The Boot Hill Site (LA 32229): An Oasis in the Desert, Eddy County, New Mexico

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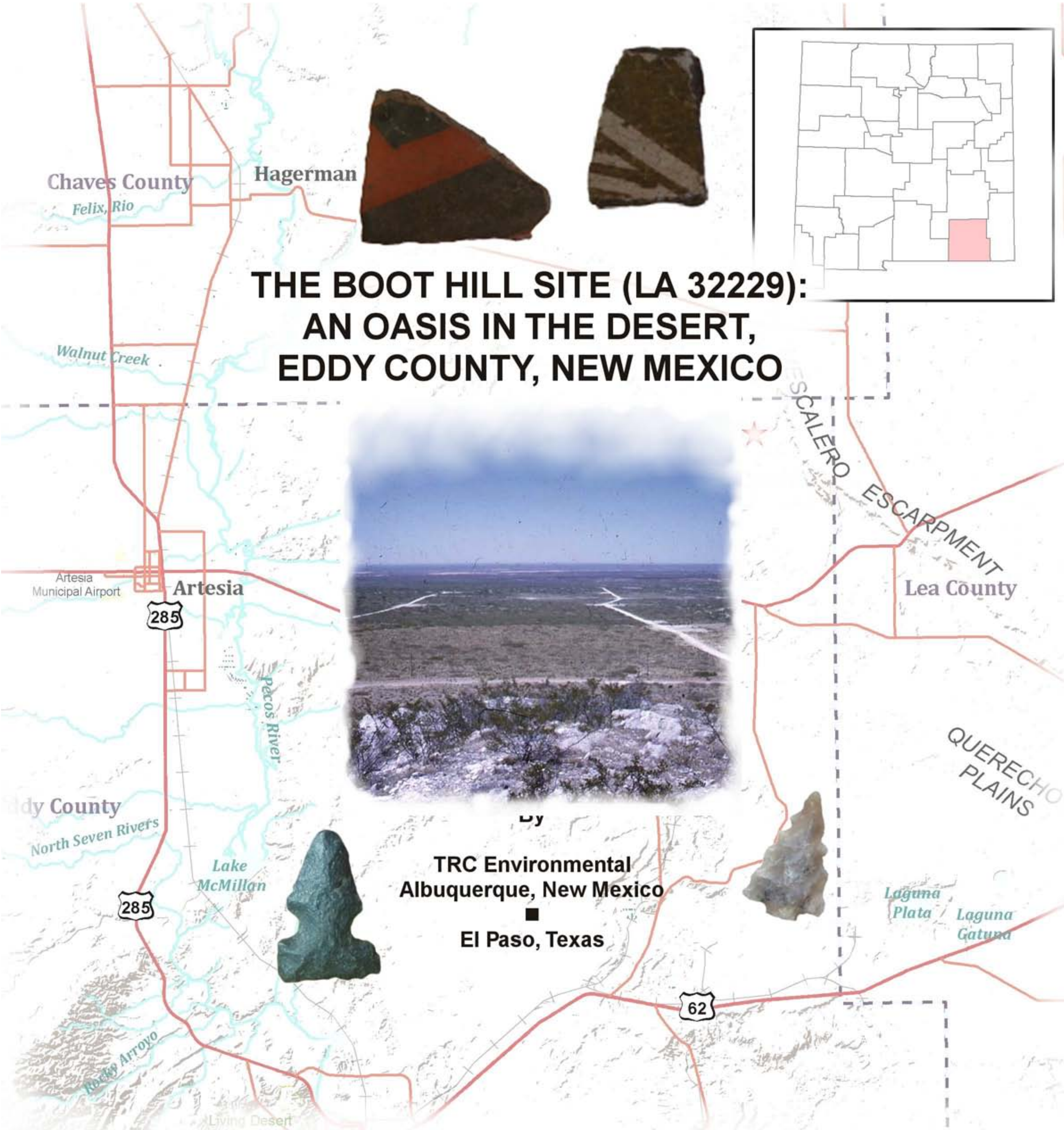

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By

TRC Environmental
Albuquerque, New Mexico
■
El Paso, Texas

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Abstract

TRC Environmental, Inc., Albuquerque, New Mexico, under contract with the Bureau of Land Management, Carlsbad Field Office, carried out the required archaeological and geomorphologic investigations at LA 32229, Eddy County, New Mexico. Under the Bureau of Land Management's Permian Basin Mitigation Program, TRC carried out Task Order 4 with the goal of providing a more comprehensive interpretative assessment of prehistoric use at LA 32229. Note, as used in this report, LA 32229 refers to the current project area, the original Boot Hill site (now known as Locus 3), not the expanded site.

This project fulfilled the responsibilities mandated under the Scope-of-Work issued on February 23, 2010 and awarded April 26, 2010. As a result, cultural materials were documented, and significant archaeological data were recovered. Task Order 4 was carried out in accordance with the National Historic Preservation Act (NHPA), 36 CFR 800, and other relevant laws, regulations, standards, and guidelines. The fieldwork was performed under ARPA Permit No. 45-8152-10-31 from June 15 through July 20, 2010 and the BLM provided funding for the project.

The testing at LA 32229 consisted of a phased strategy that included site survey and documentation, geophysical survey, geoarchaeological testing, and test excavations. The fieldwork commenced on June 15, 2010 and ended on July 20 2010, with the results of each phase contributing to the subsequent one. Phase I was a geophysical survey that employed ground penetrating radar (GPR) and magnetometer (fluxgate gradiometer). Because of vegetation cover and topography, 18 grids were surveyed. The grids were georeferenced to the TRC site datum. Geoarchaeological testing and evaluation followed the geophysical survey. Manual test excavations were conducted concurrently with the geoarchaeological testing with constant collaboration between the two groups. The final phase was detail mapping of surface features and a 10 percent sample of surface artifacts. Nine discernible features were mapped within the project boundary.

Subsurface testing included the hand excavation of three trenches. Trench 1, placed over an anomaly found during the geophysical survey, consisted of 19 contiguous 1 x 1-m units west of the road. Trench 2, placed in the location of the Lea County Archaeological Society excavations, consisted of seven contiguous 1 x 1-m units west of the road. Trench 3, placed over a subsurface geophysical anomaly, consisted of five contiguous 1 x 1-m units east of the road. The combined level of effort was 31 m^2. The cultural assemblage recovered during testing consisted of 6,508 artifacts of which 367 were sherds, 4,432 were debitage, 35 were ground stone fragments, 20 were cores, 11 were bifaces, 17 were projectile points, 6 were hammerstones, and 1,620 were faunal remains.

The final phase of the project consisted of artifact analysis. Analyses include macrofloral and pollen samples; starch residue; FTIR residue; eight AMS dates; diatom analysis; and rhyolite XRF sourcing. Of the feature-related radiocarbon samples submitted, Feature 3 yielded a conventional age of 1440±25 B.P. Combined with the diagnostic artifacts, seven of the corrected AMS dates suggest a continuous use of the Boot Hill site from the Formative 1 through Formative 6 periods (A.D. 575 through 1250).

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1.0 Introduction

1.1 Project Description

This report presents the results of the documentation of and limited testing at the Boot Hill site (LA 32229) in extreme northeastern Eddy County, New Mexico conducted by TRC under Task Order 4 of the Bureau of Land Management's (BLM) Permian Basin Mitigation Program for the Carlsbad Field Office (Figure 1.1). The project goal was to provide a more comprehensive interpretative assessment of the site and to fulfill the responsibilities mandated under the Scope-of-Work issued on February 23, 2010 and awarded April 26, 2010. As a result, cultural materials were documented, and significant archaeological data were recovered. Task Order 4 was carried out in accordance with the National Historic Preservation Act (NHPA), 36 CFR 800, and other relevant laws, regulations, standards, and guidelines. The project results provide a critical tool for the future management of archaeological resources contained within the site. Subsequently, this information will contribute to the BLM's Land Study and provide a valuable tool for the future management of federally owned lands within southeastern New Mexico. The fieldwork was performed under ARPA Permit No. 45-8152-10-31 from June 15 through July 20, 2010 and the BLM provided funding for the project.

1.2 Project Location

LA 32229, [redacted] is on undulating alluvial fan terraces and ridges bisected northeast-southwest by the Bogle Tank arroyo. Mescalero Escarpment lies to the east and the Mescalero Sands is to the west (Figures 1.1 and 1.2). [redacted]

Note, as used in this report, LA 32229 only refers to the current project area, the original Boot Hill site (now known as Locus 3), not the expanded site. CR 254 (Radio Road) forms the northern boundary of the project area. Several well pad locations, access roads, pipelines and power line service roads occur in the immediate area. Additionally, cattle graze freely within the project area and vehicular traffic is common. Bogle Tank, in the northeast portion of the project area, is a medium-size stock tank within the primary arroyo catch basin and provides a permanent water source for the free-ranging cattle.

[redacted]

Figure 1.1 Project area location map

Figure 1.2 Environmental setting looking northeast

1.3 Previous Investigations

The Lea County Archaeological Society (LCAS) conducted excavations at LA 32229 during the summers of 1957 and 1958, with each excavator keeping the items he or she found (Corley and Leslie 1960:1). The LCAS excavations were west of the bladed road (CR 220), totaled about 1350 feet^2 (125.4 m^2), and included a 90-foot (27.4-m) manually dug trench. Cultural deposits extended as much as 4 feet (1.2 m) below the surface. The excavations uncovered three juvenile burials, of which one (Burial 1) included funerary objects. A fourth burial, containing about 90 shell beads, had been uncovered on the point of the hill by a Boy Scout troop shortly before the LCAS excavations (Corley and Leslie 1960:4–5). The whereabouts of the human remains and associated shell beads is currently unknown. Artifacts recovered during the LCAS fieldwork included 961 pottery sherds, 127 projectile points, hammerstones, various flaked stone tools (knives, scrapers, drills, gravers) and ground stone (manos, metates, polishing stones) artifacts, and faunal remains (shell and bone). The projectile point assemblage included a Midland-like base fragment as well as Archaic and Formative point types. Most of the ceramic assemblage consisted of Jornada Brown (n=434, 45.2 percent) and Chupadero Black-on-white (n=330, 34.3 percent) sherds but also contained Mimbres Black-on-white (n=8, 0.8 percent) (Corley and Leslie 1960:5–16). A small carbon sample collected by the BLM Carlsbad Field Office in the 1990s from midden deposits exposed in the road cut yielded a date of 1290±90 B.P. (Beta-39193). The original LA 32229 and its materials have never been formally analyzed and only a brief preliminary report (Corley and Leslie 1960) has been written.

A records search conducted through ARMS and the BLM indicated 23 previously recorded sites within a 1.2-km (0.75-mile) radius of LA 32229 (Table 1.1). LA 32229 (SR 168) was placed on the New Mexico State Register of Cultural Properties in 1970 (Riskin 2000:147). As a result of a visit by TRC in 2002, six sites—LA 32267, LA 49226, LA 50305, LA 128720, LA 128701, and LA 128722—were subsumed within LA 32229 (Condon et al. 2002).

Table 1.1 Sites within 1.2 km (0.75 miles) of the Boot Hill (LA 32229) site

LA No.	Other Nos.	Reference	NMCRIS
26997	NMAS 5083	Aylward 1980 Hunt 1990	14453 35591
32266	AR-3—6-201 LCAS B3	None	
43308	AR-30-6-832 NM-06-832 ENM 10092	Beimly 1975	28500
43309	AR-30-6-833 NM-06-0833 ENM 10093	Beimly 1975 OCA 2003	28500 82356
49641	PAC/ED-42	Kalina 1984a	7343
49817	PAC/ED-056	Kalina 1984b	7353
50828	5675	Haskell 1984	2630
61244	PAC/ED-117 NM-06-4449	Hunt 1987 LMAS 2010	18966 116929
77514	NM-06-4866 NMAS 5920	Haskell 1989 Clifton and Sanders 2000	28250 62888
125225		Clifton and Sanders 2000	62888
125226		Clifton and Sanders 2000	62888
125229		Clifton and Sanders 2000	62888
125234		Clifton and Sanders 2000	62888
125235		Clifton and Sanders 2000	62888
125236		Clifton and Sanders 2000	62888
125244		Clifton and Sanders 2000	62888
125257		Clifton and Sanders 2000	62888
138838	LA 125229?	OCA 2003	82356
165603		LMAS 2010	116929
165605		LMAS 2010	116929
165606		LMAS 2010	116929
165608		LMAS 2010	116929
165609		LMAS 2010	116929

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1.4 Research Goals

Traditional interpretations of southeastern New Mexico identify cultural adaptation as a linear progression from mobile hunter-gatherers to sedentary, ceramic-using agriculturalists (Whalen 1994; Wiseman 2003). While this interpretation has proven accurate in many parts of the Southwest, adaptive strategies within the Jornada Mogollon region are more complex (Abbott et al. 1996; Condon et al. 2008; Hogan 2006; Wiseman 2003). Current research infers that, due in part to the diverse resource base associated with a semiarid environment and possible influences from Plains populations, hunter-gatherer adaptations persisted well into the Formative period (Whalen 1994:632). LA 32229 may provide data for addressing questions regarding regional interaction, settlement, and subsistence.

This project uses a strategy employed by earlier research, which emphasizes the collection of sufficient data (spatial, technological, and geomorphological) to address questions on site structure, with special attention to chronology and function. The data are oriented toward addressing the larger question of adaptive behavior patterns (Condon et al. 2008; Hard 1983; O'Laughlin and Martin 1989, 1990; Quigg et al. 2002). Specific research questions are addressed within each broad research domain. Some questions have relevance to more than one research domain.

1.5 Report Content and Summaries

This report provides a detailed description of the data generated through fieldwork and analysis, and concludes with cultural interpretations and recommendations for the testing and documentation at LA 32229. The first chapter provides a general introduction and summary, along with a brief description of the site and setting. Chapter 2 presents information on the natural environment. Chapter 3 describes the relevant cultural history of the project area. Chapter 4 provides the theoretical models under which data recovery was conducted. Chapter 5 summarizes the field methods. Chapter 6 discusses the results of the geophysical survey and how its results helped direct the archaeological testing. Chapter 7 presents the testing results from the three trenches and surface survey.

The second section of the report consists of analytical aspects of the study. Chapter 8 presents the analytical methods used for the different artifact classes. Chapter 9 presents the results of the geomorphological analyses. Chapter 10 describes in detail the lithic analysis and Chapter 11 the ceramic analysis. Chapter 12 presents the faunal analysis and Chapter 13 results of radiocarbon dating. Chapter 14 is conclusions, with results of the various specialized studies that include palynology, macrobotanical, starch residue, FTIR, site structure, features, subsistence, fauna, land use, and regional interaction and trade. Chapter 15 is a research assessment of settlement, subsistence, technology and regional interaction with specific research questions and domains addressed by the specialized analysis. Chapter 16 is the recommendations and management concerns for site preservation and future research issues.

The appendices contain the results of the various analyses—radiocarbon assays (Appendix A), macrobotanical and pollen analyses (Appendix B), Diatom analysis (Appendix C), stable isotope (Appendix D), starch grain (Appendix E), FTIR residue (Appendix F), XRF obsidian (Appendix G), General Land Office (GLO) Maps (Appendix H), Collections from early excavations at Boot Hill (Graham 2010) (Appendix I), Lea County Archaeological Society (LCAS) Report on the Boot Hill Site, 1960 (Appendix J), Photographs from LCAS 1957–1958 Excavations at the Boot Hill Site (Appendix K), Complete Geophysical Report (Appendix L), and Map Pocket.

2.0 Environmental Background

2.1 Introduction

This chapter discusses the geological history, ecological resources, climate, hydrology, and paleoenvironmental background of the project region. Moreover, this chapter lays the foundation for developing an understanding of how prehistoric peoples interacted with their natural surroundings and how environmental processes affected the preservation of the archaeological record within the project area. A more comprehensive discussion is presented in Hall (2002).

2.2 Physiography

Physiographically, LA 32229, which is in extreme northeastern Eddy County in southeastern New Mexico, lies within the Pecos Valley Section of the Great Plains Province, which includes the eastern third of New Mexico (Hawley 1986a:24). The Pecos Valley Section contains "the terraced valleys of the Pecos and Canadian rivers and flanking piedmont plains and tablelands. Inner river valleys range from reaches with broad floors, occupied by floodplains and low terraces, to relatively shallow canyons" (Hawley 1986b:26). East of the Pecos, Quaternary aeolian deposits mantle large areas of older valley-border surfaces. Much of the Pecos Valley Section is underlain by Permian bedrock—gypsiferous and saline evaporites, limestone, dolomite, mudstone, shale, and sandstone. Solution-subsidence depressions, varying greatly in size, are common as the result of dissolution of evaporite and carbonate units (Hawley 1986b:26–27).

Although the Pecos Valley Section has been divided into the Upper Pecos Valley Subsection and the Lower Pecos Valley Subsection (includes the project area) (Hawley 1986a:24), a recent division into six subsections—Pecos Floodplain/Terrace, Southwest Pecos Slopes, Northern Pecos Slopes, Mescalero Plain, Portales Valley, and Canadian River Drainage—provides finer detail (Hogan 2006:2-2–2-3). The project area is within the Mescalero Plain, a piedmont surface that slopes gently westward from the base of the steeply inclined Mescalero Ridge (Caprock escarpment) to the Pecos River and extends south from the Portales Valley to the New Mexico-Texas state line. The Mescalero Plain is a broad area with low relief characterized by erosional surfaces and alluvial and fluvial deposition. Although, regionally, the terrain is level, the Mescalero Dunes mantles most of the area. Dunes, drainages, sinks, and rock outcrops provide the Mescalero Plain with local relief (Hogan 2006:2-3).

This alluvial environment is demarcated by mesquite-stabilized coppice dunes and associated areas of deflation. Deflated areas tend to form between dunes and are generally covered with small siliceous gravels and unconsolidated sands. Dune development is the result of aeolian translocation from the Pecos River Terrace system and from slope wash accumulation initiating from the Mescalero Escarpment. This undulating topography includes Pleistocene to Holocene aeolian sand (Qe Unit), recent alluvium (Qa Unit, Holocene), and older alluvium (Qoa Unit, Pleistocene) (Hogan 2006:2-6).

Quaternary-aged alluvial deposits extend west from the Caprock, with a series of north-south ridges characterizing the base of the alluvial deposits (Railey et al. 2009:11). The LA 32229 geological unit consists of Holocene to Middle Pleistocene aeolian and piedmont deposits (Qep)—"interlaid aeolian sands and piedmont-slope deposits along the eastern flank of the Pecos River valley, primarily between Roswell and Carlsbad; typically capped by thin aeolian deposits" (Railey et al. 2009:13).

2.3 Paleoenvironmental Context

Paleoenvironmental reconstructions for southeastern New Mexico have traditionally relied upon inter-disciplinary data derived from Quaternary palynology, geomorphology, macro- and micropaleontology, thermoluminesence analysis, dendrochronology, and radiocarbon dating (Abbot et al. 1996) (Figure 2.1). Reconstructions based on a combination of pollen evidence and radiocarbon dates present the framework for the most widely referenced sequence of paleoclimates in southeastern New Mexico (Oldfield and Schoenwetter 1975:157). Paleoenvironmental research in the greater Southwest has tentatively correlated with stratigraphic sequences within the project area (Hall 2002). The following sections present a general overview of the paleoenvironment of southeastern New Mexico and a summary of Hall's (2002) paleoenvironmental and stratigraphic correlations for the Mescalero Plain region of New Mexico.

Analysis indicates that approximately 14,000 years ago, during the late Pleistocene, southeastern New Mexico was characterized by warm steppe conditions with mixed grassland and boreal forest. Then, about 10,000 years ago, dry steppe conditions prevailed with grasses, chenopods, composites, sagebrush, oak, and juniper dominating the landscape. This increasingly semiarid continental climate with warmer summers and cooler winters continues today (Landis and Bamat 1986:22). Antev's (1948) work in the Southwest, including southeastern New Mexico, recognized the last 10,150 years (the Neothermal) as comprising three distinct climatic periods—the Anathermal, Altithermal and Medithermal.

The Anathermal (10,150–7500 B.P.) marks the transition from the cooler, moister conditions of the late Pleistocene postglacial environment to one of increasing aridity. The Altithermal (ca. 7500–4500 B.P.) is characterized by an extremely arid environment. While Antev's (1948) model indicates a consistent lack of moisture throughout the Southwest, recent studies suggest these dry, drought-like conditions may not have been so widespread (Macias et al. 2000:2-10). The Medithermal (4500 B.P.–present) is currently characterized by variable climatic conditions of seasonal aridity and precipitation.

Van Devender et al.'s (1987:332) analysis compiled from human coprolites and packrat middens indicates a vegetation shift from woodland to grassland environments at 9000 to 8000 B.P. in southeastern New Mexico. Moreover, Van Devender and Spaulding (1979:709) suggest extreme aridity, as proposed by Antev's Altithermal period, may not have been indicative of the northern Chihuahuan Desert. Monsoonal summers provided increased moisture in this region as compared to the northern Southwest. A final shift from grassland to desert scrub occurred within southeastern New Mexico ca. 4000 B.P.

Variations in environmental conditions have directly affected both faunal and floral resources, and in turn, have affected the resource base supporting human occupation. Juniper and oak woodlands and grass prairies supported large megafauna during the late Quaternary. The shift from grassland to desert scrub during the Holocene forced many species into higher elevations. Smaller, more adaptable species remained in the lower elevations characteristic of southern New Mexico. This transition undoubtedly affected human subsistence patterns. While the correlation between culture and environment is not dependent on any one factor, data preserved in the archaeological record may provide an avenue to address specific issues of prehistoric land use in southeastern New Mexico (Macias et al. 2000:2).

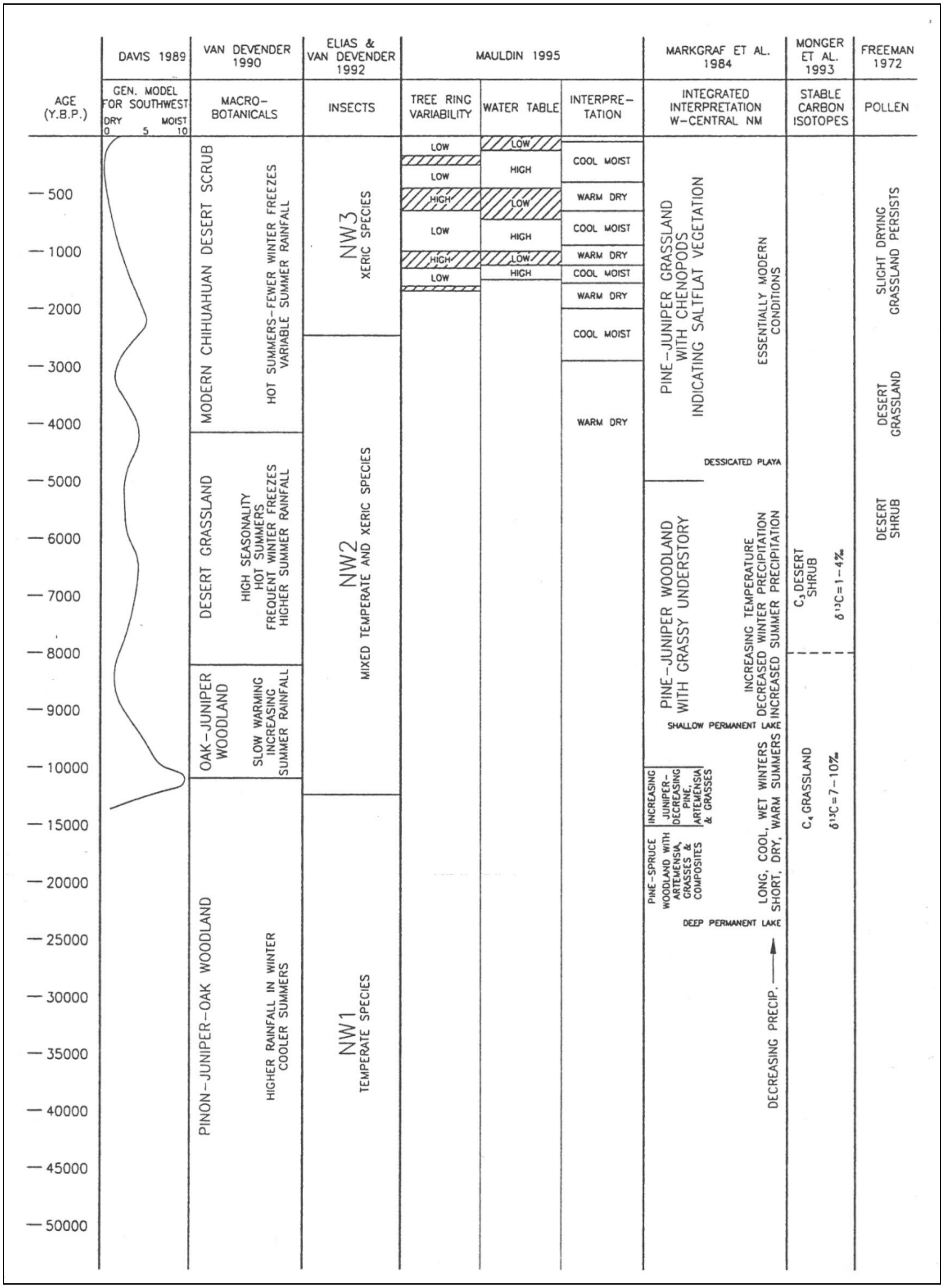

Figure 2.1 Schematic summary of paleoenvironmental data from the northern Chihuahuan Desert

(from Abbott et al. 1996:42, Figure 11)

2.3.1 Correlating Paleoenvironmental and Stratigraphic Evidence (Hall 2002)

The following information is taken directly from Hall's (2002:15–16) geomorphic history of the Mescalero Sands and associated ancestral landscapes during the late Pleistocene period. Figure 2.1 provides a comparative paleoenvironmental table for comparison to Hall's (2002) interpretative model.

2.3.1.1 100,000 to 130,000 (to <400,000?) B.P.

During the Sangamon Interglaciation, the regional climate was arid, perhaps drier than the Holocene. During this period of dry climate, the calcic Mescalero paleosol may have developed on the weathered surface of Permian and Triassic shale and sandstones. The Mescalero paleosol may also have formed during pre-Sangamonian periods of arid climate. The Mescalero paleosol underlies the Mescalero sands and occurs throughout the region beyond the sand sheet.

2.3.1.2 90,000 to 100,000 B.P.

Subsequent to the formation of the Mescalero paleosol and prior to its burial by the Unit 1 sand of the Mescalero sand sheet, an episode of erosion removed the upper soil horizons and left the resistant petrocalcic horizon or caliche.

2.3.1.3 70,000 to 90,000 B.P.

During the warm late Wisconsinan (oxygen isotope stage 5A) and the early part of the early Wisconsinan (stage 4), the Unit 1 aeolian sand was deposited on top of the eroded Mescalero paleosol. The source of the aeolian sand is probably alluvium derived from an eastward retreat of the Caprock escarpment of the Ogallala Formation. Unit 1 is the first aeolian sand body of the Mescalero Sands; prior to this time, the sand sheet did not exist.

2.3.1.4 15,000 to 70,000 B.P.

After deposition of Unit 1 sand, the sand sheet was stable during the remainder of the Wisconsinan, and a noncalcic red argillic soil formed on the aeolian sand. The Bt soil developed during the moist climate of the Wisconsinan. Because of the absence of a calcic horizon in the paleosol, the annual precipitation may have exceeded 20 inches, 50 percent more than modern rainfall. The vegetation may have been sagebrush grassland (Hall 2001).

2.3.1.5 15,000 to 25,000+ B.P.

During the late Pleistocene, environmental conditions were cooler and wetter than today. More surface water was present west of the Caprock escarpment, as indicated by the presence of mollusk-bearing springs and cienega deposits. A higher water table in the Ogallala filled countless playa lakes on the adjacent high plains and fed numerous springs at the foot of the Caprock escarpment.

2.3.1.6 9000 to 15,000 B.P.

The dramatic shift to warmer and drier conditions at the end of the last glacial maximum resulted in major geomorphic, hydrologic, and biotic changes. The water table dropped, playa lakes became desiccated, springs stopped flowing, and sagebrush vanished from the grasslands. General erosion of the landscape resulted in the removal of the upper part of the Wisconsinan argillic soil, exposing the red Bt horizon at the denuded surface. During this interval, Paleoindians may have camped at remnant springs and cienegas.

2.3.1.7 5000 to 9000 B.P.

During the early half of the Holocene, after the shift from moist to drier climate, winds picked up fine sand from dried cienegas and streams and deposited the sand as aeolian Unit 2, which formed a mantle over the Wisconsinan red Bt paleosol and the older Unit 1 sand. The vegetation may have been desert shrub grassland. Either Early Archaic people avoided the Mescalero Plain during the accumulation of Unit 2 aeolian sand or their sites were obliterated by aeolian processes. Very few sites from this time interval have been discovered.

2.3.1.8 500 to 5000 B.P.

After the deposition of Unit 2 aeolian sand, the Mescalero Sands were quasi-stable; the surface vegetated but with low relief parabolic dunes and some sand movement, perhaps resembling modern conditions. A soil did not form during this time interval, except for organic-rich anthrosols associated with prehistoric occupations. Most of the archaeological sites on the sand sheet correlate with this period of quasi-stability. The vegetation on the sand sheet was a desert grassland or desert scrub grassland, perhaps with shin oak.

2.3.1.9 100 to 500 B.P.

During this recent time interval, the Loco Hills soil formed on the sand sheet and on flood plains of small streams that drain through the area and on colluvial slopes. The Loco Hills is an A horizon soil that formed on stable surfaces by the accumulation of organic matter from desert grassland vegetation. The Loco Hills soil may merge with organic-rich anthrosols at archaeological sites.

2.3.1.10 0 to 100 B.P.

The greatest, most rapid geologic change that has occurred in the Mescalero Sands since its formation is the recent deflation of the sand sheet and accumulation of coppice and parabolic dunes. The recent erosion of the previously stable sand sheet and Loco Hills soil is probably related to historic land-use changes, especially the introduction of large numbers of grazing animals that would have affected plant cover on the sand sheet. In the past century, vast areas of the sand sheet have been deflated and the resulting sand has accumulated as coppice dunes around Torrey mesquite and as parabolic dunes where shin oaks are present.

2.3.2 Commentary on Late Prehistoric Climatic History (Hall 2002:16)

The archaeological record of the past 5,000 years converges on the stable surface of Unit 2 aeolian sand. Sedimentary deposits that could contain information on past environments are not present on the sand sheet. Thus, direct evidence for prehistoric paleoclimatic history of the Mescalero Sands is elusive.

The regional paleoenvironmental history of southeastern New Mexico is incomplete, although a general picture can be summarized. The hot and dry climate of the mid-Holocene, Antev's (1948) Altithermal, dominated the regional landscape. The last phase of accumulation of Unit 2 aeolian sand coincides with this period of aridity. After the Altithermal, the climate gradually became less arid. A period of slightly cooler, moister climate was evident by about 2,500 years ago and lasted to about 1,000 years ago. While slightly moister conditions during this time interval are recorded in alluvial sequences (Hall 2002), the Mescalero sand sheet did not respond to the moister climate, unless the response was increased vegetative cover and greater stability of the sand sheet. Similarly, the end of the interval of moist climate and change to drier conditions about 1,000 years ago had no discernible effect on the sand sheet. In addition, the peak of the recent dry conditions about 500 years ago does not seem to be visible in the sand sheet record, although it is at this time that the Loco Hills soil began to form on the sand sheet and elsewhere. While sand sheet stability and the formation of the Loco Hills soil coincide with the last half of the Little Ice Age and its cooling effects at high latitudes and high elevation sites, the geomorphic response at low elevations is unremarkable. Regardless, the presence of the Loco Hills soil testifies to landscape stability during the past few centuries, until the dramatic changes related to historic land use.

2.4 Geology and Soil Stratigraphy

The stratigraphic sequence within the Mescalero Plain has been influenced by alternating periods of deflation and sediment accumulation. These cyclical episodes, interspersed with periods of stability, resulted in the development of complex and locally distinct dune formation sequences for the immediate region (Hall 2002; Landis 1985). Reeves (1965) interpreted the dune formation processes within the Mescalero Plain dune environment as consisting of a series of accumulating sand deposits both Pleistocene and Holocene in age. Hall's (2002) recent interests in the project area have resulted in a more complex soil sequence for the project area.

The stratigraphic sequence for the project area consists of five possible soil units, with at least seven sub-units, which overlay Permian and Triassic bedrock (Figure 2.2). These soil units constitute the stratigraphic sequence completely or in part within the project area and are summarized in the following section. For a more detailed description of the relevant stratigraphic profiles, the reader is referred to Hall (2002).

2.4.1 Rustler and Dockum Formations

The Permian unit is characterized by the Rustler Formation, a magnesian limestone and associated sandstone. The late Triassic units are associated with the Dockum Group sandstone formations, which consist of five sub-strata and overlie the Permian formations within the project region (Hall 2002).

2.4.2 Mescalero Paleosol

The Mescalero Paleosol is the Bk petrocalcic deposit, a caliche containing quartz sand, silt, clay, and occasional chert clasts that underlies the entire Mescalero sand sheet. This compact deposit may have formed on weathered Permian and Triassic sandstone bedrock during a period or multiple periods of arid climate. The Mescalero Paleosol is about 40–80 cm thick and dates between ca.600,000 and 90,000 B.P. (Hall 2002:3).

2.4.3 Unit 1 Aeolian Sand

The Unit 1 aeolian sand was the first sand deposit that formed over the Mescalero Paleosol and the initial (basal) deposit in the Mescalero Sands stratigraphic sequence. This sand deposit consists of fine to very fine subangular to subrounded quartz sand that is yellowish red to red (5YR 5/8, 2.5YR 5/8) and lacks pedogenic qualities (e.g., bedding). This unit is generally 40–60 cm thick but is as much as 3 m thick in some areas. Unit 1 formed between about 70,000 and 90,000 B.P. (Hall 2002:3–4).

2.4.4 Red Bt Paleosol

The red Bt paleosol, a red to dark red (2.5YR 4/8, 2.5YR 3/6) argillic noncalcareous quartz sand with modest clay content and carbonate filaments, overlies Unit 1. This paleosol is 30–70 cm thick and formed between 15,000 and 60,000 B.P. (Hall 2002:4).

2.4.5 Unit 2 Aeolian Sand

The Unit 2 aeolian sand consists of fine to very fine subrounded to rounded reddish yellow (5YR 6/6) quartz sands that are noncalcareous. This deposit varies from less than 1 m to 5 m in thickness. The Unit 2 deposit formed between about 5000 and 9000 B.P. (Hall 2002:4).

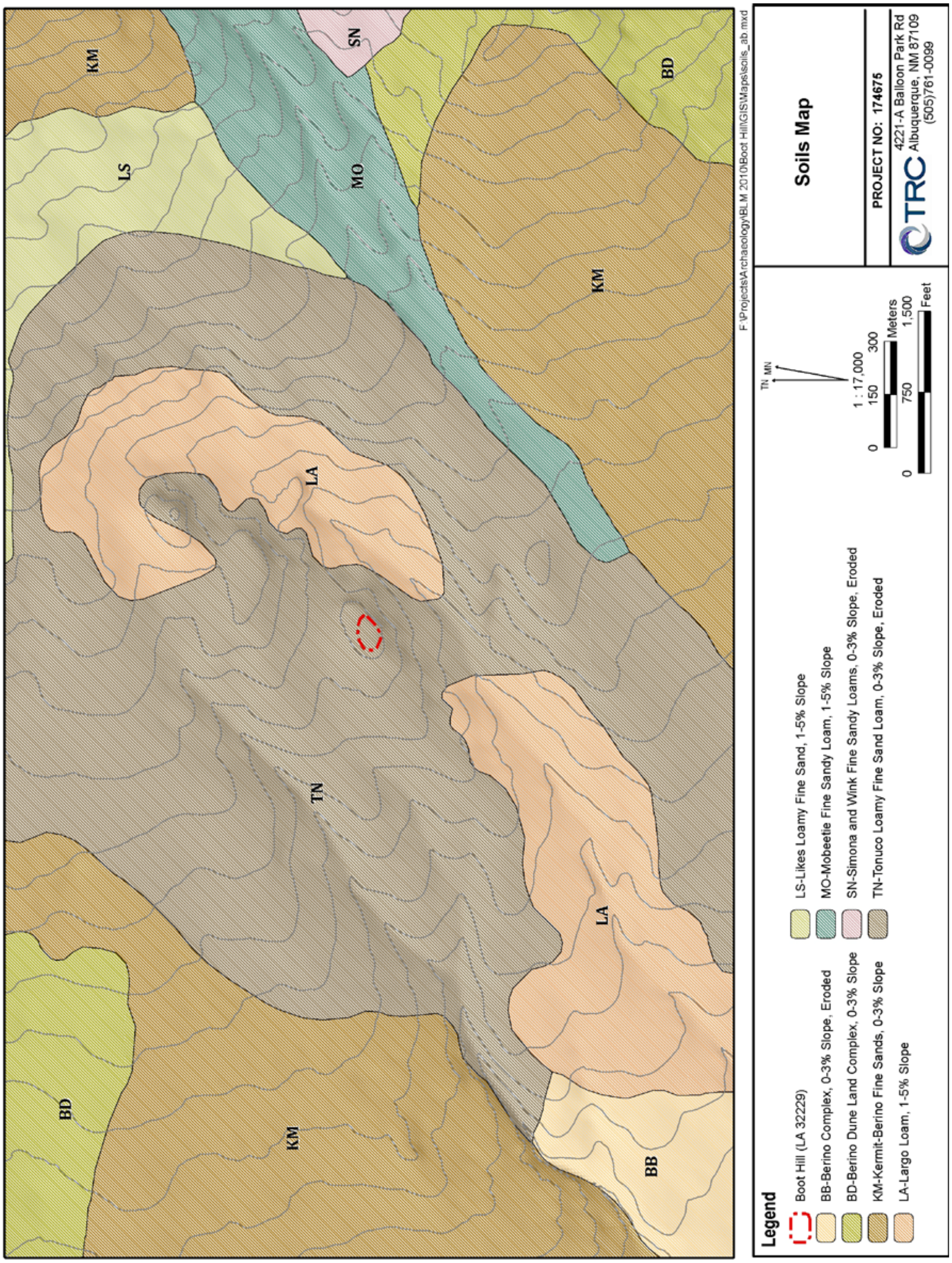

Figure 2.2 Soil series map of the LA 32229 area

2.4.6 Clay Bands

Clay bands, consisting of sand, clay, and iron oxides, occur about 1.5 to 3.0 m below the top of Unit 2. The bands are discontinuous, secondary features in Unit 2 that are leached of carbonates and may have resulted from organic acids, such as that in shin oaks, leaching clays and minerals from the ground surface. Clay bands are regionally common, but are not necessarily expected within the project area. The bands formed during the last 5,000 years, after the sand sheet accumulated (Hall 2002:5).

2.4.7 Loco Hills Soil

The Loco Hills soil is a generally noncalcareous, reddish brown to reddish yellow to yellowish red (5YR 4/4, 5YR 6/6, 5YR 5/6) A horizon with low organic content that lacks a B horizon and overlies aeolian sand Units 1 and 2 and late Holocene alluvial deposits. The latter are expected in the immediate project area. The soil consists of silty, very fine to fine, subrounded to rounded quartz sand. The A horizon reflects a period of environmental stability. The Loco Hills soil dates to about 160±90 B.P. (Hall 2002:5).

2.5 Water Resources

Although several water sources exist within the project area—most prominently Bogle Tank and Bogle Tank arroyo—the Mescalero Plain is generally considered hydrologically isolated, primarily receiving water from local precipitation (Figure 2.3). The Pecos River and its tributaries that drain east from the Sacramento Mountains, including the Pintada Arroyo, the Rio Hondo, the Rio Peñasco, and the Seven Rivers-Dark Canyon drainage system, are major water sources west of LA 32229. The Pecos River, however, is more than 26 km (16 miles) west of the project area and may not have played a critical role in prehistoric adaptive strategies within the project area (Hogan 2006; Landis 1985).

Hall (2002) and Bamforth (1988) suggest the numerous small basins and intermittent arroyos within the Mescalero Plain may have provided semi-permanent or seasonal water sources for small groups of hunter-gatherers living in the region. The effectiveness of these localized water sources, however, has yet to be studied extensively.

Water-bearing formations in the Mescalero Plain are recharged by precipitation and the infiltration of water from numerous tributaries north and east of the project area. Although much of the water flowing intermittently through Bogle Tank arroyo empties into small playas south and southwest of the project area, some water permeates the ground and charges the underlying water table. However, the vast majority of discharged ground water is used by vegetation within and adjacent to draws. The effect of seasonal moisture in the environment is almost immediately expressed by increased vegetation within localized niches.

Springs or seeps formed directly from the porous alluvium or exposed Permian bedrock may also have provided water for prehistoric populations. Hall (2002:12) identified possible remnant spring and cienega locations along the eastern margins of the Mescalero Plain. These spring locales are characterized by light olive calcareous sands, which contain a variety of aquatic snail species. Areas adjacent to the prehistoric springs may have contained potential campsite locales (Ashley 2001:183; Hall 2002:12–13). Monument Spring and Mescalero Spring, both below the Caprock, are two of the better known springs in the general area. Historic lowering of the water table has subsequently dried up many springs that were once used prehistorically. While large springs have been identified in Eddy County, these water sources are not an accurate reflection of past water sources.

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2.6 Climate

The climate of southeastern New Mexico is characterized as both a hot arid desert and a cold arid steppe by the Köppen-Geiger climate classification (Kottek et al. 2006:261). LA 32229 is near the juncture of both. Eddy County has a semiarid, continental climate characterized by erratic rainfall, hot summers, and mild winters. The average annual precipitation in the Carlsbad area is 315 mm (12.4 inches). The wettest months are May through October. Most of the wet period rainfall occurs as brief, heavy thunderstorms and originates in the Gulf of Mexico (Houghton 1971:77, 80). "Moisture is supplied by the general southeasterly circulation of moist air over the Gulf of Mexico from the Bermuda high pressure area, which shifts westward in summer" (Houghton 1977:95). Snowfall is light, ranging from 76–203 mm (3–8 inches) (Houghton 1971:77).

The average annual temperature is 15.4º–17.6ºC (60º–64ºF). Temperatures of at least 31.9ºC (90ºF) are common during the summer. The frost-free season is 200–220 days (Chugg et al. 1971:6). Relative humidity averages 45 percent annually. Although winds are light throughout most of the year, averaging 17.7 km (11 miles) per hour, spring is the windy season. Average wind speeds in March are 25.7 km (16 miles) per hour. Winds are mainly from the west-southwest in winter and spring and from the south-southeast the rest of the year. Winds greater than 50 km (31 miles) per hour are generally from the west-southwest (Bennett 1986:50–51; Houghton 1971:80).

2.7 Flora

LA 32229 is within the Great Plains division of the Upper Sonoran Zone, which includes the broad slopes east of the Pecos Valley (Bailey 1913:25, Plate I). During much of the Holocene, grasslands were widespread at low-lying elevations, but historic disturbances and cattle overgrazing have allowed xeric species to invade and dominate these areas. The current vegetation of the project area is variously classified as desert grassland (Castetter 1956:256), Grassland Savanna (Gross and Dick-Peddie 1979:118), Semidesert Grassland (Brown and Lowe 1994), and Plains-Mesa Sand Scrub (Dick-Peddie 1993a, 1993b:124, 128–129). Most of the Plains-Mesa Sand Scrub areas occur in former grassland areas (Dick-Peddie 1993b:128). Drought and overgrazing, however, have drastically reduced the grass cover. As a result, forbs and shrubs have replaced the various bunchgrasses (e.g., grama grasses) favored by livestock. The deep sands of the Mescalero Plain "are dominated by species which are deep-sand tolerant or even deep-sand adapted. The absence of sand-adapted species on mesquite dunes attests to the recent origin on the dunes" (Dick-Peddie 1993b:128). The sand sagebrush (*Artemisia filifolia*) is the most common sand scrub shrub. Other major Plains-Mesa Sand Scrub plants include honey mesquite (*Prosopis glandulosa*), broom snakeweed (*Gutierrezia sarothrae*), fourwing saltbush (*Atriplex canescens*), soaptree yucca (*Yucca elata*), skunkbush (*Ephedra torreyana*) broom indigobush (*Psorothamnus scoparius*), sand bluestem (*Andropogon hallii*), hairy grama (*Bouteloua hirsuta*), bush muhly (*Muhlenbergia porteri*), sand dropseed (*Sporobolus cryptandrus*), sand verbena (*Abronia angustifolia*), burweed (*Ambrosia acanthicarpa*), annual buckwheat (*Eriogonum annuum*), and false snapdragon (*Maurandya* spp.) (Dick-Peddie 1993b:128–129, 137–138). Honey mesquite (Prosopis glandulosa) is common in sandy soils along arroyos or playa margins.

2.8 Fauna

The Plains-Mesa Sand Scrub provides adequate habitat for a variety of vertebrate and invertebrate fauna. Macroscopic invertebrates include insects such as flies, ants, beetles, termites, millipedes and centipedes, arachnids, and occasional worms and snails. Mammals include coyote (*Canis latrans*), pronghorn (*Antilocapra americana*), desert cottontail (*Sylvilagus audubonii*), black-tailed jackrabbit (*Lepus californicus*), yellow-faced pocket gopher (*Cratogeomys castanops*), kangaroo rat (*Dipodomys* spp.), woodrat (*Neotoma* spp.), and various mice (Findley et al. 1975). Although now locally extinct, bison (*Bison bison*) formerly occurred in the area. Various birds, such as the mourning dove (*Zenaida* *macroura*), red-tailed hawk (*Buteo jamaicensis*), scaled quail (*Callipepla squamata*), roadrunner (*Geococcyx californianus*), burrowing owl (*Athene cunicularia*), and Chihuahuan raven (*Corvus cryptoleucus*) are present (Peterson 1990). The western rattlesnake (*Crotalus viridis*), western diamondback rattlesnake (*Crotalus atrox*), desert kingsnake (*Lampropeltis getula*), bullsnake (*Pituophis melanoleucus*), coachwhip (*Masticophis flagellum*), western box turtle (*Terrapene ornata*), Plains spadefoot (*Spea bombifrons*), Plains leopard frog (*Rana blairi*), collared lizard (*Crotaphytus collaris*), and Texas horned lizard (*Phrynosoma cornutum*) are among the reptiles and amphibians present (Williamson et al. 1994).

3.0 Cultural History

3.1 Introduction

Within southeastern New Mexico local cultural sequences have been developed for the northern Middle Pecos (Jelinek 1967), the Sierra Blanca area (Kelley 1984), the southern Guadalupe Mountains (Applegarth 1976), the Eastern Jornada (Corley 1965; Leslie 1979), and the Carlsbad Basin/Brantley Reservoir area (Katz and Katz 1985a, 1985b). In addition, Stuart and Gauthier (1984), Sebastian and Larralde (1989), and Katz and Katz (1993, 2001) have prepared comprehensive cultural overviews for southeastern New Mexico. This cultural overview borrows heavily from Katz and Katz (1985a, 1985b, 1993, 2001), yet attempts to tie in cultural correlates presented in competing historical overviews. The first section of this chapter provides a generalized cultural overview followed by an evaluation of LA 32229 occupations through time.

