown, L. Mark Raab, Janet L. McVickar, W. Geoffrey Spaulding, Douglas J. Kennett, Andrew York, and Phillip L. Walker
1999 Demographic Crises in Western North America During the Medieval Climatic Anomaly. Current Anthropology 40(2):137–170.

Jones, Joshua G., Timothy M. Kearns, and Janet L. McVickar (editors)

2010 Archaeological Investigations for the AT&T Nexgen/Core Project: New Mexico Segment. Western Cultural Resource Management. Farmington, New Mexico.

Justice, Noel D.
2002 Stone Age Spear and Arrow Points of the Southwestern United States. Indiana University Press, Bloomington and Indianapolis.

Kelly, R.L. 2000. *Thinking about Prehistory. In Models for the Millennium: Great Basin Anthropology Today.* Salt Lake City: University of Utah Press.

Kelly, Robert L. 1995. *The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways.* Washington D.C: Smithsonian Institution Press.

Lord, Kenneth J., and William E. Reynolds
1985 Archaeological Investigations of Three Sites within the Wipp Core Area, Eddy County, New Mexico. Chambers Consultants and Planners, Albuquerque.

Mallouf, Robert J.
2005 Late Archaic Foragers of Eastern Trans-Pecos Texas and the Big Bend. In The Late Archaic Across the Borderlands, edited by Bradley J. Vierra, pp. 219–246. University of Texas Press, Austin.

Mallouf, Robert J.
1985 A Synthesis of Eastern Trans-Pecos Prehistory. Master's thesis, Department of Anthropology, University of Texas at Austin.

Meltzer, David J., and Michael B. Collins
1987 Prehistoric Water Wells on the Southern High Plains: Clues to Altithermal Climate. Journal of Field Archaeology 14(1):9–28.

Mescalero Apache Tribal Historic Preservation Office for White Sands Mistle Range.
N.D. "Guide to Plants of Traditional Importance." Prepared by Mescalero Apache Tribe for the White Sands Mistle Range, New Mexico Presentation located within SEARCH Database Background Research

Miller, Myles, Graves, Tim B., Leslie, Robert H.,
2016 The Merchant Site A Late Prehistoric Ocha Phase Settlement in Southeastern New Mexico 2016. El Paso: Versar Cultural Resources.

Miller, Myles R., and Tim Church
2009 Theoretical Perspectives. In Significance and Research Standards for Prehistoric Archaeological Sites at Fort Bliss: A Design for the Evaluation, Management, and Treatment of Cultural Resources, edited by Myles R. Miller, Nancy A. Kenmotsu, and Melinda Landreth, pp. [4]1–15. Fort Bliss

Environmental Division, Fort Bliss Garrison Command, Historic and Natural Resources Report No. 05-16. Geo-Marine, El Paso.

Miller, Myles R., and Nancy A. Kenmotsu
2004 Prehistory of the Jornada Mogollon and Eastern Trans-Pecos Regions of Texas. In The Prehistory of Texas, edited by Timothy K. Perttula, pp. 205–265. Texas A&M University Press, College Station.

Myles R. Miller Nancy A Kenmotsu, Melinda R Lanfreth.
2009. *Signifigance and research Standards for Prehistoric Archaeological Sites at Fort Blis: A Design for the Evaluation, Management, and Treatment of Cultural Resources.* Fort Bliss: Historic and Natural Resources Report, 05-16 .

Newman, M., and P. Julig
1989 The Identification of Protein Residues on Lithic Artifacts from a Stratified Boreal Forest Site. Canadian Journal of Archaeology 13:119-132.

Pierce, Christopher. 1987. " A CRITIQUE OF MIDDLE-RANGE THEORY IN ARCHAEOLOGY." 1-10.

Prewitt, Elton R.
1981 Cultural Chronology in Central Texas. Bulletin of the Texas Archeological Society 52:65–89.

Railey, Jim A.
2010a Reduced Mobility or the Bow and Arrow? Another Look at “Expedient” Technologies and Sedentism. American Antiquity 75(2):259–286.

Railey, Jim A., Matthew S. Bandy, and Lance Lundquist
2011 Radiocarbon Dates, Climate Change, and Settlement-Subsistence Trends in the Permian Basin Study Area, Southeastern New Mexico. In Patterns in Transition: Papers from the 16th Biennial Jornada Mogollon Conference, edited by Melinda R. Landreth, pp. 191–232. El Paso Museum of Archaeology, El Paso.

Jim A. Railey, Ph.D SWCA Environmental Consultants.
2015. Red Tank Archaeological Data Recovery at LA 43257 for the Zia II Natural Gas Pipeline, Eddy County, New Mexico . Albuquerque: Prepared for: Carlsbad Field Office, Bureau of Land.