3.2 Paleoindian Period (ca. 10,000–5500 B.C.)

The Paleoindian period (ca. 10,000–5500 B.C.) includes the earliest recognized cultures in the American Southwest and is divided into three sub-periods or complexes—Clovis (10,000–9000 B.C.), Folsom (9000–8000 B.C.), and Plano (8000–5500 B.C.)—which generally correspond with the Paleoindian 1, 2 and 3 phases of Katz and Katz (1993:I-103, 2001:33–34). At the close of the Pleistocene epoch, most of New Mexico was covered by montane coniferous forest of fir and pine trees (Dick-Peddie 1993:16). At ca. 11,000–10,000 B.C., Douglas fir, Southwestern white pine, and dwarf juniper were present at an elevation of 2,000 m (6,562 feet) in the Guadalupe Mountains (Dick-Peddie 1993:16). Now-extinct megafauna, such as mammoth (*Mammuthus primigenius*) and a more robust form of bison (*Bison antiquus*), roamed the lush grasslands and congregated at playas. Paleoindians hunted these late Pleistocene mammals and most likely scavenged the dead or diseased when the opportunity presented itself. These highly mobile people are primarily known through their distinctive tool kit, which is characterized by several lithic technologies, highlighted by fluted and parallel-flaked projectile points. The degree to which Paleoindians subsisted on vegetal resources is little understood. Currently, however, a number of researchers now view Paleoindian groups as more generalized hunter-gatherers who also exploited a variety of floral and smaller faunal resources (Cordell 1997:96, 99; Ferring 1995; Haynes and Haury 1982; Johnson 1987; Moore 1996:40). While Paleoindians represent the earliest recognized human inhabitants of North America, new data from South America providing alternate theories and dates for human occupation in the Americas suggest the 10,000 B.C. beginning date for the occupation of North America may be tenuous. Of the 113 Paleoindian sites recorded in southeastern New Mexico, as of June 1990, 19 were in a variety of topographical settings throughout Eddy County (Katz and Katz 1993:I-107, Table 15).

3.2.1 Clovis Complex (Paleoindian 1: ca. 10,000–9000 B.C.)

The Clovis complex, which is generally accepted as the earliest human occupation in New Mexico, is characterized by the Clovis point—a diagnostic, large lanceolate spear point with a single short basal flute on both faces. Excavation of Hermit's Cave in Last Chance Canyon in the Guadalupe Mountains produced late Quaternary radiocarbon dates. The charcoal samples, potentially representing the human occupation of the cave, were also associated with mammoth and dire wolf remains (Sebastian 1989:29). Edgar B. Howard's excavations at Burnet Cave, which is along the southern portion of Rocky Arroyo, produced a Clovis point (which Howard initially called “Folsom”) in association with bison bones (Howard 1932:19). A single radiocarbon sample provided a late Paleoindian date of 7432±300 B.P. (Sebastian 1989:31). Smith et al. (1966) reported early Paleoindian components at the Rattlesnake Draw site west of the Caprock.

The Clovis lithic tradition is characterized by two diverse technologies—a biface technology resulting in large fluted projectile points, and a core and blade technology resulting in large, curved prismatic blades (Collins 1999a, 1999b; Green 1963; Hester 1972; Stanford 1991). Variation in Clovis assemblages has been traditionally viewed as limited, although current research seems to indicate more variability in tool type (Collins 1999a:46). Examination of stone selection reflects preference for high-grade chert and chalcedony (Condon et al. 2006). However, locally available materials, such as quartzite, silicified woods, and shales are common within Clovis assemblages (Hester 1972). Discernment of a highly mobile Clovis subsistence and settlement pattern is strengthened by the predominance of nonlocal raw materials, such as obsidian, basalt, chert, and chalcedonies from west and central Texas.

3.2.2 Folsom Complex (Paleoindian 2: 9000–8000 B.C.)

The Folsom complex is characterized by the small, finely made lanceolate Folsom projectile point, which exhibits a single flute, extending almost the entire length of the point, on each face. Technologically, the Folsom point developed from the preceding Clovis point form. Unlike Clovis points, however, "though heavily utilized and often damaged by impact fractures, Folsom points were frequently recovered, repaired, and re-used. For this reason, they often show evidence of extensive resharpening" (Boldurian and Cotter 1999:116). The Folsom tool kit also includes unfluted Midland points, knives, pointed scrapers, choppers, drills, gravers, spokeshaves, abrading stones, awls, and needles (Gunnerson 1987:13). Folsom assemblages are "oriented toward butchery and the working of hides, bone and wood" (Amick 1996:411).

Both the Clovis and Folsom lithic traditions possess many technological similarities. In fact, these similarities have often been interpreted as a continuation of one lithic technology passed between similar groups. However, further analysis has shown that Clovis and Folsom lithic traditions possess only tentative parallels and that each tradition is individualistic and unique. In general, the Folsom lithic tradition is distinguished by a variety of reduction strategies and subsequent tool forms. Traditional evidence indicates Folsom lithic technologies were dominated by flakes from bifacial cores. The lanceolate, fluted point that exemplifies Folsom technology is distinguished from the Clovis fluted projectile point by a generally smaller size, the length, and morphology of the flute, parallel flaking of the lateral margins, and more extensive grinding on the lower lateral margins. Significantly, Folsom projectile points are predominantly produced from flakes. Unfluted lanceolate forms, identified as Midland points, occur within Folsom sites in southeastern New Mexico (Sebastian 1989:31). Folsom assemblages often reflect more variability in tool type than earlier traditions. Raw material selection associated with Folsom assemblages consistently retains high percentages of cryptocrystalline silicates, as well as local materials, such as quartzite and silicified sandstone (Condon et al. 2006; Hester 1972:120).

The association of Folsom points with *Bison antiquus*—a late Pleistocene bison that was larger than modern bison (*Bison bison*) (McDonald 1981)—suggests Folsom groups were primarily bison hunters (Amick 1994, 1996; Figgins 1927; Judge 1973; Staley and Turnbow 1995), but pronghorn, canid, and rabbit bones have also been recovered from Folsom sites (Frison 1978, 1991). Unlike modern bison, *Bison antiquus* formed smaller herds and was adapted to savannah grasslands (McDonald 1981:204–205). On the other hand, like modern bison, *Bison antiquus* may have wintered in protected foothills and intermontane basins and during spring and summer, may have moved to the open grassland plains. Consequently, Folsom groups may have preferred intermontane basins during the winter and plains during the warm season. Although the seasonality data are limited, Folsom bison assemblages on the Southern Plains represent summer/early fall procurement (Amick 1996:412–413). Folsom groups are viewed as highly mobile, but generally limited to the Great Plains and its peripheries. In addition, the earliest evidence for communal hunting occurs with Folsom assemblages. These communal hunts required greater social organization and control than that evidenced in Clovis sites (Frison 1978:243–250, 1991:276–288).

Folsom components occur at several sites in southeastern New Mexico, including Blackwater Locality No. 1, the Elida site, and the Milnesand site (Agogino and Rovner 1969; Boldurian 1981; Broilo 1971; Cotter 1938; Hester 1972; Stanford and Broilo 1981; Warnica 1959). At LA 32229, Corley and Leslie (1960:11) identify a possible Midland variant, which is contemporaneous with, or analogous to, Folsom. Additional Folsom-age artifacts within the southeastern New Mexico have been reported from Burnett Cave south of Carlsbad, from LA 165710 southwest of Laguna Plata in Eddy County, and from LA 22122 (NMSU 578) along the eastern margin of Laguna Plata in Lea County (Howard 1935; Laumbach et al. 1979; Komulainen-Dillenburg and Lukowski 2010).

3.2.3 Plano Complex (Paleoindian 3: 8000–5500 B.C.)

The Plano complex, which may be viewed as a series of Late Paleoindian complexes, represents the end of the Paleoindian period. Evidence suggests increasingly drier conditions appeared around 10,000 years ago (Judge and Dawson 1972; Peter and Mbutu 1993). Adaptive changes to this more xeric environment are associated with the emergence of the Plano complex. Plano sites tended to be located in areas with relatively easy access to increasingly restricted water sources. Although many Plano sites in the western United States represent mass bison kills, campsites have also been reported. Changes in subsistence economies between Folsom and the subsequent Plano complex consisted of a shift from hunting now-extinct fauna (e.g., *Bison antiquus, Equus* sp., *Camelops* sp.) to hunting modern, extant species. Communal hunting techniques were employed and focused primarily on bison. The earliest Plano manifestations are frequently associated with now-extinct forms of bison, but by 7000 B.C., only modern fauna were available (Carmichael 1983, 1986; Cordell 1979:20, 1997:96, 99; Judge 1982:48–49; Wheat 1972). Traditional interpretations of subsistence patterns support a continued reliance on bison but assume a gradual shift towards a more generalist subsistence strategy.

Plano complex projectile points lack flutes and instead, consist of large lanceolate forms with basal grinding and long parallel flaking (Wheat 1972; Wormington 1957). The Plainview complex contains laterally thinned points—Plainview, Meserve, Milnesand, and Frederick—and is generally considered the earliest Plano complex. The indented base series includes Firstview, Alberta, and Cody complex points, such as Eden and Scottsbluff. Agate Basin and Hell Gap points comprise the constricted base series (Cordell 1979:21). Regionally, a possible Plainview variant was recovered at LA 165710 within the Maroon Cliffs Special Management area (Hurst 1976:49). The transition from Late Paleoindian to Archaic-oriented subsistence and settlement organization is ambiguous. Lack of reliable dates from buried sites hinders current interpretation of this period.

3.3 Archaic Period (5500 B.C.–A.D. 500)

The climate became warmer and more arid during the Archaic (5500 B.C.–A.D. 500). Although this period saw a continuation of the mobile hunting and gathering pattern of the Paleoindian period, there was a shift towards resource diversification. A variety of smaller resources became more critical to the subsistence strategies of Archaic populations. In other words, the Archaic adaptation was a "diffuse" economy (Judge 1982:49). The resource base included a variety of plants and the modern suite of Plains fauna. Archaic populations probably had a primary dependence 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. Areas where the density and distribution of key plant resources were predictable on a seasonal basis were reoccupied (Judge 1982:49). Lithic technology, perhaps reflective of a more generalist, nomadic subsistence pattern, also is more stylistically varied. The higher frequency of grinding tools during the Archaic suggests an increased reliance on floral resources. Unlike other areas of New Mexico, Archaic components in southeastern New Mexico have not yielded evidence of an early agricultural subsistence base (Stuart and Gauthier 1984:267).

As of June 1990, 162 Archaic sites were recorded in a variety of topographical settings throughout Eddy County, with most associated with blowouts, dunes, ridges, and hill slopes (Katz and Katz 1993:I-114, Table 18). A more recent study of radiocarbon dates from excavations in southeastern New Mexico identified 30 of 229 samples that date to the Archaic period (Railey et al. 2009). Based on these dates, the authors identified three periods of intensification using summed radiocarbon probability data: 1) 2600–2300 B.C., 2) 1900–1600 B.C., and 3) 1400–300 B.C. (Railey et al. 2009:50). These data tend to highlight a near absence of radiocarbon samples that date prior to 3000 B.C., as exemplified by Katz and Katz (1985b). During the Brantley Reservoir project, 17 Archaic period components were identified and radiocarbon dated. However, not one of the sites predated 3000 B.C. (Katz and Katz 1985a:35). Nonetheless, an Early Archaic presence is suggested by the recovery of diagnostic projectile point bases (Katz and Katz 1985a:35). Roney (1985:68) reports two Archaic dates from Hooper Canyon Cave, which is in Dark Canyon on the eastern flanks of the Guadalupe Mountains. Wood charcoal samples from a layer directly overlying the cave floor yielded radiocarbon dates of 395±90 B.C. and 940±110 B.C. (Roney 1985:68). Applegarth's (1976:165) excavation of Honest Injun Cave and Dark Canyon Cave yielded Archaic materials, including baskets, large corner-notched projectile points, basin metates, atlatls, and darts. She notes that limestone was used extensively in tool manufacture, comprising more than 50 percent of the raw material recovered from Hermit's Cave, Honest Injun Cave, and Dark Canyon Cave (Applegarth 1976:166). A range of Early to Late Archaic projectile points was observed on sites recorded during a survey of the high country of Guadalupe Mountains National Park (Katz 1978:55). Investigation of ring middens at the South Seven Rivers site and Sheep Draw Canyon yielded nine radiocarbon dates ranging from 1245–900 B.C. and from 1920–410 B.C., respectively (Condon 2002; Wiseman 1999), placing these features firmly in the Middle and Late Archaic periods.

Katz and Katz (1993:I-113) have divided the Archaic period of southeastern New Mexico into four phases—Archaic 1, 2, 3, and 4—primarily on the basis of projectile point styles. In addition, Katz and Katz (1993:I-113) have identified a hiatus (3200–1700 B.C.) between Archaic 1 and Archaic 2. It is not known whether this hiatus reflects an absence of human activity or is the result of low archaeological visibility (Katz and Katz 1993:I-113). While their classification system establishes a mechanism for chronological control of datable sites, the temporal range for the Archaic period is often too broad and too ambiguous for precise statements of interpretation (Katz and Katz 1993:I-101). Despite the temporal flexibility, the cultural sequence does present a much needed framework for developing a more precise chronology for a temporal period that spans more than 5,000 years.

3.3.1 Archaic 1 (5500–1700 B.C.)

Although poorly known, the Archaic 1 (5500–3200 B.C.) is characterized by the Jay point—a lanceolate form with weak shoulders and a long, tapered stem. Jay points have been found close to the Pecos River. No local phases have been defined within the Archaic 1 (Katz and Katz 1993:I-118–I-119).

3.3.2 Archaic 2 (1700–1000 B.C.)

The Archaic 2 (1700–1000 B.C.), which began after a 1500-year cultural hiatus, has only been identified in the Brantley Reservoir area where it occurs locally as the Avalon phase. Identification of this phase is based primarily on one site (LA 44544) and on several isolated burned rock hearths in the Brantley area. Artifact types correlated with radiocarbon assays are relatively nonexistent. Chronological control was based solely on radiocarbon dates recovered from the isolated hearths (Katz and Katz 1985b:397, 1993:I-119). More recent data from Puntos de los Muertos (LA 116471) in Eddy County, however, provides additional chronometric information from similar burned rock features (Wiseman 2003:166). Although the data are limited, the Avalon phase apparently had a riverine focus. LA 44544 is a river mussel procurement site. Freshwater mussels were collected, processed, and cooked alongside the river. Associated Avalon phase artifacts include grinding implements and shell tools. No diagnostic projectile point is associated with the Archaic 2 (Katz and Katz 1985a:36, 39, 1993:I-119; Wiseman 2003:8). The lack of a typological assemblage for the Archaic II exemplifies the need for documented evidence for the Middle Archaic period.

3.3.3 Archaic 3 (1000 B.C.–A.D. 1)

The Archaic 3 (1000 B.C.–A.D. 1) is equated with the McMillan phase of the regional cultural sequence. Chronological parameters were developed from radiocarbon dates obtained from LA 38233 along the Pecos River. Medium, stemmed dart points with a triangular blade and pronounced shoulders distinguish the lithic assemblage (Leslie 1978:133; Katz and Katz 1985b:398-399, 1993:I-119). Additional cultural attributes include the presence of large burned rock features. Annular burned rock features excavated at LA 131686 near Sheep Draw Canyon in Eddy County yielded conventional radiocarbon dates of 3130 ±50 B.P. and 3430±70 B.P., and calibrated ages of 1500–1260 B.C. and 1920–1600 B.C., respectively. In a similar fashion, LA 131687, south of Sheep Draw Canyon, yielded conventional radiocarbon dates of 2460±40 B.P. and 2770±40 B.P. and calibrated ranges of 670–410 B.C. and 1010–820 B.C., respectively (Condon 2002). These dates from wood charcoal samples fall firmly within the Archaic 3 and augment the existing chronometric data for this phase. More recent test excavations at LA 154539 carried out by Lone Mountain Archaeological Services near Cedar Canyon, Eddy County, New Mexico yielded radiocarbon dates and accompanying assemblages that suggest site use between 760 and 680 B.C. and 670 and 400 B.C. (Boggess et al. 2009:77, 99).

3.3.4 Archaic 4 (A.D. 1–500)

The Archaic 4 (A.D. 1–500), the terminal Archaic phase, is defined by type sites LA 38276 and LA 48761 along the Pecos River. Data derived from both sites provided the framework for the development of the Brantley phase, the transitional stage between the Archaic and Formative periods in the Brantley Reservoir area of southeastern New Mexico. The Archaic 4 lithic assemblage is characterized by generally triangular dart points with weak to pronounced shoulders, straight to expanding stems, and straight to convex bases (Leslie 1978:122). Projectile points common to this phase are the San Pedro and varieties of the Pecos dart point (Katz and Katz 1985a:32, 1993:I-120). Burned rock features increased in frequency during the Archaic 4 (Katz and Katz 1993:I-120). The early Hueco phase (Leslie 1979:188) is another local phase within the Archaic 4 (Katz and Katz 1993:I-120, 2001:36).

3.4 Formative Period (A.D. 500–1375)

The Formative or late Prehistoric period (A.D. 500–1375) is marked by the introduction of ceramic technology and the presumed introduction of the bow and arrow. While the domestication of plants is relatively well-documented in periphery areas, evidence of agriculture within southeastern New Mexico is extremely limited. The paucity of evidence for plant domestication in this area presents an enduring enigma that continues to hinder attempts at interpreting subsistence patterns in southeastern New Mexico, but does not preclude its assumed practice, along with sedentism. A primary reliance on hunter-gatherer strategies, however, is traditionally assumed for this region of New Mexico.

As of June 1990, 667 Formative sites were recorded in a variety of topographic settings in Eddy County. A slight majority (n=356, 53.4 percent) are in dunal settings (Katz and Katz 1993:I-121, Table 21). To the southwest, in the high country of the Guadalupe Mountains, Katz (1978:87) tested a ring midden with associated E1 Paso Polychrome and Jornada brownware sherds, as well as Perdiz and Livermore projectile points. The feature yielded a radiocarbon date of A.D. 710±50, placing it in the early Formative period. More recent projects, such as test investigations at LA 43315 near Loco Hills, New Mexico, yielded brownware sherds and a radiocarbon date with a calibrated range of A.D. 887–1023 (Boyer 1995:33). Excavations at LA 104607, which is along Bear Grass Draw east of Artesia, produced 40 El Paso Bichrome sherds and a single charred corn kernel (Clifton 1995:25). Recently, several late Prehistoric structures and extramural features were excavated at LA 29363 (Macho Dunes) in advance of construction activities associated with the Carlsbad Relief Route (Zamora 2000:iii). Excavations at LA 68188 (the Fox Place) uncovered 12 pithouses, one socio-religious structure, storage pits, and numerous corncob fragments. Twelve radiocarbon assays provided an occupational range dating between A.D. 1250 and 1425 (Wiseman 2002:iii).

The cultural sequence developed by Leslie (1979) for the eastern extension of the Jornada Mogollon is commonly applied to sites in the vicinity of Carlsbad, New Mexico. This sequence, which is based on earlier work by Lehmer (1948) and Corley (1965), roughly follows the pithouse-to-pueblo transition found in the other major cultural areas of New Mexico and west Texas. However, these earlier cultural frameworks are based on a definitive transition from a hunter-gatherer subsistence model to an agriculturally based society. Clearly, these cultural sequences are not easily applied to southeastern New Mexico. Katz and Katz (1985b; 1993) provide a more regionally accepted cultural sequence for southeastern New Mexico, which has been modified herein. Katz and Katz (1993:I-120–I-133) divide the Formative into seven phases which have been developed upon more regionalized fieldwork and attempt to create a synthesis based upon locally available data.

3.4.1 Formative 1 (A.D. 500–750)

Although the introduction of ceramic technology distinguishes the Formative 1 (A.D. 500–750) from the Archaic 4, many of the associated subsistence and settlement patterns that are attributed to later sites are absent. Cultural attributes associated with the Formative 1 represent a continuation from the Archaic (Katz and Katz 1993:I-126). As with the Late Archaic, projectile points have diagonal notching and convex to straight edges and bases. The points, however, are smaller than dart points but larger than arrow points (Katz and Katz 1993:I-126). Katz and Katz (1993:I-126) refer to these points as “darrow” points, which are slightly less than 3 cm long. Leslie’s (1978:118–125) Types 5 and 6A thru 6D are associated with the Formative 1. Ground stone artifacts include flat one-hand manos, unshaped slab metates, and bedrock mortars. For ceramics, plain brownwares, primarily non-local types, predominate. Although Jornada Brown is the most common, Middle Pecos Micaceous Brown, South Pecos Brown and Alma Plain also occur (Katz and Katz 1993:I-127). Formative 1 includes three local phases—late Hueco (southeast) (Leslie 1979:188), Early 18-Mile (Middle Pecos area) (Jelinek 1967), and early Globe (Brantley Reservoir area) (Katz and Katz 1985a:45–47, 1993:I-127, 2001:38).

3.4.2 Formative 2 (A.D. 750–950)

Distinguishing characteristics of the Formative 2 (A.D. 750–950) include domestic architecture, arrow points, and black-on-white pottery. Except for being smaller, the arrow point forms are similar to those of the preceding phase. (Katz and Katz 1993:I-127–I-128) Characteristic points of the Formative 2 include Leslie’s (1978:106–109) Types 3A (Scallorn) and 3B (a Scallorn variant). Local brownwares—Middle Pecos Micaceous Brown and South Pecos Brown—predominate. Red Mesa Black-on-white and Cebolleta Black-on-white pottery occur north and south of the Brantley area, respectively (Katz and Katz 1985a:46, 1993:I-128). Local phases within the Formative 2 consist of early Querecho (southeast) (Leslie 1979:188, 190), Late 18-Mile (Jelinek 1967), and middle Globe (Katz and Katz 1985a:45–47, 1993:I-128). Painted pottery is not associated with the middle Globe phase (Katz and Katz 1985a:46, 1993:I-128).

3.4.3 Formative 3 (A.D. 950–1075)

In general, the Formative 3 (A.D. 950–1075) reflects an intensification of occupation (Katz and Katz 1993:I-128–I-129). While many of the general characteristics of the preceding phase continued, an increase in stylized biface variation is recognized. Characteristic arrow points consist of Leslie’s (1978:106–115) Types 3A thru 3F (Scallorn variants and Livermore). Ground stone tools include convex-faced manos and oval basin metates. Local brownwares—Middle Pecos Micaceous Brown in the north—dominate the pottery assemblages but local and non-local graywares occur. Crosby Black-on-gray represents the graywares in the Middle Pecos area. In the south, both local and non-local brownwares are present and Mimbres Black-on-white replaces Cebolleta Black-on-white (Katz and Katz 1993:I-128–I-129). Local phases within the Formative 3 consist of Early Mesita Negra (Middle Pecos locality) (Jelinek 1967), late Querecho (Leslie 1979:188, 190), and late Globe (Katz and Katz 1985a:45–47, 1993:I-129).

3.4.4 Formative 4 (A.D. 1075–1125)

The settlement pattern of the Formative 4 (A.D. 1075–1125) contrasts sharply with the preceding phase. A reduction in occupation intensity is reflected in the decrease in the number and size of sites throughout the region. Subsurface structures replaced surface architecture. Although projectile point types of the Formative 3 continued into the Formative 4, variability, especially in size, is evident. The ground stone assemblage includes one-hand manos with one or two use-wear surfaces and oval basin metates. Local graywares increased in frequency, while local brownwares, except for McKenzie Brown, decreased. Chupadero Black-on-white appeared throughout southeastern New Mexico (Katz and Katz 1993:I-129–I-130). Local Formative 4 phases include Late Mesita Negra (Middle Pecos locality) and pre-Crosby (Roswell locality) (Jelinek 1967), early Maljamar (southeast) (Leslie 1979:190–191), and early Oriental (Brantley locality) (Katz and Katz 1985a:47–48, 1993:I-130).

3.4.5 Formative 5 (A.D. 1125–1200)

The Formative 5 (A.D. 1125–1200) reflects a reversal of the settlement pattern of the previous phase. Sites are larger and surface architecture is present. This phase also marks a shift from a riverine orientation to an increased upland settlement pattern. Fewer sites with fewer features are along the Pecos River (Katz and Katz 1993:I-130). Arrow point morphology changed from corner-notched to side-notched forms with concave bases, such as Leslie's (1978:96, 98–100) Types 2A and 2B. The production of local brownwares continued but some types disappeared. For example, McKenzie Brown replaced South Pecos Brown. Small quantities of intrusive types occurred throughout the region. El Paso Polychrome and Three Rivers Red-on-terra cotta appeared ca. A.D. 1150 in the Brantley area (Katz and Katz 1985a:47, 1993:I-130). Local phases within Formative 5 consist of Early McKenzie and Crosby (Jelinek 1967), late Maljamar (Leslie 1979:190–191), and early-middle Oriental (Katz and Katz 1985a:47–48, 1993:I-130–I-131).

3.4.6 Formative 6 (A.D. 1200–1300)

Most Formative 6 (A.D. 1200–1300) sites are small and exhibit a variety of architectural forms and patterns—pit structures, surface rooms, artifact scatters. The projectile point types are the same as those of the preceding phase (Katz and Katz 1993:I-131). Quantities of bison bone, maize pollen, and small, thick, steep end scrapers have been found in the Middle Pecos area (Jelinek 1967). Local textured and corrugated brownwares replaced local plain brownwares in the south and Middle Pecos Black-on-white became the dominant pottery type in the north. Glazed pottery may occur at the very end of this regional phase (Katz and Katz 1993:I-131). Local phases within Formative 6 include Late McKenzie and Roswell (Jelinek 1967), transitional Maljamar/Ochoa ('Malchoa') (Leslie 1979:191–192), and middle Oriental (Katz and Katz 1985a:47–48, 1993:I-131–I-132).

3.4.7 Formative 7 (A.D. 1300–1375)

The Formative 7 (A.D. 1300–1375) coincides with the beginning of the "Little Ice Age." In the southeast area, structures changed from large, deep pit structures to shallower pit structures to single surface rooms. Short-term camps were also occupied. Small stone circles, possible tipi rings, appeared in the Brantley and Middle Pecos areas. The short-term camps and stone circles may represent a subsistence strategy that focused on the procurement of bison. The recovery of shaft smoothers, notched ribs, and alternately beveled diamond-shaped knives in the southeast also suggests bison hunting. Projectile points consist of Leslie's (1978:99, 101, 103) Type 2C (Harrell). Overall, pottery decreased in quantity and type. Textured brownwares outnumber plain brownwares and non-local painted types are dominant (Katz and Katz 1985a:48, 1993:I-132; Leslie 1979:192). Local phases within the Formative 7 include post-McKenzie

(Jelinek 1967), early Ochoa (Leslie 1979:192), and late-middle Oriental (Katz and Katz 1985a:47–48, 1993:I-132). Post-A.D. 1375 phases include the Phoenix phase (A.D. 1450–1540) and the Seven Rivers phase (post-A.D. 1540).

3.5 Protohistoric to Historic Periods (A.D. 1375–Present)

Cabeza de Vaca, along with other survivors of a Spanish shipwreck on the Texas coast, probably passed through the southern portion of southeastern New Mexico on their return to Mexico in 1535 (Scurlock 1989a:53). Later, in 1541, Francisco Vasquez de Coronado may have entered the extreme northern portion of the area during his expedition to the Plains in search of the riches of "Quivira" (Scurlock 1989a:53–54). In the late sixteenth century, Antonio de Espejo and Castaño de Sosa led expeditions that followed the Pecos River Valley through southeastern New Mexico (Scurlock 1986:92–93, 1989a:54). Native groups encountered by the Spanish were nomadic Apaches and Jumanos. In 1630, Fray Alonso de Benavides mentioned a temporary encampment of Jumanos that was potentially on the plains east of Carlsbad (Kelley 1986:20). Based on historical evidence, Kelley (1986:22) hypothesizes that the Jumanos, a nomadic people, possibly occupied the Pecos River Valley in the vicinity of Carlsbad. From 1650 into the early nineteenth century, several Spanish military expeditions entered southeastern New Mexico in hopes of engaging these nomads either commercially or militarily. Slave raiding was also part of the Spaniards' agenda (Katz and Katz 1985a:58; Scurlock 1989a:55). Apache groups encountered by the Spanish included the Querechos, Vaqueros, and Faraones. The Siete Rios Apache, a group that lived near present-day Carlsbad, were first mentioned in 1659. In the late nineteenth century, these Apache groups and others became part of the Mescalero Apache (Scurlock 1989b:37). Comanche began entering the area by the middle of the nineteenth century (Scurlock 1989b:38).

By the mid-nineteenth century, livestock ranchers were migrating into southeastern New Mexico, attracted by the offer of available grazing land. The Homestead Act of 1862 guaranteed citizens a quarter section of land if it was settled and improved. By the 1880s, the Eddy brothers and the Pecos Irrigation and Investment Company were attempting to irrigate the Pecos River Valley, supplying much-needed water to farms in the area. The railroad reached Eddy in 1891. In 1899, the residents of Eddy, New Mexico voted to change the name of their town to Carlsbad in order to promote the medicinal qualities of nearby springs that were likened to those in Karlsbad, Bohemia (Katz and Katz 1985a).

Guano was mined in the Carlsbad Caverns until the 1920s when the caverns were declared a national monument. Since then, the caverns have attracted tourists to the area. In 1910, the Madison Well near Artesia was among the first to produce oil (Pratt 1989a:235). In the late 1920s, potash became one of the area's prominent industries. A major development in the oil and gas mining industry in the region came about with the formation of the E1 Paso Natural Gas Company in 1928. The Carlsbad Army Air Field was organized in June 1942 as part of the World War II war effort (Pratt 1989b:267). More recently, the Waste Isolation Pilot Plant (WIPP) began operation in 1999. The WIPP site is located in the underground salt beds southeast of Carlsbad. This facility is designed for disposal of transuranic radioactive waste.

3.6 LA 32229: Temporal Context

LA 32229 is a medium-large multicomponent site with artifact assemblages indicative of occupations possibly starting in the middle Paleoindian period, encompassing the Archaic and Formative periods, and terminating during the Protohistoric period. In all likelihood, most of these occupations were seasonal and short-term rather than continuous sedentary episodes. In contrast, the LCAS's (Corley and Leslie 1960) exposure of possible structures and the documentation of burials suggest LA 32229 experienced extended occupational episodes, possibly during the Formative period. Using data presented in Corley and Leslie (1960) and Condon et al. (2002) a summary of chronometric evidence is provided below.

As stated previously, the Paleoindian period in southeastern New Mexico ranges between 10,000 and 5500 B.C., with the most relevant phase for LA 32229 dating between 9000 and 8000 B.C. Corley and Leslie (1960:11, 13, 18) identified a Midland-like base fragment and a possible channel flake, suggesting the possible presence of a mid-Folsom component.

The Archaic period dates between 5500 B.C. and A.D. 500, but surprisingly, this long temporal span is represented at the site by only a few projectile points. Based on one Midland-like point fragment and San Pedro-like projectile points, a near absence of site use is indicated prior to 1500 B.C. The LCAS (Corley and Leslie 1960:10, 13) recovered projectile points similar to San Pedro (1500/1000 B.C.–A.D. 300/1000) or Tularosa variants (100 B.C.–A.D. 700/900). These point types span the terminal Archaic and extend well into the Formative period (Carmichael 1986:92; Condon et al. 2008:113; Justice 2002:217; Turner and Hester 1993:188). Also illustrated are Livermore variants (Corley and Leslie 1960:12), which date between ca. A.D. 100 and 800 and bridge the Archaic and Formative periods. While a Late Archaic presence is suggested by the projectile point assemblage, what form these occupations take is unclear. Moreover, the extent to which the typologies reflect site function and the accuracy of dates assigned to these point types are questions that need to be addressed. Formative period occupations are more obvious and appear to reflect increased use of the site. Previous site excavations recovered at least two distinct Formative projectile point types—Scallorn (A.D. 850–1100) and Harrell (A.D. 1100–1500) (Corley and Leslie 1960:9, 12). The age-range assigned to these point types indicates site occupation between A.D. 850 and 1500.

The site's ceramic assemblage is diverse, with at least 10 pottery types identified by Corley and Leslie (1960:16). The most prominent are Jornada Brownware and painted wares (A.D. 200–1350), El Paso Brown (A.D. 200/400–1300), El Paso Polychrome (A.D. 1200–1450), Mimbres Black-on-white (A.D. 850–1150), Three Rivers Red-on-terra cotta (A.D. 1100–1300), Chupadero Black-on-white (A.D. 1100–1300), and Casa Colorado Black-on-white (A.D. 1150–1400).

A single radiocarbon date is available for LA 32229. A radiocarbon sample, collected and processed in 1990, consisted of carbonaceous sediment and soil from a midden exposed in the CR 220 road cut. The sample (Beta 39193) yielded a conventional age of 1290±90 B.P. and calibrated age ranges of cal A.D. 600 to 900 and cal A.D. 917–966 (2-sigma calibration), which correlates with the Formative 1 through 3.

Using the ceramic assemblage, two periods of increased and/or prolonged use of the site are discernible after A.D. 500. The first period, A.D. 200/400 to 1000 is represented by Jornada Brown (n=434, 45.2 percent) and El Paso Brown (n=48, 5.0 percent) as documented by Corley and Leslie (1960:16). Mimbres Black-on-white, dating between A.D. 850 and 1150, is included in this period. The second period, post-A.D. 1100, includes Chupadero Black-on-white (n=330, 34.3 percent)—the second most prevalent pottery type—and Three Rivers Red-on-terra cotta, El Paso Polychrome, and Casa Colorado Black-on-white. The Late Archaic projectile points and Formative pottery types indicate LA 32229 experienced intermittent use during the Late Archaic and Formative periods.

4.0 Theoretical Orientation

4.1 Research Design

The theoretical orientation of the testing project took advantage of the opportunity to investigate LA 32229, a prehistoric site along the margins of the Mescalero Escarpment in Eddy County, New Mexico. This site is on an undulating terrace system that has yielded a range of cultural assemblages that include a possible structure, dense artifact scatters, burials, thermal features, and culturally associated soil horizons. The extent of the cultural components and their contextual integrity were unclear, possibly reflecting single or limited occupational events. The testing project provided an opportunity to examine cultural activities that had not been obscured or intermixed through time, thereby contributing to an understanding of prehistoric hunter-gatherer systems at LA 32229 specifically, and to southeastern New Mexico in general, a region that has remained somewhat unclear prehistorically.

The fundamental research objective of the testing project was to map the spatial limits of the primary occupation area, including surface artifacts and features, to discern the location of the LCAS (1957 and 1958) excavations, to carry out limited test excavations, and to analyze recovered materials in order to summarize the status of the archaeological data from the site. The second objective was to develop a geophysical map identifying subsurface features and anomalies associated with LA 32229. The third objective was to identify the soil sequence at the site and to correlate the contextual integrity of the cultural deposits with the site's depositional context. The latter two objectives provided the necessary data for evaluating spatial diversity and land-use patterns at LA 32229 and for correlating these data to current models of prehistoric mobility and adaptation. The ultimate value of this project is the providing of relevant data for determining future research efforts and data recovery strategies at LA 32229 and similar sites in the region.

4.2 Theoretical Framework: Explanatory Statement

The archaeological research program was guided by several basic theoretical assumptions. First, culture incorporates a complex set of rules or systems of knowledge that integrate "an extrasomatic adaptive system that is employed in the interaction of a society with its environment and with other sociopolitical systems" (Binford 1965:205). As a result, a cultural system can be characterized by its structure and organization. The structure of a system derives from the number, distribution, and arrangement of its components at a given point in time. The patterned interaction among these components constitutes the organization of the system (Clarke 1968; Owens 2003).

The fundamental theme underlying the construct of extrasomatic adaptive systems (i.e., cultural ecology) is that social systems are analogous to biological systems (Cadwallader 1959). Both organisms and societies are defined by "a system that exchanges matter with its environment, presenting import and export, and consequently, the building-up and breaking-down of its components" (Miller 1978:141). This organizational structure maintains a dynamic equilibrium that establishes an approximation of harmony between inflow and outflow with the environment (Miller 1978). Inability to maintain this balance results in the extinction of an organism or the failure of a culture to survive. Therefore, culture as a complex adaptive system may remain stable or change at varying rates depending on the overall balance of the human ecosystem. Subsequently, a series of regulatory mechanisms are developed that enable the transfer of energy from the environment into the social sphere of the cultural system. The emphasis on integration of culture and environment is considered fundamentally important for understanding the structure and organization of hunter-gatherer societies. In fact, the exploitation and distribution of resources (i.e., available energy) act as primary determinants in the distribution of populations across the landscape (Kelly 1983).

The systematic movement of populations, and consequently, material goods, across a landscape entails a significant investment of energy, and therefore, must result in a substantial benefit with regard to fitness (e.g., caloric investment). As a result, the selection of mobility, subsistence, and settlement strategies is based on a balance between success and failure. These management systems or resource strategies can be calculated within two opposing models of biotic variability—predictable versus unpredictable environments (Neff 1992:142).

Within predictable or congruent environments, the selection and acquisition of resources support the development of centralized specialization (i.e., craft specialization, ceramic production) and economic exchange (i.e., complex political systems, systematic regional interaction) as population density increases within a given region. In contrast, unpredictable or incongruent environments (patchy resource distribution) will create systems oriented towards the organization of smaller population groups (Kelly 1995) (Figure 4.1). Smaller population groups utilize exchange as one of several loose-knit mechanisms that optimize resource acquisition.

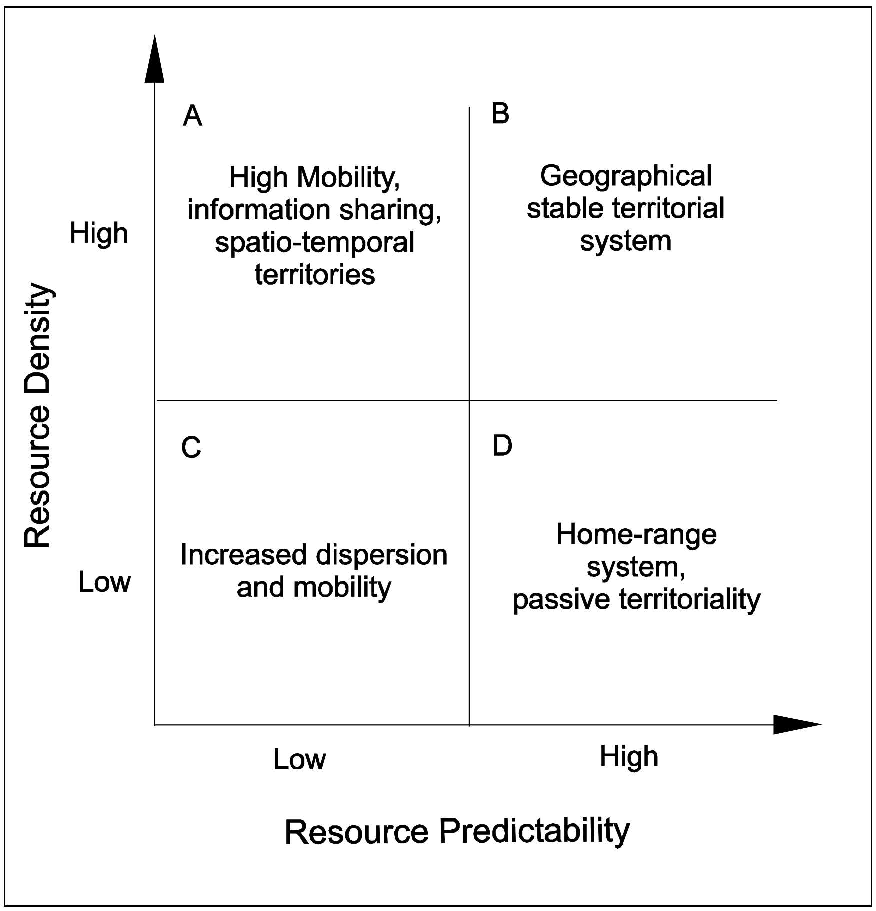

Figure 4.1 Adaptive strategies based on resource predictability and resource density

(modified from Kelly 1995:190, Figure 5-4)

Other strategies that increase economic success are migration, increased mobility, exploitation of a broad resource base, and maintenance of a widespread network of social interaction. Patterning of site locations and assemblage variability suggests that by A.D. 1100/1200, several factors, including population increase and severe fluctuations in precipitation, resulted in a shift in mobility strategies, resource acquisition, and site location within southeastern New Mexico.

4.3 The Forager-Collector Continuum

Identifying subsistence and settlement strategies represents the initial stage of interpreting hunter-gatherer adaptations within the Boot Hill region. Understanding how and why cultures change is a primary goal of archaeological research; however, the ability to evaluate culture change over time is dependent on the ability to identify organizational systems at specific points in time. Thus, identifying and understanding cultural variability at a given point along a time continuum must be achieved before temporal variation can be measured (Binford 1980).

Hunter-gatherer societies, which characterize much of southeastern New Mexico, are generally marked by less complex organizational systems and tend to exhibit less status differentiation, lower population levels, and smaller population centers (Lee and DeVore 1976). The adaptive strategies of hunter-gatherer groups are more oriented toward the distribution of natural resources and are more likely to manifest in a form that maximizes resource acquisition, such as increased mobility or the development of trade and exchange networks.

The scheduling and nature of resource acquisition depends on the regional extent and spatial structure of the selected resource(s), and the seasonality and temporal extent of resource availability. Theoretically, in regions where resources are abundant and available on a year-round basis, hunting-and-gathering groups can operate without a complex resource scheduling system. As population increases or resources become more limited, different strategies are required for the group to remain economically self-sufficient (Testart 1982). In areas with low resource productivity and/or irregular availability, complex scheduling of group foraging activities may be necessary to obtain resources over the entire year (Kelly 1983). Ultimately, hunter-gatherer groups can be characterized along a continuum ranging from forager-oriented on one end of the spectrum to collector-oriented on the other (Binford 1980; Kelly 1983).

Binford's (1980) forager and collector systems reflect differential use of the environment as expressed through mobility strategies. Within his model, two primary mobility strategies are presented: 1) residential and 2) logistical. Residential mobility is equated with high mobile foraging in which family groups move from one resource patch to another and where an immediate-return economy is practiced. Ethnographically, this strategy appears to be most effective when resources are congruent, predictable, and diverse (Binford 1980; Doleman 2005; Vierra and Doleman 1994; Yellen 1976). As residential sites are expected to reflect all activities associated with subsistence and settlement—including the terminal focus of procurement, consumption, and maintenance—the archaeological record is expected to be saliently visible and diverse.

In contrast, collector systems are associated with the movement of individuals or small groups from a residential base camp for task-specific activities exemplified by procurement of specific plants and/or by opportunistic hunting. Resources are obtained, not for individual consumption, but for the greater community. A delayed-economic strategy is correlated with logistical/collector mobility strategies. This strategy has been ethnographically associated during periods when resources are incongruent, unpredictable, and scarce. Because logistical sites are expected to be task-specific and of short duration, the archaeological record of such sites is expected to be vague and limited in terms of the activities conducted.

4.4 The Cultural Ecology Approach

Current theoretical models defining cultural adaptation and human behavior include cultural ecology (Bettinger 1991; Butzer 1982; Krebs and Davies 1997). This theoretical paradigm is based on models of behavioral ecology first introduced by Julian Steward (1955) to identify patterns in social organization. Steward's (1955) pioneering interpretations have since been modified by Butzer (1982), Dunnel (1996), Rindos (1984), and Winterhalder and Goland (1997). As a result, cultural ecology is a diversified field of inquiry that draws upon numerous disciplines, including the social sciences, biology, economics, ecology, and geography. Although models of cultural ecology are ultimately founded on evolutionary principles, they generally do not examine evolutionary origins directly, nor do they directly monitor changes in the cultural analogy of gene frequency through time, at least when applied directly to archaeological data (Bamforth 2002). Because models of cultural ecology are not time transgressive, a synchronic approach to human behavior and adaptive strategies, as they relate to cultural and natural environments, is the theoretical framework for this project.

The cultural ecology approach focuses on the adaptive relationships of a culture or group to its environment (Anderson 1974; Butzer 1982; Helm 1962; Vayda and Rappaport 1968). In short, the cultural ecology position asserts that human populations possess problem-solving abilities that manifest at various levels, including physiological, morphological, and behavioral (Boone et al. 1998). These problem-solving abilities, or adaptive strategies, represent a series of fitness-enhancing behavioral responses to varying environmental scenarios (Boone et al. 1998).

Three interrelated components of the human ecosystem provide the primary framework for interpreting human adaptation within southeastern New Mexico: 1) human populations as a biological phenomenon, 2) the opportunities and constraints offered by the available resources, and 3) the strategies adapted by cultural systems that enable them to survive on a collective level. Each component consists of subcomponents that must be taken into account. In general, populations reflect adaptive diversity and evolutionary success by their relative size. Populations that exhibit growth are generally associated with favorable exploitation of the environment. In contrast, populations in decline represent a lack of social organization and successful resource gathering, commonly resulting in population decrease. The systemic nature of social organization is further reflected in where and how a population chooses to exploit the landscape. This generalization implies that all behaviors will either be successful or unsuccessful. In fact, the evolutionary process operates on a separation between the rate of environmental change and biological change. Evolution can only work within a generational time frame, but the environment can change instantaneously. The success of human populations is dependent on the optimization of available resources, and minimizing cost and expenditure of time and energy. Among the interrelated systems that affect this cost-benefit ratio are technology, mobility, settlement and subsistence strategies, and ultimately, the ability to adapt to environmental change (Bettinger 1980; Butzer 1982; Clarke 1968).

In archaeology, especially prehistoric hunter-gatherer archaeology, the more abstract social and cognitive dimensions of cultural systems tend to be very difficult, but not theoretically impossible, to discern. The environment is both spatially heterogeneous and temporally dynamic. The spatial availability of resources provides a population with opportunities, as well as constraints, and ultimately guides cultural adaptation. The predictability and concentration or patchiness of resources strongly influences the timing, size, and location of socioeconomic groupings of hunter-gatherers operating with more or less limited extraction, processing, and transportation technologies. Patterns of settlement and socioeconomic organization are thus closely linked with spatial and seasonal patterns of resource availability. Consequently, the assumption underlying organizational approaches to explaining cultural variability is that humans seek to maximize certain resources in response to environmental conditions (Bettinger 1980). Furthermore, most applications assume that net energetic efficiency in foraging is a valid proximate measure of fitness, and consequently is maximized by natural selection. This simple, reductionism approach suggests the allocation of time or energy is determined by the spatiotemporal structure of the system (Jochim 1989:106).

The foraging-collector continuum and the cultural ecology approach allow the formulation of a series of research questions directly applicable to sites within southeastern New Mexico. The theoretical paradigms presented here also provide the framework on which to base future, more extensive investigations. To this end, the questions primarily concern resource availability and shifting land-use patterns over time and can be used to identify adaptive strategies used at LA 32229.

4.5 Regional Interpretive Models

As previously discussed, the Archaic period in southeastern New Mexico spans almost 6,000 years with little evidence for long-term sedentism or reliable evidence of agricultural dependency (Fifield 1984; Shelley 1994). This assessment agrees with interpretative models presented by Katz and Katz (1985b), Lord and Reynolds (1985), and Wiseman (2002) in which no major shifts in subsistence or settlement occurred within the region despite major shifts in environmental stability. In contrast, an oscillation between a mixed-spectrum economy during periods of resource scarcity and an economy focused on large herd animals during periods of environmental stability and resource availability is suggested by Shelley (1994).

The Archaic period in southeastern New Mexico, although not well understood, is generalized as a broad-based, mixed-economy hunter-gatherer adaptation (Sebastian and Larralde 1989; Stuart and Gauthier 1984). This interpretation is in keeping with fluctuations in biotic availability and oscillations in climate during the 6,000-year span. Applegarth (1976) and Shelley (1994) characterize this period as pre-ceramic small game hunter-gatherers with no reliance on agriculture (Shelley 1994). In support of this interpretation, there is little evidence for sustained hunting of artiodactyls in the low-lying draws of the region. Doleman (2005) argues for large-scale residential mobility that encountered scheduling conflicts for resource acquisition during “bloom or bust” scenarios. This lifestyle would have forestalled the adoption of agriculture in the region because unpredictable precipitation and great distances between adequate lands would have precluded successful cultivate a plant such as maize. Consequently, the general inability to accurately place Archaic populations across the landscape hinders further modeling of this long time period.

The subsequent Formative period can be interpreted as a continuation of highly mobile, mixed-spectrum subsistence patterns of the Archaic period, with little change despite the introduction of the bow and arrow and pottery. The second half of the Formative period, however, exhibits an increase in sedentism, a presumed increase in population, a reliance on domesticates, and an increase in regional interaction. Sites dating to this period (post-A.D. 1200) include Bloom Mound (Kelley 1984), the Henderson site (Rocek and Speth 1986), Fox Place (Wiseman 2002), and the Laguna Plata site (Condon et al. 2010a).

The Formative period, as further defined by Hogan (2006), is generally characterized by the production of Jornada Brown ceramics, the limited presence of intrusive ceramic types, subterranean domestic structures (pithouses), the limited presence of cultigens, and an increase in sedentism. A shift in group mobility and site structure is punctuated by a presumed increase in population. Binford (1965) argues that the stimulus for plant domestication was the development of population density in excess of what could be supported in a particular region by hunter-gatherers. This disequilibrium between population and resources resulted in an increase in the need for social aggregation, and subsequently, social complexity (Cohen 1977).

Agriculture has been seen as offering such a significant and obvious economic advantage to hunter-gatherer populations that once the proper knowledge was introduced, the acceptance of the new economy would be axiomatic (Cohen 1977). While this premise may hold true for portions of the Southwest, the resource diversity identified within, and adjacent to, southeastern New Mexico may have precluded the need for entrenched agriculture despite an assumed increase in regional population. LA 32229 contains evidence for multiple occupations and extended site use during the Late Archaic and throughout the Formative period, and is in proximity to possible seasonal water sources afforded by springs, escarpment runoff, and small catchments basins. The site, therefore, may provide data on short-term sedentism and potential use of horticulture as a supplemental subsistence strategy during the Formative period.

Wills and Huckell (1994) argue for a model of complex mutualism that evolved between cultivation and foraging in the face of changing climate and unpredictable resource availability in a post-A.D. 200 world.

The domestication of plants was a survival tactic implying that the economic value of cultigens outweighed the economic value of plants commonly selected by foraging strategies.

Hard (1983) and Doleman (2005) offer an alternative model suggesting that despite increasing populations, hunter-gatherers continued in a mixed land-use pattern that shifted group location within southern New Mexico. This land-use pattern is directly affected by seasonal orientation and resource availability. As a result, mobility is structured around a series of complex residential and logistical moves that provide access to resources that are distributed in a spatiotemporal fashion (Diehl 1997:254). Consequently, plant domestication offered a supplementary subsistence strategy that may have been used in a limited fashion to expand foraging opportunities, not necessarily as a response to resource stress (Hard 1983). This model differs from Wills and Huckell's (1994) primarily in the causal factors underlying the advent and practice of horticulture, as well as the duration and extent of sedentism during the early Formative period.

At the core of both economic-based strategies are biotic variability and the selection of dominant cultural traits that enabled or optimized survival along a graduated adaptive system. Interspecies competition and biotic variability are evidenced through population growth during the early Formative period (i.e., the start of aggregated population systems and complex social systems) and fluctuating climatic conditions (Grissino-Mayer et al. 1997). It is hypothesized that dominant cultural traits, in particular, seasonally oriented sedentism (e.g., logistical winter alluvial fan use versus residential summer basin use) that developed during the early Formative increased group fitness, offset extreme variations in environment, and enabled the continued optimization of the biotic and cultural landscape.

Based on Hard's (1983) interpretation, a model of subsistence, settlement, and mobility is proposed for the Late Archaic and Formative periods that supports a fluctuating continuum from residential to logistical mobility patterns and is opportunistic in nature. During the Formative period, mobility and subsistence may have been modified by the limited use of domesticated plants (i.e., maize, beans, squash).

5.0 FIELD METHODS

Peter C. Condon and Benjamin G. Bury

The general work plan for the testing project is outlined below. The section discusses mapping, surface collections, manual excavations, and geomorphology.

5.1 Locating Previous Excavations

One of the primary goals of this project was to discern the location of the LCAS (1957–1958) excavations. TRC's proposed method for locating the previous excavations consisted of a multi-phase approach. Initial work consisted of an examination of aerial photographs to discern human-made site disturbances, particularly those that have a geometric pattern (e.g., squares, rectangles, lines). TRC attempted to contact LCAS and Boy Scout members who had participated in the 1950's activities at the site (see Appendix I). Because the Boot Hill site has been subjected to frequent unauthorized excavations and surface collecting, the locations of disturbances were recorded with a global positioning system (GPS) unit and an electronic distance measurer (EDM).

In addition to verifying anomalies found in aerial photographs, interviewing informants, and examining excavation photographs for landmarks, TRC also used soil probes and auger holes in those areas with a high probability of having been previously excavated. Differences in site stratigraphy and the potential discovery of buried grid stakes and other excavation debris (by the LCAS) were considered as strong evidence for the previous investigations. However, because of the time lapse since the 1957–1958 excavations, major natural changes (e.g., wind and water erosion), in addition to modern impacts (roads, unauthorized excavations and collecting), made the search for the previous investigations difficult.

Geophysical prospecting was performed by New South Associates Inc., and included ground penetrating radar (GPR) and magnetometer (fluxgate gradiometer) instruments. Survey blocks were established over a broad area of the site, encompassing a total of about 4,714 m^2 (1.16 ac). Selection of survey block locations was based on a combination of factors, including management and research needs, vegetation, overall size, and expected data returns. The results, supplemented with the other methods described above (e.g., photographs, interview data, and auger holes) aided the search for previous excavations and subsurface cultural features (see Geophysical Analysis, Chapter 6 and Appendix L). The geophysical survey employed ground penetrating radar (GPR) and magnetometer (fluxgate gradiometer) surveys.

5.2 Mapping and Surface Collection

Earlier evaluations at LA 32229 completed varying levels of effort that included surface inventory and delineated the site boundary. LA 32229 (SR 168) was placed on the New Mexico State Register of Cultural Properties in 1970 (Riskin 2000:147). The initial site inspections prior to this testing project indicated cultural materials were differentially spread across the site since previous field sessions. Adverse impacts to the site ranged from light to heavy, with the most notable resulting from arroyo incising, aeolian deflation, and local collecting. Oil and gas development does not appear to be a factor at LA 32229.

Initial work during this testing project focused on establishing a Cartesian coordinate grid and datum. Both GPS and EDM instruments were used to establish and document the provenience controls. Using known points from previous investigations, the LCAS datum and backsight subdatum were tentatively verified, and the original grid system was reestablished. Once previous datum locations and the grid system were determined, the overall accuracy of the LCAS map was checked for modifications or updates. Once the LCAS excavation area was verified, TRC marked the overall site boundary as defined by the BLM-Carlsbad Field Office with surveyor's flagging tape and the UTM coordinates were collected for precise mapping. The UTM coordinates of the TRC site datum were recorded by using a Trimble Geo XT GPS. Site grids were oriented to true north. All grid coordinates were tied into the site datum's corrected UTM coordinates.

After the boundary for LA 32229 was delineated, a pedestrian survey was conducted across the site. Singular artifacts, artifact concentrations, and features were marked with pin flags and were point provenienced using the EDM or the Trimble GeoXT GPS. Due to the site's artifact density, a random 10 percent sampling strategy recording one of every ten artifacts was employed. Artifacts selected were documented and analyzed in the field using a standardized classification system that included, at minimum, artifact and material type. Diagnostic artifacts, including projectile points, decorated pottery, rim sherds, exotic, and unusual artifacts were collected. When encountered, obsidian was also collected. Collected material was placed in resealable polyethylene bags with an acid-free identification tag. The tags contained the project number, site number, provenience number, unit or block number, depth below datum, feature number when applicable, north and east coordinates, contents, excavator(s), date, and the assigned collection number.

5.3 Manual Excavations

Manual excavation techniques followed the basic recovery methods of the Bear Grass Draw project conducted by TRC Environmental (Condon et al. 2008a). The testing plan outlined excavating 30 1 x 1-m units in three trenches to investigate the site. Deviations from the plan were made after consultation with George MacDonell, Lead Archaeologist, BLM-CFO.

During the manual excavations, horizontal control was limited to 1 m x 1-m grid units. Stratum I was excavated as a natural level, usually associated with overlying modern aeolian sand deposits. Subsequent soil horizons were designated consecutive numerical values (Stratum II-Level 1, Stratum III-Level 1, etc.) which were later correlated with the stratigraphic series for the site. Feature 3, a small soil stain in Trench 1, was excavated. All excavated sediments were processed through ⅛-inch hardware screens.

Once exposed, Feature 3 was documented; data regarding dimension, construction detail, possible chronological age, and function was collected. Samples included carbon-stained sediment and wood charcoal recovered in the form of charred wood. Samples were submitted for AMS radiocarbon dating. Wood charcoal from Feature 3 and Levels 1, 2, 4, and 5 from Unit 3, Trench 1 were collected and submitted for AMS dating. In addition, bulk soil samples were submitted for AMS dating from three geomorphological localities.

After being photographed and drawn in plan view, Feature 3 was bisected to obtain a cross-section profile. The profile was drawn and photographed. All sediments were processed through ⅛-inch hardware mesh or collected for additional studies. A final plan view was drawn and a photograph taken after the feature was excavated. The center point of the feature was calculated in reference to the grid system, and all horizontal provenience information was referred to that point.

6.0 GEOPHYSICAL ANALYSIS

Shawn M. Patch

6.1 Introduction

A geophysical assessment was conducted within selected portions of LA 32229. The geophysical survey was designed to address three specific research goals (Appendix L, complete geophysical report). The first was to identify and locate the LCAS excavations conducted in 1957–1958. The second was to identify additional archaeological features and offer interpretations about patterning and other cultural activities. The third was to assess the overall potential of geophysical techniques as a BLM management tool for archaeological sites. The BLM scope-of-work called for a geophysical survey of an area equivalent to 100 x 100 m (10,000 m^2 or 2.4 ac). The scope was modified after a field visit by BLM officials and a discussion of the challenges inherent in an area of that size.

6.2 Methods

Instrumentation included ground penetrating radar (GPR) and magnetometer (fluxgate gradiometer). Survey blocks (n=18) were established over a broad area of the site, encompassing a total of about 4714 m^2 (1.16 ac). Selection of survey blocks was based on a combination of factors, including management and research needs, vegetation, parcel size, and expected data return. Vegetation proved to be the most challenging for two reasons. First, it prohibited the establishment of large parcels for more efficient surveying, thus requiring more time. Second, clearing of vegetation was time-intensive and detrimental to long-term site preservation because of its destabilization effect on the terrain.

In order to effectively collect and process geophysical data, it is necessary to establish a formal grid. In this case, grid layout was accomplished with three metric tapes and surveyor's chaining pins. The actual size, orientation, and layout of each grid was determined by surface features and orientation of the targets. All grid corners were mapped with TRC's EDM. Geophysical data were collected in each of the 18 separate grids (Appendix L). With the exception of Grids 1 and 6, most others were generally longer along one axis (Table 6.1, Figure 6.1).

6.3 Results

The GPR survey was conducted with a Geophysical Survey Systems, Inc. (GSSI) SIR 3000 control unit with an attached 400MHz antenna. Effective depth penetration was approximately 1.5 m. GPR data were collected at either 25- or 50-cm intervals. Transect spacing is chosen based on a balance between the types of expected features, required resolution, and time. In general, 50-cm transects are standard and have been shown to work very well for identifying medium to large features (Pomfret 2006). Closer transect spacing, such as 25 cm, does not necessarily reveal any new features, although it sometimes can, but rather provides increased resolution and a better image. Because the sampling interval was doubled, the field time required for data collection increased accordingly.

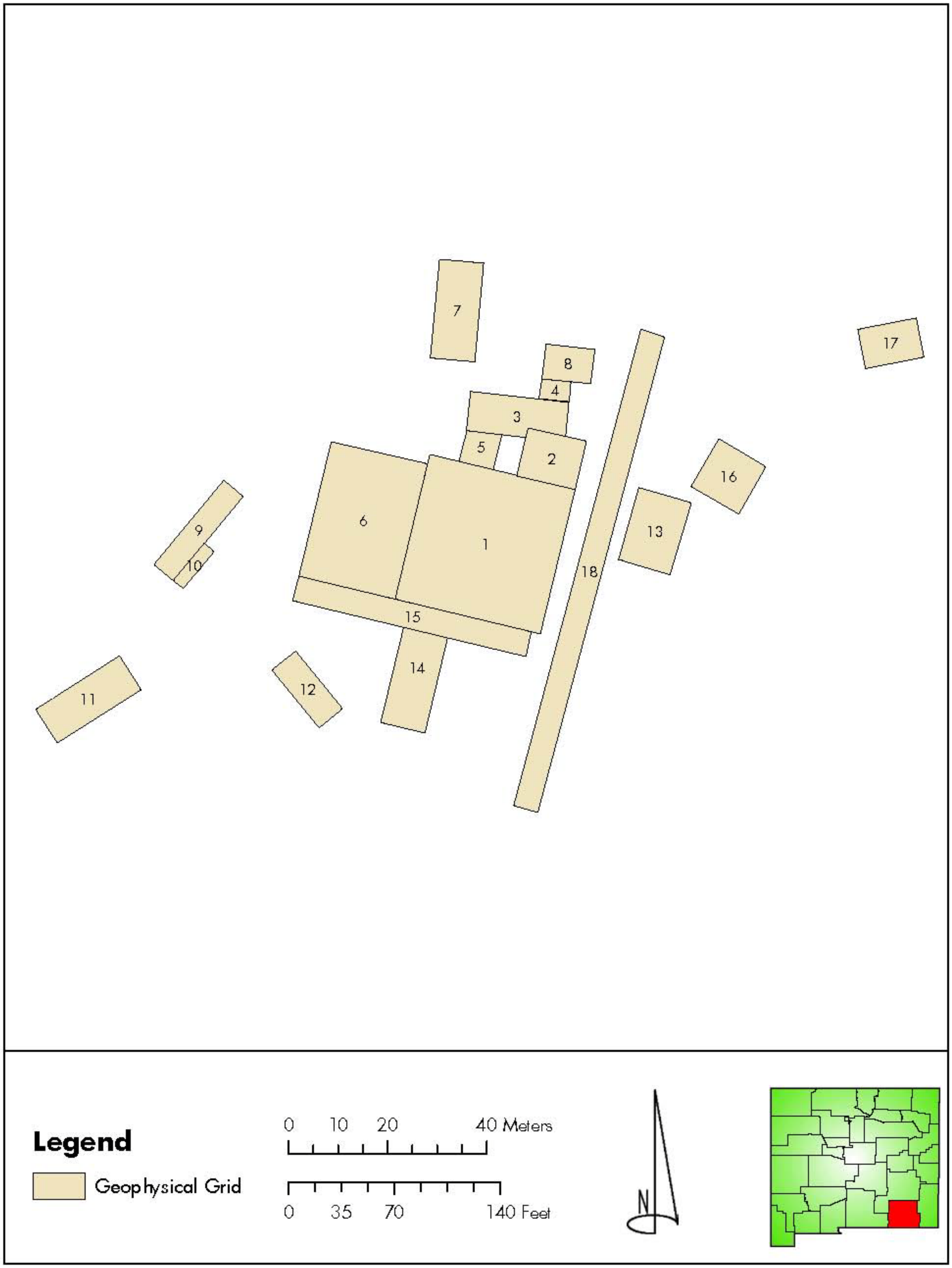

Figure 6.1 Location and layout of geophysical survey grids

Table 6.1 Geophysical survey grids

Grid	X Length	Y Length	Area (square meters)	GPR Transect (cm)	GPR Antenna (mhz)	Mag Sampling Density
1	30	30	900	25	400	16/m
1	30	30	900	25	900	16/m
2	12	10	120	25	400	16/m
3	20	8	160	25	400	16/m
4	6	4	24	25	400	16/m
5	7	8	56	25	400	16/m
6	20	28	560	50	400	16/m
7	9	20	180	50	400	16/m
8	10	7	70	50	400	16/m
9	5	22	110	50	400	16/m
10	2.5	15	37.5	50	400	16/m
11	8	20	160	50	400	16/m
12	15	6	90	50	400	16/m
13	11	15	165	50	400	16/m
14	9	25	225	50	400	16/m
15	48	5	240	50	400	16/m
16	11	11	121	50	400	16/m
17	12	8	96	50	400	16/m
18	5	100	500	NA	NA	16/m
Total			**4714.5**			

Magnetometry is particularly well suited to archaeological sites because of the magnetic variations found in many subsurface features (Aspinall et al. 2009). Technically, magnetometry is a passive geophysical method that maps local variations in the earth's magnetic field. One of the primary benefits of magnetic surveys is the rate at which data can be acquired. Large areas can generally be covered in a small amount of time, particularly in open areas with few surface obstacles. For these reasons, magnetometry has become the workhorse of archaeological geophysics (Kvamme 2006a:206). The primary limitation of magnetometry is its inability to resolve targets at depths greater than 1 to 2 m. Magnetometry is well suited to discovering metal and thermally altered features (e.g., burned structures, floors) (Aspinall et al. 2009). The magnetic survey was conducted with a Bartington Instruments Grad 601 fluxgate gradiometer. All data were collected using the zig-zag method, which is also quite fast. Prior to data collection, each grid was cleared of obvious surface metal such as tin cans and other debris.

Both the GPR and magnetometer yielded good results, with high quality datasets. Amplitude slice maps of GPR data are provided in Appendix L. The amplitude slice maps have been color enhanced to better indicate reflective contrasts. Blues and greens represent low amplitude values, while reds and whites indicate high amplitude values. GPR profiles show particular areas of interest (e.g., point reflection or geologic feature).

GPR data were acquired in 17 of the 18 survey parcels. Results indicate at least 39 distinct anomalies representing both natural and cultural objects/features (Table 6.2, Figure 6.2, Appendix L). Not all survey parcels yielded anomalies, particularly those on the northern and eastern fringes (grids 5, 7, 8, 16, and 17). Conversely, many more anomalies are evident in the remaining parcels, with a notable cluster in Grid 1.

This parcel corresponds to the highest topography on the site, and it seems reasonable to conclude that more intense cultural activity may have occurred at this locus.

Table 6.2 GPR anomalies and probable interpretations

ID	Depth (cmbs)	Interpretation	ID	Depth (cmbs)	Interpretation
1	50-70	bedrock	21	50-70	feature
2	50-70	bedrock	22	50-70	feature
3	50-70	bedrock	23	50-70	feature
4	50-70	bedrock	24	50-70	feature
5	50-70	pit feature	25	50-70	feature
6	50-70	pit feature	26	50-70	bedrock
7	50-70	pit feature	27	50-70	bedrock
8	50-70	pit feature	28	50-70	metal
9	50-70	pit feature	29	50-70	metal
10	50-70	pit feature	30	50-70	metal
11	50-70	metal	31	50-70	metal
12	50-70	metal	32	50-60	feature
13	50-70	metal	33	50-70	feature
14	50-70	metal	34	50-70	feature
15	50-70	metal	35	50-70	feature
16	50-70	rocks	36	40-60	feature
17	40-70	feature	37	50-70	bedrock
18	50-70	metal	38	50-70	feature
19	50-70	feature	39	50-70	feature
20	50-70	feature			

Magnetic data were collected in all 18 survey grids. Results indicate at least 61 distinct anomalies, representing a range of probable feature types (Table 6.3, Figure 6.3, Appendix L). While they are more broadly distributed than the GPR anomalies, several grids did not yield any magnetometer anomalies (Grids 8, 10, 12, and 16). Not surprisingly, however, is the degree of clustering toward the central portion of the survey area, which also occurs with the GPR data. Interpretation of these anomalies is necessarily basic. However, it is clear from the magnetic data that there are differences in their overall strength. Some appear as dipoles, which suggest possible metallic objects, but not exclusively. Based on current knowledge of the site, and anomaly morphology, these have been divided into possible burned areas (which may or may not be well defined features), and general magnetic features.

6.4 Interpretations

Several preliminary interpretations can be offered from the geophysical data. While not exhaustive, the geophysical data provide a unique perspective on overall site conditions, particularly with respect to the presence of suspected features and stratigraphic differences. Numerous anomalies were identified in both geophysical datasets. It is nearly impossible to determine what these are with 100 percent certainty without some type of verification through traditional archaeological ground-verification methods. However, there is sufficient information available to generate general inferences regarding possible cultural activities. Several large probable pit features were identified, with a primary cluster in Grid 1. They have regular, circular shapes in plan view, and are basin shaped in profile. Their sizes generally range from 1 to 2 m in diameter. It is possible that these could have formed naturally and then were exploited culturally.

Figure 6.2 **Map showing GPR anomalies in the survey grid**

Table 6.3 Magnetic anomalies and probably interpretations

ID	Interpretation	ID	Interpretation
40	Feature	71	Burned area
41	Feature	72	Burned area
42	Feature	73	Feature
43	Feature	74	Burned area
44	Feature	75	Feature
45	Feature	76	Feature
46	Feature	77	Feature
47	Feature	78	Feature
48	Feature	79	Burned area
49	Feature	80	Burned area
50	Feature	82	Burned area
51	Feature	82	Burned area
52	Feature	83	Burned area
53	Feature	84	Feature
54	Feature	85	Feature
55	Feature	86	Feature
56	Feature	87	Feature
57	Feature	88	Feature
58	Feature	89	Feature
59	Feature	90	Feature
60	Feature	91	Feature
61	Feature	92	Feature
62	Feature	93	Feature
63	Feature	94	Feature
64	Feature	95	Burned area
65	Feature	96	Burned area
66	Feature	97	Burned area
67	Feature	98	Feature
68	Feature	99	Feature
69	Burned area	100	Burned area
70	Burned area		

Numerous small, high amplitude features are present with signatures characteristic of metal. That is, their reflection amplitudes "ring" considerably throughout the profile, a phenomenon that is caused by the radar signal reverberating between the metal object and the surface. Given their depths, they do not appear to be surface objects. Possible explanations might include nails, cans, or other large ferrous objects. These are cultural but not associated with the prehistoric occupation of the site. It is reasonable to conclude that these are likely objects from either earlier archaeological investigations or the aeolian burial of modern refuse. The degree of anthropogenic modification at the Boot Hill site is extensive. Walking across the site it is apparent that major burning events have occurred (also visible on aerial photography). Several features are present in the magnetic data that are likely associated with burning events. Some may represent discrete features such as processing pits, while others might be magnetically enhanced areas that resulted from large-scale activities.

The GPR data indicate major differences in subsurface conditions across the sampled areas. Numerous broad areas of high amplitude reflection are present in Grids 1 and 6. Although irregular, they form a distinct band running approximately east-west across the highest landform, with depths ranging from 50–70 cm. In both plan and profile views, these are distinct areas of high contrast, which indicates objects and/or materials that are substantially different from the surrounding matrix. These areas likely represent caliche outcrops that may be better formed or enhanced by water retention and are not cultural.

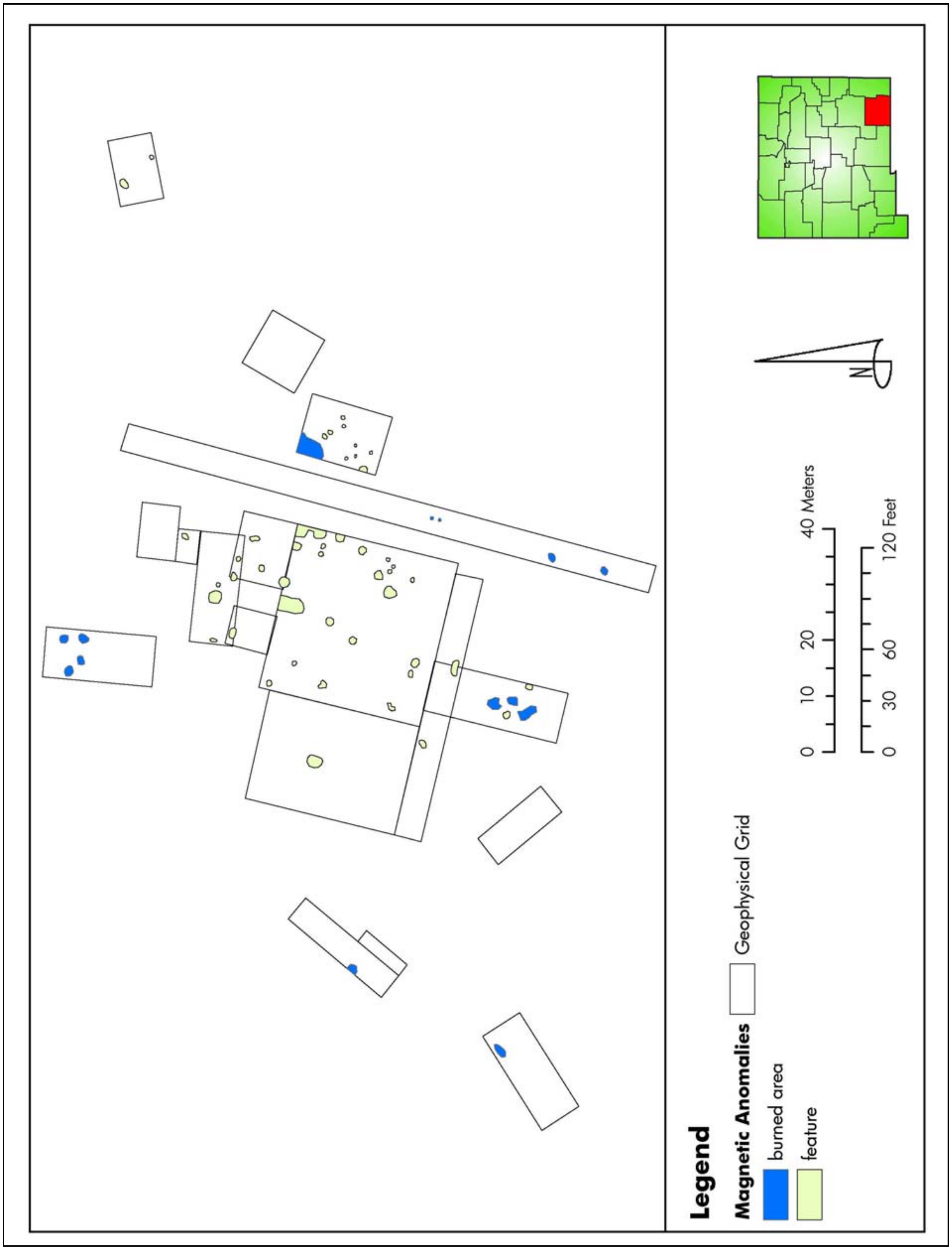

Figure 6.3 Composite map showing magnetic anomalies in the survey grid

In the central portion of the survey area there appears to be more deposition. Individual GPR profiles clearly indicate major changes in RDP values between what has been interpreted as aeolian sand and underlying bedrock. Deposition is somewhat shallower on the northern, western, and southern edges, and considerably shallower on the far eastern edge. Simple observation of surface conditions confirms this, with major color differences in sediments and clear areas of erosion/deflation on the eastern edge.

This project was designed to address three specific research questions: 1) helping discern the location of the 1957–1958 LCAS excavations; 2) help discern the location of buried cultural features; and 3) assess the usefulness of geophysics as a management tool by the BLM for archaeological resources in the Permian Basin.

At the time of the geophysical survey, TRC had determined the approximate location of the LCAS excavations. The LCAS investigations included a large trench oriented parallel to CR 220 on a slightly north-sloping area away from the site's highest point. Because of its orientation, data collection in this area had occurred in an east-west direction. This was done to provide a maximum number of transects perpendicular to the long axis of the blocks. Despite expectations to the contrary, the geophysical data did not clearly indicate the edges of the LCAS excavated areas. While the edges of the blocks themselves were not clearly delineated, metal objects may be an indication of either nails or trash associated with the excavations. Why were the earlier excavations not detected directly with the geophysical instruments? This is a complicated question, but one that deserves an answer. Multiple variables are likely responsible, although they have more to do with site specific conditions than the instruments. Detection of any anomaly is based on the assumption of contrast. In order for an object to be detected, it must be substantially different from the surrounding matrix. This is the principle underlying all geophysical investigations.

At Boot Hill, the sediments are essentially homogeneous, with aeolian sand on top of caliche bedrock. The thickness and depth of deposits varies considerably across the site (as seen in the geophysical data). Excavation of these sediments, screening for artifacts, then filling the holes again with the same material likely did not produce enough contrast for the survey instruments. Over time, as the deposits were weathered, whatever differences might have been visible would likely be erased. Unless the excavations extended into the bedrock itself, leaving a clear boundary, the probability is low for identifying those areas with geophysics alone.

The second goal was to help discern the location of buried cultural features. A large number of anomalies were identified that have been interpreted as cultural. However, it is virtually impossible to determine with complete certainty what type of feature may be represented by a particular anomaly (Kvamme et al. 2006b). In general, it is sometimes possible to offer possible interpretations based on size, shape, depth, signal strength, and contrast. In broad terms, interpretation of geophysical anomalies is divided into natural and cultural classes, based on their presumed origin and use. Natural anomalies are primarily limited to caliche bedrock, although other types may also be present. Cultural features include both prehistoric and modern activities. Many of these originate from activities spanning several decades. Potential prehistoric features are differentiated based on size, shape, depth, orientation, and reflective strengths. In general, they are more subtle and not as easily identified as metal objects. For obvious reasons, some features are more easily identified than others (e.g., burned pithouse, burned rock midden versus posts or burials). The magnetic data suggest several areas that have been thermally altered from burning. These are not necessarily high-fired burned features, but they appear to have been heated. In other cases, smaller point anomalies might represent posts or individual burned rocks.

Geophysical techniques have tremendous potential for aiding management of archaeological sites (Kvamme et al. 2006a). Several variables must be considered in order to maximize that potential. Geophysical methods have the advantage of being non-invasive, relatively inexpensive, fast, efficient, and remarkably accurate. However, each of these depends on additional variables such as site type, environmental setting (e.g., soils, geology), surface obstacles (e.g., vegetation, excessive metallic debris), and operator experience.

The geophysical survey of the Boot Hill site yielded information that would not have been possible with any other method. Specifically, we now have a better understanding of the spatial distribution of potential features (both horizontal and vertical), which can be used for further interpretations about past cultural activity when compared to data from similar archaeological sites. Approximately 100 anomalies were identified using GPR (n=39) and magnetometer (n=61) methods (Tables 10.2 and 10.3, Figure 6.4). Somewhat surprisingly, there is little overlap in the data between the two methods.

TRC and New South Associates recommends the BLM carefully consider competing issues for future geophysical surveys. Vegetation can be expected to be a concern since it limits the effectiveness of geophysical data collection over wide areas. GPR and magnetometry worked extremely well and provided useful data on internal site structure and depositional setting. TRC and New South Associates offers the following recommendations. Broadly, geophysical investigations can be applied in the areas of research, NRHP eligibility evaluations, and resource management. They offer several distinct advantages, as outlined earlier, but should not be viewed as a substitute for traditional methods. Rather, they are complementary and can enhance the overall testing results and interpretations at a particular site.

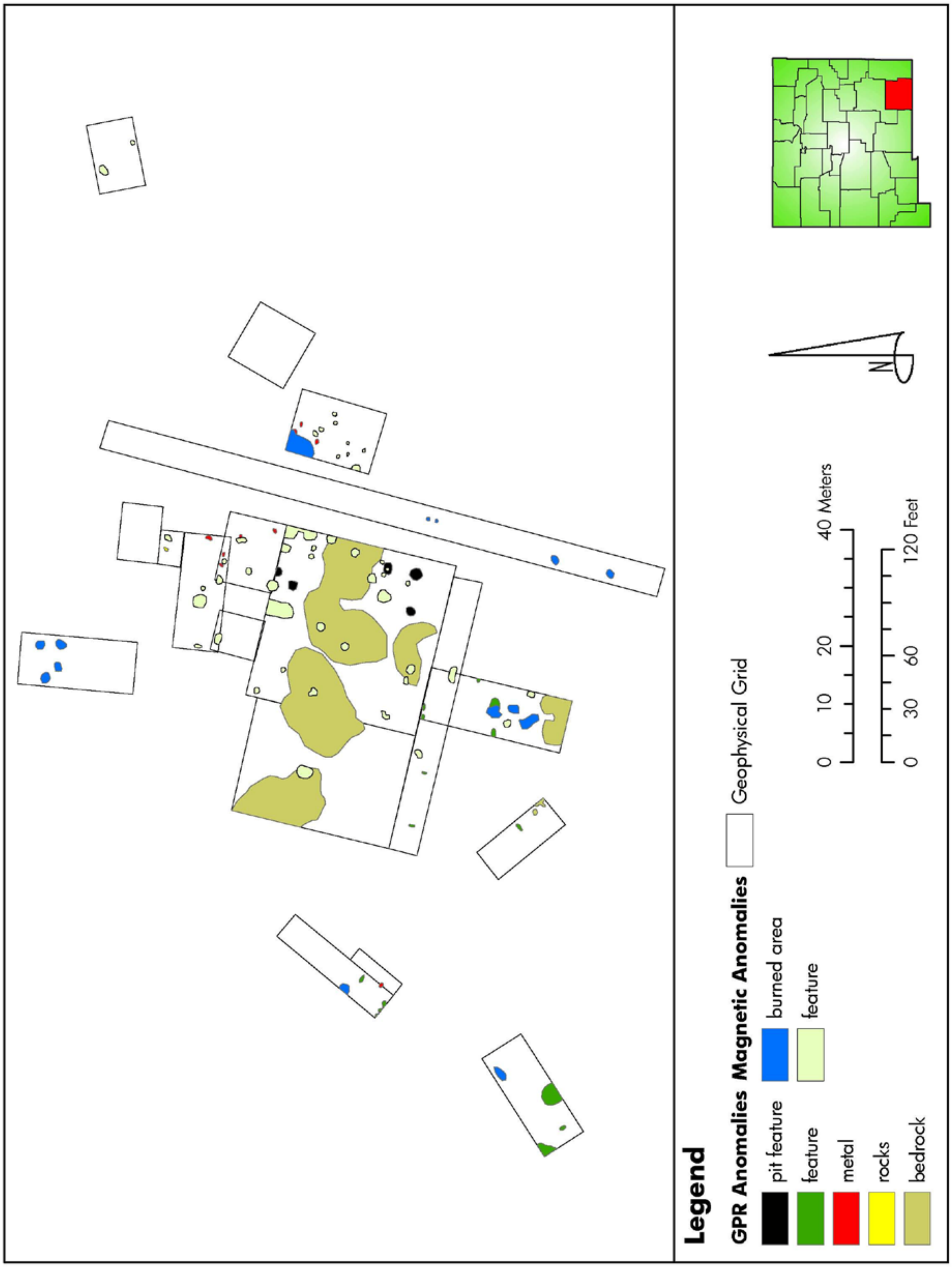

Figure 6.4 Composite map showing all geophysical anomalies identified at Boot Hill

7.0 Archaeological Testing Results

Willi Hermann

7.1 Lea County Archaeological Society (LCAS) Excavations

The original Boot Hill site, currently designated Locus 3 of a much enlarged LA 32229 (Condon et al. 2002:32–35), [redacted] A large drainage emptying into [redacted] borders the south and east edges of Boot Hill (Locus 3). Springs were formerly along the [redacted] "Tradition has it that many such springs were still flowing shortly after the turn of the [twentieth] century" (Corley and Leslie 1960:1). Fan-like Quaternary alluvial deposits extend a short distance west from the base of the [redacted] Railey et al. 2009:11). [redacted] The geological unit of the site consists of Holocene to Middle Pleistocene aeolian and piedmont deposits, "interlaid aeolian sands and piedmont-slope deposits along the eastern flank of the [redacted] valley, [redacted] typically capped by thin aeolian deposits" (Railey et al. 2009:13). The vegetation is variously classified as Desert Grassland (Castetter 1958:256), Grassland Savanna (Gross and Dick-Peddie 1979:118), Semidesert Grassland (Brown and Lowe 1994), and Plains- Mesa Sand Scrub (Dick-Peddie 1993).

A north-south bladed road [redacted] and buried waterline traverse the main portion of Boot Hill, which has also been heavily impacted by ranching, oil and gas activities, unauthorized collecting and excavations, and archaeological excavations by the LCAS. Cultural deposits are visible in the road cut and a dark, organically stained midden is evident on the hill, including within the road cut. Currently, flaked-stone artifacts, sherds, bone, burned rock, and burned adobe are visible on the surface. Two possible structures and three thermal features were identified on Boot Hill during a survey by TRC (Condon et al. 2002:33).

The LCAS, a newly formed organization at that time, conducted excavations at Boot Hill during the summers of 1957 and 1958, with each individual keeping the items he or she found (Corley and Leslie 1960:1). The LCAS excavations were west of the bladed road, totaling about 1,350 ft^2 and included a 90-ft manually dug trench (Figure 7.1). Cultural deposits extended as much as 4 ft below the surface. The excavations uncovered three burials, of which one (Burial 1) included funerary objects. All three were children. A fourth burial, containing about 90 shell beads, had been uncovered on the point of the hill by a Boy Scout troop shortly before the LCAS excavations. The whereabouts of the human remains and associated shell beads is currently unknown. Artifacts recovered during the LCAS fieldwork included 961 sherds, 127 projectile points, hammerstones, various chipped stone (knives, scrapers, drills, gravers), ground stone tools, (manos, metates, polishing stones) and faunal remains (shell and bone). The projectile point assemblage included a Midland-like (Paleoindian) base fragment as well as Archaic and Formative point types.

The results from the ceramic analysis by LCAS indicated most of the ceramics consisted of utility wares (n=49/50.9 percent) and painted wares (n=472/49.1 percent). Within the sample of utility wares (n=489), the most of the pottery types consisted of Jornada Brown (n=434/88.70 percent), El Paso Brown (n=48/9.80 percent), Plain Corrugated Brown (n=5/1 percent), and Indented Corrugated Brown (n=2/0.5 percent). The pottery types identified as painted wares consisted primarily of Chupadero Black-on-white (n=330/69.7 percent), followed by Red Wash ceramics (n=30/6.3 percent), El Paso Polychrome (n=19/4 percent), Casa Colorado Black-on-white (n=18/3.8 percent), Terracotta Body-Plain Red (n=17/3.9 percent), Three Rivers Red on-terracotta (n=21/3.6 percent), and Mimbres Black-on-white (n=8/1.3 percent). Additional smaller quantities of painted wares included Plain Red Body (n=6/1.1 percent).

A small carbon sample collected by the BLM Carlsbad Field Office in the 1990s from midden deposits exposed in the road cut yielded a date of 1290±90 B.P. (Beta 39193) (2-Sigma correction A.D. 600–900, A.D. 917–966). The original Boot Hill site and its materials have never been formally analyzed, and only a brief preliminary report has been written (Corley and Leslie 1960).

[redacted]

[redacted]

7.1.1 Locating Previous Excavations

One of the primary goals of the present project was to identify the location of the LCAS (1957–1958) excavations. The LCAS excavations consisted of contiguous 5 x 5-ft units within two 30 x 30-ft blocks. Block 1 was completely excavated, with final depths varying from 6 inches to 4-ft below ground surface. Approximately half of Block 2 was excavated. In addition, a 90-ft trench was dug as an extension of Block 1 (Corley and Leslie 1960:4). TRC's proposed method for locating the previous excavations consisted of a multi-phase approach. Initial work consisted of an examination of aerial photographs to discern human-made site disturbances, particularly those that have a geometric pattern (e.g., squares, rectangles, lines). TRC attempted to contact LCAS and Boy Scout members who had participated in the 1950's activities at the site (see Appendix I). Because the Boot Hill site has been subjected to frequent unauthorized excavations and surface collecting, the locations of disturbances were recorded with a global positioning system (GPS) unit and an electronic distance measurer (EDM).

In addition to verifying anomalies found in aerial photographs, interviewing informants, and examining excavation photographs for landmarks, TRC also used soil probes and auger holes in those areas with a high probability of having been previously excavated. Differences in site stratigraphy and the potential discovery of buried grid stakes and other excavation debris (by the LCAS) were considered as strong evidence for the previous investigations. However, because of the time lapse since the 1957–1958 excavations, major natural changes (e.g., wind and water erosion), in addition to modern impacts (roads, unauthorized excavations and collecting), made the search for the previous investigations difficult.

Geophysical prospecting was performed by New South Associates Inc., and included ground penetrating radar (GPR) and magnetometer (fluxgate gradiometer) instruments. Survey blocks were established over a broad area of the site, encompassing about 4,714 m^2 (1.16 ac). Selection of survey block locations was based on a combination of factors, including management and research needs, vegetation, overall size, and expected data returns. The results, supplemented with the other methods described above (e.g., photographs, interview data, and auger holes) aided the search for previous excavations and subsurface cultural features (see Geophysical Survey and Appendix L). The geophysical survey employed ground penetrating radar (GPR) and magnetometer (fluxgate gradiometer) surveys. Eighteen geophysical survey blocks of various sizes were examined. Results of the survey revealed anomalies that may have been the LCAS excavations and the location of buried cultural features and their general depth (see Geophysical Survey and Appendix L).

7.2 TRC Archaeological Testing Results (Phase I)

TRC initiated testing at LA 32229 in June (2010) and completed testing in July (2010) (Figure 7.2). Testing consisted of site mapping, surface collecting, geophysical surveying, and geomorphological investigations. Phase I of testing consisted of establishing the Locus 3 boundaries which would define the limits of the major investigations of the testing, identifying the LCAS site datum, establishing a TRC datum, and correlating the TRC grid of true north with the LCAS grid system of magnetic north. The Locus 3 boundary was established using site documentation provided by the BLM-CFO (Figure 7.1). Electronic shapefiles (.shp) of the site was uploaded onto a Trimble GeoXT GPS receiver equipped with ArcPad 7.1 field mapping software, thereby facilitating the Locus 3 boundary delineation using solid orange flagging tape.

A datum, consisting of steel rebar with a stamped aluminum cap containing the site number, was placed at a central location near the highest point of the site. The location of the datum was also recorded with a Trimble GeoXT global positioning system receiver. A UTM coordinate with an easting, northing (NAD 83) and elevation was assigned to the datum, creating a grid system of UTM values. All grid coordinates were mapped with an electronic distance measurer (Nikon DTM 652) and tied into the overall grid system.

All discernible features within Locus 3 were documented, trowel tested, assigned a point provenience, and mapped. In addition, additional features outside the Locus 3 boundary were also documented for future reference. These features are not discussed in detail in this report, but their locations are provided in Appendix K for future research purposes. Because of the large quantity of artifacts, TRC in consultation with the BLM-CFO, employed a 10 percent, or 1 in 10, random sampling strategy in recording surface artifacts. LA 32229 was surveyed using parallel linear transects spaced at 10-m intervals. Every tenth artifact along each linear transect was pin flagged and assigned a point provenience and recorded. The resulting data provided a representative sample of the surface artifacts. Like the features, additional artifacts outside the Locus 3 boundary were field recorded and their description and location information is provided in Appendix K.

7.3 Survey Results

A representative 10 percent random sample of 158 surface artifacts was recorded within the project boundary. This assemblage, primarily targeted for spatial data, included provenience information and recording artifact types that included 6 categories (Table 7.2). At least 11 pottery types were recorded, including brownware variants of Jornada Brownware, El Paso brownware, and decorated brownware. Slipped brownware variants, corrugated brownware sherds, and El Paso Bichrome were also documented. Additional types included Chupadero Black-on-white, Socorro Black-on-white, unidentifiable ceramics, Three Rivers Red on-terracotta, unknown white wares, and Mimbres.

7.3.1 Testing Level of Effort (Phase II)

Subsurface testing included the hand excavation of three trenches (Figure 7.2). Trench 1, placed over an anomaly (Feature 1) found during the geophysical survey, consisted of 19 contiguous 1 x 1-m units west of the road. Trench 2, placed in the location of the LCAS excavations (Feature 2), consisted of seven contiguous 1 x 1-m units west of the road. Trench 3, placed over a subsurface geophysical anomaly, consisted of five contiguous 1 x 1-m units east of the road. The combined level of effort was 31 m^2, exceeding the 30 m^2 outlined in the scope of work. The placement and configuration of the trenches was done after consultation with the BLM archaeologist. Table 7.1 presents a summary of the data-recovery effort. The cultural assemblage recovered during testing consisted of 6,508 artifacts (Table 7.2) of which 367 were sherds, 4,432 were debitage, 35 were ground stone fragments, 20 were cores, 11 were bifaces, 17 were projectile points, 6 were hammerstones, and 1620 were faunal remains.

Manual excavations were done in 1 x 1-m units mapped with an EDM. Stratum I was excavated as a disturbed natural level and consisted of overlying modern aeolian sand deposits mixed with underlying midden materials and modern artifacts. Subsequent soil horizons were designated with consecutive numerical values (Stratum II-Level 1, Stratum III-Level 1, etc.) which were later correlated with the stratigraphic series for the site. Excavation of the three trenches included exposing Stratum I-aeolian sands, Stratum II LCAS backfill, and Stratum III-anthrosol. Stratum II was not encountered in Trench 1. Data regarding dimensions, construction details, possible chronological age, and function were collected and submitted for macrobotanical and AMS radiocarbon dating. Samples, including carbon-stained sediment, wood charcoal, and soil samples were processed by flotation, and light fractions were submitted for macrobotanical analysis.