Railey, Jim A.
2016a. *Permian Basin Research Design Volume I: Archaeology and Native American Cultural Resources.* Albuquerque.

2016b Early Farming and the Fate of Archaic Hunter-gatherers in the Albuquerque Basin. In Late Holocene Research on Foragers and Farmers in the Desert West, edited by Barbara J. Roth and Maxine E. McBrinn, pp. 16-57. University of Utah Press, Salt Lake City.

Railey, Jim A.
2017. Archaeology and the History of Plant Use in Far Southeastern New Mexico. In W. W. Flynn, Plant Utilization in Southeastern New Mexico: Botany, Ethnobotany, and Archaeology (pp. 25-44). Carlsbad: Bureau of Land Management- Carlsbad Field Office.

Reuther, J. D., Lowenstein, J. M., Gerlach, S. C., Hood, D., Scheuenstuhl, G., & Ubelaker, D. H.
2006. The use of an improved pRIA technique in the identification of protein residues. *Journal of Archaeological Science*, *33*(4), 531-537. https://doi.org/10.1016/j.jas.2005.09.008

Schiffer, M.D. 1976. "Behavioral Archaeology." *Academic Press.*

Schiffer, M.D. 1999. "Behavioral Archaeology: Some Clarifications." *American Antiquity 64* 166-168.

Simpson, Sean
2004 A Data Recovery of Four Sites Near Dark Canyon, Eddy County, New Mexico. Mesa Field Services, Carlsbad, New Mexico.

2010a A Data Recovery of Seven Archaeological Sites at the Tony Federal Wells. Mesa Field Services.

2010b Holocene Thermal Feature Types in Archaeological Sites of the Mescalero Sands Environment, New Mexico. M.A. thesis, Department of Anthropology, University of Nevada-Reno.

Smith, Calvin B., John Runyan, and G. Agogino
1966 A Progress Report on a Pre-Ceramic Site at Rattlesnake Draw, Eastern New Mexico. Plains Anthropologist 11:302–313.

Speth, John D. (editor)
2004 Life on the Periphery: Economic Change in Late Prehistoric Southeastern New Mexico. Museum of Anthropology, University of Michigan Memoirs No. 37, Ann Arbor.

Steward, J.H.
1968. "Cultural Ecology." *In International Encyclopedia of the Social Sciences, Vol. 4* 337-334

1955. *Theory of Cultural Change.* Urbana: University of Illinois Press.

Thomas, David Hurst.
1989. "Diversity in Hunter-Gatherer Cultural Geography. In, Quantifying Diversity in Archaeology." In *New Directions in Archaeology*, by R. D. Leonard and G. T. Jones, 85-91. Cambridge University Press.

Turnbow, Christopher A.
1997 Projectile Points as Chronological Indicators. In OLE Volume II: Artifacts, edited by John C. Acklen, pp. 161–230. Public Service Company of New Mexico, Albuquerque.

Turner, Ellen Sue, and Thomas R. Hester
1993 A Field Guide to Stone Artifacts of Texas Indians. Texas Monthly Field Guide Series. Second Edition. Gulf Publishing Company, Houston.

Turpin, Solveig A.
1994 Lower Pecos Prehistory: The View from the Caves. In The Caves and Karst of Texas, edited by W.R. Elliott and G. Veni, pp. 69–84. National Speleological Society, Huntsville, Alabama.

Warnica, J.W.
1966 New Discoveries at the Clovis Site. American Antiquity 31:345–357.

Weir, Frank A.
1976 The Central Texas Archaic. Ph.D. dissertation, Department of Anthropology, Washington State University, Pullman.

White, Leslie A.
1959*The Evolution of Culture: The Development of Civilization to the Fall of Rome.* New York: McGraw-Hill,

White, Leslie A. *The Science of Culture, a Study of Man and Civilization.* New York: Grove Press, 1949. Print

Wiseman, Regge N. 2010. *Land of the Relentless Sun: An Examination of Prehistoric Site Structure Along the Lower South Seven Rivers Drainage, Eddy County, New Mexico.* Santa Fe: Office of Archaeological Studies, Archaeology Notes 284.

Wiseman, Regge N. (editor)
2014 The Archaeology of Lower Nash Draw: Excavations at Seven Prehistoric Sites and Documentation of One Recent Historic Site Along NM 128 From Jct. NM 31 to WIPP Turnoff, Eddy County, New Mexico (Milepost

0 to Milepost 10.6). Archaeology Notes 398, Museum of New Mexico, Office of Archaeological Studies, Santa Fe.

Whitehead, W. T.
2017. Ethnobotany and Paleobotany in Southeastern New Mexico. In W. W. Flynn, Pant Utilization in Southeastern New Mexico: Botany, Ethnobotany, and Archaeology (pp. 65-89). Carlsbad: Bureau of Land Management-Carlsbad Field Office.