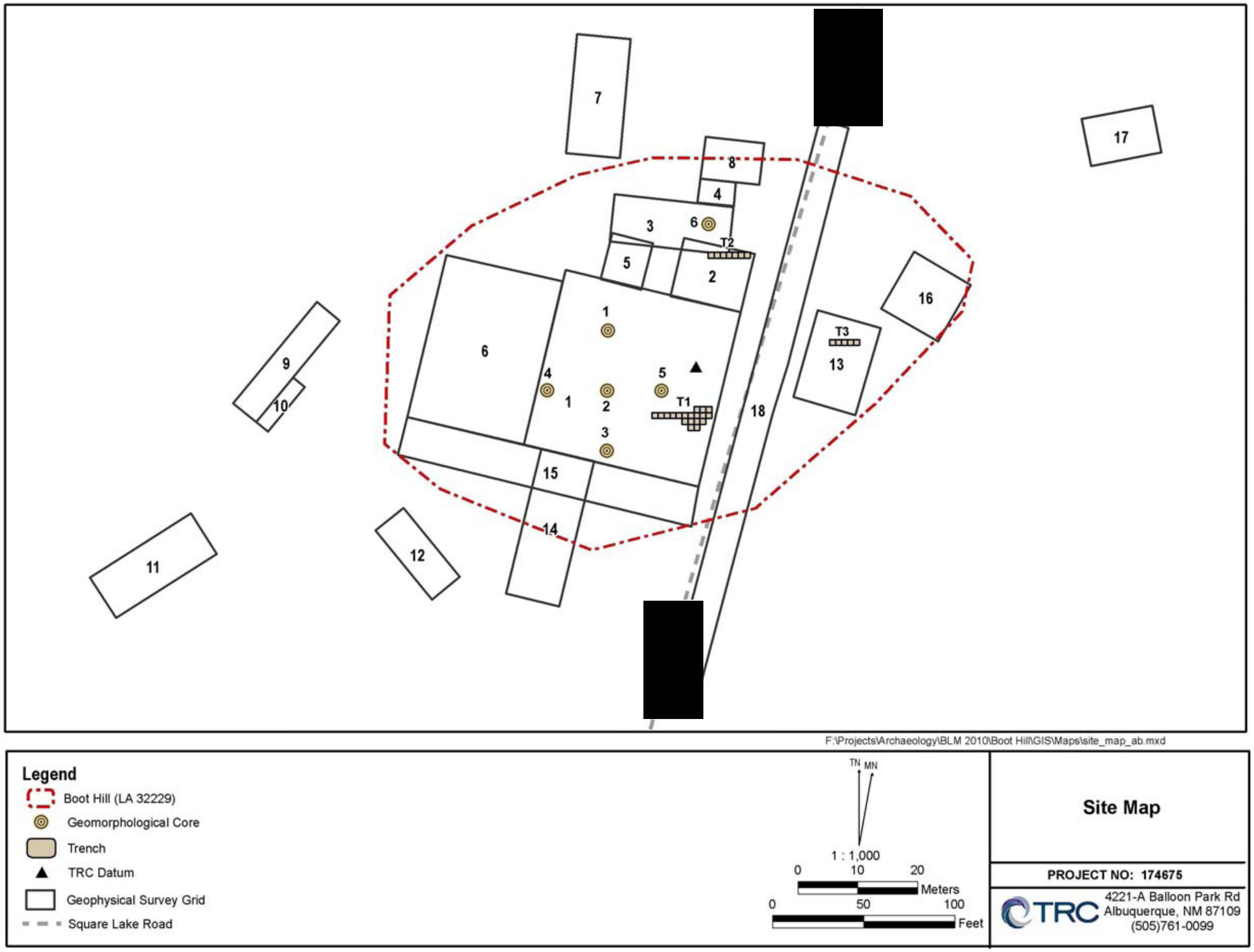

Figure 7.2 LA 32229 map showing TRC excavation trenches

Table 7.1 Summary data for level of effort at LA 32229

Excavation Unit No.	Excavation Size (m)	Total (m^2)
Trench 1	19 x 1	19
Trench 2	7 x 1	7
Trench 3	5 x 1	5
Total Effort Expended		**31**

Table 7.2 2010 assemblage summary data for LA 32229

Provenience	Artifact Type	Artifact Number	Frequency (%)
Trench 1	Lithic Debitage	2,948	66.65
	Ground Stone	21	0.47
	Core	10	0.02
	Hammerstone	3	0.00
	Bifaces	10	0.02
	Projectile Points	11	0.02
	Ceramics	248	5.61
	Fauna	1162	26.27
	Subtotal	**4423**	
Trench 2	Lithic Debitage	773	66.93
	Ground Stone	9	0.08
	Core	6	0.05
	Hammerstone	2	0.00
	Projectile Point	2	0.00
	Ceramics	103	8.92
	Fauna	260	22.51
	Subtotal	**1155**	
Trench 3	Lithic Debitage	711	75.64
	Ground Stone	5	0.05
	Core	4	0.04
	Hammerstone	1	0.00
	Biface	1	0.00
	Projectile Point	4	0.04
	Ceramics	16	1.70
	Fauna	198	21.06
	Subtotal	**940**	
Surface	Lithic Debitage	48	30.38
	Cores, Manufacturing Tools	7	4.43
	Chipped Stone Tools	1	6.33
	Projectile Points	1 (collected)	6.33
	Ground Stone	3	1.90
	Ceramics	27 (18 collected)	17.09
	Bone Fragments	71	44.94
	Subtotal	**158 (19 collected)**	

7.3.2 Features

Table 7.3 summarizes nine features documented during the site survey. None of the features is within any of the three hand-dug trenches. Although the features were not excavated, their documentation provides information for future research potential. Additional features were documented outside the Locus 3 boundary, and are summarized in Appendix K for future research reference. Minimal trowel probing was conducted in order to retrieve morphological and contextual integrity data without damaging their feature

Table 7.3 Feature data summary within the excavation area

Feature No.	Feature Dimensions (m)	Feature Attributes	Associated Artifacts	Contextual Integrity
10	1.0 x 1.0 m	Burned caliche concentration (100+)	None	Subsurface ~0.10 cm dark organics
11	1.5 x 1.0 m	Burned caliche concentration (~50)	None	Subsurface ~0.10 cm carbon stain/charcoal/ brownware
40	1.75 x 1.0 m	Burned caliche cluster (25–50) w/carbon-stained sediments	Brownware	Subsurface ~0.10 cm
60	0.75 x 0.75 m	Burned caliche cluster (~60)	Flaked stone/Lithic debitage	Subsurface ~0.10 cm charcoal/debitage
61	2.0 x 3.0 m	Burned caliche scatter (~70)	Flaked stone/Lithic debitage	Subsurface ~0.10 cm good
62	4.0 x 4.0 m	Burned caliche scatter (100+)	Flaked stone/Lithic debitage	Subsurface ~0.10 cm debitage
63	5.0 x 4.0 m	Burned caliche scatter (100+) w/carbon-stained sediment	Brownware	Subsurface ~0.10 cm debitage/brownware
65	3.0 x 3.0 m	Burned caliche scatter (~100)	Brownware, Flaked stone, debitage	Surface/Paleosol debitage/brownware
66	3.0 x 2.0 m	Burned caliche scatter (100+) w/carbon-stained sediments	None	Subsurface ~0.10 cm carbon stain

7.4 Manual Excavations

Locus 3, the area where test excavations were placed, is on a hillcrest overlooking a well cut arroyo to the east and south that drains from Bogle Tank Draw. Vegetation consists of dense stands of mesquite, creosote bush and various grasses. Surface sediments are mottled or blended brown to very-dark brown (7.5YR 4/3, 7.5YR 2.5/2), the result of mixing with an underlying anthrosol that covers most of the hilltop. The overall stratigraphy within the trenched areas is continuously rich in organics from the surface to the underlying caliche, suggesting significant anthrogenic processes. An effort to measure levels of enriched carbon in soils is dependent on the photosynthesis from decayed organic materials. Soil samples of enriched carbon sediment were collected from each of the three trenches. Analysis of carbon-enriched soil produced from biodegradable human refuse could potentially offer insight into prehistoric diets and the types of woody plant species used for wood fuel (Frederick 2011). However, to characterize these trends in soil carbon can sometimes only provide limited information from the effects of a disturbed mixed matrix.

7.4.1 Trench 1 (Feature 1)

Trench 1 consisted of 19 contiguous 1 x 1-m units in the southeastern portion of the geophysical survey grid 1, north of the LCAS B-5 excavations (Runyan 1971). Trench 1 was placed over an anomaly identified during the geophysical survey. Excavation was initiated with the placement of units 1.1 through 1.10 oriented in a line from east to west (Figure 7.3). Surface and bottom elevations for all units were recorded with the EDM from the site datum. After removing the disturbed Stratum I, the surface of Stratum III was clearly discernible, and extended beyond the exposed units. As the excavation continued, the additional units 1.13, 1.14, and 1.19 were added to the northeast, and units 1.11, 1.12, 1.15, 1.16, 1.17, and 1.18 were added to the southeast in an effort to define the extent of the staining (Figure 7.4). The darkest sediments exposed within the eastern portion of Trench 1 were designated Feature 1. Feature 1-A is described as a small circular carbon stain that was encountered at the base of Feature 1, Unit 1.3. This feature was fairly intact, and one wood charcoal sample was recovered for radiocarbon dating. The resulting excavations of Trench 1 provided no clear evidence of any boundary for Feature 1.

Three strata were identified during excavation of the 19 units within Trench 1. The overlying Stratum I consisted of unconsolidated, dark brown (7.5YR 3/2), carbon-stained silty sand that ranged in depth from 1 to 20 cm below ground surface (bgs). Gravel inclusions were frequent, and approximately 66 burned caliche cobble fragments were noted on the surface of Trench 1. At the Stratum I/Stratum III contact, a patchy matrix of dark to very-dark brown soils (7.5YR 4/3, 7.5YR 2.5/2) was noted. Forty-two burned caliche cobble fragments were recorded, and 59 ceramics were recovered from Stratum I. The underlying Stratum III deposit consisted of semi-compact, dark brown to very dark gray (7.5YR 3/2 to 7.5YR 3/1) carbon-stained silty loam and ranged from 20–40 cm bgs. During the screening of Stratum III feature fill, 167 ceramic pieces were recovered. Stratum III was terminated at the contact with pink caliche bedrock. Stratum II, designated as LCAS excavation backfill, was not encountered in Trench 1.

Excavation of Trench 1 recovered 4,164 artifacts, which are displayed as frequencies within each excavation unit (not including the faunal assemblage), in Figure 7.5. Lithics include 2,948 pieces of debitage, 21 ground stone artifacts, 12 bifaces, 10 cores, 9 projectile points, and 3 hammerstones (Figure 7.6). Ceramics consist of 230 pieces represented by 14 types (Table 7.5). Approximately 692 burned caliche cobble fragments were encountered in the trench. The faunal assemblage consists of 1162 specimens.

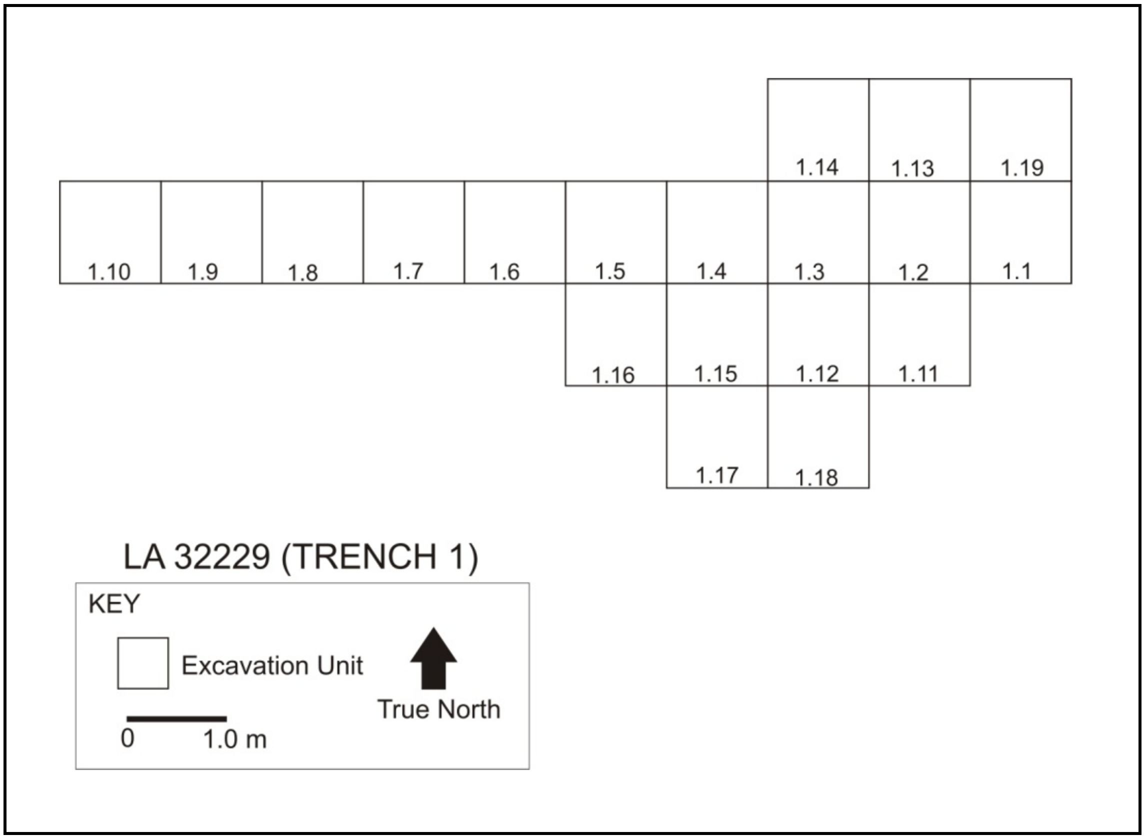

Figure 7.3 Trench 1 plan view and designated excavation units

Figure 7.4 Trench 1 showing the interface between Stratums I/III, and irregular outline of Feature 1 anthrosol

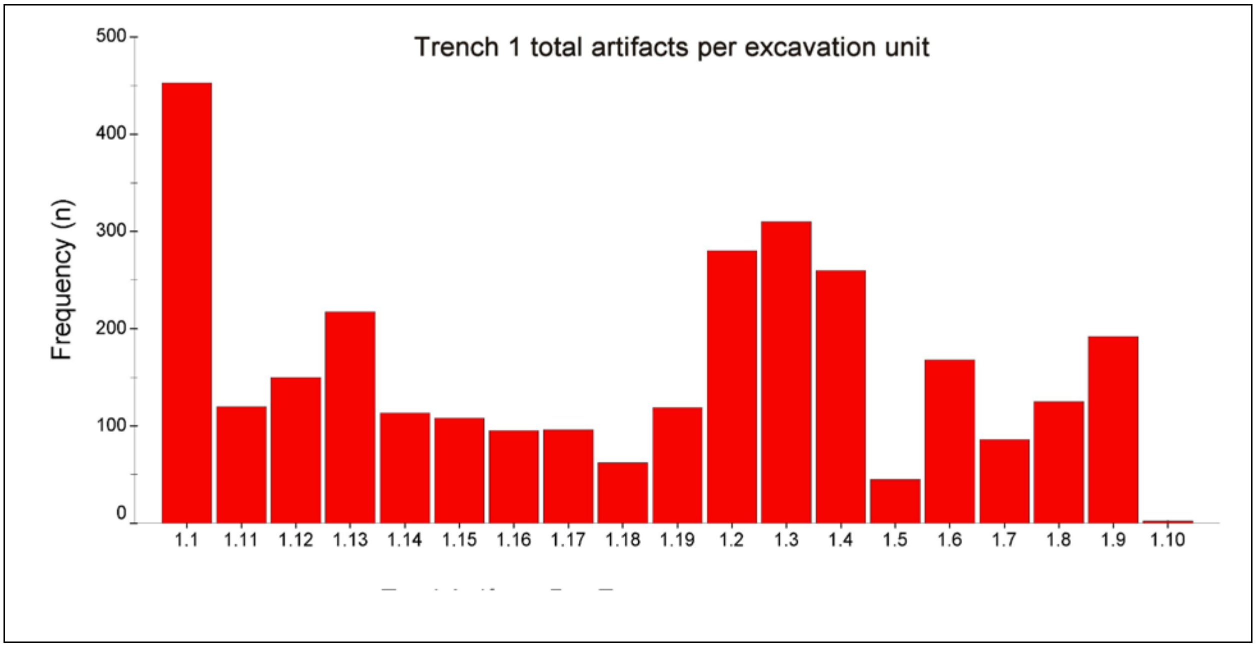

Figure 7.5 Trench Area 1 artifact frequency per excavation unit, LA 32229

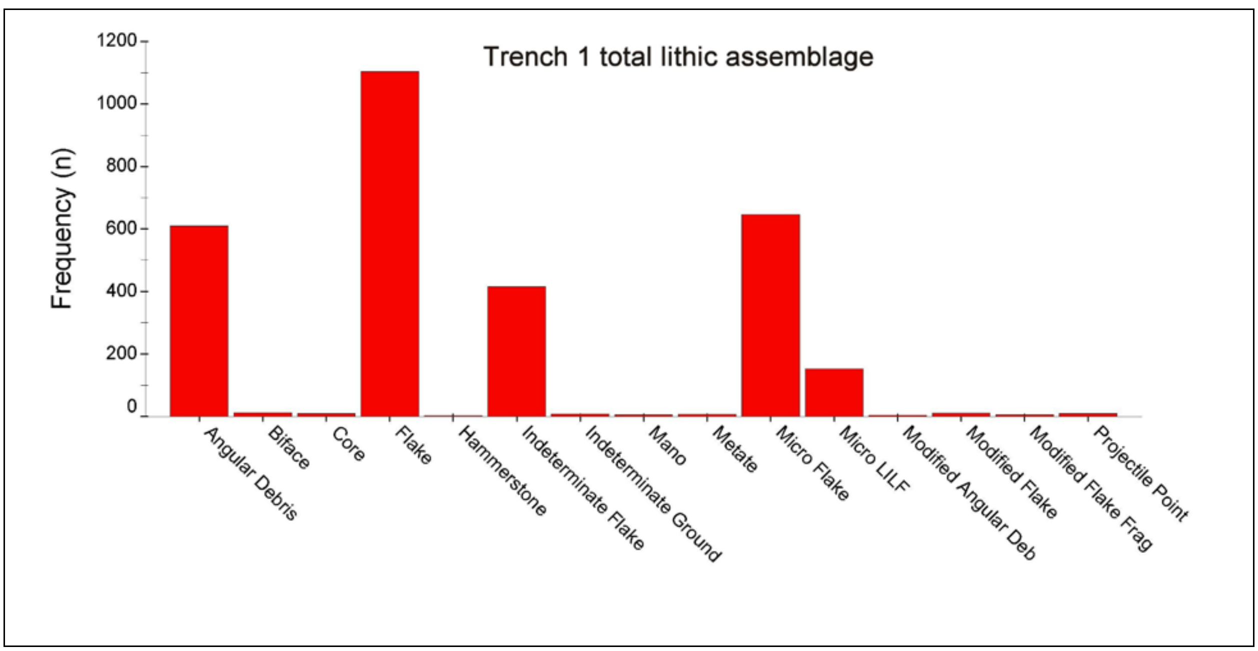

Figure 7.6 Trench 1 lithic assemblage, LA 32229

Table 7.4 Ceramic Types, Trench 1

Ceramic Type	Stratum I	Stratum II	Total
Chupadero B/W	7	21	28
Jornada Brown	22	95	117
Jornada Decorated	3	1	4
El Paso brownware	2	8	10
El Paso Polychrome	2	4	6
Mimbres	1	3	4
Three Rivers Red/Terracotta	3	3	6
Socorro B/W	6	9	15
Corona Corrugated	2	1	3
South Pecos	14	15	29
South Pecos decorated	---	1	1
Playas Red	---	1	1
Unknown, Painted, Monochrome	---	4	4
Gila Polychrome	---	1	1
Unknown, Unpainted,		1	1
Total	**62**	**168**	**230**

7.4.2 Feature 1

Feature 1 was a poorly defined, amorphous carbon stain in Trench 1 that could not be accurately delineated. After being documented and photographed, the fill in Feature 1 was excavated using 10-cm arbitrary levels. Each excavation unit was terminated at the contact of sterile soils or caliche bedrock. The resulting profile of Feature 1 revealed an undulating, darkly mottled anthrosol with no clear definition or indication of pit features or structures (Figure 7.7). However, the potential of subsurface structures, hearths, or storage pits, cannot be ruled out in nearby portions of the site. The high density of artifacts in Trench 1 suggests Feature 1 was an aggrading anthrosol formed from continuous or frequent occupations, and may represent intentional dumping of refuse outside a primary occupation zone. Disturbances from looting may have contributed to the mixing of the deposits and resulted in little stratigraphic integrity.

The nature of the anthrogenic soil, a true dark earth, in the vicinity of Trench 1 at the Boot Hill site is unusual. The behavioral and natural processes responsible for its formation warrant further investigation. Middens of this nature in the Mescalero Sands are unusual. Although the initial geoarchaeological impression of this deposit is that it is heavily mixed (Chapter 9), an attempt was made to test the age of the deposit through AMS radiocarbon ages obtained from pieces of charcoal collected from levels 1, 2, 4, and 5 within Unit 3 of Trench 1. The deposits in the top 20–30 cm are clearly mixed and of doubtful integrity (Table 8.6). The AMS dates are of substantially older age than those from the lower levels. The reversed dates are suggestive of what one might expect from excavation backfill. However, the results also suggest some areas of deeper deposits may have integrity. The AMS dates from the lower two levels retain their stratigraphic chronology and suggest they may retain their spatial integrity. While the dates obtained during this testing phase *suggest* this might be the case, the degree of integrity and extent of such deposits is still undetermined. Should they exist, a larger scale excavation would be required to uncover such deposits and extract any data they contain. The four radiometric dates from Unit 3 all support a Formative occupation (Figure 7.7).

Table 7.5 Radiocarbon dates from Unit 1.3

Sample	Location	13C/12C	pMC	C^{14} Age B.P.	CALIB 2-Sigma Age Range (Stuiver et al. 2011)	Cultural Affiliation
UGA-8339	Level 1	-24.1‰	83.89	1410±30	A.D. 591–665	Formative 1
UGA-8338	Level 2	-24.4‰	87.70	1050±25	A.D. 899–919 A.D. 962–1025	Formative 2–3
UGA-8337	Level 4	-24.4‰	89.70	870±25	A.D. 1047–1089 A.D. 1121–1139 A.D. 1149–1224	Late Formative 3–Early Formative 6
UGA-8336	Level 5	-24.6‰	84.66	1340±25	A.D. 654–719 A.D. 742–769	Middle Formative 1–Early Formative 2

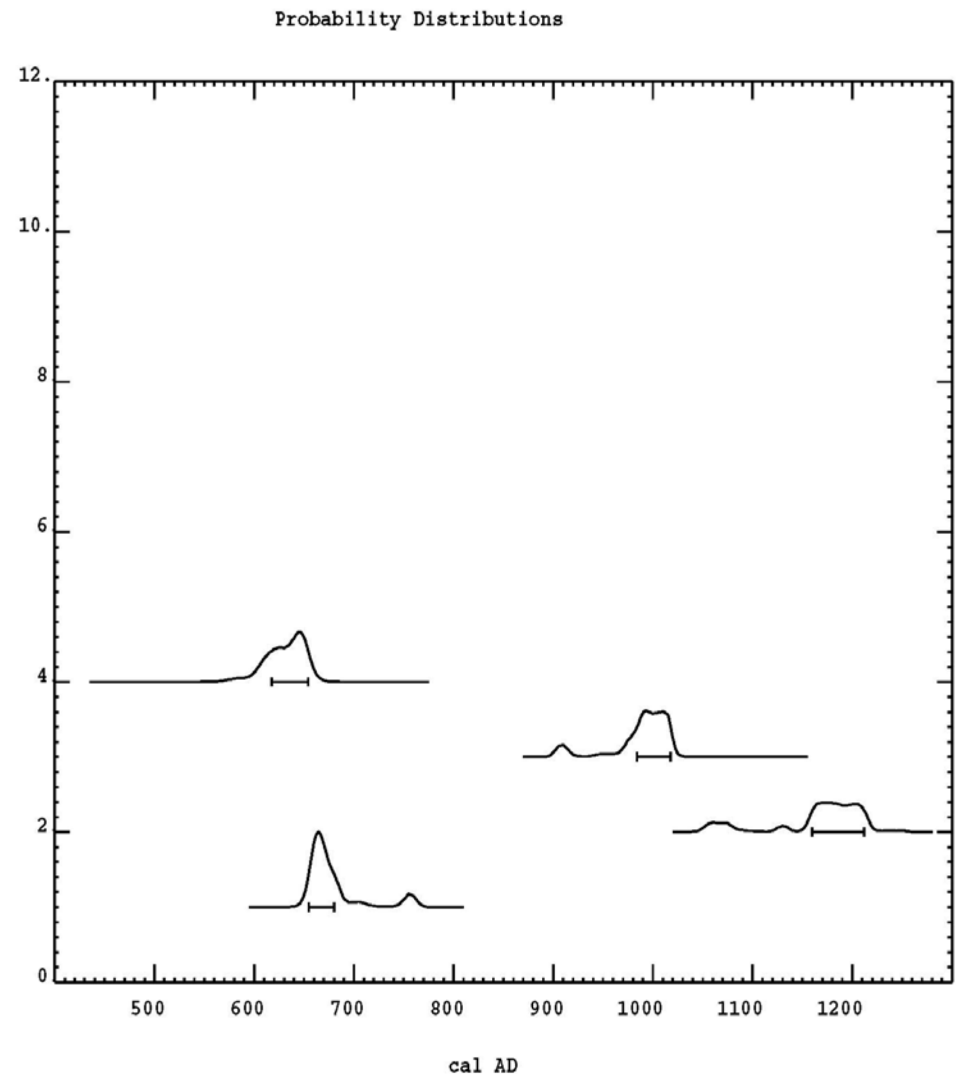

Figure 7.7 Four radiocarbon date calibrations

7.4.3 Feature 3

A small carbon-stained pit feature, designated Feature 3was encountered within the lower levels of Excavation Unit 1.3. Feature 3 was a clearly defined, circular pit encountered 70 cm below surface at the base of Stratum II, Feature 1, Unit 1.3. The stain was approximately 26 cm in diameter (Figures 7.8 and 7.9). After being documented and photographed, Feature 3 was drawn in plan view and bisected along a north/south oriented axis line. The west wall cross section of Feature 3 revealed a bowl-shaped profile that ranged in depth from 70 to 87 cm below datum. The feature matrix contained one distinct depositional zone, and consisted of a dark gray (7.5YR 4/1) semi-compact carbon-stained matrix. Stratum I was terminated at the contact with compact caliche bedrock. A sufficient amount of wood charcoal fragments were recovered from near the base of the feature and submitted to the University of Georgia for radiocarbon dating. The resulting AMS assay yielded a conventional age of 1440±25 B.P. (UGA 7608) and a 2-sigma calibrated age of A.D. 575 to 651 (Stuiver et al. 2011), placing Feature 3 within the Formative I phase (Figure 7.10). This date supports the four dates from Unit 3 (Table 7.6).

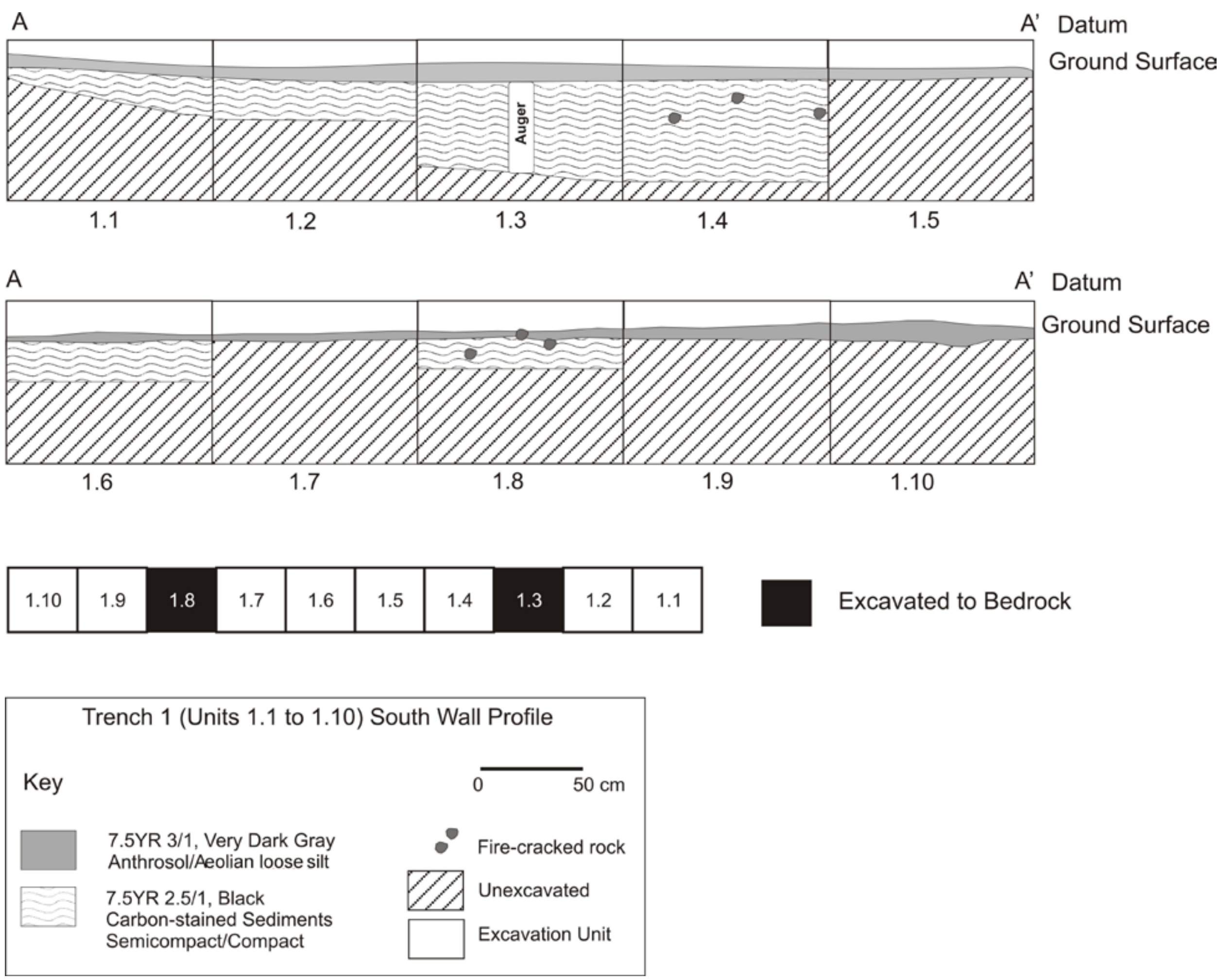

Figure 7.8 LA 32229 Trench 1 south wall profile

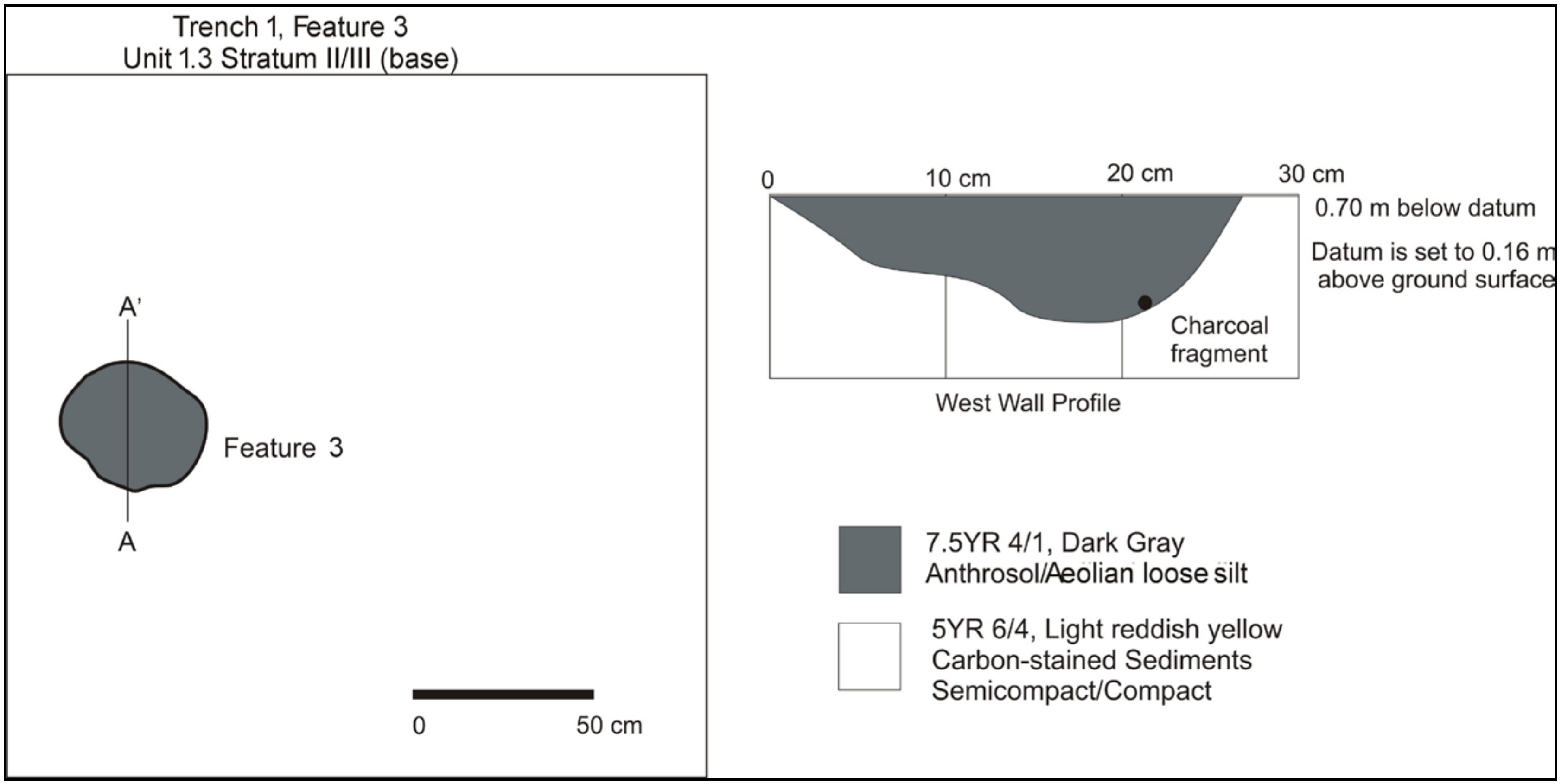

Figure 7.9 Trench 1 Feature 3 plan view and west wall profile

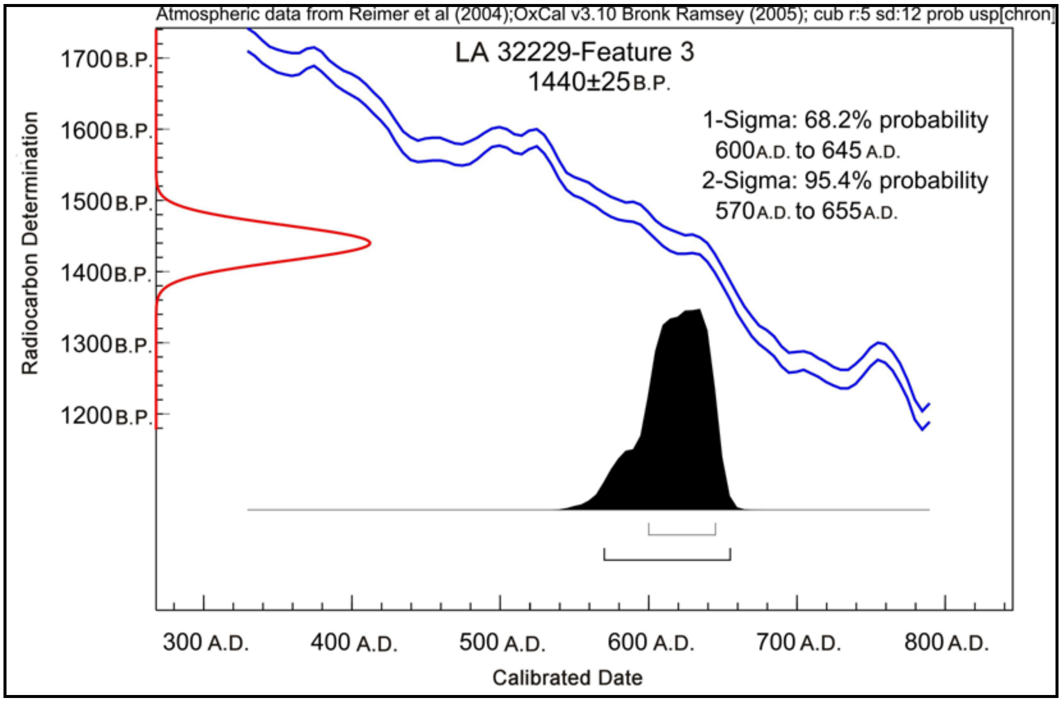

Figure 7.10 Calibrated histogram for corrected age estimates

7.4.4 Trench 2

Trench 2 consisted of seven contiguous 1 x 1-m units in the northeastern portion of the geophysical survey grid 2, in the vicinity of the LCAS B-5 excavations (Runyan 1971). Trench 2 is 25 m north from Trench 1. Excavation units, designated 2.1 to 2.7, were oriented linearly from west to east (Figures 7.11 and 7.12). Using the results of the geophysical investigations, Trench 2 was placed over GPR anomalies interpreted as possible evidence of LCAS disturbances.

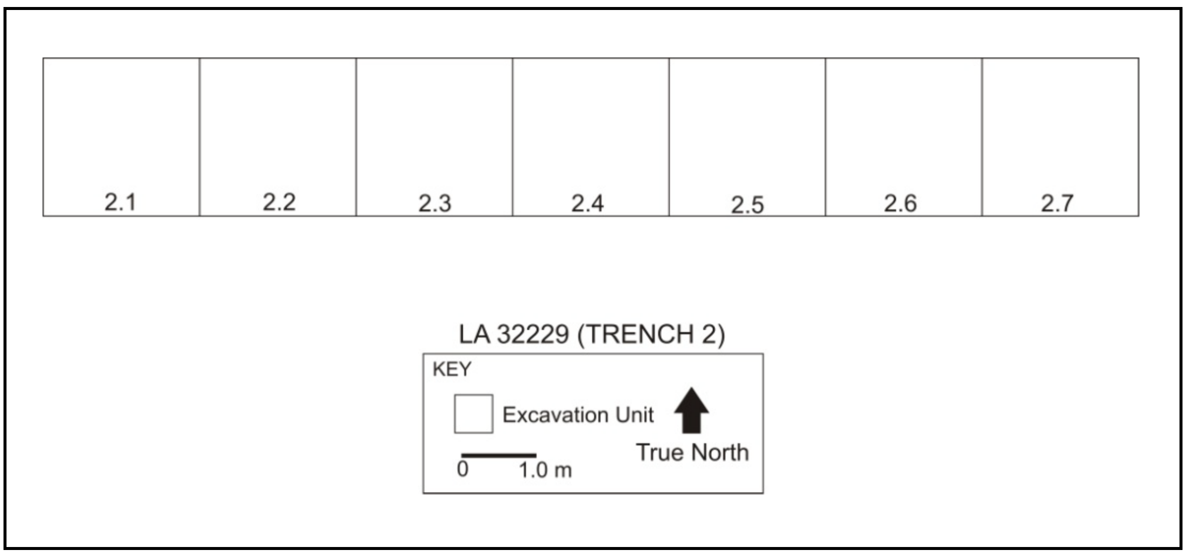

Figure 7.11 Trench 2 plan view and designated excavation units

Figure 7.12 Trench 2 showing the interface between Stratum I/III, of the Feature 2 anthrosol

Three strata were identified during excavation of the seven units within Trench 2. Stratum I was removed as a natural level and screened through ⅛-inch hardware mesh. The surface sediments consisted of brown, unconsolidated silty sand (7.5YR 4/3) and contained many small gravel inclusions. Approximately 17 burned caliche cobble fragments were noted on the surface of Trench 2.

Stratum II consisted of a fine, brown sand lens (7.5YR 4/4), with no cultural material or other inclusions. This stratum was interpreted as fill from the LCAS excavations, probably collected from the Querecho Sands to the southwest. This deposit ranged from 12 to 30 cm below surface, with a maximum thickness of 12 cm in Unit 2.2. Stratum III consisted of a black, silty loam (5YP 2.5/1) and occurred both above and below Stratum II, with a maximum depth of 50 cm below surface at the contact with underlying caliche bedrock.

Excavation of Trench 2 recovered 1,282 artifacts. These are listed as frequencies for each unit (not including the faunal assemblage) in Figure 7.13. Lithics include 773 pieces of debitage, 9 ground stone items, 6 cores, 2 projectile points, and 2 hammerstones (Figure 7.14). Ceramics include 99 pieces representing 8 types (Table 7.7). Approximately 308 burned caliche cobble fragments were encountered. The faunal assemblage consists of 260 specimens.

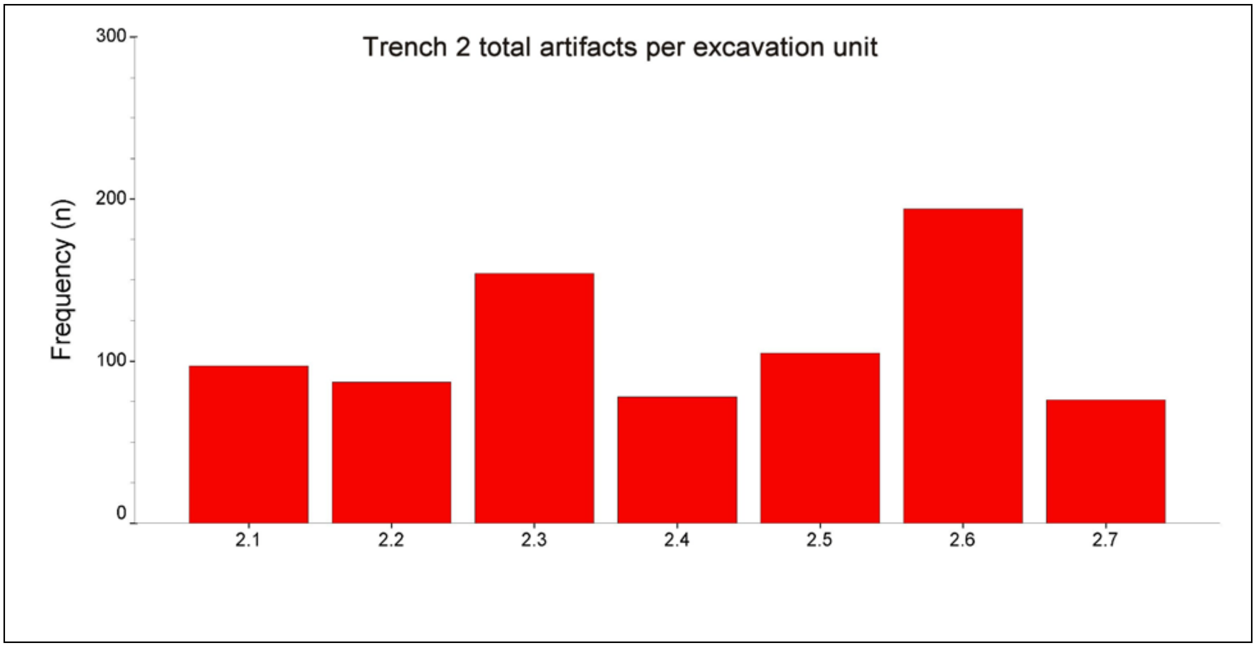

Figure 7.13 Trench 2 artifact frequency per excavation unit, LA 32229

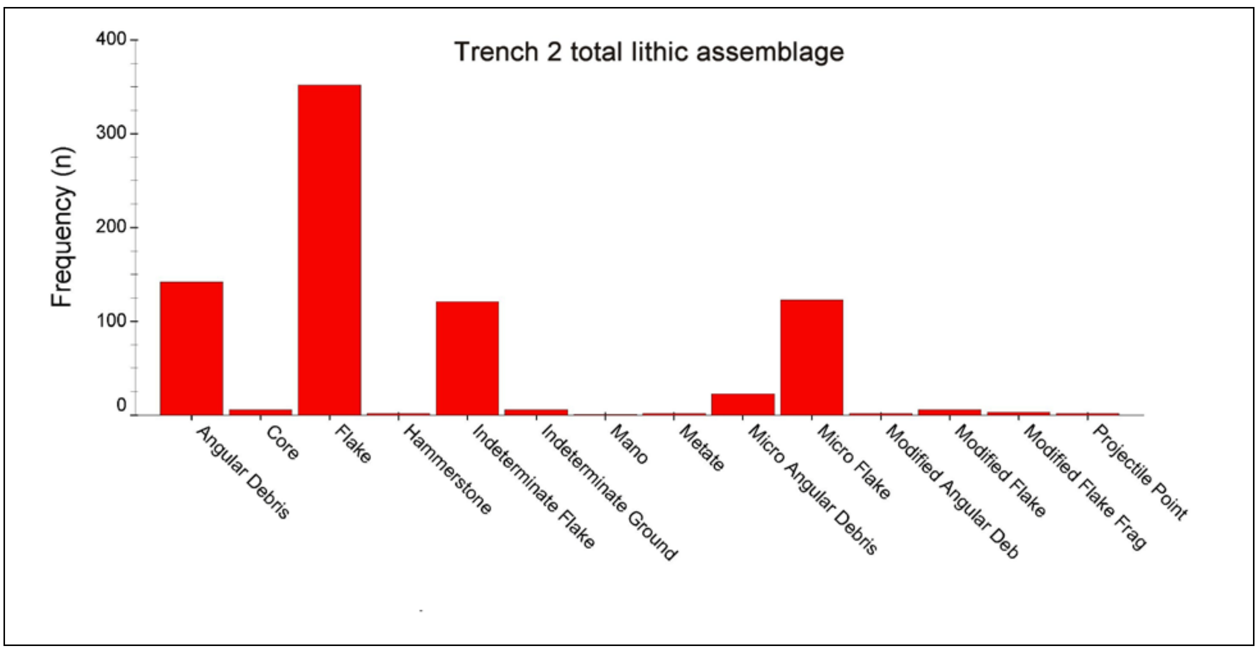

Figure 7.14 Trench 2 lithic assemblage, LA 32229

Table 7.6 Trench 2 Ceramic Types

Ceramic Type	Stratum I	Stratum II	Total
Chupadero Black-on-white	4	10	**14**
Jornada Brown	4	50	**54**
Jornada Decorated	1	3	**4**
El Paso brownware	---	3	**3**
El Paso Polychrome	---	2	**2**
Three Rivers Red-on-terracotta	1	2	**3**
Socorro Black-on-white	3	---	**3**
South Pecos	2	14	**15**
Grand Total	**15**	**84**	**99**

7.4.5 Feature 2

Feature 2 was a deposit of aeolian sand within the Stratum III anthrosol, and was interpreted as fill from the LCAS excavations. After being documented and photographed, the fill in Trench 2 was excavated using 10-cm arbitrary levels. Each excavation unit was terminated at the contact of sterile soils or caliche bedrock. The resulting profile of Feature 2 revealed a sloping lens of fine brown sand (7.5YR 4/3), surrounded by a darkly mottled anthrosol (5YR 2.5/1), with no clear definition or indication of pit features or structures (Figure 7.15). However, the potential of subsurface structures, hearths, or storage pits cannot be ruled out in nearby portions of the site. The high density of artifacts within Stratum III of Trench 2 suggests this was an aggrading midden deposit formed from continuous or frequent occupations. Disturbances from looting may have contributed to the mixing of the deposits and resulted in poor stratigraphic integrity. Presumably, the portion of the anthrosol beneath the sand lens has been less disturbed by modern activities.

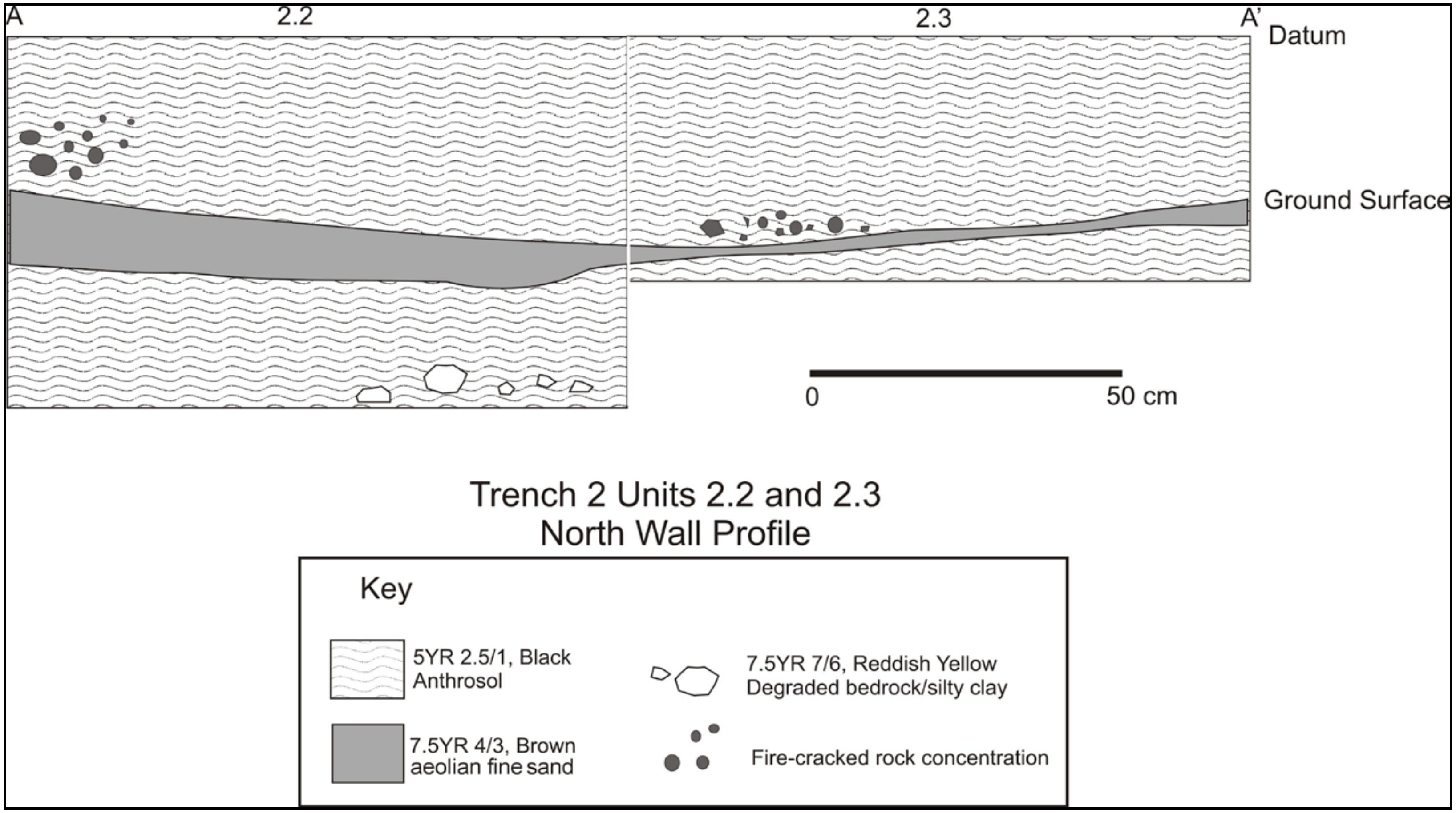

Figure 7.15 LA 32229 Trench 2, excavation Units 2.2 and 2.3 north wall profile

7.4.6 Trench 3

Trench 3 consisted of five contiguous 1 x 1-m units in the northern portion of the geophysical survey grid 13 in the LCAS B-5 area (Runyan 1971). Trench 3 is 22 m northeast from Trench 1 and 19 m southeast from Trench 2. Excavation Units (3.1–3.5) were oriented from west to east (Figure 7.16). Using the results of the geophysical survey, Trench 3 was placed over an anomaly found in the GPR data.

Excavations of Trench 3 resulted in the removal of five strata exposing various shades of a dark, well developed anthrosol (Figure 7.17). Stratum I and Stratum III were correlated with the same strata from Trenches 1 and 2. Stratum I was loose, brown aeolian sand (7.5YR 4/2) mixed with gravels that reached a maximum depth of 28 cm below ground surface in Unit 3.4. Stratum III was a dark, silty loam (7.5YR 3/1) associated with the anthrosol that covers wide areas of the site. The remaining strata were limited to Unit 3.2, and consisted of lenses of backfill from a looters pit (Figure 7.18).

Within the disturbed matrix of Stratum I, 30 fire-crack rocks and burned caliche were encountered. In addition, several pieces of ceramics, lithic debitage, bone fragments, a ground stone fragment, and one projectile point were documented. One Three Rivers Red on-terracotta ceramic was noted. Modern and possibly historic items such as Pepsi bottle glass, one soda can possibly from the 1960s, and one plastic bread clip were also encountered about 20 to 30 cm below surface. At the contact of Stratum II, Zone VI is characterized by lighter colored soils followed by additional undulating zones of light and dark gray and brown colored sediments (see Figure 7.18). Charcoal fragments noted throughout Stratum I and Stratum II were determined to be unreliable for radiocarbon analysis.

Trench 3 yielded 1023 artifacts. The artifact assemblage (not including the faunal assemblage) is presented as frequency per unit in Figure 7.18 and by lithic artifact class in Figure 7.19. The lithic assemblage includes 711 pieces of debitage, 5 ground stone items, 4 cores, 1 biface, 4 projectile points, and 1 hammerstone (Figure 7.19). The ceramic assemblage includes 18 pieces. About 173 burned caliche cobble fragments were encountered. The faunal assemblage consists of 198 specimens.

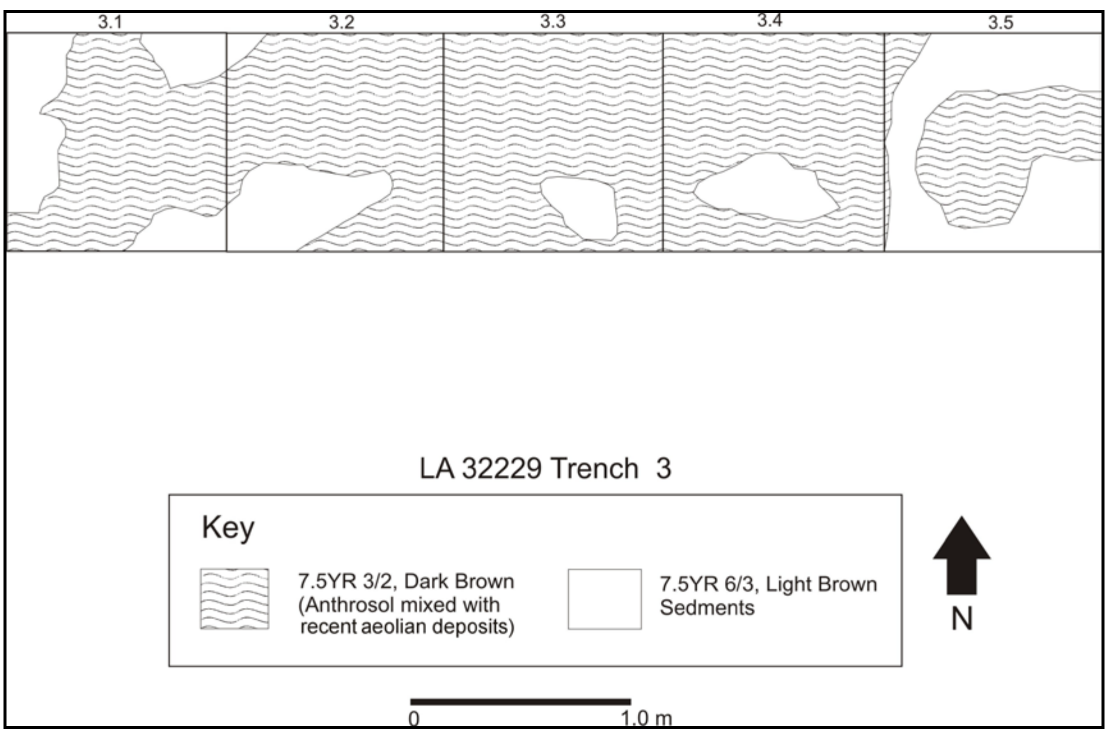

Figure 7.16 Trench 3 plan view and designated excavation units

Figure 7.17 Trench 3 showing the interface between Stratum I/II, of the intrusive pit

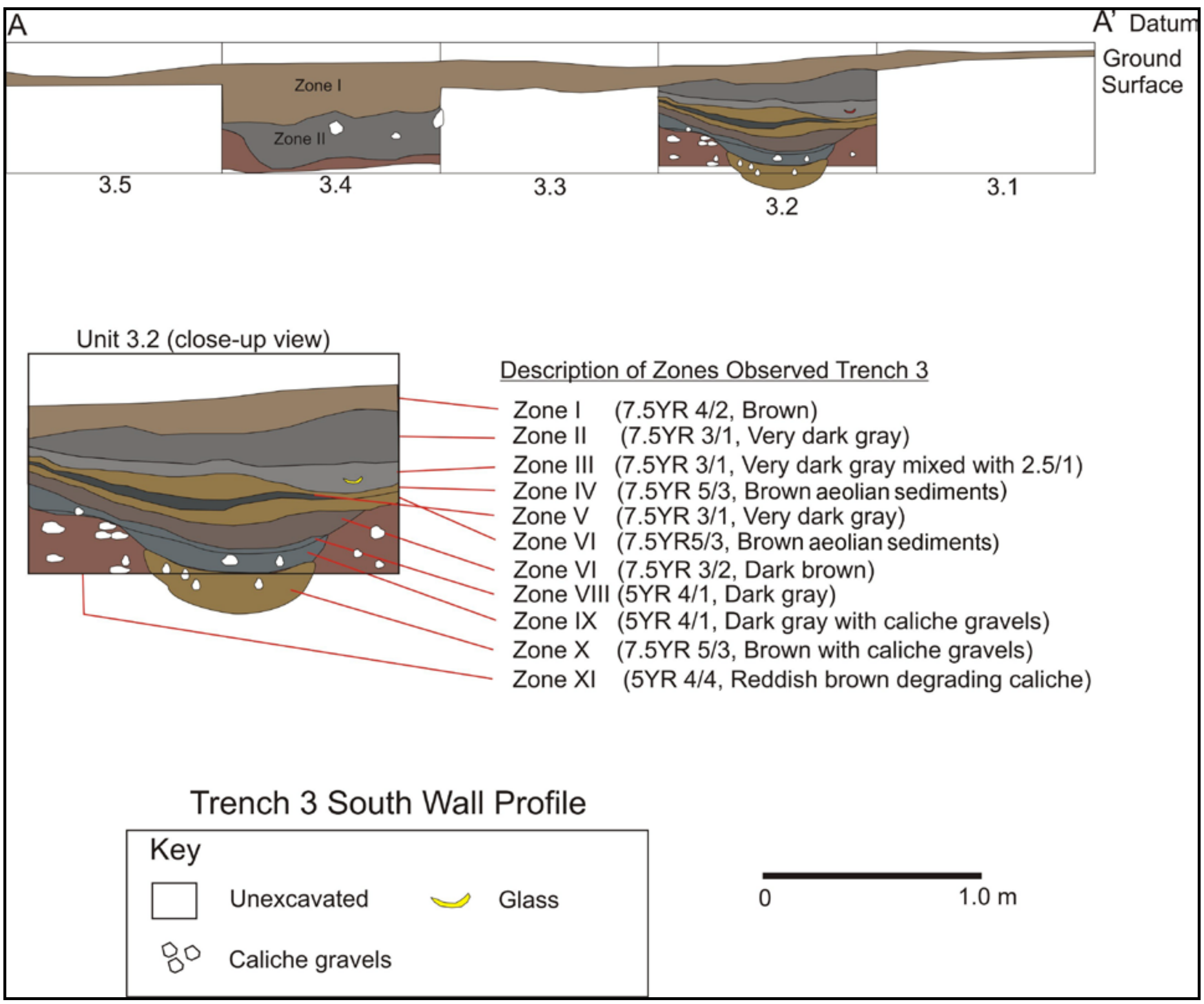

Figure 7.18 LA 32229 Trench 3 south wall profile and Unit 3.2 close-up view

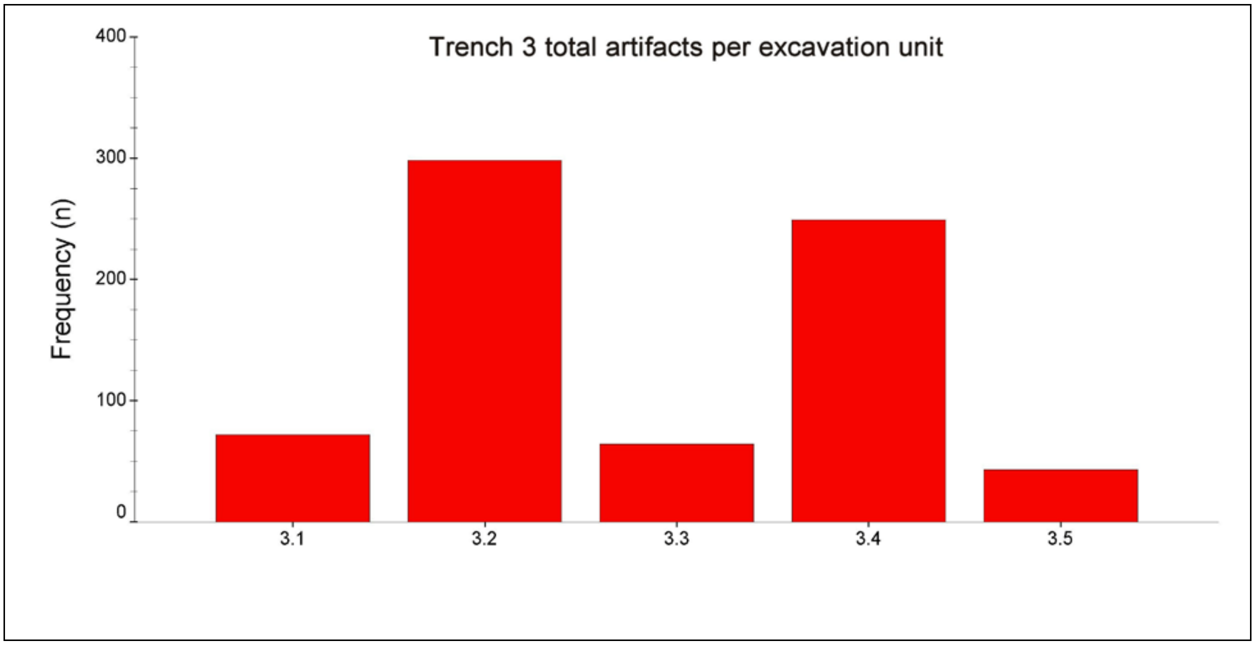

Figure 7.19 LA 32229, Trench 3 artifact frequency per excavation unit

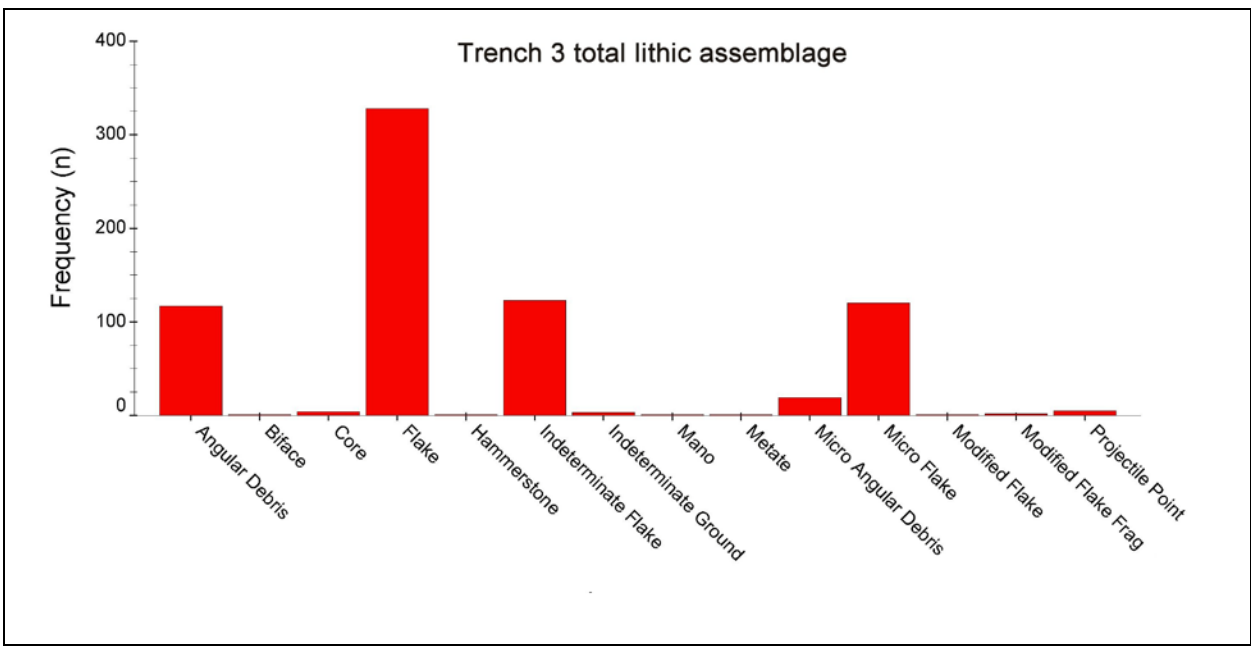

Figure 7.20 LA 32229, Trench 3 lithic assemblage

7.4.7 Intrusive Pit

An intrusive pit was originally identified during the geophysical survey. During excavation of Unit 3.2 it was determined to be an intrusive looters pit dug into Stratum III, the anthrosol that covers much of the site. After being documented and photographed in plan view, the intrusive pit was excavated using 10-cm arbitrary levels. Bisecting the pit revealed a profile consisting of eight lenses in addition to Stratum I and III (Figure 7.19). These intermittent lenses of sediment illustrate episodes of modern excavation and refilling.

7.5 Summary

With the exception of fire-cracked rock, which was counted for each unit level, all cultural material recovered during excavation was collected. Radiocarbon, macrobotanical, FTIR organic residue, starch grain analysis, XRF, and INAA samples were selectively collected from appropriate contexts (Table 7.8). Plan views and profiles were drawn for all excavated features. The site and excavations were photographed to ensure a detailed record of the investigations.

Table 7.7 Samples submitted for analysis

Analysis	Sample	Provenience
Radiocarbon Analysis(AMS), (N=4)	Charcoal	TU 1.3/Feature 3
	Charcoal	TU 1.3/Level 1
	Charcoal	TU 1.3/Level 2
	Charcoal	TU 1.3/Level 4
	Charcoal	TU 1.3/Level 5
	Charcoal	Locality 1
	Charcoal	Locality 2
	Charcoal	Locality 3
Diatom Analysis (N=3)	Soil Sample	Locality 1/MARL
	Soil Sample	Locality 2
	Soil Sample	Locality 3/120 cm below surface
FTIR Analysis (N=27)	Ground stone	TU 1.2/Level 2
	Ceramic	TU 1.13/Level 2
	Ground stone	TU 2.1/ Level 2
	Ceramic	Surface
	Ceramic	TU 1.4/Level 4
	Ground stone	TU 2.3/Level 3
Isotope Analysis (N=27)	Soil Sample (BH1-1)	TU 1.3
	Soil Sample (BH1-2)	TU 1.3
	Soil Sample (BH1-3)	TU 1.3
	Soil Sample (BH1-4)	TU 1.3
	Soil Sample (BH1-5)	TU 1.3
	Soil Sample (BH1-6)	Control Sample Profile

Analysis	Sample	Provenience
	Soil Sample (BH1-7)	Control Sample Profile
	Soil Sample (BH1-8)	Control Sample Profile
	Soil Sample (BH1-9)	Control Sample Profile
	Soil Sample (BH1-10)	Control Sample Profile
	Soil Sample (BH1-11)	Control Sample Profile
	Soil Sample (BHC6-1)	Core 6 Profile
	Soil Sample (BHC6-2)	Core 6 Profile
	Soil Sample (BHC6-3)	Core 6 Profile
	Soil Sample (BHC6-4)	Core 6 Profile
	Soil Sample (BHC6-5)	Core 6 Profile
	Soil Sample (BHC6-6)	Core 6 Profile
	Soil Sample (BHC6-7)	Core 6 Profile
	Soil Sample (BHC6-8)	Core 6 Profile
	Soil Sample (BHC6-9)	Core 6 Profile
	Soil Sample (BHC6-10)	Core 6 Profile
	Soil Sample (BHC6-11)	Core 6 Profile
Pollen Analysis (N=3)	Soil Sample	Locality 1
	Soil Sample	Locality 2
	Soil Sample	Locality 3
Starch Analysis N=8)	Metate fragment	TU 3.2/Level 2
	Ceramic	TU 1.4/Level 1
	Ground stone	TU 2.3/Level 3
	Ceramic	TU 1.4/Feature 2
	Ceramic	TU 3.2/Level 2
	Ceramic	TU 1.4/Level 6
	Ceramic	TU 2.5/Level 2
	Ground stone	TU 2.4/Level 1
XRF Analysis (N=5)	Obsidian	TU 2.3/Level 3
	Obsidian	TU 1.16/Level 2
	Obsidian	TU 1.3/Level 4
	Obsidian	Surface
	Obsidian	Surface
INAA (N=8)	Jornada brownware	TU 2.1/Level 2
	Jornada brownware	TU 2.2/Surface
	El Paso brownware	TU 1.6/Level 3
	Chupadero Black-on-white	Surface

Analysis	Sample	Provenience
	Corona Corrugated	Surface
	Mimbres	Surface
	South Pecos	Surface
	Socorro Black-on-white	Surface

8.0 Analyses Methods

Peter C. Condon and Kenneth L. Brown

Laboratory tasks included preparation and cataloguing of field material and analysis of the recovered assemblage. An outline of the analyses conducted is presented below followed by Table 8.1 showing the number of samples submitted. Lithic analysis included identification of reduction technology, reduction trajectory, material type, and use-wear patterns. A sample of flaked and ground stone implements with potential of retaining organic residues were submitted for further analysis (Adams 1999; Hard et al. 1996, Quigg et al. 2001). Projectile point types were identified using established typologies. Sherds were sorted and identified according to type and temper. The Minimum Vessel Number (MVN) was assessed by color, thickness, temper, and, when possible, refits. These methods, used in conjunction with chronometric data, helped develop a more precise interpretation of ceramic trends through time (Abbott et al. 1996). A sample of sherds was selected for organic residue analysis. Proposed analyses include radiocarbon dating, macrobotanic, pollen, starch grain, and fauna. Analytical procedures are presented below. Artifacts and other durable items not selected for special analysis (residue studies, chronometric dating, etc.) were washed and catalogued according to standards in the Southeast New Mexico Regional Research Design (SENMRRD) and entered into an ACCESS database table (Hogan 2006). All artifacts and original supporting documentation were transferred to TRC's Albuquerque facility in preparation of curation at the Museum of Indian Arts and Culture, Museum of New Mexico in Santa Fe.

Table 8.1 Samples submitted and analyzed

Sample Type	Quantity	Description
Flaked stone	4487	4432 debitage, 18 projectile points, 20 cores, 11 bifaces
Ground stone	35	6 hammerstones, mano and metate fragments
Ceramics	409	17 types
Fauna	1620	11 taxa
Radiocarbon C^{14}	8	5 charcoal, 3 sediment
XRF	3	rhyolite
Starch	8	3 ground stone; 5 sherds
Pollen	3	
Macrobotanical	4	flots
Diatoms	3	
Stable Isotopes	27	
FTIR	6	3 sherds, 3 ground stone

8.1 Lithics

8.1.1 Flaked-Stone Analysis

Flaked-stone studies focused on identifying cultural/temporal markers, subsistence related function, and activity diversity. TRC used four lithic attribute categories for debitage. The attributes included 1) size, 2) dorsal cortex, 3) platform remnant shape and type, and 4) raw material. Chipped stone was sorted into five sizes—<1 cm; 1 to <2 cm; 2 to <3 cm; 3 to <4 cm; and ≥4 cm (Ahler 1989; Andrefsky 1998). Dorsal cortex is commonly used as a proxy measure for identifying reduction stage and trajectory (Andrefsky 1998:118; Odell 2004:126). The percentage of dorsal cortex was estimated for each unbroken flake. Platform remnant analysis addressed two attribute categories: platform remnant type and platform remnant shape. Platform remnant type refers to the type of platform preparation, which provides evidence for identifying a core reduction sequence. The lithic analysis was done by Benjamin Bury.

8.1.1.1 X-Ray Fluorescence Spectrometry

TRC submitted samples of obsidian artifacts for x-ray fluorescence spectrometry (XRF) analysis to identify the source of the obsidian. Samples were submitted to Dr. Steven Shackley at the University of California, Berkley's Geoarchaeological XRF Laboratory, Berkeley, California.

8.1.2 Ground Stone Analysis

Ground stone was assigned tool form (mano, metate, mortar, indeterminate, or unidentified fragment), number of functional surfaces, evidence of recycling such as use for heating, and material type. Ground stone implements were used to guide site activity interpretations in addition to acquiring organic residues pertinent to agriculture and subsistence. Ground stone analysis was done by Benjamin Bury.

8.2 Ceramic Analysis

Ceramic analysis addressed chronological, technological, and regional interaction topics. Attributes included stylistic type, vessel form, vessel portion, and weight. Rim sherd analysis included orifice diameter and rim profile. Miller (1990) noted that small and eroded El Paso brownware sherds are difficult to identify by type. Therefore, sherds less that 3 cm in diameter were not analyzed. Instrumental Neutron Activation Analysis (INAA) provided information about the sudden influx of pottery types at A.D. 1250 to 1300 and the equally rapid decline as it relates to trade networks. Identifying clay, temper, and other manufacturing material sources contributed to the ceramic technology, regional variability, and possible mobility and trade networks. In addition, spatial and temporal analysis of the distribution of ceramic types helped determine the occupation and abandonment sequences and elucidate intra-site settlement patterns and social organization.

8.2.1 Instrumental Neutron Activation Analysis (INAA)

INAA is an analytical technique used for qualitative and quantitative multi-element analysis of trace elements in pottery. This supplemented the existing INAA study being funded by the Permian Basin Mitigation Program grant awarded to TRC in 2010. Samples included local brownware variants, Chupadero Black-on-white, and El Paso Brown sherds. Results are being compared to existing data sets available at the University of Missouri University Research Reactor (MURR) and at the Fort Bliss Directorate of Public Works, Environmental Division, Conservation Branch, El Paso, Texas. Samples were submitted to Michael Glasscock of MURR.

8.3 Faunal Analysis

Faunal analysis focused on levels of importance concerning animal resource exploitation, discard patterns, the effect of environmental setting on preservation, and the length and intensity of occupation. Interpretations focused on elucidating cultural behaviors (e.g., subsistence patterns, hunting, butchering, bone technology, ceremonialism), and environmental reconstruction. The recognition of subsistence patterns includes seasonality when discernable. Refits were made and fresh breaks mended whenever possible, reducing the total number of specimens. Variables recorded for each specimen included the determination of the lowest possible taxon (e.g., order, family, genus, species) or animal size (e.g., small bird, large mammal), element, side, portion, condition (e.g., burned, gnawed, presence of butchering marks, worked). Faunal analysis also included a determination of the minimum number of individuals (MNI), as well as the numbers of identified specimens present (NISP).

Faunal analysis also targeted changes in subsistence pertinent to agriculture and the hunting of bison. For example, Akins (2002:155) suggests sedentary groups tend to hunt a variety of species in the immediate vicinity of a settlement and the taxa diversity reflects the richness of the local environment. Hunting at a distance from the settlement tends to be more selective (Akins 2002:156). Analysis attempts to discern these patterns in the assemblage. In addition, do bison remains indicate nearby or distance hunting, i.e., do the remains represent both low and high meat-value elements or are they mainly high value elements? Do the bison elements reflect intensive processing for marrow and grease extraction? Is seasonality represented by the bison or other artiodactyl remains (e.g., deer, pronghorn, mountain sheep)? Is the assemblage age selective (e.g., young versus mature, mature versus old). Are fetal/neo-natal individuals present? Are butchering patterns determinable? Which taxa were dietary staples, and did they change through time? Faunal analysis was conducted by Marie E. Brown and Kenneth L. Brown.

8.4 Geomorphology

The stratigraphic sequencing and depositional history, including an assessment of playa dynamics, was conducted by Charles Frederick and Phillip Shelley. Geoarchaeological analysis included micromorphology and stable isotope analysis of sediments, radiocarbon dating of soil units, and climatic reconstruction based on diatom analysis and pedogenic organic/carbonates development of soils.

8.4.1 Stable Isotope Analysis

Stable isotope analysis can provide a form of proxy measure of past precipitation and related temperature variations in identified faunal remains, soils and sediments. Common isotopes include ^{13}C, ^{18}O, and ^{15}N. Variability in isotope composition, in particular ^{13}C values, reflects climate-driven shifts in the abundance in C_3 and C_4 plant species, and provides information on the paleodiet. Stable isotope samples were collected from pedogenic carbonates occurring in soil units exposed during excavations. Stable isotope analysis was conducted at the Colorado Plateau Stable Isotope Laboratory, Northern Arizona University, Flagstaff, Arizona.

8.4.2 Diatom Analysis

Diatoms are algae whose cellular contents are enclosed between two valves of silica that is preserved when the organism dies. Diatoms occur in abundance from extant and fossil lake or playa deposits. In terms of importance, diatoms of different taxa have different temperature, salinity, water depth, water clarity, and lake/playa nutritional content tolerances and respond quickly to changes in these factors. Diatom analysis was conducted by Barbara Winsborough, Leander, Texas, in conjunction with Charles Frederick.

8.5 Macrobotanical Analysis

Sediments were collected from excavated contexts that might yield prehistoric plant remains. Samples were processed in the laboratory using the Flote-Tech Flotation System of R. J. Dausman Technical Services, Inc. Standardized 10-liter samples were processed (Hunter and Gassner 1998). Interpretations are important for the two primary foci of the botanical analysis: the elucidation of cultural behaviors (e.g., subsistence patterns, gathering, planting and harvesting, ceremonialism), and environmental reconstruction. The recognition of subsistence patterns included seasonality data, if available. Identification of taxa that may have been encouraged to grow in the site proximity (e.g., rye, grasses; maize) may lend important information about the adoption of early horticulture and agriculture in the region. Evidence for the abandonment of agriculture in the mid–late fourteenth century is examined in addition to how subsistence strategies changed in response to the increased abundance of bison beginning in the late thirteenth century. Botanical remains were analyzed by Richard Holloway of Quaternary Services, Flagstaff, Arizona.

8.6 Pollen Analysis

The extremely sandy environment and probable thermal association of soil stains reduced the likelihood for the preservation of pollen. An off-site sample was collected for control purposes. Richard Holloway of Quaternary Research conducted the pollen analysis.

8.7 Starch Grain Analysis

Starch analysis was conducted on selected ground stone and pottery sherds based on context and likelihood for yielding results. Starch signatures of various plant species can be distinguished from one another by using a combination of light and chemical tests. Starch characteristics, individually defined by shape, intensity, color, and absorption, can be used in place of, or in combination with, other features of the plant to facilitate the identification of plant remains (McNair 1930). TRC submitted samples to Linda Perry of The Foundation for Archaeobotanical Research in Microfossils, Fairfax, Virginia.

8.8 Organic Residue Analysis (FTIR)

Ground stone surfaces and sherds were selected for extracting proteins and fatty residues. Previous research demonstrates organic residue samples can be extracted from burned rocks (Malainey and Malisza 2003; Quigg et al. 2001). This type of investigation assumes importance when environmental conditions are not conducive to the preservation of primary organic data, such as macrobotanical and faunal remains. This included a limited number of samples for Fourier Transform Infrared Spectroscopy (FTIR) analysis (Quigg personal communication, 2010). Samples were submitted to Linda Scott-Cummings of PaleoResearch Institute, Golden, Colorado.

8.9 Radiocarbon Dating

Radiocarbon assays of organic remains, charred seeds and wood charcoal, will serve as the primary basis for evaluating site chronology. Addressing many of the research questions depends on the accurate placement of cultural contexts within a temporal framework. Radiocarbon samples were submitted to the Center for Applied Isotope Studies at the University of Georgia, Athens. When feasible, wood and seeds were identified prior to submittal. Dating annuals was preferred over perennials or wood. Sediment samples were dated from physiographic landforms.

The resulting carbon dioxide was cryogenically purified from the other reaction products and catalytically converted to graphite. Graphite 14C/13C ratios were measured using the CAIS 0.5 MeV accelerator mass spectrometer (AMS). The sample ratios were compared to the ratio measured from the Oxalic Acid I (NBS SRM 4990). The sample 13C/12C ratios were measured separately using a stable isotope ratio mass spectrometer and expressed as δ13C with respect to PDB, with an error of less than 0.1‰. The quoted uncalibrated dates are given in radiocarbon years before 1950 (years B.P.), using the 14 C half-life of 5568 years.

8.10 Curation

All cultural material, field notes, analysis forms, and documents generated during the course of the project were processed in accordance with 36 CFR 79, the Curation of Federally Owned and Administrated Archaeological Collections. The collections were processed in accordance with the current policies and standards defined by the Museum of Indian Arts and Culture, Museum of New Mexico, Santa Fe, where they will be curated.

9.0 GEOMORPHOLOGY

Charles D. Frederick, Brittney Gregory, and Phillip Shelley

9.1 Introduction

This chapter presents the results of geoarchaeological investigations in and around the Boot Hill Site. This work focused on three issues: 1) the stratigraphy and integrity of the site, 2) the nature of the anthrosol and its formation, and 3) potential sources of paleoenvironmental information.

9.2 Previous Work

Several different authors have mapped the geology of the landscape in the vicinity of the Boot Hill Site during the last 50 years. The first comprehensive map of the region was published by Dane and Bachman (1958) and subsequently was formalized a few years later (Dane and Bachman 1965). This work was subsequently included on the Texas Bureau of Economic Geology (1976) map of the Hobbs area and identifies the entire area around the site as "sand sheets, dunes and dune ridges, undivided." More recently, the New Mexico Bureau of Geology and Mineral Resources (2003) mapped the entire region as "eolian and piedmont deposits (Holocene to middle Pleistocene)—Interlayered eolian sands and piedmont slope deposits…typically capped by thin eolian deposits." These large-scale mapping efforts provide an image of the major geologic trends, but fail to record the detail that is present in the real landscape at a scale that is relevant for archaeological investigation.

Although more detailed mapping is desirable for archaeological applications, such maps are uncommon. Hunt (1977) mapped the surficial deposits of southeastern New Mexico, and his map provides a bit more detail by delineating the floodplains of the arroyos and dry washes from the coppice dune mantled uplands. Even greater detail is was provided by a geomorphic map compiled by Steve Hall for the Loco Hills area immediately south of the site (Altschul et al., 2005; see also Hall and Goble 2008:282) but unfortunately this map stops just short of the site. Hall has worked in the immediate vicinity of the site but the map provided for the area near the Boot Hill Site (Hall 2002a:38, Map 2) merely shows the location of specific described sections, and does not map the geomorphology like the Loco Hills map (Altschul et al., 2005; see also Hall and Goble 2008:282).

Recent investigations concerning the late Quaternary stratigraphy of the Mescalero Sands have been performed by Steve Hall (e.g. Hall 2002a; 2002b; Hall and Goble 2008; Alschul et al. 2005). Hall (2002a; 2002b) describes three phases of aeolian deposition on top of the Mescalero Caliche. Unit 1 (aka. the Lower Sand) is described as up to 4 m thick and was dated by means of optically stimulated luminescence (OSL) dating to the period between 70,000 to 90,000 years B.P. This deposit exhibits a prominent argillic horizon that Hall and Goble named the Berino paleosol. A phase of erosion truncated the top of the Berino paleosol prior to deposition of Unit 2 (aka the Upper Aeolian Sand). This deposit is described by Hall as the main component of the Mescalero Sands, may be as much as 5 m thick, and was OSL dated to the period between 6300 and 8900 years B.P., and Hall and Goble extrapolate the age of Unit 2 to 9000 to 5000 years B.P. Hall describes a thin A-horizon formed at the top of the Upper Aeolian Sand which he named the Loco Hills Soil that is distinct from anthrosols that have formed concurrent with prehistoric occupations. Hall and Goble's (2008) description of the Loco Hills soil is more consistent with a cumulic sediment/soil rather than a soil formed in an existing deposit, and would therefore seem to merit recognition as a distinct aeolian depositional unit. A third phase of recently begun aeolian activity is named Unit 3 in Hall (2002a; 2002b) and is comprised of the modern coppice and parabolic dunes. Hall and Goble (2008) omitted Unit 3 as a formal stratigraphic unit from the most recent publication. Indeed, Hall and Goble (2008:283) note that "the distribution and age of *the two sand layers that make up the Mescalero sand sheet* have a direct bearing on the visibility, hence distribution, of known archeological sites" (emphasis mine). One would expect that age and distribution of the two most recent aeolian deposit (Unit 3 and Unit 2) would control archaeological site visibility rather than the two oldest.

The basal deposit in Hall's work is the Mescalero caliche (or Mescalero paleosol), which is widely observed across the Mescalero Plain which extends between the caprock escarpment on the western side of the Llano Estacado and the Pecos River. This prominent calcic horizon, like the much older caprock formed in the Ogallala Formation, is a prominent impediment to erosion today, and formed during a prolonged period of relative landscape stability in the middle Pleistocene. Kennedy (1997) documented 22 exposures of the Mescalero caliche and noted that it exhibits a wide range in morphology, ranging from a Stage IV to a Stage VI calcic horizon. The Mescalero caliche is thought to have formed in the middle Pleistocene because in most places it is formed in the Gatuña formation, which contains reworked deposits of the 620,000-year-old Lava creek B tephra that originated from the Yellowstone area of southwestern Wyoming. Kennedy (1997:6) also cites uranium-series ages obtained by Rosholt and McKinney (1980) and Powers and Holt (1993) derived from the upper part of the Mescalero Caliche that indicate it formed prior to 570,000±110,000 and 420,000±60,000 years B.P.

9.3 Field Methods

Geoarchaeological fieldwork at the site consisted of three tasks: 1) reconnaissance, 2) coring, and 3) sampling for understanding anthropic enrichment of the soil on the hillcrest. The reconnaissance examined the landscape around the site, in particular the alluvial valley to the east and south of the site. These areas were walked in order to gain an impression of the age of the deposits in the immediate vicinity of the site, and better understand processes that have influenced this location in the past. This provided a perspective useful in understanding the anthropic nature of the soil on the hill, in addition to providing information useful in understanding how the landscape around the site has changed through time. When significant exposures were encountered, a GPS coordinate was recorded, and the exposures were briefly described, photographed, and in a few cases sampled for radiocarbon, diatom or other analyses.

On the hillcrest, a suite of six cores/shovel tests were performed in order to assess the integrity and nature of the deposits present. The cores were made with an Eijkelkamp percussion corer and an open sided gouge was used to sample the deposits. Unfortunately, the loose sandy sediment that comprises the soil on the hillcrest proved difficult to sample with the gouge, which would often slip out of the core barrel and back into the hole as the gouge was removed from the hole. When this happened, another core was attempted nearby, but in most cases, the subsequent cores would suffer the same fate. In these instances, a shovel test was excavated in order to obtain a window into the subsurface, and in most cases, this hole was about the same size of the area already disturbed by the thwarted coring attempts. Most cores were less than 1 m long and ended at the top of the Mescalero Caliche or extended a short distance into it. Once a core was retrieved, the open side of the gouge was shaved with a trowel, and subsequently photographed and described. In the case of shovel tests, one wall of the excavation was cleaned with a trowel, photographed and described. Soil descriptions were made in general accordance with Schoeneberger et al (2002). Upon completion of the description, samples were collected from each profile using 2.5 cm diameter paleomagnetic sample boxes. These samples were obtained at irregular intervals. Field exposures were evaluated using a soils-geomorphology approach following Birkeland (1999). Specific reference to the development of soil calcic soil horizons follows the nomenclature described by Gile et al. (1981) and Holliday and Jacobs (1995).

One of the most prominent first impressions of the site is the degree of anthropogenic alteration of the soil that has occurred upon the hillcrest. The soil A-horizon is very black colored and appears to have been substantially altered through human activity. In order to better understand the nature and degree of this edaphic alteration, soil samples were collected from three locations: the site center, the northern margin of the hill, and a control sample collected off the hill but in a similar landscape position. The samples from the site center derived from Trench 1, whereas the second column of samples was collected from Core 6, located near Trench 2. The control column was collected from a similar topographic position (a hillcrest) about 350 m to the north. This profile was exposed with a shovel and subsequently cleaned and described, and a suite of bulk soil samples collected in a continuous column sample at 5 cm increments.

9.4 Laboratory Methods

A suite of 69 soil samples were collected in the field from the six cores/shovel tests in the center of the site and from the control column. Given the limited size of the cores, most of these samples were collected in 2.5-cm square plastic paleomagnetic boxes and all work was done on the less than 2-mm size fraction. For each sample a basic suite of physical properties were determined, including the texture, the percent loss-on-ignition, the magnetic susceptibility, and the calcium carbonate equivalent. The results of these analyses are presented on Table 9.1. The methods employed in each analysis are described in detail below.

9.4.1 Particle Size

The particle size distribution (or texture) of each sample was determined on a Beckman-Coulter LS 13-320 multi-wavelength laser sizer. Samples were first subsampled, and then placed in a small beaker on a hot plate to which concentrated (30 percent) hydrogen peroxide was added in order to remove organic matter and a 5 percent solution of sodium hexametaphosphate was added to disperse the fine fraction. Samples were brought to a boil and then left on the hot plate until the reaction had ceased or the color of the sediment had changed, at which point they were removed from the hot plate, cooled and then measured on the LS-13-320. The results of these analyses are presented as percentages of sand, silt and clay, as well as in the form of descriptive statistics that are presented in phi units (a negative log base 2 conversion of millimeters). In the phi system, sands exhibit phi values between 0 and 4, silts between 4 and 9, and clay > 9 phi. The USDA soil texture class for each sample was determined using the Soil Texture calculator provided by the NRCS website (NRCS 2010).

9.4.2 Organic matter (LOI)

The amount of organic matter in each sample was estimated by the loss-on-ignition (or LOI) method, which can provide a reasonable proxy for organic carbon content under certain conditions. LOI can also overestimate organic carbon where lattice expandable clays and other minerals than incorporate water in their structure (e.g. gypsum) are present. This method used here involved weighing a sample into a porcelain crucible, drying in an oven at 150˚C overnight to drive off all interstitial and structural water, reweighing, and then combusting in a muffle furnace at 450˚C for 2 hours. The resulting weight loss-upon-ignition is then considered to be an approximation of organic matter.

9.4.3 Magnetic Susceptibility

Magnetic susceptibility is a general measure of the degree to which a sample may be magnetized, and provides basic information on the magnetic mineralogy of the sample, which may vary owing to a variety of factors, such as depositional processes, soil development, and human occupation. The general application of magnetic susceptibility in archeological studies has been discussed in detail by Dalan (2008) and Dalan and Bannerjee (1998).

Table 9.1 Boot Hill soil core and laboratory data

Sample	Depth	Xlf	Xfd	CaCo3	LOI	Sand	Silt	Clay	Mean	Median	Sorting	Skewness	Kurtosis	USDA Texture
	(cm)	$10^{-8}m^3kg^{-1}$	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(phi)		(phi)			Class
1	4	55.7	4.1	5.1	2.58	84.3	13.75	1.95	2.87	2.66	1.23	0.44	1.71	Loamy Sand
2	9.5	57.4	4.7	10.2	5.33	78	19.91	2.09	3.09	2.69	1.52	0.50	1.49	Loamy Sand
3	15	58.9	4.9	11.8	5.27	79.9	18.24	1.86	2.96	2.64	1.56	0.37	1.66	Loamy Sand
4	21	61.1	4.3	13.2	5.10	81	17.45	1.55	2.91	2.63	1.39	0.38	1.48	Loamy Sand
5	30.5	44.3	1.3	14.1	4.44	80.8	17.46	1.74	2.83	2.56	1.72	0.24	1.85	Loamy Sand
6	35.5	42.5	-1.1	17.8	4.62	79.9	18.37	1.73	2.92	2.64	1.60	0.27	1.66	Loamy Sand
7	41	34.5	-1.8	16.4	4.21	79.9	18.42	1.68	2.91	2.63	1.60	0.25	1.64	Loamy Sand
8	48.5	39.8	-0.4	19.4	3.24	83.7	14.5	1.8	2.69	2.46	1.58	0.27	1.96	Loamy Sand
9	56	24.8	-8.3	27.5	2.76	79.1	18.91	1.99	2.91	2.62	1.71	0.25	1.65	Loamy Sand
10	61.5	24.9	-11.9	25.7	2.38	85.6	13.08	1.32	2.14	2.33	1.86	-0.05	1.62	Loamy Sand
11	70	22.5	-11.5	26.6	2.90	82.4	15.94	1.66	2.44	2.39	1.88	0.09	1.64	Loamy Sand
1	2.5	59.0	5.2	20.1	3.15	86.2	12.16	1.64	2.69	2.53	1.28	0.30	1.86	Sand
2	7.5	57.0	3.9	15.9	5.26	78	19.97	2.03	3.03	2.67	1.68	0.36	1.63	Loamy Sand
3	12.5	61.3	4.6	15.3	4.97	80	18.23	1.77	2.96	2.63	1.51	0.40	1.63	Loamy Sand
4	17.5	56.9	3.4	16	5.22	79.7	18.62	1.68	2.97	2.64	1.44	0.42	1.48	Loamy Sand
5	22.5	61.5	4.8	14.9	5.28	78.5	19.73	1.77	3.03	2.69	1.48	0.40	1.44	Loamy Sand
6	27.5	51.2	3.4	17.2	5.38	79.8	18.54	1.66	2.93	2.63	1.60	0.28	1.69	Loamy Sand
1	5	57.2	4.1	12.8	3.53	81.1	16.65	2.25	3.00	2.70	1.42	0.49	1.76	Loamy Sand
2	15	54.9	5.9	17.4	4.48	80.3	17.99	1.71	2.92	2.61	1.61	0.30	1.78	Loamy Sand
3	17	46.3	5.0	19.8	3.36	81.4	16.98	1.62	2.89	2.66	1.50	0.23	1.71	Loamy Sand
4	20	19.7	1.5	43.9	2.60	84.1	14.39	1.51	2.02	2.19	2.03	0.00	1.00	Loamy Sand
5	24.5	20.1	0.8	46.7	1.88	81.8	16.56	1.64	2.13	2.32	2.13	-0.01	1.15	Loamy Sand

Sample	Depth	Xlf	Xfd	CaCo3	LOI	Sand	Silt	Clay	Mean	Median	Sorting	Skewness	Kurtosis	USDA Texture
6	29	23.9	0.4	35.8	2.26	80.8	17.44	1.76	2.51	2.45	1.93	0.09	1.55	Loamy Sand
7	34	13.1	-5.8	57.3	1.63	73.4	23.29	3.31	3.15	2.67	1.85	0.50	1.31	Loamy Sand
8	40	48.0	2.8	20.4	3.77	81.8	16.74	1.46	2.89	2.66	1.42	0.25	1.63	Loamy Sand
9	43	31.5	-0.3	28.3	3.52	82.6	15.9	1.5	2.68	2.56	1.59	0.12	1.58	Loamy Sand
10	47	14.7	-5.8	72.9	2.12	58.2	35.25	6.55	4.12	3.47	2.30	0.50	1.11	Sandy Loam
11	52	21.4	-3.3	23.8	1.58	67.7	27.91	4.39	3.52	2.98	1.96	0.52	1.27	Sandy Loam
1	3	63.0	4.6	10.3	3.56	82.8	15.52	1.68	2.88	2.66	1.34	0.34	1.60	Loamy Sand
2	6.5	67.0	4.6	10.5	4.97	77.6	20.42	1.98	3.10	2.74	1.48	0.45	1.40	Loamy Sand
3	9	64.8	3.7	11.2	4.78	72.1	25.06	2.84	3.41	2.89	1.69	0.56	1.30	Sandy Loam
4	12	67.2	3.6	11.5	4.84	76.6	21.29	2.11	3.11	2.73	1.70	0.36	1.59	Loamy Sand
5	16	64.6	3.6	13.1	5.13	76.8	21.2	2	3.10	2.72	1.62	0.38	1.49	Loamy Sand
6	22.5	52.7	2.5	14.8	4.79	76	22.16	1.84	3.16	2.80	1.46	0.45	1.27	Loamy Sand
7	24.5	56.5	1.6	15.2	4.82	75.3	22.84	1.86	3.19	2.86	1.41	0.42	1.20	Loamy Sand
8	28	52.3	2.3	19.1	4.86	74.8	23.27	1.93	3.18	2.81	1.48	0.41	1.24	Loamy Sand
9	37	13.0	-8.0	81.8	1.69	61.2	33.44	5.36	3.76	3.18	2.32	0.43	1.11	Sandy Loam
1	2	49.5	4.1	12.5	3.18	87.5	11.04	1.46	2.63	2.52	1.34	0.14	1.98	Loamy Sand
2	6	56.0	5.0	16.3	2.80	80	17.78	2.22	2.97	2.70	1.72	0.28	1.98	Loamy Sand
3	9	49.4	5.7	14.4	3.31	82.9	15.21	1.89	2.84	2.57	1.44	0.41	1.85	Loamy Sand
4	13	56.4	5.6	14.1	3.34	80.9	17.32	1.78	2.87	2.56	1.68	0.30	1.92	Loamy Sand
5	16.5	52.0	4.7	17.6	4.20	78.4	19.77	1.83	3.04	2.70	1.50	0.41	1.48	Loamy Sand
6	20	50.6	5.5	17.6	4.19	82	16.12	1.88	2.74	2.51	1.80	0.21	2.12	Loamy Sand
7	30.5	22.5	1.7	31.3	2.50	82	16.55	1.45	2.48	2.46	1.81	0.03	1.47	Loamy Sand
8	36	19.7	2.3	41.1	2.36	80.1	18.16	1.74	2.50	2.47	1.94	0.08	1.43	Loamy Sand
9	44	47.4	6.2	22	3.63	77.9	20.14	1.96	3.03	2.67	1.54	0.42	1.45	Loamy Sand
10	54	12.0	7.3	46.7	2.27	76.2	21.38	2.42	3.00	2.64	1.78	0.36	1.43	Loamy Sand

Sample	Depth	Xlf	Xfd	CaCo3	LOI	Sand	Silt	Clay	Mean	Median	Sorting	Skewness	Kurtosis	USDA Texture
1	2	49.0	-12.0	8.2	3.80	79.3	18.34	2.36	3.05	2.71	1.47	0.49	1.62	Loamy Sand
2	5	55.1	2.7	10.7	3.05	82.1	16	1.9	2.88	2.61	1.48	0.35	1.84	Loamy Sand
3	9	49.8	4.1	15.7	3.54	81.4	16.71	1.89	2.88	2.59	1.55	0.34	1.82	Loamy Sand
4	13	48.7	3.3	14.4	4.08	78.5	19.45	2.05	3.06	2.72	1.46	0.46	1.48	Loamy Sand
5	18	47.1	0.2	12.2	3.86	86	12.66	1.34	2.65	2.49	1.39	0.19	1.87	Loamy Sand
6	22	49.0	1.1	15.4	3.75	83.2	15.41	1.39	2.87	2.67	1.29	0.28	1.54	Loamy Sand
7	26	42.7	0.2	17	3.23	84.5	14.11	1.39	2.77	2.57	1.33	0.25	1.70	Loamy Sand
8	32	40.5	-1.1	18.5	3.24	84.7	13.86	1.44	2.75	2.54	1.34	0.28	1.78	Loamy Sand
9	36	39.7	0.6	20.2	4.03	82.6	15.94	1.46	2.81	2.59	1.40	0.26	1.56	Loamy Sand
10	41	32.2	-2.5	24	3.08	83.6	15.04	1.36	2.78	2.56	1.31	0.26	1.48	Loamy Sand
11	45	19.0	-6.7	42	1.79	78.9	18.6	2.5	2.72	2.38	1.92	0.34	1.50	Loamy Sand
1	2.5	49.4	3.6	5	1.49	82.3	15.34	2.36	3.09	2.90	1.19	0.47	1.68	Loamy Sand
2	7.5	44.0	5.3	8.9	2.10	83	15.02	1.98	3.03	2.82	1.12	0.46	1.51	Loamy Sand
3	12.5	41.6	6.5	12.1	2.23	84.4	14.1	1.5	2.86	2.69	1.22	0.27	1.58	Loamy Sand
4	17.5	41.2	6.6	12.3	1.92	84	14.44	1.56	2.93	2.72	1.10	0.38	1.41	Loamy Sand
5	22.5	40.3	6.4	11.2	2.10	82.2	16.16	1.64	3.03	2.81	1.07	0.43	1.29	Loamy Sand
6	27.5	33.2	-8.3	13.7	2.08	83.6	14.89	1.51	2.89	2.70	1.29	0.24	1.66	Loamy Sand
7	32.5	37.8	6.7	15.4	2.20	82.4	16	1.6	3.00	2.78	1.11	0.38	1.30	Loamy Sand
8	37.5	35.8	7.5	15.8	1.92	83.1	15.49	1.41	2.92	2.73	1.24	0.23	1.52	Loamy Sand
9	42.5	34.8	6.6	16.6	1.40	86	12.71	1.29	2.66	2.54	1.40	0.10	1.83	Loamy Sand
10	47.5	35.1	5.7	21.7	1.59	80.1	18.27	1.63	3.05	2.84	1.36	0.22	1.55	Loamy Sand
11	52.5	34.3	5.8	19.9	2.09	80.9	17.46	1.64	2.99	2.77	1.32	0.28	1.47	Loamy Sand

In order to measure the magnetic susceptibility the samples were first dried and weighed, and then the low frequency (470 Hz) and high frequency (4700 Hz) magnetic susceptibility (kappa) was measured in SI units on the o.1 setting on a Bartington MS2 meter and an MS2b sensor (see Dearing 1999a). The mass corrected magnetic susceptibility (chi, or χ_{lf}) and coefficient of frequency dependency (χ_{fd}) were then calculated. The coefficient of frequency dependency (χ_{fd}), is the percent difference in magnetic susceptibility measured at low and high frequencies (calculated as: $\chi_{fd} = (\chi_{lf} - \chi_{hf})/ \chi_{lf})*100$). Elevated values of χ_{fd} (ca. >10 percent; Gale and Hoare 1991:213) are indicative of increased concentrations of fine-grained ferrimagnetic minerals, most often maghemite, in top soils (Dearing et al 1996; Dearing 1999b) but none of the samples measured exhibited elevated values of χ_{fd}. The χ_{lf} magnetic susceptibility values are presented on Table 9.1 and are reported in SI units ($10^{-8}m^3kg^{-1}$).

9.4.4 Stable Carbon Isotopes of Bulk Soil Organic Matter

In addition to the preceding analyses, a group of 27 samples were submitted to the Colorado Plateau Stable Isotope Laboratory for the determination of the stable carbon isotopic composition of the bulk soil organic matter and the percentage organic carbon. Five samples were submitted from Trench 1, and eleven samples were submitted from Core 6 and the control column. These results are presented in Table 9.2.

The organic carbon for each sample was determined by calculating the amount of carbon dioxide released during combustion at 1000˚C in a Carlo Erba NC2100 Elemental Analyzer (EA). Encapsulation in tin, in the presence of a pulse of oxygen, leads to flash combustion at 1700 ℃, which converts all the carbon to CO_2. The carbon dioxide was then passed through a heated column of copper and separated from nitrogen on a gas chromatograph column, and sent to the mass spectrometer in a helium stream for measurement. To calculate percent carbon the mass spectrometer records the area under the curve for the carbon dioxide peak. Standards with known amounts of carbon are analyzed in each daily run, and the relationship between peak area, known percent carbon, and sample mass are used to calculate the percent carbon of samples with unknown C. The $\delta^{13}C$ value of the carbon dioxide was then measured on a Thermo Electron gas isotope-ratio mass spectrometer (Richard Doucett 2011, personal communication).

9.4.5 Comment on Organic Matter Values

It should be noted here that the data generated here provide estimates of organic carbon derived from two methods (Loss-on-ignition and on an elemental analyzer) and that the resulting data, although highly correlated, are not identical. The loss-on-ignition method was used for all of the core samples, and the Stable Carbon Isotopic study employed an elemental analyzer (described above). The results of the two methods can be compared for Core 6 and the Control Column, and when this is done it is apparent that the LOI values are approximately 2.8 to 4 times larger than the values determined on the elemental analyzer. The two data sets are highly correlated (correlation coefficient = 0.908) but clearly different. The elemental analyzer values should more faithfully represent the carbon content of the soils and the larger LOI values are most likely due to overestimation of organic matter owing to the presence of structural water in the minerals present.

9.5 Results of Investigations

9.5.1 Coring On Hillcrest

The results of the coring work performed on the hillcrest are provided in table form in Appendix D and the results of the lab work performed on samples collected from the cores is graphically summarized in Figures 9.1 and 9.2 and discussed in detail, below.

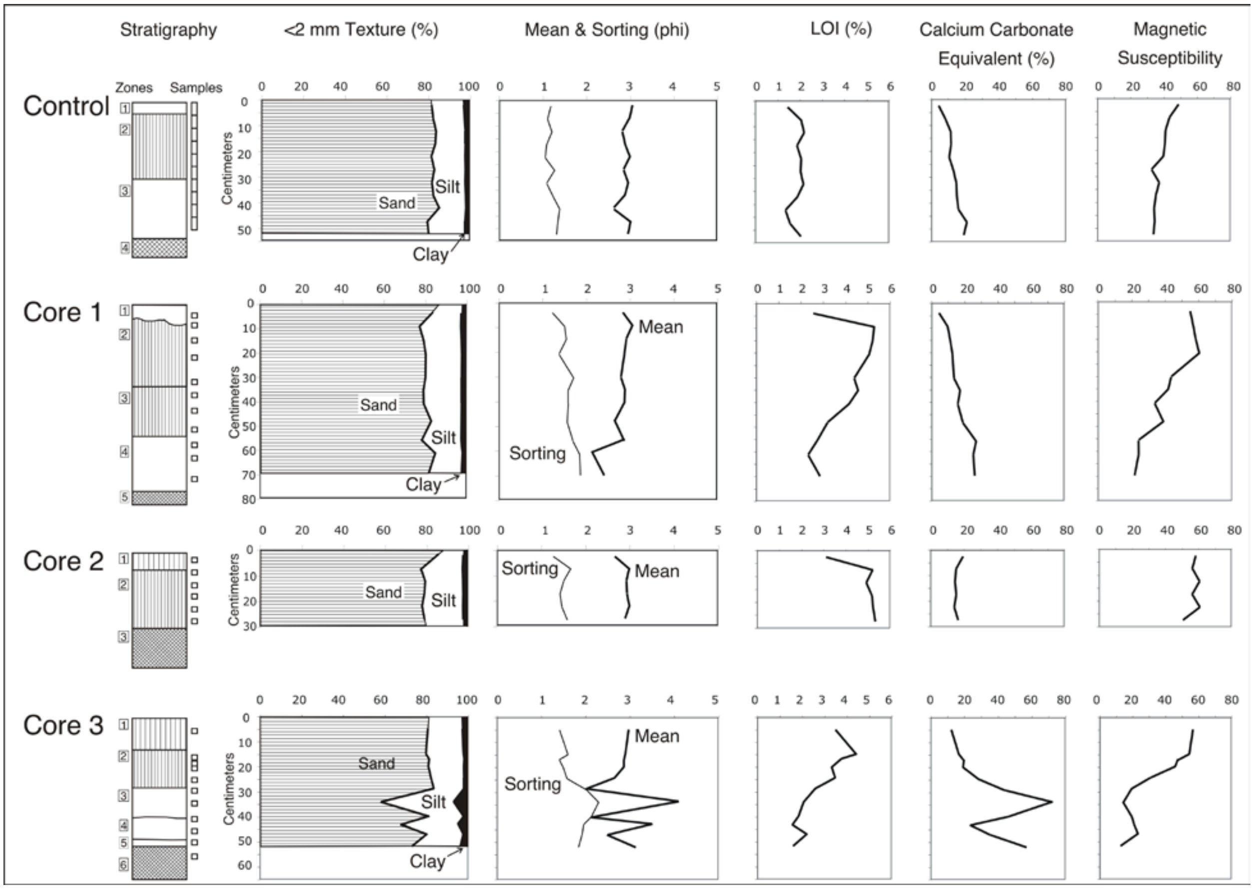

Figure 9.1 Plot of the laboratory data for the control column and cores 1, 2 and 3 in the core of the site

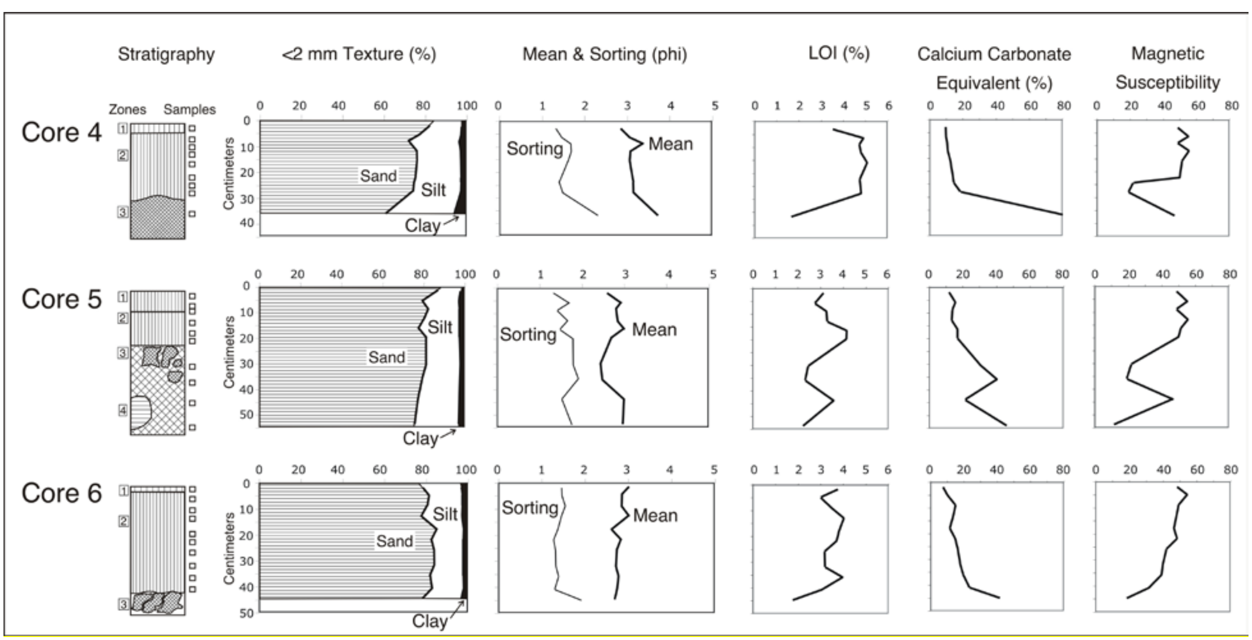

Figure 9.2 Plot of the laboratory data for the cores 4, 5 and 6 in the core of the site

9.5.1.1 Stratigraphy on the Hill

Coring on the hillcrest consistently identified three stratigraphic units: 1) Hall's aeolian Unit 3, 2) Hall's aeolian Units 2 and 3) the Mescalero Caliche. The appearance of Unit 2 on the site is significantly different than Hall describes owing to anthrogenic alteration of the soil profile.

9.5.1.1.1 *Unit 3*

Most exposures exhibited a thin drape of the most recent aeolian deposit that Hall (2002a; 2002b) calls Unit 3. This deposit ranged from 2–13 cm thick in the cores and control section but presumably is much thicker in the coppice dunes that are scattered across the landscape but that have been cleared from the hilltop. The sand associated with Unit 3 is of similar size to Unit 2, ranging between 2.7 and 3.1 phi (fine to very fine sand) but is often slightly better sorted (although all of these deposits exhibit sorting values between 1 and 2 phi and therefore classify as poorly sorted).

In the control section Unit 3 appeared to be pedogenically unaltered (a yellowish red (5YR 5/6, d)), but in the cores from the center of the site this deposit exhibited a subtle but noticeable melanization or darker color (very dark grayish brown (10YR 3/2, m) to brown (10YR 4/3, m)) which implies a greater organic carbon content. Loss-on-ignition analysis of these samples supports this inference (Table 9.1). In the control column the Unit 3 sample contained 1.5 percent LOI whereas in the core of the site this deposit exhibited LOI values between 2.5 and 3.8 percent. Given the relatively young age of Unit 3, and the absence of such melanization in the control section, the increase in organic carbon in the core of the site is most likely due to post-depositional upward (or bidirectional) transfers of more organic rich anthrogenic soil formed in Unit 3 by means of fauna (such as termites, ants and worms) and flora.

9.5.1.1.2 *Unit 2*

The main sedimentary deposit at the site is Aeolian Unit 2, the deposition of which Hall (2002a; 2002b) has dated to the early-middle Holocene between 5,000 and 9,000 years B.P. Texture analysis of the cores (Table 9.1 and Figures 9.1 and 9.2) clearly shows there is no clay-rich subsoil present on the site, either in the form of clay lamellae (or "clay bands" as described by Hall 2002b:19) which Hall describes for Unit 3, or associated with the Berino paleosol formed at the Unit 1, or the Bt horizon associated with the Mescalero paleosol which is found directly on top of the Mescalero Caliche. Rather, Unit 2 is consistently a loamy sand that rests directly upon the Mescalero Caliche.

In the control section, Unit 2 exhibits an A-Bw soil profile with minor organic enrichment in the form of an A-horizon, which is somewhat different from the Loco Hills soil described by Hall at the top of Unit 2. Hall's description of the Loco Hills soil is one of a thin (10–20 cm) cumulic soil formed in a recent aeolian deposit younger than Unit 2, but older than Unit 3 and is described as thin and lacking a subsoil. The soil observed in the control profile exhibited a 25 cm thick A-horizon and a cambic B-horizon. It could be argued that this soil A-horizon is anthrogenic in nature, and the presence of small fragments of burned rock in the soil could be used as evidence supporting such an interpretation. However, it is also possible that this is the soil formed in Unit 2 during the approximately 4600 years of stability that followed the end of Unit 2 deposition. Without data from another control profile from a similar landscape position where there is no prehistoric cultural presence, it is impossible to exclude an anthrogenic origin for this soil, but the data gathered here clearly shows that the soil formed in the control column is significantly different from the soil formed on the hill crest in the core of the site.

The appearance of Unit 2 in the core of the site is dramatically different from Hall's (2002b:16) description of Unit 2 owing to the anthrogenic alteration of this deposit in the five millennia that passed following the end of Unit 2 deposition. Unit 2 is described by Hall (2002b:16) as reddish yellow (5YR 6/6) whereas Unit 2 in the core of the Boot Hill site is consistently black (either 10YR 2/1 or N2.5/0). Only one core in this area deviated from this (Core 1) and the color of Unit 1 below the A-horizon was dark brown (10YR 3/3). The differences between Unit 2 in the control column and the site core are even more striking when the results of the bulk soil stable carbon isotopes are examined (Table 9.2 and Figures 9.3 and 9.4).

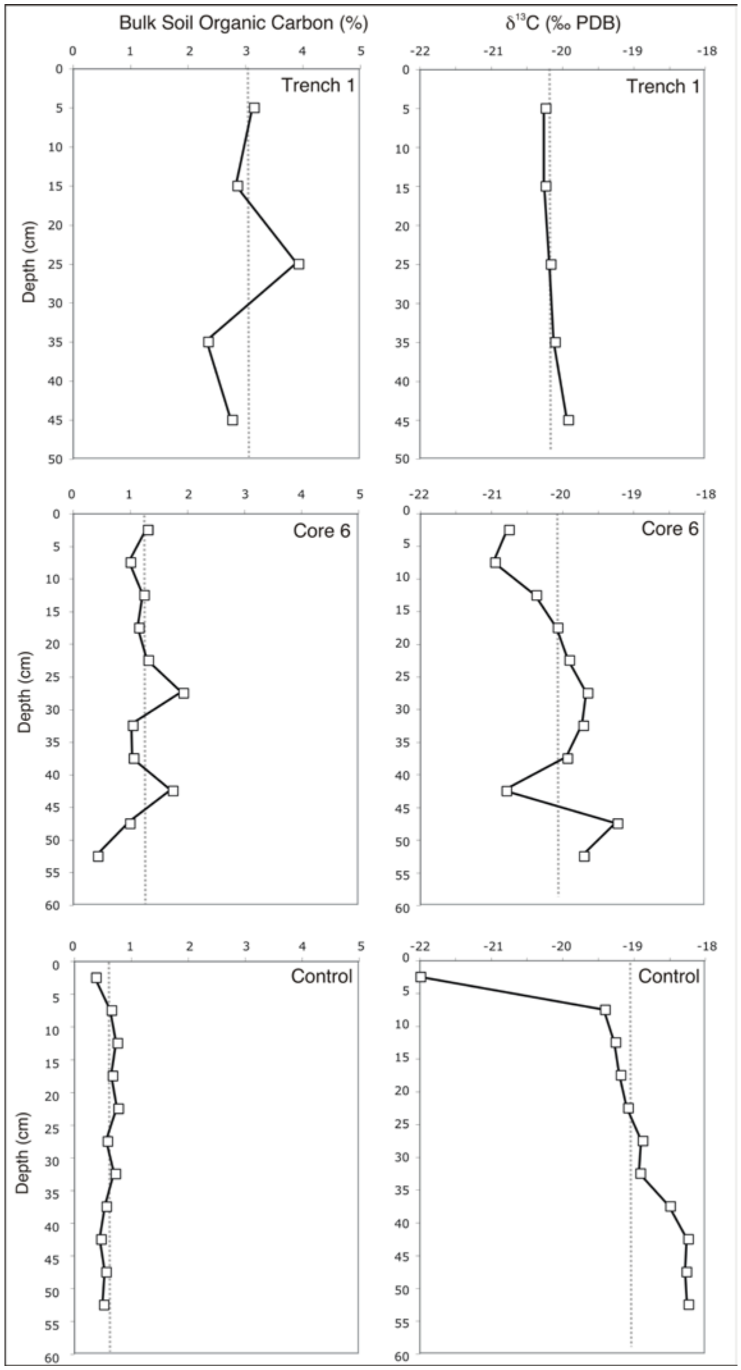

Figure 9.3 Bivariate plots illustrating the depth variation in organic carbon and stable carbon isotopic composition of bulk soil organic matter. Dotted lines denote the average value for the column.

Upper Panel: Results obtained from Trench 1, in the core of the site. *Middle Panel*: Results obtained from Core 6, on the northern margin of the site (approximately 30 m north of Trench 1); *Lower Panel*: Results obtained from the control column situated on the next hillcrest to the north (approximately 355 m north of Trench 1). Note: the uppermost sample in the stable isotope column was omitted from the average value shown.

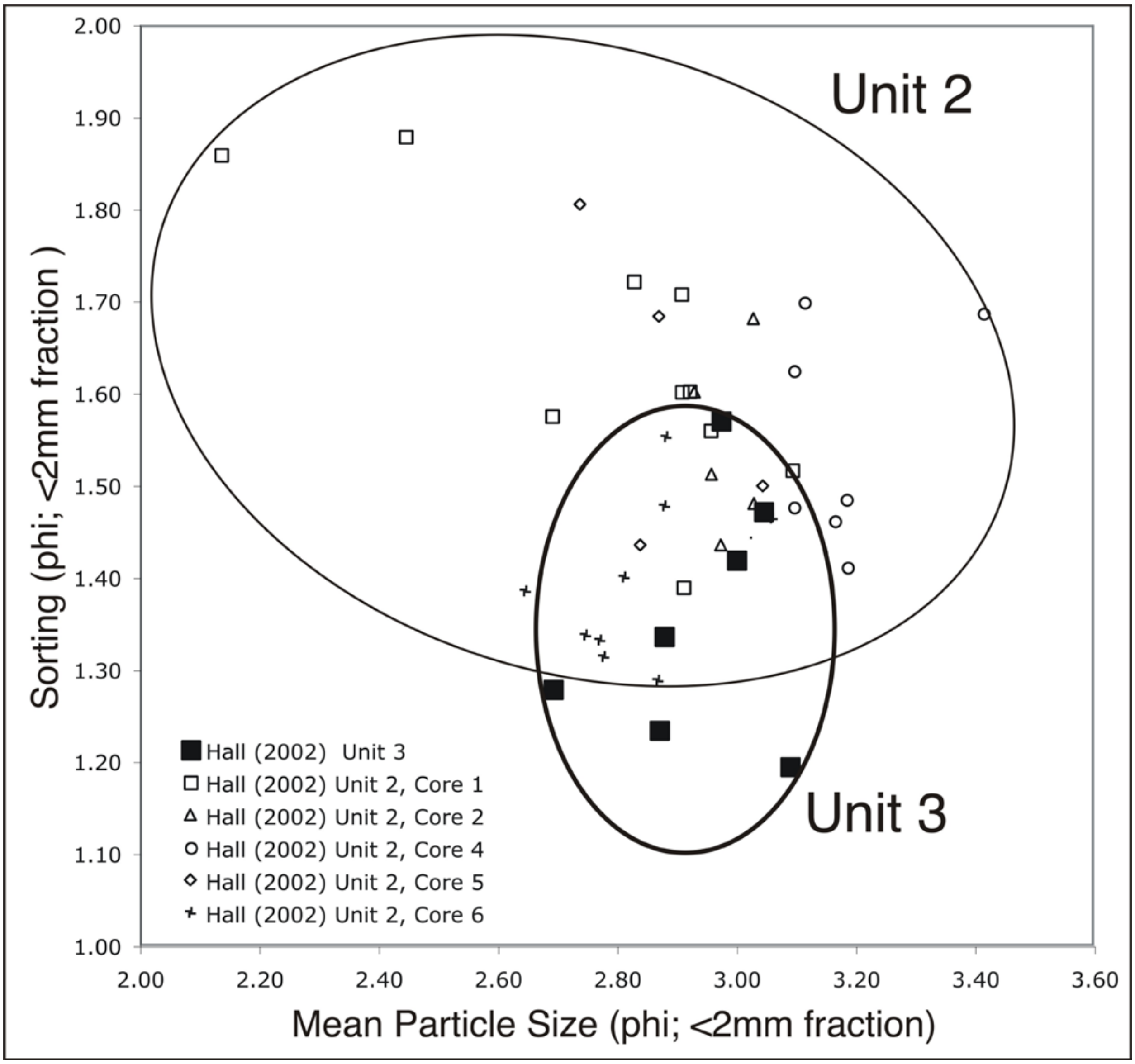

Figure 9.4 Plot of the mean particle size versus the sorting (in phi units) for texture analysis of the <2mm size fraction of samples collected from the cores on the hillcrest.

The ellipses show the general size-sorting fields of aeolian Unit 3 and aeolian Unit 2.

Table 9.2 Stable Isotopes

Provenience	Sample	$\delta^{13}C$	Carbon	Depth
	Designation	**(‰)**	**(percent)**	**(cm)**
TRC Excavation	Sample 1	-20.23	3.16	0-10
Trench 1	Sample 2	-20.23	2.87	10-20
	Sample 3	-20.16	3.93	20-30
	Sample 4	-20.10	2.36	30-40
	Sample 5	-19.91	2.78	40-50
	Average	-20.13	3.02	

Provenience	Sample	$\delta^{13}C$	Carbon	Depth
	Designation	(‰)	(percent)	(cm)
Core 6	BHC6-1	-20.75	1.31	0-5
	BHC6-2	-20.94	1.01	5-10
	BHC6-3	-20.36	1.25	10-15
	BHC6-4	-20.06	1.16	15-20
	BHC6-5	-19.90	1.32	20-25
	BHC6-6	-19.64	1.94	25-30
	BHC6-7	-19.70	1.05	30-35
	BHC6-8	-19.92	1.06	35-40
	BHC6-9	-20.78	1.75	40-45
	BHC6-10	-19.22	1.00	45-50
	BHC6-11	-19.69	0.44	50-55
	Average	-20.09	1.21	
Control	BH1-1	-21.99	0.39	0-5
	BH1-2	-19.40	0.66	5-10
	BH1-3	-19.25	0.76	10-15
	BH1-4	-19.18	0.68	15-20
	BH1-5	-19.08	0.78	20-25
	BH1-6	-18.88	0.59	25-30
	BH1-7	-18.91	0.73	30-35
	BH1-8	-18.49	0.57	35-40
	BH1-9	-18.23	0.48	40-45
	BH1-10	-18.26	0.56	45-50
	BH1-11	-18.23	0.52	50-55
	Average	-19.08	0.61	

Note: Average for the control column excludes the top sample.

Assuming for the sake of discussion that the control column represents natural pedogenesis and has not been significantly altered by anthrogenic activity, then the comparison of the three profiles for which we have determined the carbon content and stable carbon isotopic composition of soil organic matter show a progression of increasingly altered profiles.

9.5.1.1.3 *The Control Column*

The plot of organic carbon versus depth for the control column indicates that there has been a very modest increase in organic carbon in the A-horizon (around 0.16 percent) compared to the parent material. The C-13 content of the Bw horizon is about 1 per mil heavier than the organic matter forming the A-horizon, which indicates that the organic matter that formed the A-horizon contained about 10 percent more material from C_3 plants than the cambic horizon at depth. At the base of the cambic horizon about 64 percent of the soil organic matter appears to have been derived from C_4 plants. The uppermost sample in the control column (derived from Unit 3) is significantly more C_3 enriched, yielding a value of -21.99‰ which indicates that about 64 percent of this organic matter derived from C_3 plants, and this most likely reflects the contribution of organic carbon from the mesquite coppice dunes.

9.5.1.1.4 *Core 6*

Core 6 was located on the north side of the central part of the site, near TRC Trench 2, in a position that is intermediate between Trench 1 and the control profile. The organic enrichment of the A-horizon in Core 6 appears to be between 0.8 percent and 0.9 percent over the base of the profile, which is about 5 times more than the A-horizon in the control column. The plot of $\delta^{13}C$ by depth shows that the base of the A-horizon and the top contained more C_3 derived carbon than the base of the profile or the middle of the A-horizon. The average value of the carbon isotopes in this profile is almost identical to the profile from Trench 1, but contains significantly less organic carbon (Figure 9.5).

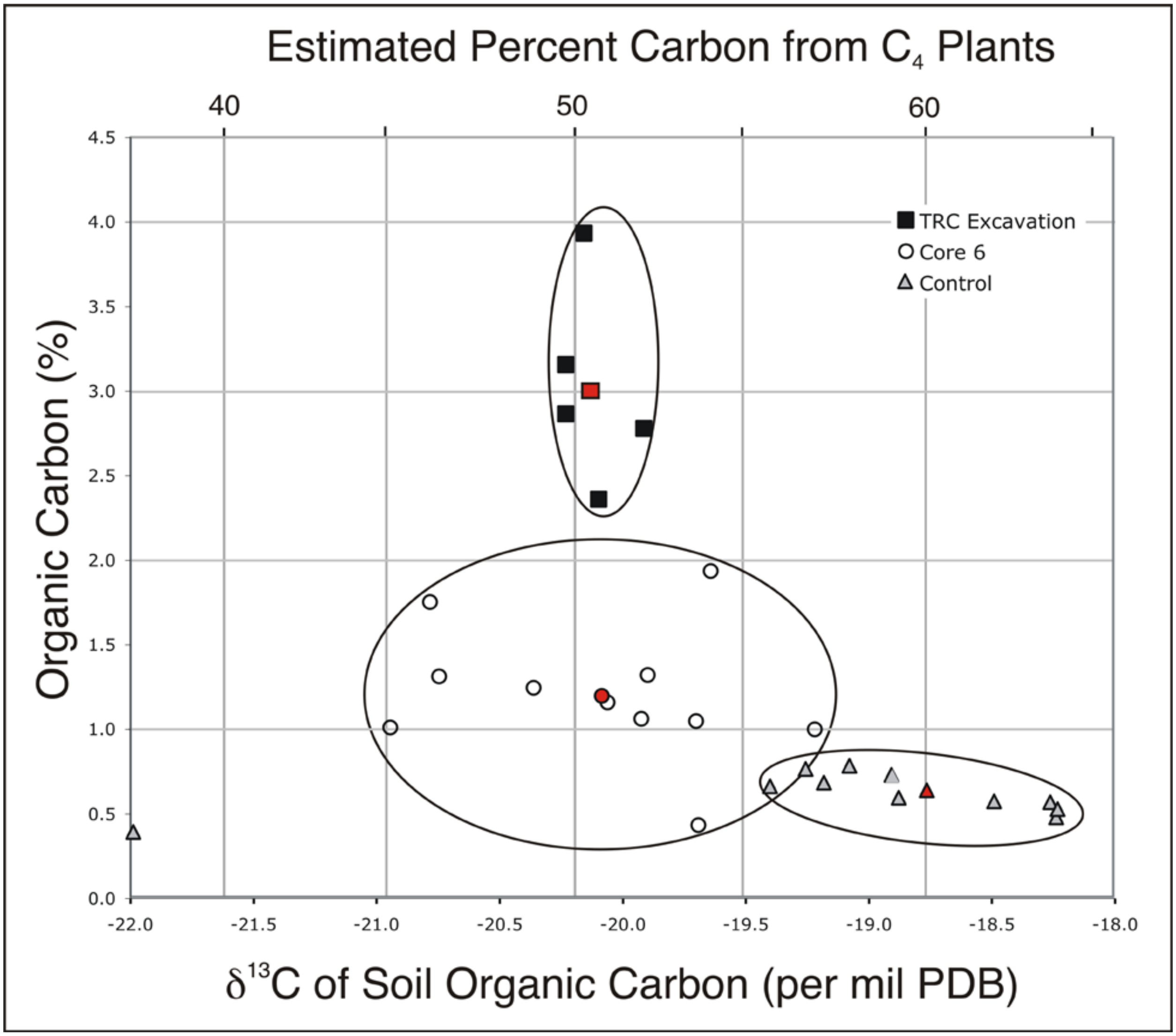

Figure 9.5 Plot of the percent soil organic carbon versus the stable isotopic composition of the soil organic carbon for samples collected from the center of the site (labeled TRC Excavation), Core 6 (on the north side of the hill crest near Trench 2) and the control column (collected from the next hill crest to the north).

Red data markers denote group averages and the ellipses denote the range of values for prehistoric organic carbon. One sample was excluded from the ellipse and average for the control column

9.5.1.1.5 *Trench 1*

The results of the carbon analysis for the five samples from Trench 1 indicate that the organic carbon content is nearly uniform with depth, in both concentration and carbon isotopic composition. The average carbon content of the Trench 1 samples (3.02 percent) represents a 2.5 percent increase over the parent material (0.52 percent average for the three lowest samples in the control column), and is approximately 15.6 times the organic carbon enrichment observed in the A horizon formed in the control column. Hence the very dark color of the anthropic A-horizon is due to a significant increase in organic carbon compared to natural, non-anthrogenic A-horizons. The shift in stable carbon isotopic composition between the control and the two profiles in the core of the site indicates the anthrogenic carbon was derived from 49–50 percent C_3 sources, which is about 10 percent more than the base of the control profile. This suggests that a wood source, such as fuel wood, may account for a significant amount of the difference between the control profile and the site anthrosol.

9.5.1.1.6 *Mescalero Caliche*

The Mescalero Caliche comprised the base of all of the exposures examined by coring/shovel testing. Most exposures only revealed the very top of this deposit, and in many places this unit has been disturbed by pedoturbation. In general terms, the Mescalero Caliche exhibits a Stage III to Stage IV calcic horizon morphology, and ranged in color from white (10YR 8/1) to pink (7.5YR 7/3), and exhibited laminar to brecciated structure.

9.5.2 Reconnaissance of Arroyo Cutbanks

In addition to work on the hill, limited observations were made from the landscape surrounding the hill, most notably from the stream that lies east and south of the site. Samples were collected from three localities adjacent to the stream to test for the potential to yield paleoenvironmental information.

9.5.2.1 Locality 1: [redacted]

The first locality is situated adjacent to the modern stream channel at the eastern limits of the Loci defined by Condon (2002) that includes the original Boot Hill excavation (Figure 9.6**)**. At this locality the stream exposes a 1.5 m cut bank revealing two late Holocene alluvial deposits (Figure 9.7). For the following discussion, the lower alluvial unit is hereafter referred to as the Late Holocene Alluvium, and the deposit overlying it is termed the Recent Alluvium. The older of the two deposits, Late Holocene Alluvium, comprises the majority of the exposure and appears to be approximately 1.3 m of alluvium that is contemporaneous with at least some of the occupations on the hilltop to the west.

[redacted]

[redacted] [redacted]

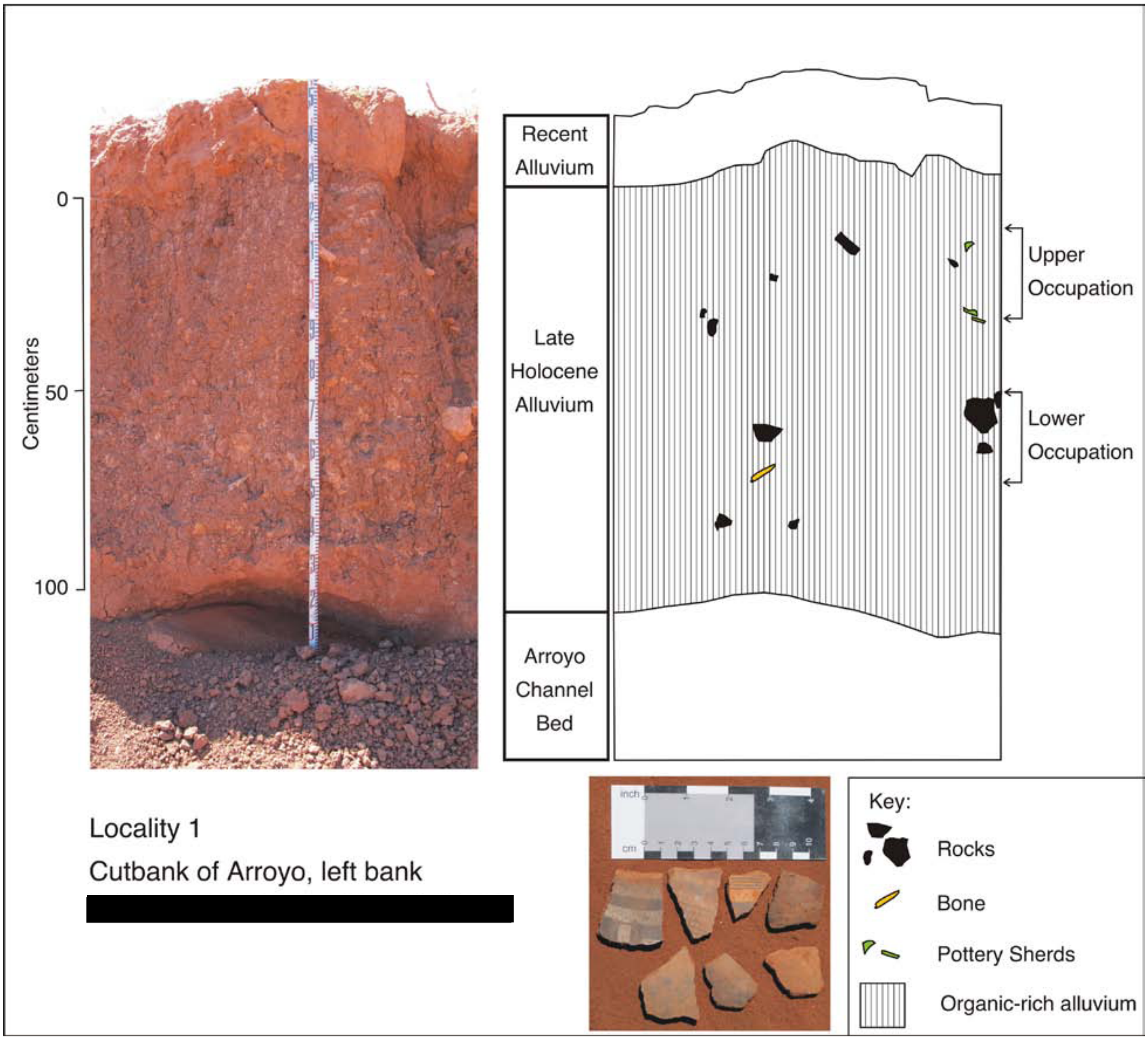

Figure 9.7 Photograph of the cutbank exposed at Locality 1

Right Panel: Line drawing made from the photograph showing the alluvial deposits exposed in the cutbank and the stratigraphic position of cultural material observed. Lower Photo: Example of sherds collected from the upper occupation a few meters south of the cutbank where the top of the Late Holocene Alluvium is beveled by erosion.

The Late Holocene Alluvium consists of a fine-grained organic rich alluvial deposit that in several places contains many aquatic mollusks, primarily snails. Two bulk soil samples were collected from this exposure for documentation of the snail fauna, but these were not analyzed at the time this report was written. A single diatom sample was collected from this exposure at the same depth as a bulk sediment radiocarbon sample (1.2 m below surface), and the diatom sample yielded a sparse diatom flora (Winsborough, Appendix C) indicative of an ephemeral wetland surface that was occasionally damp but not submerged for long periods. The presence of rams horn aquatic snails indicates that this surface ponded water long enough for a mature snail fauna to develop and that these conditions occurred several times throughout the period of deposition of this alluvial unit. In addition to examining the diatoms, Winsborough also noted the presence of pollen, phytoliths and crysophyte cysts, which when considered in light of the snails, suggests that this deposit may have the potential of yielding a reasonable paleoenvironmental record.

The age of this deposit is indicated by two lines of evidence, one of which is conflicted. A bulk sediment radiocarbon sample was collected from 1.2 m below surface within this deposit but the resulting age indicates that somehow the label for this sample and the sample from Locality 3 were switched. The age returned for this deposit from the University of Georgia Center for Applied Isotope Studies was 8,800±30 years B.P. (UGAMS-7611), but this is clearly wrong, but just slightly younger than the age that was anticipated from Locality 3, that was collected adjacent to a proboscidean tusk. The age returned for the tusk was 2,030±25 years B.P. (UGAMS-7610) and this is in the range that the sample from Locality 1 was anticipated to yield. It is unclear where the labeling error occurred but the remainder of this report will assign the ages as anticipated rather than as reported by the University of Georgia. Hence, the age for the lower part of the deposit exposed at Locality 1 is 2030±25 years B.P.

The other age evidence from this deposit consists of two, stratified and buried prehistoric occupations present within the late Holocene alluvium. The deepest of these was around 80–100 cm below the surface and consisted of burned rock, flakes and bone, some of which appeared to be large enough to be bison. No temporally diagnostic material was observed from this occupation but given the relative stratigraphic position this occupation is anticipated to date to slightly younger than 2,000 years B.P. A second prehistoric occupation was observed near the top of the Late Holocene alluvium. This occupation contained lithic debitage, burned rock and ceramics (Figure 9.8 for an example of the ceramics found within this occupation). This occupation in the examined section lies 20–40 cm below the surface.

Overall, the impression formed in the field is that the Late Holocene alluvium is likely to be correlative to Unit D recently described by Quigg et al. 2010 on West Amarillo Creek, in Potter County, Texas, which was deposited between roughly 2000 and 1000 years B.P.

The Recent alluvium rests unconformably upon the Late Holocene alluvium, and in this section is only 20 cm thick, but elsewhere in the valley more than 1 m of this deposit is present. No archaeology was observed in the recent alluvium.

9.5.2.2 Locality 2: [redacted]

At Locality 2, the left cutbank of the stream exposes about 2 m of alluvium, within which there appears to be a distinctive light colored deposit that in the field was thought to be a marl. Marls are a common component of the alluvial deposits on the draws of the Southern High Plains (cf. Holliday 1995) and are often indicative of early Holocene sediments. A bulk sediment radiocarbon sample was collected from about 60 cm below the surface from a cutbank exposure where the marl appeared to be overlain by recent alluvium, and radiocarbon dating of this sample yielded an age of 1250±25 years B.P. (UGAMS-7609; see Figure 9.8, upper photo). This is younger than anticipated because the marl appears to be beneath the Late Holocene alluvium (see Figure 9.8, lower photo). Further work may clarify the age of this deposit.

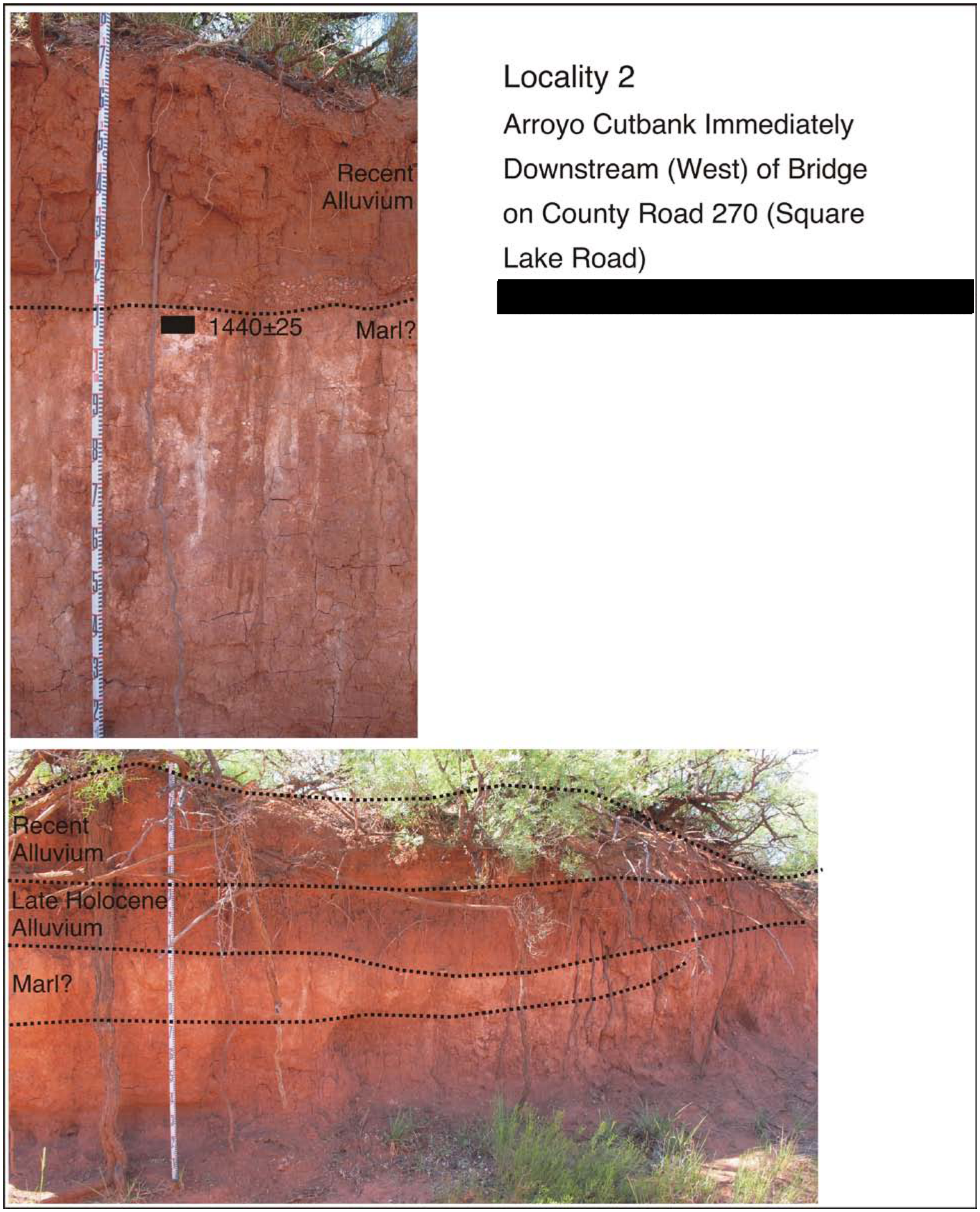

Figure 9.8 Photographs of the stratigraphy exposed at Locality 2

Upper Photo: Photograph of the exposure from which a bulk sediment radiocarbon sample was collected from a deposit that appears to be a marl. *Lower Photo*: Photograph of another cutbank nearby that shows the marl located beneath both the recent alluvium and the Late Holocene alluvium.

A sample of this deposit was submitted for diatom analysis but Winsborough (Appendix C) reports that no diatoms were present.

9.5.2.3 Locality 3: [redacted]

At Locality 3 a small fragment of a proboscidean tusk was observed eroding out from a pale green mud near the base of a 2 m tall cutbank (Figure 9.9). About 40 cm of the tusk was exposed and had been planed off by erosion on the streambed. A bulk sediment sample was collected from the green sediment just above the tusk and this yielded a radiocarbon age of 8800±30 years B.P. (UGAMS-7611). The gleyed color of this deposit implies a reduced and saturated edaphic environment and may be a wetland deposit, although a diatom sample collected from this sediment yielded no diatoms and no mollusks or other macrofossils indicative of wet conditions were observed.

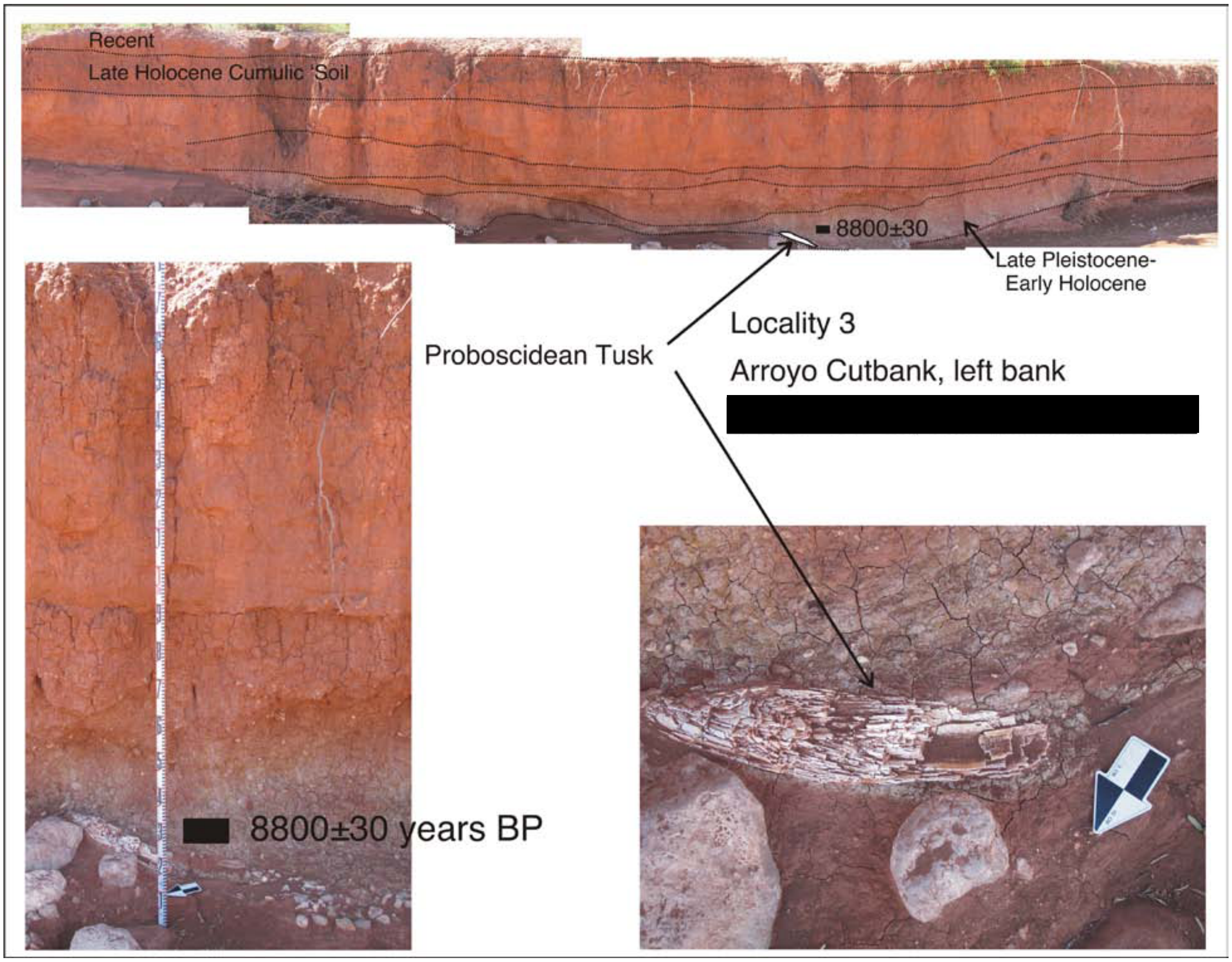

Figure 9.9 Photographs of the stratigraphic relationships observed at Locality 3

Upper photo: Photo mosaic of the cutbank from which the proboscidean tusk was observed eroding out. Deposits described previously are shown at the top of the profile. *Lower left*: Close up view of the profile above the proboscidean tusk, which is visible in the bottom left of the photo. The black box denotes the stratigraphic position of the bulk sediment radiocarbon sample collected from this exposure. *Lower right*: Close up view of the proboscidean tusk.

The cutbank also exposed about six physically distinct alluvial deposits, which probably span much if not most of the Holocene.

9.5.3 Summary of Alluvial Stratigraphy

The brief reconnaissance of the alluvial lowland adjacent to the site suggests that multiple different age alluvial deposits are present in this valley, and that these deposits hold a potential to harbor *in situ* prehistoric occupations. Only one of the deposits is known to harbor prehistoric occupations at this time (the Late Holocene Alluvium) but all of the Holocene deposits have this potential. The preceding discussion is illustrative rather than exhaustive because the time available for the geoarchaeological work on the Boot Hill site was insufficient to sort out the sequence of Late Quaternary alluvial deposits. However, doing so would provide one means of understanding late Quaternary environmental changes in this landscape. If a backhoe excavations were used to augment natural exposures, it is likely that a relatively complete sequence of late Pleistocene and Holocene alluvial deposits may be reconstructed. Of the deposits examined, the Late Holocene alluvium possesses a clear potential for reconstructing paleoenvironmental change in the valley that may be contemporaneous with the site occupation, and this should be pursued if more information on this subject is desired.

9.6 Discussion

The results of the geoarchaeological investigations have provided information on the stratigraphy of the site and its local environment, some details on the nature of the anthrosol at the site and its origin, and limited information on the integrity of the site, and where potential sources of paleoenvironmental information may be found.

The upland portion of the site is primarily situated within Hall’s (2002a) Unit 2, and this deposit has witnessed extensive human alteration. The deposits present in the core of the site near Trench 1 have been extensively altered by human activity and are quite correctly classified as anthrosols. The documentation of the organic matter distribution in the cores indicates that although there is some variation in the depth distribution of organic carbon, in most profiles the organic enrichment is present throughout the entire solum (all of Unit 2) and this can only happen with extensive mixing of the deposit, either as part of the prehistoric land use, post-depositional disturbance, or a combination of these processes. The organic enrichment of <400 year old Unit 3 deposits in the core of the site suggests that post-depositional bioturbation would be one of the major factors in this process, and that with more time, the Unit 3 deposits would eventually be incorporated into the anthrosol by non-human agency.

Given the apparent extent of disturbance of the Unit 2 deposit, the prospect of *in situ* occupational deposits for any but the most recent prehistoric occupations would seem to be poor, and the best preservation potential would be for negative relief features such as pits and burials and pit houses, if present.

If one steps back from the hill and examined the broader archaeological presentation on the landscape, the alluvial lowland appears to contain at east one alluvial deposit that is contemporaneous with occupation of the hill, and may preserve prehistoric occupations in primary context. Although the spatial extent of these deposits is limited and poorly defined at this time, it is likely that a more useful archaeological record may be preserved here than on the hill. The presence of proboscidean remains in a distinctive deposit in the arroyo floor suggests that a potential for much older archaeological remains is present in the valley.

9.6.1 Thoughts on future research

The nature of the anthrogenic soil at the Boot Hill Site, a true *dark earth*, is curious in this landscape. The behavioral and natural processes responsible for its formation and the spatial implications of this deposit merit further investigation. The work here demonstrated the magnitude of the organic carbon enrichment, but barely scratched the surface of understanding this deposit, either as an oddity in this edaphic landscape (in isolation, if you will) or from a more comprehensive perspective that places the formation of this deposit, and others like it, into a broader behavioral context.

Middens are not uncommon in archaeological sites, but middens of this nature are indeed unusual (this midden is readily observed on aerial images and stands as a prominent feature on the landscape). The closest features to this I am familiar with are the burned rock or ring middens in central and west Texas, southern New Mexico and northern Mexico, but these features, however, exhibit extensive quantities of burned rock, and although still widely debated, are clearly earth ovens in some cases. The anthrogenic soil on the Boot Hill site differs in a number of ways. First, it lacks significant quantities of burned rock. This is not to say that burned rock is absent, as it is clearly present, but it is a minor component compared to burned rock middens. Second, it is aerially extensive, more so than most burned rock middens. Although there are numerous ways of dissecting a deposit such as this, the development of international interest in carbon-rich anthrosols has provided some very interesting and applicable interdisciplinary research in recent years.

Academic interest in Amazonian Dark Earths (or ADEs) or *terra pretas* over the last 20 years (e.g. Lehman et al. 2003a; Woods et al 2009; Glaser 2006; Woods 2000) has led to the development of an active and rapidly growing group of researchers interested in processes referred to in the collective as "biochar." Biochar is defined as "*a 2,000 year-old practice that converts agricultural waste into a soil enhancer that can hold carbon, boost food security and discourage deforestation. The process creates a fine-grained, highly porous charcoal that helps soils retain nutrients and water*" (International Biochar Initiative 2011). International interest in biochar has grown exponentially as awareness of its potential as a means of carbon sequestration has increased.

Although this specific interest is tangential to ours, the fluorescence of research on soil carbon dynamics (e.g. Major et al. 2010) and processes as they may relate to prehistoric deposits such as the anthrosol at the Boot Hill site provides a body of data that may be successfully tapped to understand this enigmatic deposit. For instance examination of the soil *in situ* via soil micromorphology (e.g. Ruvio et al 2008; Arroyo-Kalin 2008) may provide some useful information on the character of the deposit and its organic constituents. Likewise, detailed characterization of the organic constituents (macro as well as chemical by-products, and associated elements such as phosphorus) as compared to natural soils formed on Aeolian Unit 2, may draw a sharp focus on what materials were added to the soil (e.g. Jarbas Ferreira Cunha et al 2009; Lehman et al 2004; Major et al. 2010; Worslley de Souza 2009).

Although the initial geoarchaeological impression of this deposit is that it is heavily mixed, this can also be tested through the application of various analytical techniques that determine at the age structure of either the deposit, the minerals themselves, or the organic matter within the deposit. AMS radiocarbon ages obtained from pieces of charcoal collected from different depths within the deposit as well as single grain OSL dates collected at discrete depths would both provide an image the mobility of fine particulate material within the solum that would inform on the stratigraphic integrity of the deposit. Juxtaposing such data with the age of the bulk organic matter in the soil at different depths would also provide a contrasting view of the movement of more soluble organic matter phases. Comparing all of this information with the depth distribution of temporally diagnostic cultural material recovered from traditional excavation methods would provide a yet more nuanced view. These are but a few ways in which additional analysis of the Boot Hill anthrosol may reveal the processes and materials that created this unique deposit.

10.0 LITHIC ANALYSIS

This chapter presents the analysis of the lithic artifacts recovered by TRC during testing at LA 32229. The chapter is organized by Trench Units, concluding with a discussion of spatial patterns discerned within and between the excavated areas. Given the amount of bioturbation and historic disturbances, artifacts were not separated by excavation level. A total of 4,520 lithic artifacts was analyzed. This included debitage (n=4,432), ground stone (n=35), cores (n=19), projectile points (n=17), bifaces (n=11), and hammerstones (n=6).

The analytical methods employed rely primarily on the measurement of attributes rather than the classification of types. Although no single lithic attribute can accurately identify or characterize a lithic assemblage with regard to technology or technique, a cumulative data set is presented that builds upon individual attribute categories (Carr and Bradbury 2001:134). The benefit of this approach is that a database of attribute measurements can be filtered by different technological or typological criteria at any time and by any researcher. This is in contrast to a typological analysis where an artifact is first identified based on a presumed function or technology (Andrefsky 2001:9). The comprehensive examination of lithic attributes allows for the interpretation of reduction strategies and trajectories based on definable characteristics. This analysis strategy involves overlapping data sets, which allow for the identification and evaluation of re-occurring patterns related to technology and technique, and when viewed in a broad interpretive sense, are critical to establishing parameters for understanding the organization of technology (Andrefsky 1998:63; Tomka 1989:137).

10.1 Methods of Lithic Analysis

Variability in nomenclature exists in the field of lithic analysis, and more than one set of analytic methods exists for examining lithic artifacts (Andrefsky 1998:62; Kooyman 2002:46). Ambiguity can be minimized, however, through the establishment of a standardized set of techniques and definitions that facilitate the analysis (Andrefsky 1998:85). Standardization allows for analytical replication and consistency in interpretation. The nomenclature adopted for this project draws heavily from the works of Andrefsky (1998) and Crabtree (1982). Measurements were recorded using Mitutoyo Digital Calipers accurate to 0.01 mm. Weight was recorded to the nearest tenth of a gram using an Ohaus electronic scale. Although the Boot Hill fieldwork (July 2010) occurred after the Permian Basin Mitigation Program Archaeological Data Comparability Workshop held in May, the field recording of artifacts and initial laboratory analysis of recovered artifacts preceded distribution of the workshop results (Railey 2010a). However, the attributes incorporated into the final workshop coding spreadsheets and guidelines were used for the Boot Hill analysis and can be converted into the workshop format.

10.1.1 Lithic Debitage

Lithic debitage refers to all pieces of stone that are the byproducts of flaked-stone tool manufacture or maintenance (Andrefsky 1998; Crabtree 1972; Odell 2004). The classification system selected for this analysis is based on flake morphology, and includes nine categories that establish the baseline for the subsequent analyses. These include: 1) complete flakes, 2) proximal-flake fragments, 3) lateral flake fragments, 4) medial/distal flake fragments, 5) morphologically indeterminate flake fragments, 6) micro-flakes, 7) angular debris, 8) micro-angular-debris, and 9) modified flakes and flake fragments.

Complete flakes are defined as flakes that retain a platform remnant, dorsal and ventral surfaces, and an identifiable termination and lateral margins. The flake may not necessarily be 100 percent complete, as long as all attributes defined in the methodology can be accurately measured. Further, bulbs of force and eraillure scars are not always pronounced on flakes, especially within assemblages composed of poor quality raw materials, and should not be considered a necessary attribute for defining a flake. Proximal flake fragments have all the attributes of complete flakes except for an identifiable termination. In this analysis, all flakes with step terminations were classified as proximal fragments.

Limited attribute flake fragments include lateral, medial/distal, and indeterminate flake fragments. The minimum requirement for placement in these categories is the identification of dorsal and ventral flakes surfaces. Lateral fragments also have identifiable terminations and platforms, but have been split laterally. Angular debris include pieces of debitage that could not be placed within a flake category. Micro-flakes measure less than 10.0 mm in maximum dimension, and included all flake morphologies listed previously, but from very small flakes, mostly produced during retouching and platform trimming. Similarly, micro-angular-debris is defined as pieces less than 10.0 mm in maximum dimension that could not be confidently placed within any other category. These last two classes were created as a result of the large volume of small flakes and angular debris within the assemblage.

Dorsal surface attributes recorded within the assemblage include scar counts and percentage of cortex. Only scars greater than one quarter the length of the flake were counted to avoid recording scars not related to primary flake removals prior to flake detachment (Andrefsky 1998:106; Crabtree 1972:14). In general, the number of dorsal flake scars increase, and the percentage of dorsal cortex decreases, as the reduction sequence progresses (Mauldin and Amick 1989:73; Tomka 1989:143). Cortex was placed into one of four categories: 1) none, 2) less than 50 percent, 3) greater than 50 percent, and 4) 100 percent. Cortical cover on angular debris was measured as a percentage of the entire piece. Cortical cover was also recorded on all other debitage classes except those measuring less than 10.0 mm.

Ventral surface attributes that were monitored included presence/absence of an eraillure flake, bulbar definition, and the presence/absence of platform-remnant lipping. The presence/absence or prominence of these attributes on the ventral surface of a flake may provide information on the amount of applied force or application load, striking angle, and physical characteristics of the percussor used during flake initiation (Andrefsky 1998). Light or moderate force may leave a minimal eraillure flake scar or no scar at all. A large scar may indicate a high degree of applied force. These observations can be relevant to the interpretation of reduction technique, with hard-hammer percussion generally equated with intense force when applied to flake dynamics. Energy from a softer hammer, such as an antler billet swung with equal force as a hard hammer, may be absorbed and then dispersed, leaving a small eraillure flake, or perhaps none at all (Crabtree 1972:9, 74; Hayden and Hutchings 1989:241).

Bulbar definition was monitored to evaluate the application load concept. Hard hammer percussion tends to result in pronounced bulbs of force. Due to the displacement of force, soft hammer percussion often produces a diffuse bulb of force. Two subjective categories were created to evaluate this attribute: 1) salient, and 2), diffuse. Platform lipping, which occurs at the juncture between the platform remnant and the ventral surface, is generally associated with bifacial reduction or pressure flaking, although some studies have found no such relationship (Patterson and Sollberger 1978). During previous analyses, platform lipping was found difficult to categorize, and was consequently recorded as present or absent. Lipping was recorded as present if it could be felt while running a finger across the juncture between the platform remnant and ventral surface of the flake.

Metric attributes measured on platform remnants include maximum thickness and width, which relate to core size and reduction techniques (Andrefsky 1998:92; Kooyman 2002:79). The platform remnant is the segment of the flake or flake fragment that retains a portion of the surface or original platform of the objective piece. This attribute allows examining platform preparation on the objective piece, or core. Additionally, platform remnant analysis provides a method for investigating raw materials selection, reduction strategies, and possibly the energy expended in tool manufacture.

Non-metric platform remnant categories selected for this analysis include: 1) cortical, 2) battered/abraded, 3), collapsed 4) crushed, 5) unifaceted, and 6) multifaceted, and 7) curved (Andrefsky 1998:94). Cortical platform remnants retain a portion of the outer cortex of the parent material. Unifaceted platforms exhibit a smooth, non-cortical flat surface. A multifaceted platform remnant contains portions of multiple truncated flake scars across its surface. An abraded/battered platform remnant is similar to a multifaceted platform remnant, but is characterized by battering or abrasion. Also recorded was the presence or absence of platform preparation along the juncture between the remnant surface and dorsal flake surface. These were categorized as either trimming or abrading. Trimming is defined as small, patterned flake removals intended to refine the platform shape. Abrading allows for platform preparation by removing any overhangs, and tends to result in small, stepped flakes scars and abrasion. Removal of the overhang strengthens a platform, preventing collapse during flake removal. A collapsed/crushed platform remnant commonly results from insufficient preparation, resulting in the crushing or shearing of the platform rather than successful flake detachment.

Metric attributes including maximum dimension, length, width, midpoint thickness, maximum thickness, and weight were recorded on all complete flakes. With the exception of midpoint thickness and length, the same attributes were measured on proximal flake fragments. Lateral fragments were measured for all attributes except width. Maximum dimension and weight were recorded for all other classes of debitage.

The length of complete flakes was measured along the proximal–distal axis on the ventral surface of the flake. A measurement was taken from the point of force application to the extreme opposite end. Width was measured along the widest point perpendicular to the length axis. Midpoint thickness was measured from dorsal surface to ventral surface, halfway down the length of the flake, and maximum thickness was measured at the thickest point. Platform remnant width was measured from right margin to left margin, perpendicular to the axis measured for flake length. Platform remnant thickness measured the maximum dimensions perpendicular to the platform remnant width, from dorsal surface to ventral surface.

Modification on debitage was recorded by face and margin, and classified as retouch, use-wear, or both. Modified edges were further characterized by four shapes: 1) straight, 2) convex, 3), concave, and 4) irregular. Edge angles were measured with a goniometer. Although precise measurements of edge angles are difficult to replicate between researchers, they can be used to differentiate between very basic uses. More acute an edge angle are best suited for cutting tasks while edge angles of 75 to 90 degrees imply a scraping function (Andrefsky 1998:154).

10.1.2 Cores and Hammerstones

Cores are defined as nuclei, or objective pieces, from which flakes of varying sizes have been detached (Andrefsky 1998; Crabtree 1972). However, cores used solely as sources of raw material for flake production, or as objective pieces for biface production, are often difficult to differentiate from those intended for use as tools themselves. In this analysis, lithic artifacts were classified as cores if they exhibited more than one conjoining flake scar. Cores were subdivided into six categories: 1) unidirectional, 2) multidirectional, 3) bifacial, 4) core tool, 5) bipolar, and 6) tested cobble. Unidirectional cores exhibit flake scars originating from a single platform in a single direction. Multidirectional cores exhibit flake scars in more than one direction, and from more than one platform. Bifacial cores exhibit flakes scars from opposing platforms that share a single margin. Core tools include any form of core that shows signs of use other than as an objective piece for flake detachment. Bipolar cores exhibit battering and/or flake scars from opposing directions where the piece rested on an anvil. Tested cobbles are nodules of raw materials with one or two flake scars.

Metric attributes recorded on cores include maximum length, width, thickness and weight. All dimensions were measured at 90 degree angles from the axis measured for maximum dimension. Non-metric attributes include platform counts, scar counts, and percentage of cortical cover.

The minimum requirement for hammerstones is the presence of one location of use-wear. However, the term "hammerstone," is a functionally biased reference that may be misleading with regard to technology. Traditionally, hammerstones have been defined as percussors used to detach flakes from cores (Crabtree 1972:11). While this interpretation may be accurate in many cases, hammerstones may also be used to pulp or mash softer resources as well. Metric attributes recorded on hammerstones were the same as those for cores. The number of use locations was also counted.

10.1.3 Bifaces and Projectile Points

Bifaces are defined as objective pieces with two flaked faces that meet to form a single continuous edge (Andrefsky 1998:172). Any particular biface may have served multiple functions, including use as a tool itself, or as a preform for further refinement (Odell 1980). Metric attributes measured on bifaces included length, width, thickness, and weight, with the measurements oriented with the longitudinal axis from the proximal to distal end. Percentage of cortical cover was also recorded.

Bifaces with hafting elements, or diagnostic stylistic attributes, were classified typologically as projectile points, drills, etc. and placed within a regional typology (Justice 2002; Turner and Hester 1993). Metric attributes measured on diagnostic bifaces were the same as those measured on nondiagnostic bifaces, with the addition of blade length, shoulder to corner length, base width, and neck width. Non-metric attributes included base shape, notching location/hafting style, and blade shape. Wear indicating use as something other than as a projectile point was also recorded (Ahler 1971).

10.1.4 Ground Stone

Artifacts identified as grinding implements were classified as: 1) manos, 2) metates, and 3) indeterminate fragments. The sample of ground stone was very small, and other ground stone implements (e.g., pestles, mortars, etc.) were not present. Metates and grinding slabs are usually associated with processing organic materials, but were likely used for multiple materials that required grinding. In either case, use-wear on metates is caused by working the surface with another implement. Slab metates are identified by use-wear patterns on a flat surface. Basin metates are usually defined by a hollowed out surface created from a circular grinding motion. Manos are hand implements used on a typically stationary metate, with use-wear created from working the surface against the metate. Manos can be further characterized as one-handed or two-handed tools, or as pestles, and may have multiple worked surfaces. Metric attributes measured on ground stone artifacts included maximum length, width, thickness and weight. Complete tools were oriented by their use-wear surfaces. Non-metric attributes included the number and shape of ground surfaces.

10.2 Trench 1

A total of 3,003 lithic artifacts was recovered from Trench 1 (Table 10.1). Raw materials included chalcedony, chert, igneous, limestone, orthoquartzite, quartzite, rhyolite, siltstone, and silicified wood.

Table 10.1 Lithic assemblage from Trench 1

Lithic Category										Count	Percentage
Debitage										2,948	98.16
Ground Stone										21	.69
Projectile Points										11	.36
Bifaces										10	.33
Cores										10	.33
Hammerstones										3	.03
Total										**3,003**	**100 percent**

10.2.1 Lithic Debitage

The lithic debitage was sorted into nine categories for analysis (Table 10.2).

Table 10.2 Lithic debitage categories, Trench 1

Debitage Category	Count	Percentage
Complete flakes	668	22.65
Micro-flakes	647	21.94
Angular debris	611	20.72
Indeterminate flake fragments	415	14.07
Proximal flake fragments	204	6.91
Distal/medial flake fragments	179	6.07
Micro-angular-debris	151	5.12
Lateral flake fragments	53	1.79
Modified flakes and flake fragments	20	0.67
Total	**2,948**	**100 percent**

10.2.1.1 Complete Flakes and Proximal Flake Fragments

Tables 10.3 and 10.4 list the non-metric attributes recorded for complete flakes and proximal flake fragments. Of the 668 complete flakes, 67.51 percent (n=451) have no dorsal cortex and were classified as tertiary. Secondary flakes, with less than 50 percent dorsal cortex, comprise 16.91 percent (n=113) of the assemblage. Flakes with greater than 50 percent and less than 100 percent cortex (n=54), and those with complete cortical cover (n=50), were classified as primary flakes, and comprise the remaining 15.56 percent of the assemblage. Collectively, 32.48 percent (n=217) of the flake assemblage exhibited some dorsal cortex, suggesting a complete reduction trajectory at this site locus. These findings reflect a tentative interpretation due to the limited number of cortex-bearing flakes in comparison to the greater number of flakes without cortex that may be produced during core reduction. However, the greater frequency of flakes with no dorsal cortex suggests that a complete reduction sequence is represented, with an emphasis on late-stage lithic production. Dorsal flake scar counts mirror the proportions of dorsal cortex, with the majority of flakes exhibiting one or two scars. However, a significant number have three or four scars, suggesting late-stage lithic reduction. The raw materials types and counts for each one are presented in Table 10.5.

Platform remnants were measured on 872 complete flakes and proximal flake fragments with complete platforms (Table 10.6). Analysis of all 872 flakes and proximal flake fragments focused on remnant type, which consisted of seven classes: 1) cortical, 2) unifaceted, 3) abraded/battered, 4) collapsed, 5) crushed, 6) multifaceted, and 7 curved. Cortical platforms, reflecting very early reduction sequences, comprised 10.66 percent (n=93) of the assemblage. Unifaceted platforms, which can reflect any stage of reduction, comprised

52.63 percent (n=459) of the assemblage. Collapsed/crushed platform types included 18.57 percent (n=162) of the assemblage, and indicate minimal core preparation prior to flake removal. Multifaceted platform remnants reflect advanced reduction sequences, and in combination with other flake attributes, can be associated with biface technology. Of the 872 specimens analyzed, 11.23 percent (n=98) exhibits multiple facets. Curved platform remnants are associated with soft hammer percussion, and account for 2.4 percent (n=21) of the assemblage.

Table 10.3 Trench 1 summary counts for complete flakes

Trench 1 (n=668)		Count
Termination	Axial	25
	Feather	482
	Hinge	161
Lipping	Absent	369
	Present	299
Bulb	Diffuse	562
	Salient	106
Eraillure	Absent	564
	Present	104
Platform	Abraded	32
	Collapsed	106
	Cortical	71
	Crushed	29
	Curved	19
	Multifaceted	67
	Unifaceted	344
Prep.	Abraded	69
	Battered	6
	Trimmed	77
Cortex	0 percent	451
	0-49 percent	113
	50-99 percent	54
	100 percent	50
Scars	0	55
	1-2	495
	3-4	117
	5-6	1

Table 10.4 Trench 1 summary counts for proximal flake fragments

Trench 1 (n=204)		Total
Platform	Abraded	7
	Collapsed	16
	Cortical	22
	Crushed	11
	Curved	2
	Multifaceted	31
	Unifaceted	115
Lipping	Absent	128
	Present	76
Bulb	Diffuse	167
	Salient	37
Eraillure	Absent	157
	Present	47
Prep.	Abraded	28
	Battered	1
	Trimmed	29
Cortex	0 percent	162
	0-49 percent	23
	50-99 percent	9
	100 percent	10
Scars	0	12
	1-2	165
	3-4	27
	5-6	0

Table 10.5 Raw material counts for complete and proximal flake fragments, Trench 1

Complete Flakes		Proximal Flake Fragments	
Material	**N=668**	**Material**	**N=204**
Chalcedony	238	Chalcedony	63
Chert	285	Chert	100
Igneous	7	Igneous	1
Limestone	45	Limestone	7
Orthoquartzite	9	Obsidian	1
Quartzite	75	Orthoquartzite	3

Complete Flakes		Proximal Flake Fragments	
Material	**N=668**	**Material**	**N=204**
Rhyolite	5	Quartzite	28
Siltstone	4	Siltstone	1

Table 10.6 Flake platforms, Trench 1

Trench 1	Platform Thickness	Platform Width	Max. Dimension	Max. Length	Max. Width	Mid. Thickness	Max. Thickness	Weight (g)
Complete Flakes								
Mean	3.61	9.35	18.99	15.5	15.86	4.15	4.71	1.65
StD	2.38	5.74	7.79	7.21	7.84	2.56	2.82	
Proximal Flake Fragments								
Mean	3.70	9.90						
StD	2.64	6.64						

The presence or absence of eraillure flakes and platform lipping was monitored by combining the complete flake and proximal flake fragment assemblages (n=872). Platform lipping, which occurs at the juncture of the platform remnant and ventral surface, is tentatively associated with soft hammer percussion or pressure flaking. Platform lipping was identified on 43 percent (n=375) of the analyzed assemblage, suggesting the use of soft hammer percussion may have been common. Of the 872 specimens analyzed, only 17.31 percent (n=151) exhibited eraillure flake scars. This supports the patterns seen in platform lipping, which points toward soft hammer rather than hard hammer percussion. While the absence of an eraillure flake does not by itself suggest the use of soft hammer percussion, or a biface-manufacturing trajectory, it does indicate a variety of reduction techniques may have been employed.

Bulbar definition was also monitored to evaluate the application load concept. Two subjective categories were created to evaluate this lithic attribute: 1) diffuse, and 2), salient. Diffuse bulbs comprised 83.6 percent (n=729) of the assemblage. Strong or salient bulbs of force were recorded in only 1.39 percent (n=143) of the assemblage. These data indicate low to moderate application loads, suggesting flake initiation and detachment did not require high amounts of energy. This strengthens the argument for a frequent occurrence of soft hammer percussion.

10.2.1.2 Limited Attribute Debitage

The remaining unmodified lithic debitage included micro-flakes (21.94 percent/n=647), angular debris (20.72 percent/n=611), indeterminate flake fragments (14.07 percent/n=415), distal/medial flake fragments (6.07 percent/n=179), micro-angular-debris (5.12 percent/n=151), and lateral flake fragments (1.79 percent/n=53). Data for lateral flake fragments are listed in Tables 10.7 and 10.8. In general, the same pattern observed in the assemblage of complete flakes is replicated in this sample. For example, most bulbs of force are diffuse, and the number of salient bulbs is proportionate with the number of observed eraillure flake scars. Further, most of the flakes have lipped, unifaceted, platform remnants. Most of the flakes also have one or two dorsal flake scars, and less than 50 percent dorsal cortex. Table s10.9 and 10.10 list the data for the remaining classes of debitage. As with the rest of the sample, most of the pieces are chert and chalcedony, have less than 50 percent dorsal cortex and have one or two flake scars.

Table 10.7 Trench 1 summary counts for lateral flake fragments

Trench 1		Total
Termination	Axial	1
	Feather	34

Trench 1		Total
	Hinge	8
	Step	10
Lipping	Absent	33
	Present	20
Bulb	Diffuse	47
	Salient	6
Eraillure	Absent	46
	Present	7
Platform	Abraded	2
	Collapsed	4
	Cortical	5
	Crushed	1
	Multifaceted	3
	Unifaceted	38
Prep.	Abraded	7
	Trimmed	7
Cortex	0	43
	0-49	2
	50-99	3
	100	5
Scars	0	6
	1-2	45
	3-4	2

Table 10.8 Flake platforms for lateral flake fragments

	Platform Thickness	Max. Dimension	Max. Thickness	Weight
Mean	4.86	23.00	6.01	2.59
StD	2.55	10.47	3.16	

Table 10.9 Trench 1 summary counts for raw material, cortex, and scars on limited attribute debitage

Material	Distal/ Medial	Indeterminate Flake Fragments	Angular Debris	Micro-flakes	Micro-angular-debris	Total
Chalcedony	57	146	275	298	81	857
Chert	91	173	261	282	61	868
Igneous	1	1	2	0	0	4
Limestone	5	26	22	6	0	59
Obsidian	1	0	1	5	0	7
Orthoquartzite	2	3	1	9	0	15
Quartzite	19	63	46	44	8	180
Rhyolite	1	1	1	0	1	4
Silic. Wood	0	1	0	0	0	1
Siltstone	2	1	2	3	0	9
Total	**179**	**415**	**611**	**647**	**151**	**2003**

Material	Distal/ Medial	Indeterminate Flake Fragments	Angular Debris	Micro-flakes	Micro-angular-debris	Total
Cortex						
0	132	162	340	502	0	**1136**
0-49	17	23	251	291	0	**582**
50-99	13	9	20	42	0	**84**
100	17	10	0	27	0	**54**
Total						**1856**
Scars						
0	17	12	0	0	0	29
1-2	138	165	0	0	0	303
3-4	22	27	0	0	0	49
5-6	2	0	0	0	0	2
Total	**179**	**204**	**0**	**0**	**0**	**383**

Table 10.10 Mean averages and standard deviations, Trench 1 limited attribute debitage

Debitage Category	Max. Dimension	Max. Thickness	Weight
Distal/Medial			
Mean	15.56	3.51	0.62
StD	4.56	1.97	
LAFF			
Mean	16.64	4.01	0.95
StD	6.21	1.95	
Angular Debris			
Mean	20.13		3.37
StD	8.66		
Micro-flake			
Mean	7.90		
StD	2.90		
Micro Angular Debris			
Mean	8.00		
StD	1.46		

10.2.1.3 Modified Debitage

Modified debitage from Trench 1 includes complete flakes (n=7), indeterminate flake fragments (n=5), angular debris (n=4), proximal flake fragments (n=2), lateral flake fragments (n=1), and medial flake fragments (n=1). Raw materials represented in the sample include quartzite (n=6), chert (n=8), limestone (n=1), and chalcedony (n=5).

On average, complete flakes with modification (n=7) are 41.51 mm (StD=15.27) in maximum dimension, 31.94 mm (StD=10.81) in maximum length, 35.72 mm (StD=18.6) in maximum width, 10.59 mm (StD=4.83) in midpoint thickness, 11.33 mm (StD=5.06) in maximum thickness, and weigh 21.7 g. Three have dorsal cortex. Within this sample, three appear to have been retouched, with no clear signs of use-wear. One of these is worked along one margin of one face, another along one margin of both faces, and one on both margins of one face. Two flakes have both retouch and use-wear. Of these, one has retouch along one margin of one face, with smaller flake scars and damage related to use. The other has retouching evident along both margins of one face, with signs of use along one margin. The remaining two flakes appear only to have been used, both along one margin of one face. Edge angles range from 52 to 78 degrees, intermediate between a cutting and scraping angle (Andrefsky 1998:154). Four of the edges are convex, and three are straight, suggesting the edges represent a mixture of functions. Use-wear on all of the pieces is limited to small step and crescent-shaped flake scars. No macroscopic polishing, edge rounding, hafting wear, or other types of use-related damage is evident in the sample, and none of the flakes can be classified as formal tools.

The remaining modified flake fragments (n=10) are 27.91 mm (StD=10.63) long, 6.39 mm (StD=3.06) thick, and weigh 4.25 g. Only one has dorsal cortex. Within this sample, two are retouched, with no clear signs of use. One of these is worked bifacially along one margin, and the other along one margin of one face. Six pieces are classified as both retouched and used. Three of these are worked on two margins of one face, one with use-wear along one margin, and two with use-wear along both margins. Two of these are worked on one face of one margin, both with accompanying edge wear. The sixth piece is worked bifacially along one margin, but shows signs of use-wear along both margins. Wear on the remaining two flake fragments is interpreted as use-related only. One of these has wear on both margins, the other along a single margin. Use-wear on all of the pieces is limited to small step and crescent-shaped fractures. No macroscopic polishing, edge rounding, hafting wear, or other types of use-related damage is evident in the sample, and none of the fragments appears to have been from formal tools.

The remaining four modified pieces are classified morphologically as angular debris. Three are retouched only, one bifacially along one margin, one along both margins of one face, and a third along a single margin of one face. The fourth piece is retouched along both margins of one face with accompanying edge wear. Morphologically, two worked edges are irregular in shape, one is convex, and one has a graver-like point. In total, the collection of modified pieces implies multiple functions, with no formal technological strategy other than the production of an edge capable of performing the task at hand.

10.2.2 Ground Stone

The ground stone assemblage consists of 8 morphologically unidentifiable fragments, 7 metate fragments, 5 mano fragments, and 1 complete, one-hand mano. Most of the items (66.66 percent/n=14) are gray to reddish-gray sandstone. One mano fragment, one metate fragment, and one indeterminate piece are of granitic material, and a single mano fragment is of gray limestone. On average, the indeterminate fragments are 67.52 mm (StD=21.91) in maximum dimension, and weigh 103.41 g (StD=90.43). The metate fragments are 78.77 mm (StD=19.63) in maximum dimension, and weigh 155.32 g (StD=98.33). The mano fragments are 73.86 mm (StD=12.42) in maximum dimension, and weigh 152.84 g (StD=58.74). The single complete mano is 85.25 mm long, 75.17 mm wide, 72.41 mm thick, and weighs 265.2 g. Where identifiable, the mano fragments are of one-hand implements, and the metate fragments are of slab types.

10.2.3 Bifaces

Nine biface fragments and one complete biface were recovered from Trench 1 (Figure 10.1). The complete specimen is 57.06 mm long, 40.01 mm wide, 12.72 mm thick, and weighs 29.6 g. It is of gray, locally available chalcedony, with a small amount of cortex (approximately 10 percent). The remaining biface fragments are of chert (n=6), chalcedony (n=2), and quartzite (n=1). On average, these fragments are 16.75 mm (StD=14.11) in maximum dimension, and weigh 2.19 g. Most of these specimens (n=6) are believed to be projectile point fragments. The tip of a bifacial tool showed significant macroscopic rounding and polishing.

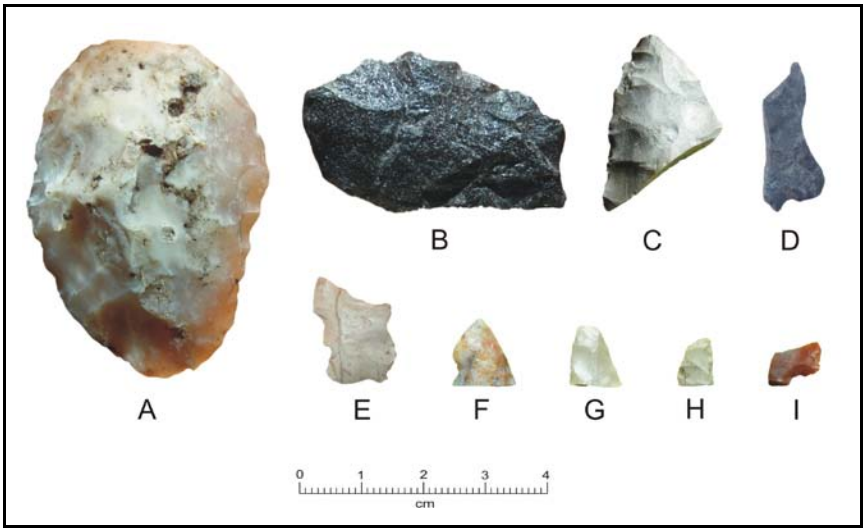

Figure 10.1 Bifaces and fragments recovered from Trench 1

a) Specimen 21, b) Specimen 19, c) Specimen 21, d) Specimen 20, e) Specimen 80
f) Specimen ?, g) Specimen 29, h) Specimen 32, i) Specimen 42

10.2.4 Projectile Points

Eleven projectile points, of which two are complete, were recovered from Trench 1 (Figure 10.2). Five are classified as Harrell/Washita variants, and are of limestone (n=1), quartzite (n=1), chalcedony (n=2), and chert (n=1). The Harrell/Washita variant triangular point type exhibits side notching, or side notching in conjunction with a distinct mid-basal notch. If basal notching is absent, the basal margin can be straight, slightly convex, or slightly concave (Justice 2002:298; Turner and Hester 1993:217). Justice (2002:298) dates this style between A.D. 1150 and 1300/1500, and it has been previously reported at the Boot Hill site (Corley and Leslie 1960). The single complete point is side-notched, is 18.83 mm long, 14.68 mm wide, 3.95 mm thick, and weighs 0.8 g. The base is concave and the blade edges are slightly irregular. Other metric attributes include neck width (6.9 mm), base width (14.04 mm), shoulder to corner distance (7.75 mm), and blade length (12.63 mm). Of the remaining Harrell/Washita variants, one is a distal fragment broken at the neck, one is broken along one corner of the base (possibly during notching), one is a proximal fragment broken approximately midway down the body, and the third is a proximal fragment broken transversely across the body, and laterally at the base.

Three projectile points are classified as Fresno variants. This style exhibits triangular, straight, or convex lateral margins, with straight-to-concave bases and overlapping flake scars along the lateral margins (Justice 2002:266–267). Various date ranges have been proposed for this style, with all occurring after A.D. 800 and as late as 1750 (Justice 2002). Two points are chalcedony and one is chert. Only one is complete. It is 14.24 mm long, 10.3 mm wide, 4.02 mm thick, and weighs 9.09 g. The base is straight and is 9.90 mm wide. The blade edges are straight with the longest being 14.83 mm.

One projectile point is tentatively classified as a Perdiz variant with smaller than average tangs/barbs, or as an Edwards point. The former dates from A.D. 1200 to 1500, and the later from A.D. 900 to 1040 (Turner and Hester 1993). The specimen is broken at the neck and may have been stemmed. It is made from a mottled gray and tan chert, is 13.91 mm wide, 2.9 mm thick, and weighs 0.9 g. The neck is 4.65 mm thick, and the longest blade is 27.0 mm. Both blade edges are straight, and the specimen is noticeably well crafted.

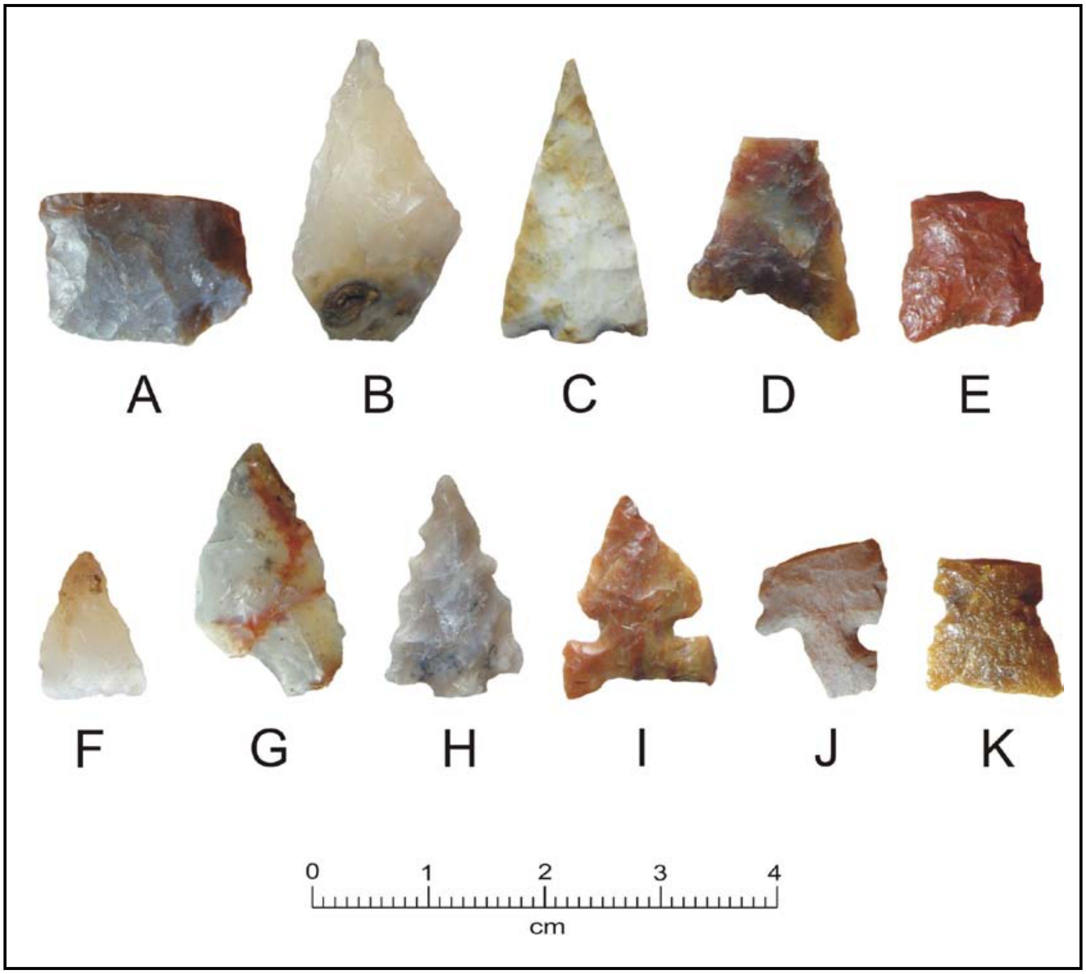

Figure 10.2 Projectile points and fragments recovered from Trench 1

a) Specimen 83-San Pedro base, b) Specimen 33-unknown, c) Specimen 37-possible Perdiz variant, d) Specimen 36-Fresno, e) Specimen 37-Fresno, f) Specimen 19-Fresno, g) Specimen 19-possible Harrell/Washita variant, h) Specimen 83-Harrell/Washita variant, i) Specimen 25-Harrell/Washita, j) Specimen 25-Harrell/Washita, k) Specimen 43-Harrell/Washita variant.

One biface fragment is classified as the base of a San Pedro projectile point, and is made from gray chert. In similar fashion to Hueco and Tularosa corner-notched point forms, this type exhibits a triangular body, expanding stem, and well-formed shoulders (Justice 2002:202). San Pedro variants traditionally coincide with the Late Archaic period, extending into the early Formative period (Carmichael 1986; Condon et al. 2008).

The remaining biface, classified as a likely projectile point, is shaped from a chalcedony flake without invasive bifacial flaking. Both flake margins are worked expediently to form a point, while the proximal end of the flake serves as the base. This piece may represent the work of a novice, or could have been an expedient tool that superficially resembles a projectile point.

10.2.5 Hammerstones

Three hammerstones were recovered from Trench 1 (Figure 10.3). One consists of light brown quartzite, is 46.02 long, 35.83 mm wide, 17.32 mm thick, and weighs 35.1 g. Two use-wear locations were recorded and the piece has 100 percent cortex. The second hammerstone is purple quartzite, is 58.05 mm long, 47.7 mm wide, 38.4 mm thick, and weighs 113.6 g. One use-wear location was recorded, and the piece has 20 percent cortex. The remaining hammerstone is a gray chalcedony nodule with five use-wear locations and approximately 40 percent cortex. It is 66.38 mm long, 60.22 mm wide, 46.69 mm thick, and weighs 188.4 g. Since all three hammerstones are of the same material that comprises most of the debitage assemblage, it can be inferred that they are multifunctional, serving as both percussors and sources for raw material.

10.2.6 Cores

Ten cores, consisting of chert (n=5), chalcedony (n=3), and quartzite (n=2), were recovered from Trench 1 (Figure 10.3). Only one is classified as incomplete. Of the remaining nine, three are classified as bipolar, three as multidirectional, two as multifunctional core tools, and one as a tested cobble. The median platform count is four, with a median scar count of five. All of the cores have some cortex, with only one having slightly more than 50 percent. On average, the nine complete cores are 49.41 mm long (StD=12.76), 43.40 mm wide (StD=12.05), 27.33 mm thick (StD=6.08), and weigh 68.45 g (StD=47.41). Noteworthy is the absence of unidirectional cores and evidence of formality.

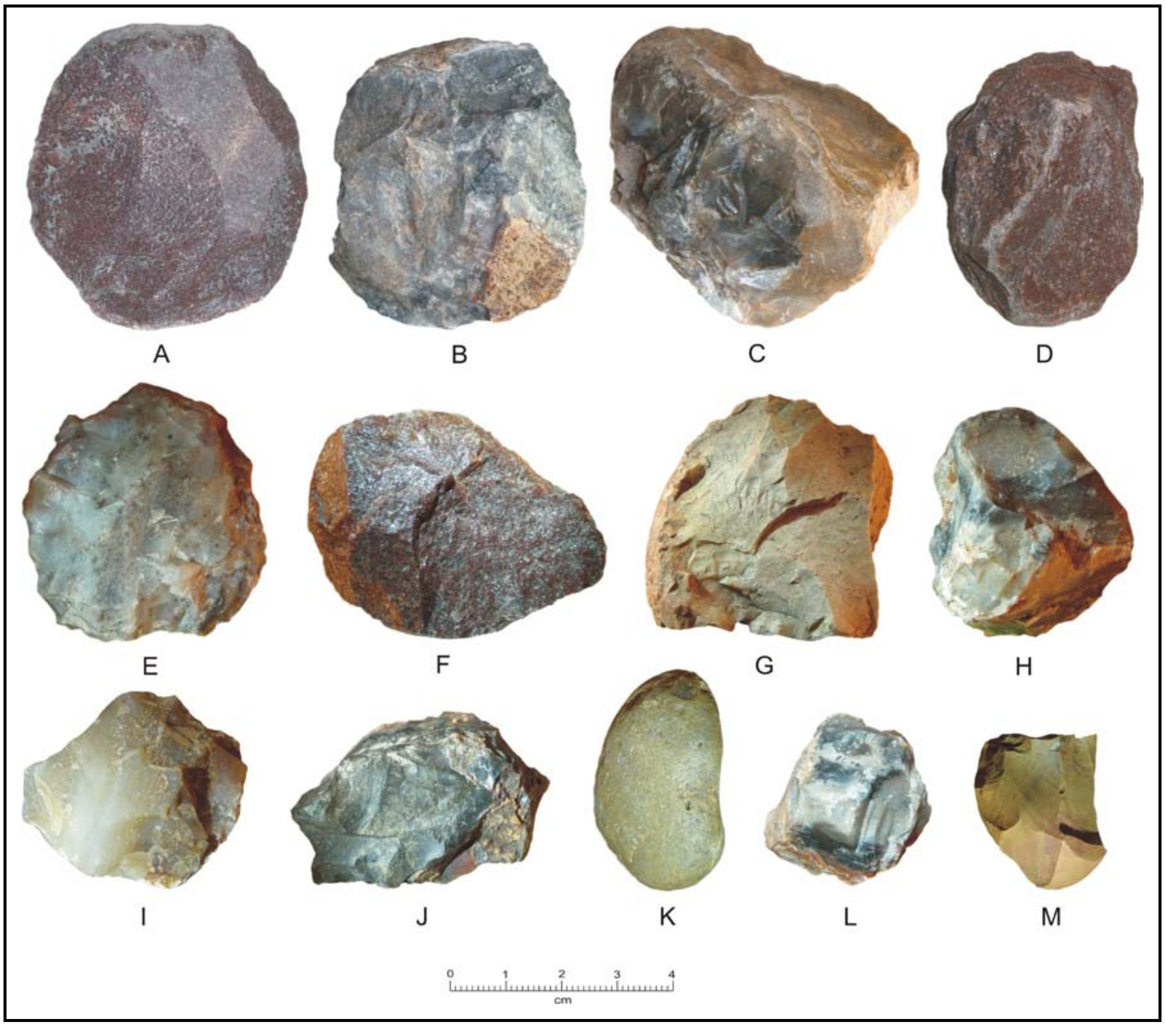

Figure 10.3 Cores and hammerstones recovered from Trench 1

a) Specimen 5-core tool, b) Specimen 37-core tool, c) Specimen 42-hammerstone, d) Specimen 24-hammerstone, e) Specimen 18-bipolar core, f) Specimen 17/73-bipolar core, g) Specimen 80-core, h) Specimen 30-tested cobble, i) Specimen 37-core, j) Specimen 37-core fragment, k) Specimen 37-hammerstone, L) Specimen ?-bipolar core, M) Specimen 92-core

10.3 Trench 2

A total of 792 lithic artifacts was recovered from Trench 2. The assemblage includes 773 (97.60 percent) pieces of lithic debitage, 9 (1.13 percent) ground stone fragments, 6 (0.75 percent) cores, 2 (0.25 percent) hammerstones, and 2 (0.25 percent) projectile points.

10.3.1 Lithic Debitage

The lithic debitage was divided into nine categories for analysis (Table 10.11). The debitage material types are presented in Table 10.12..

Table 10.11 Lithic debitage categories, Trench 2

Debitage Category	Count	Percentage
Complete flakes	195	25
Micro-flakes	123	15.9
Angular debris	143	18.5
Indeterminate flake fragments	121	15.7
Proximal flake fragments	78	10
Distal/medial flake fragments	65	8.4
Micro-angular-debris	23	3
Lateral flake fragments	14	1.8
Modified flakes and flake fragments	11	1.4
Total	**773**	**100**

Table 10.12 Raw materials for lithic debitage, Trench 2

Raw Material	Count	Percentage
Chert	388	50.2
Chalcedony	285	36.9
Limestone	45	5.8
Quartzite	42	5.4
Igneous material	6	0.8
Siltstone	3	0.4
Rhyolite	2	0.3
Obsidian	1	0.1
Silicified wood	1	0.1
Total	**773**	**100**

10.3.1.1 Complete Flakes and Proximal Flake Fragments

Tables 10.13 and 10.14 list the non-metric attributes recorded for complete flakes and proximal flake fragments. Of the 195 complete flakes, 62.56 percent (n=122) have no dorsal cortex and are classified as tertiary. Secondary flakes, with less than 50 percent dorsal cortex, comprise 23.58 percent (n=46) of the assemblage. Flakes with 50–99 percent cortex (n=18) and 100 percent cortex (n=9) are classified as primary flakes, and comprise the remaining 13.84 percent of the assemblage. Collectively, 37.43 percent (n=73) of the flake assemblage exhibit some dorsal cortex, suggesting a range of reduction trajectories at this site locus. These findings reflect a tentative interpretation due to the limited number of cortex-bearing flakes in comparison to the greater number of flakes without cortex that may be produced during core reduction. As with Trench 1, the greater frequency of flakes with no dorsal cortex suggests a complete reduction sequence is represented, with an emphasis on late-stage lithic production. Dorsal flake scar count mirrors the proportion of dorsal cortex, with most of the flakes exhibiting one or two scars. However, many (n=43) have three or four scars, suggesting late-stage lithic production.

Platform remnants were measured on 273 complete flakes and proximal flake fragments with complete platforms (Table 10.15). Analysis of all 273 flakes and proximal flake fragments also focused on remnant type, which consisted of seven classes: 1) cortical, 2) unifaceted/flat, 3) abraded/battered, 4) collapsed, 5)crushed, 6) multifaceted, and 7) curved. Similar to the assemblage from Trench 1, intermediate stages of reduction, represented by unifaceted platforms, were the predominant remnant class (53.84 percent/n=147). Cortical platform remnants only represent 10.25 percent of the sample (n=28). Collectively, both platform classes comprise 64.10 percent (n=175) of the sample of complete flakes and proximal flake fragments. Collapsed and crushed platform types comprise 15.01 percent (n=41) of the assemblage, and indicate minimal core preparation prior to flake removal. Multifaceted platform remnants reflect advanced reduction sequences and, in combination with other flake attributes, can be associated with biface technology. Of the 273 specimens analyzed, 13.91 percent (n=38) exhibit multiple facets, slightly more than remnants with cortex. Only three flakes (1.09 percent) possess curved platform remnants.

The presence or absence of eraillure flakes and platform lipping was also monitored using the combined flake and proximal flake fragment assemblage (n=273). Platform lipping was identified in 35.89 percent (n=98) of the analyzed assemblage, suggesting the use of soft hammer percussion may have been common. Of the 273 specimens analyzed, 20.14 percent (n=55) have eraillure flake scars. In conjunction with the frequency of platform lipping, soft hammer percussion appears to be the dominant reduction technique at this site locus. While the absence of an eraillure scar does not by itself suggest the use of soft hammer percussion, or a biface-manufacturing trajectory, it does indicate a variety of reduction techniques may have been employed.

Bulbar definition was monitored to evaluate the application load concept. Two subjective categories were created to monitor this lithic attribute: 1) salient, and 2), diffuse. Diffuse bulbs comprise 84.98 percent (n=232) of the assemblage, and strong or salient bulbs of force were recorded on 15.01 percent (n=41) of the assemblage. These data indicate low to moderate application loads, indicating low amounts of energy were used in flake initiation. The debitage assemblage points toward the use of both hard and soft hammer techniques, with an emphasis on the latter. Therefore, the maximization of raw materials and tool maintenance may play a major role in the structure of technological organization at this site locus. Raw material types and counts for complete and proximal flakes are presented in Table 10.16.

Table 10.13 Trench 2 summary counts for complete flakes

Trench 2 n=195		Count
Termination	Axial	14
	Feather	142
	Hinge	39
Lipping	Absent	123
	Present	72
Bulb	Diffuse	160
	Salient	35
Eraillure	Absent	158
	Present	37
Platform	Abraded	6
	Collapsed	22
	Cortical	23
	Crushed	6
	Curved	1
	Multifaceted	26
	Unifaceted	111
Prep.	Abraded	30
	Trimmed	33
Cortex	0	122
	0-49	46
	50-99	18
	100	9
Scars	0	11
	1-2	139
	3-4	43
	5-6	2

Table 10.14 Trench 2 summary counts for proximal flake fragments

Trench 2 n=78		Count
Platform	Abraded	10
	Collapsed	10
	Cortical	5
	Crushed	3
	Curved	2
	Multifaceted	12
	Unifaceted	36
Lipping	Absent	52
	Present	26
Bulb	Diffuse	72
	Salient	6
Eraillure	Absent	60
	Present	18
Prep.	Abraded	15
	Trimmed	14
Cortex	0	66
	0-49	5
	50-99	4
	100	3
Scars	0	3
	1-2	63
	3-4	12

Table 10.15 Means and standard deviations for complete and proximal flakes, Trench 2

Complete Flakes	Platform Thickness	Platform Width	Max. Dimension	Max. Length	Max. Width	Mid. Thickness	Max. Thickness	Weight
Mean	4.27	10.21	20.63	17.89	17.11	4.88	5.46	2.63
StD	3.17	6.55	9.12	17.39	7.91	3.28	3.50	
Proximal Flake Fragments	**Platform Thickness**	**Platform Width**						
Mean	3.25	8.97						
StD	2.18	5.45						

Table 10.16 Raw material counts for complete and proximal flakes, Trench 2

Complete Flakes		Proximal Flake Fragments		Total
Raw Material	Count	Raw Material	Count	
Chalcedony	65	Chalcedony	25	90
Chert	96	Chert	38	134
Igneous	4	Igneous	1	5
Limestone	18	Limestone	6	24
Quartzite	10	Quartzite	6	16
Siltstone	2	Siltstone	1	3
		Silicified Wood	1	1
Total	**195**	**Total**	**78**	**273**

10.3.1.2 Limited Attribute Debitage

The remaining unmodified lithic debitage includes angular debris (18.05 percent/n=143), micro-flakes (15.53 percent/n=123), indeterminate flake fragments (15.27 percent/n=121), distal/medial flake fragments (8.2 percent/n=65), micro-angular-debris (2.9 percent/n=23), and lateral flake fragments (1.76 percent/n=14). In general, the same pattern seen in the assemblage of complete flakes is replicated in this sample (Tables 10.17 and 10.18). As with the rest of the debitage, most of the pieces are chert and chalcedony, have less than 50 percent cortex, and exhibit one or two flake scars.

Table 10.17 Trench 2 summary counts for limited attribute debitage

Material	Lateral Flake Fragments	Distal/ Medial Flake Fragments	Indeterminate Flake Fragments	Angular Debris	Micro-flakes	Micro-angular-debris	Total
Chalcedony	3	22	42	61	50	11	**189**
Chert	5	37	60	74	64	12	**252**
Igneous	0	0	1	0	0	0	**1**
Limestone	4	2	9	3	1	0	**19**
Obsidian	0	0	0	0	0	0	**0**
Orthoquartzite	0	0	0	0	0	0	**0**
Quartzite	2	4	9	4	5	0	**24**
Rhyolite	0	0	0	1	1	0	**2**
Total	**14**	**65**	**121**	**143**	**123**	**23**	**487**
Cortex							
0	9	42	81	72	0	0	204
0-49	3	10	17	65	0	0	95
50-99	1	7	8	3	0	0	19
100	1	6	15	1	0	0	23
Total	**14**	**65**	**121**	**143**	**0**	**0**	**341**
Scars							
0	1	6	14	0	0	0	21
1-2	11	49	96	0	0	0	156
3-4	2	10	11	0	0	0	23
5-6	0	0	0	0	0	0	0
Total	**14**	**65**	**121**	**0**	**0**	**0**	**200**

Table 10.18 Means and standard deviations for limited attribute debitage, Trench 2

	Max. Dimension	Max. Thickness	Weight
Lateral Flake Fragments			
Mean	24.15	5.78	2.60
StD	8.27	2.19	
Distal/Medial			
Mean	16.95	3.68	0.89
StD	5.95	1.89	
LAFF			
Mean	17.04	4.21	0.93
StD	5.11	1.83	
Angular Debris			
Mean	21.09		4.04
StD	9.11		
Micro-flake			
Mean	7.97		
StD	1.25		
Micro Angular Debris			
Mean	8.36		
StD	1.13		

10.3.1.3 Modified Debitage

Modified debitage from Trench 2 includes complete flakes (n=6), indeterminate flake fragments (n=3), angular debris (n=1), and a possible agave knife. Raw materials represented in the sample include chalcedony (n=5), quartzite (n=2), chert (n=2), and limestone (n=2).

On average, complete flakes with modification are 44.64 mm (StD=12.16) in maximum dimension, 38.81 mm (StD=12.02) in maximum length, 35.11 mm (StD=14.01) in maximum width, 12.02 mm (StD=3.48) in midpoint thickness, 12.76 mm (StD 3.86) in maximum thickness, and weigh 20.31 g (StD 17.12). Four have dorsal cortex, all less than 50 percent. Within this sample, one appears to have been retouched along one margin of one face, with no clear signs of use-wear. One has both retouch and use-wear along one margin of one face, with accompanying use-related wear. The third has unifacial retouch and use-wear on two margins, and the fourth has use-related wear only, on two margins of one face. The remaining two flakes with no cortex have use-wear only, both along one face of one margin. Edge angles range from 50 to 83 degrees, suggesting an emphasis on scraping rather than cutting. Three edges are convex, four are straight, two are irregular, and one is concave, indicating multiple uses. Edge wear on all of the pieces is limited to small step and crescent-shaped fractures. No macroscopic polishing, edge rounding, hafting wear, or other types of use-related damage were evident in the sample, and none of the flakes could be classified as formal tools.

On average, the remaining modified pieces of debitage measure 35.52 mm (StD=7.49) in maximum length, and weigh 9.07 g (StD=5.47). None has dorsal cortex. Within this sample, two are retouched, with no clear signs of use. One of these is worked bifacially along both margins, and the other along one margin of one face. Two pieces are classified as both retouched and used. Edge angles range from 64 to 78 degrees, also implying scraping rather than cutting. Two edges are irregular, one is straight, and one is convex. Use-wear on all of the pieces is limited to small step and crescent-shaped flake scars. As with the complete flakes, no macroscopic polishing, edge rounding, hafting-wear, or other types of use-related damage was evident, and none of the fragments appears to have been from formal tools. The remaining modified piece is worked bifacially along one margin. It consists of a tabular piece of limestone that is 101.26 mm long, 12.01 mm thick, and weighs 104.1 g and may represent an agave knife.

10.3.2 Ground Stone

The ground stone assemblage consists of six morphologically unidentifiable fragments, two metate fragments, and one mano fragment. Three of the indeterminate pieces are gray to reddish brown sandstone that appear to be fire-cracked, and three are of gray granitic material. Both metate fragments are of gray to reddish gray sandstone, and the single mano fragment is granitic. None of the pieces is complete. On average, the indeterminate fragments are 64.66 mm (StD=12.20) in maximum dimension and weigh 100.23 g (StD=47.79). The metate fragments are both identified as slab forms. One is 87.08 mm in maximum dimension and weighs 240.6 g. The second is 71.8 mm in maximum dimension and weighs 183.8 g. The single mano fragment is from a one-hand implement, is 91.79 mm in maximum length, and weighs 180.5 g.

10.3.3 Projectile Points

Two projectile points were recovered from Trench 2, both incomplete (Figure 10.4). One is of gray chert and is nearly complete except for a missing stem. It resembles a Livermore style. It is 22.57 mm long, 15.51 mm wide, 2.63 mm thick, and weighs 0.6 g. The neck is 4.43 mm wide and the blade is 21.57 mm long. Both blade edges are concave. Livermore projectile points exhibit an elongated triangular body, oftentimes serrated, with well-defined shoulders that result from deep corner notching. The shoulders tend to form barbs or tangs. The narrow hafting element separates the shoulders from a short, expanding stem that is also concave along the basal margin (Justice 2002:233–235). Justice (2002:231) associates the Livermore point type to the Guadalupe Mountains of New Mexico and provides an age range of A.D. 100–800.

The second projectile point is a distal fragment, possibly from a thicker, unnotched lenticular form. The fragment is 22.35 mm long, 13.75 mm wide, 8.35 mm thick, and weighs 1.9 g. No other attributes were measurable. Given the presence of several large potlids on one face, it is likely the specimen has been thermally fractured.

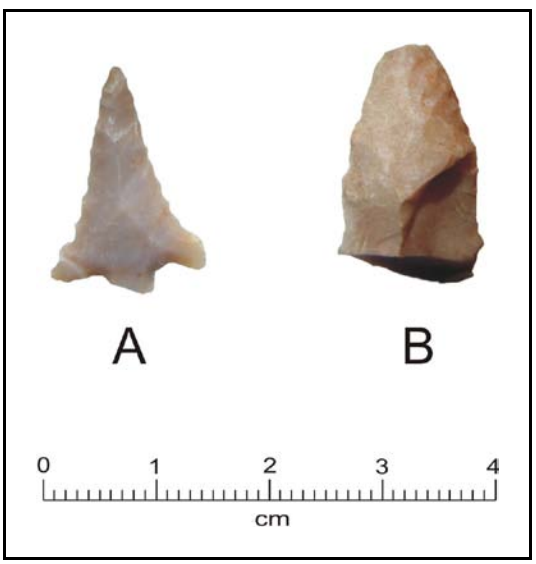

Figure 10.4 Projectile points recovered from Trench 2

a) Specimen 55-Livermore variant, b) Specimen 59-indeterminate

10.3.4 Hammerstones

Two quartzite hammerstones were recovered from Trench 2 (Figure 10.5). Both are complete, each having 100 percent cortex and two use-wear loci. One is 57.13 mm long, 51.4 mm wide, 27.75 mm thick, and weighs 110 g. The second is 46.94 mm long, 37.73 mm wide, 19.47 mm thick, and weighs 46.6 g.

10.3.5 Cores

Six cores of chalcedony (n=4) and limestone (n=2) were recovered from Trench 2 (Figure 10.5). One core is classified as incomplete. Of the remaining five, three are classified as multidirectional, one as a multifunctional core tool, and one as a tested cobble. The median platform count is two, with a median scar count of seven. All of the cores have some cortex present, with two having more than 50 percent. On average, the five complete cores measure 63.98 mm long (StD=27.74), 52.56 mm wide (StD=27.97), 36.74 mm thick (StD=15.31), and weigh 208.16 g. Noteworthy is the absence of unidirectional cores and evidence of formality.

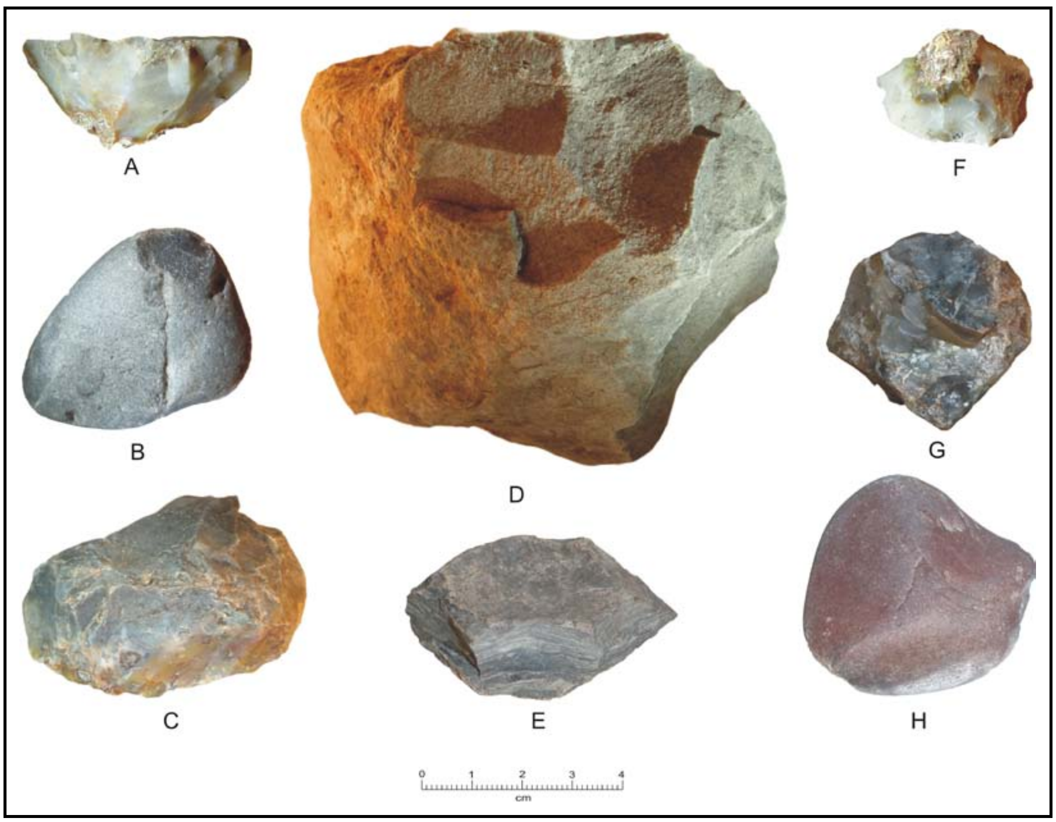

Figure 10.5 Cores and hammerstones recovered from Trench 2

a) Specimen 90/91-core, b) Specimen 64-hammerstone, c) Specimen 65-core tool, d) Specimen 51-core, e) Specimen 49-core, f) Specimen 90/91-core fragment, g) Specimen 49-tested cobble, h) Specimen 49-hammerstone

10.4 Trench 3

A total of 726 lithic artifacts were recovered from Trench 3. The assemblage consists of 711 (97.93 percent) pieces of lithic debitage, 5 (0.68 percent) pieces of ground stone, 4 (0.55 percent) projectile points, 4 (0.55 percent) cores, 1 (0.13 percent) biface, and 1 (0.13 percent) hammerstone.

10.4.1 Lithic Debitage

The lithic debitage was divided into nine categories for analysis (Table 10.19). Table 10.20 presents the debitage raw material types.

Table 10.19 Lithic debitage categories for Trench 3

Debitage Category	Count	Percentage
Complete flakes	203	28.6
Micro-flakes	120	16.9
Angular debris	117	16.5
Indeterminate flake fragments	123	17.3
Proximal flake fragments	60	8.4
Distal/medial flake fragments	49	6.9
Micro-angular-debris	19	2.7
Lateral flake fragments	17	2.4
Modified flakes and flake fragments	3	0.4
Total	**711**	**100**

Table 10.20 Raw materials for lithic debitage, Trench 3

Raw Material	Count	Percentage
Chalcedony	317	44.6
Chert	307	43.2
Quartzite	46	6.5
Limestone	28	3.1
Orthoquartzite	5	0.7
Igneous material	4	0.6
Siltstone	2	0.3
Rhyolite	1	0.1
Obsidian	1	0.1
Total	**711**	**100**

10.4.1.1 Complete Flakes and Proximal Flake Fragments

Tables 10.21 and 10.22 list the non-metric attributes recorded for complete flakes and proximal flake fragments. Of the 203 complete flakes, 65.02 percent (n=132) were classified as tertiary and had no dorsal cortex. Forty flakes (19.70 percent) have less than 50 percent dorsal cortex and are viewed as occurring earlier in the reduction sequence than the removal of the tertiary flakes. Sixteen flakes (7.88 percent) have greater than 50 percent dorsal cortex, and only fifteen (7.38 percent) had 100 percent dorsal cortex. Collectively, 34.97 percent (n=71) of the flake assemblage exhibits some dorsal cortex, suggesting a range of reduction trajectories at this site locus. These findings reflect a tentative interpretation due to the limited number of cortex-bearing flakes in comparison to the greater number of flakes without cortex that may be produced during core reduction. Similar to the assemblages from Trenches 1 and 2, the greater frequency of flakes with no dorsal cortex suggests a complete reduction sequence is represented, with an emphasis on late-stage lithic production. Dorsal flake scar counts mirror the proportions of dorsal cortex, with the majority of flakes exhibiting one or two scars. However, a large number (n=40) have three or four scars, suggesting late-stage lithic production.

Table 10.21 Trench 3 summary counts for complete flakes

Trench 3 N=203		Count
Termination	Axial	3
	Feather	145
	Hinge	55
Lipping	Absent	91
	Present	112
Bulb	Diffuse	166
	Salient	37
Eraillure	Absent	161
	Present	42
Platform	Abraded	7
	Collapsed	19
	Cortical	32
	Crushed	6
	Curved	2
	Multifaceted	16
	Unifaceted	121
Prep.	Abraded	25
	Trimmed	25
Cortex	0	132
	0-49	40
	50-99	16
	100	15
Scars	0	16
	1-2	157
	3-4	40

Table 10.22 Trench 3 summary counts for proximal flake fragments

Trench 3 N=60		Count
Platform	Abraded	7
	Collapsed	9
	Cortical	3
	Crushed	2
	Curved	1
	Multifaceted	7
	Unifaceted	31
Lipping	Absent	26
	Present	34
Bulb	Diffuse	46
	Salient	14
Eraillure	Absent	49
	Present	11
Prep.	Abraded	10
	Trimmed	9
Cortex	0	44
	0-49	9
	50-99	4
	100	3
Scars	0	3
	1-2	52
	3-4	5

Table 10.23 Means and standard deviations for complete and proximal flakes, Trench 3

Complete Flakes	**Platform Thickness**	**Platform Width**	**Max. Dimension**	**Max. Length**	**Max. Width**	**Mid. Thickness**	**Max. Thickness**	**Weight**
Mean	3.61	9.05	19.20	15.60	15.77	4.18	4.75	1.55
StD	3.04	5.27	14.88	14.23	12.08			
Proximal Flake Fragments	**Platform Thickness**	**Platform Width**						
Mean	3.13	9.11						
StD	2.13	6.52						

Platform remnants were measured on 263 complete flakes and proximal flake fragments with complete platforms (Table 10.23). Analysis of all 263 flakes and proximal flake fragments also focused on remnant type, which consisted of seven classes: 1) cortical, 2) unifaceted/flat, 3) abraded/battered, 4) collapsed, 5) crushed, 6) multifaceted, and 7) curved. Platforms reflecting early reduction sequences, such as cortical (13.30 percent/n=35) and unifaceted/flat (57.79 percent/n=152), are the predominant remnant types. Collectively, both platform types comprise 71.10 percent (n=187) of the flakes and proximal flake fragments. Collapsed and crushed platform types comprise 13.68 percent (n=36) of the assemblage, and suggest minimal core preparation prior to flake removal. Multifaceted platform remnants reflect advanced reduction sequences and, in combination with other flake attributes, can be associated with biface technology. Of the 263 specimens analyzed, only 8.74 percent (n=23) exhibit multiple facets. Curved platforms are associated with soft hammer percussion and are related to biface reduction. Only three flakes (1.14 percent) possess curved platform remnants.

The presence or absence of eraillure flakes and platform lipping was also monitored using the combined flake and proximal flake fragment assemblage (n=263). Platform lipping was identified in 55.51percent (n=146) of the analyzed assemblage, suggesting the use of soft hammer percussion may have been common. Of the 263 specimens analyzed, 20.15 percent (n=53) had eraillure flake scars. This supports the frequency of platform lipping, which indicates soft hammer rather than hard hammer percussion. While the absence of an eraillure scar does not by itself prove the use of soft hammer percussion, or a biface-manufacturing trajectory, it does indicate a variety of reduction techniques may have been employed.

Bulbar definition was monitored to evaluate the application load concept. Diffuse bulbs comprise 80.61 percent (n=212) of the assemblage. Strong or salient bulbs of force were recorded on 19.39 percent (n=51) of the flakes. These data indicate low to moderate application loads, suggesting that large amounts of energy were not used in flake initiation and detachment, and again strengthening the argument for greater frequency of soft hammer percussion,

10.4.1.2 Limited Attribute Debitage

The remaining unmodified lithic debitage included indeterminate flake fragments (17.29 percent/n=123), micro-flakes (16.87 percent/n=120), angular debris (16.45 percent/n=117), distal/medial flake fragments (6.89 percent/n=49), micro-angular-debris (2.67 percent/n=19), and lateral flake fragments (2.39 percent/n=17). Tables 10.24 and 10.25 list summary data for these classes. As with the rest of the debitage, most of the pieces are chert and chalcedony, have less than 50 percent cortex, and exhibit one and two flake scars.

Table 10.24 Trench 3 summary counts for limited attribute debitage

Material	Lateral Flake Fragments	Distal/ Medial Flake Fragments	Indeterminate Flake Fragments	Angular Debris	Micro-flakes	Micro-angular-debris	Total
Chalcedony	6	17	56	59	53	12	**203**
Chert	8	22	45	54	60	6	**195**
Igneous			3				**3**
Limestone		3	8				**11**
Obsidian					1		**1**
Orthoquartzite			1				**1**
Quartzite	2	7	10	4	6	1	**30**
Rhyolite	1						**1**
Total	**17**	**49**	**123**	**117**	**120**	**19**	**445**

Material	Lateral Flake Fragments	Distal/ Medial Flake Fragments	Indeterminate Flake Fragments	Angular Debris	Micro-flakes	Micro-angular-debris	Total
Cortex							
0	12	3	86	55			156
0-49	1	10	13	57			81
50-99	2	6	9	5			22
100	2	10	15				27
Scars							
0	2	10	14				26
1-2	12	31	106				145
3-4	3	8	3				14
5-6							0

Table 10.25 Means and standard deviations for limited attribute debitage, Trench 3

	Max. Dimension	Max. Thickness	Weight
Lateral Flake Fragments			
Mean	21.05	5.47	2.43
StD	8.18	2.82	
Distal/Medial			
Mean	18.49	4.25	1.02
StD	6.04	2.31	
LAFF			
Mean	17.68	4.47	1.02
StD	6.33	2.14	
Angular Debris		5.31	
Mean	22.32	11.12	
StD	10.32		
Micro-flake			
Mean	8.02		
StD	1.28		
Micro Angular Debris			
Mean	8.55		
StD	1.10		

10.4.1.3 Modified Debitage

Modified debitage from Trench 3 includes one complete flake and two flake fragments, all consisting of chert. The complete flake is 31.85 mm in maximum dimension, 26.63 mm long, 22.11 mm wide, 6.48 mm thick, and weighs 4.5 g. The retouched edge is straight, with a 65-degree angle on one face of one margin that has accompanying use-wear.

The remaining modified flake fragments include one that is 22.66 mm long and weighs 10 g. It is retouched bifacially along one margin and shows no signs of use. The edge is convex in plan view, with a 56 degree working edge angle. The second fragment is 48.53mm long and weighs 21.9 g. The flake has been used and is worked on one margin of one face. The edge is convex in plan view, with a working edge angle of 56 degrees.

10.4.2 Ground Stone

The ground stone assemblage consists of three unidentifiable fragments, one metate fragment, and one mano fragment. All five pieces are of gray-to reddish-gray sandstone, and appear to be fire-cracked. On average, the indeterminate fragments are 71.20 mm (StD=12.48) in maximum dimension and weigh 60.76 g (StD=12.87). The metate fragment is from a slab form, measures 89.07 mm in maximum dimension, and weighs 195.1 g. The mano fragment is from a one-hand implement, is 74.52 mm in maximum dimension, and weighs 160.5 g.

10.4.3 Bifaces

A single complete biface, of palmoxylon (silicified palm wood), was recovered from Trench 3 (Figure 10.6). It is 22.45 mm long, 20.63 mm wide, 3.61 mm thick, and weighs 2.0 g. No cortex is present and one margin along one face exhibits evidence of use in the form of small step fractures. The opposing margin is serrated. Morphologically, the specimen resembles a guitar pick.

10.4.4 Projectile Points

Four projectile points were recovered from Trench 3 (Figure 10.6). The only complete specimen is classified as a San Pedro variant. This style exhibits a triangular body, expanding stem, well-formed shoulders and usually a convex base (Justice 2002:202). San Pedro variants traditionally coincide with the Late Archaic period and extend into the early Formative period (Carmichael 1986; Condon et al. 2008). The specimen is of gray chert and is 19.32 mm long, 15.15 mm wide, 3.02 mm thick, and weighs 0.6 g. The neck is 7.05 mm wide, the base is 8.93 mm wide, the blade length is 16.05 mm, and the shoulder-to-corner dimension is 6.28 mm.

A second projectile point is also classified as a San Pedro variant, and is nearly complete except for a missing tip. It is 25.58 mm long, 21.08 mm wide, 7.33 mm thick, and weighs 3.9 g. The neck is 9.68 mm wide, and the shoulder-to-corner dimension is 7.47 mm.

The third projectile point consists of a distal fragment of a possible Harrell/Washita variant made of gray chert. The piece had failed at one notch on one margin, with no notching on the opposite margin. The piece was likely broken while notching.

The fourth projectile point is a proximal fragment of a poorly formed Fresno variant. Various date ranges have been proposed for this style, with all occurring after A.D. 800 and as late as 1750 (Dorshow et al. 2000; Justice 2002; Railey 2002). The piece is of gray chert and is 11.11 mm long, 9.88 mm wide, 3.03 mm thick, and weighs 0.3 g. The only other measurable attribute is the base, which is slightly concave in shape and is 9.23 mm wide.

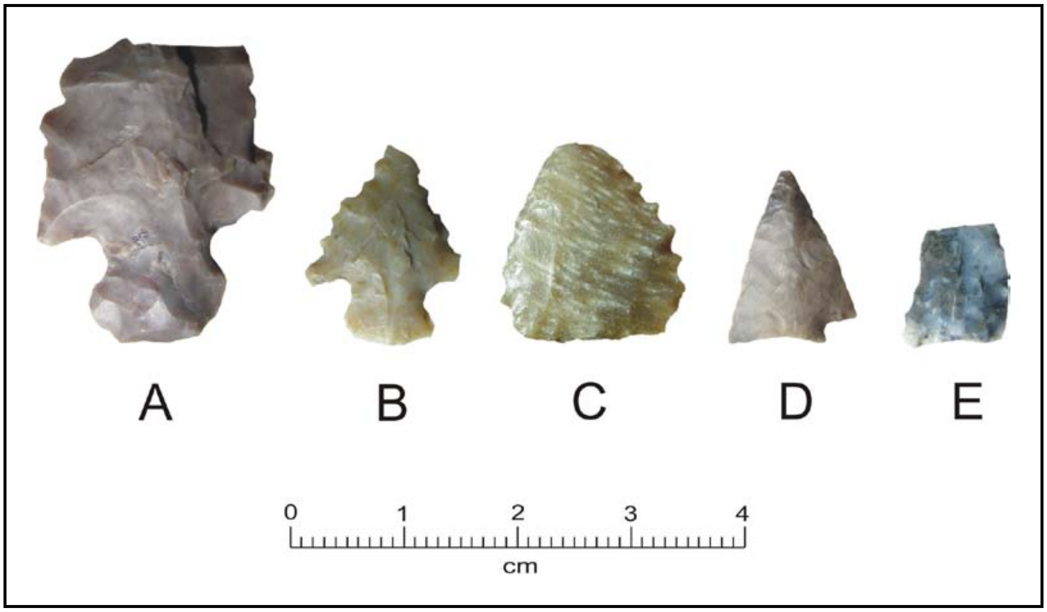

Figure 10.6 Projectile points and bifaces recovered from Trench 3

a) Specimen 109-San Pedro, b) Specimen 115-San Pedro variant, c) Specimen 103/114-biface, d) Specimen 24-possible Washita variant, e) Specimen 112-Fresno

10.4.5 Hammerstones

One incomplete hammerstone was recovered from Trench 3 (Figure 10.7). It is of purple quartzite with approximately 75 percent cortex and two use-wear loci. The specimen is 43.71 mm long, 31.8 mm wide, 24.85 mm thick, and weighs 45.8 g.

10.4.6 Cores

Four complete cores, of chalcedony (n=2), chert (n=1), and extrusive igneous material (n=1), were recovered from Trench 3 (Figure 10.7). One chalcedony core with less than 50 percent cortex is classified as a core tool. This piece exhibits an equal number of flake removals created through use as a tool as it did through intentional detachments. It is 63.59 mm long, 50.09 mm wide, 50.81 mm thick, and weighs 144.3 g. Four opposing battered platforms were recorded on the piece, and a total of eight scars were counted.

The second core is unidirectional, with two platforms, and more than 50 percent cortex. It is a red, extrusive igneous material and is 52.11 mm long, 38.43 mm wide, 26.86 mm thick, and weighs 66.8 g. Five scars were counted. The third core is multidirectional, with three platforms, eight flake scars, and less than 50 percent cortex. It is 35.78 mm long, 32.00 mm wide, 30.01 mm thick, and weighs 24.96 g. The fourth core is bipolar, with one platform opposed by a battered cortical area that was likely rested on an anvil. It is of red chert with less than 50 percent cortex. The specimen is 17.5 mm long, 13.97 mm thick, 12.32 mm wide, and weighs 3.8 g.

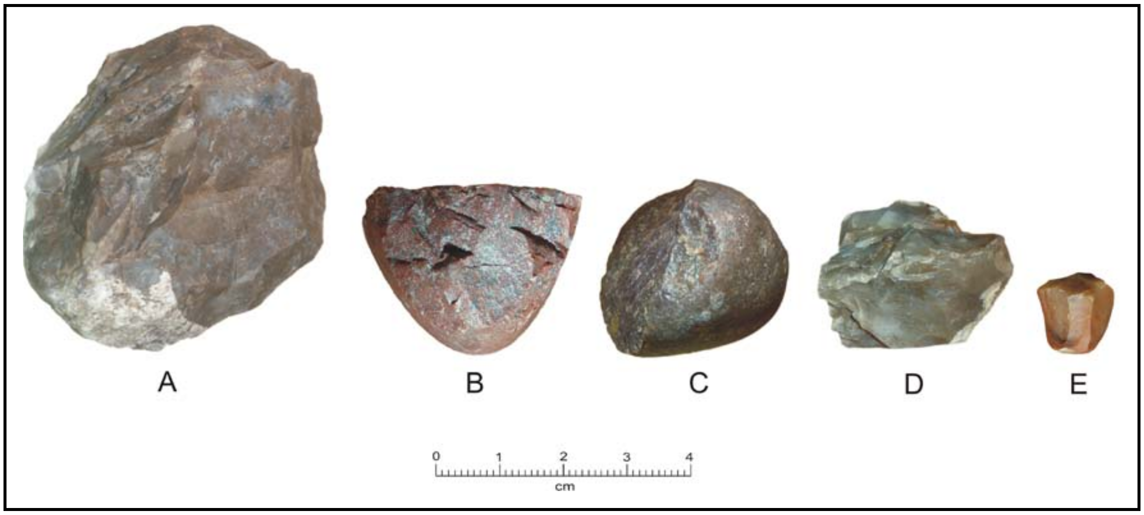

Figure 10.7 Cores and hammerstones recovered from Trench 3

a) Specimen 108-core tool, b) Specimen 109-core, c) Specimen 107-hammerstone, d) Specimen 103/114-core, e) Specimen 107-bipolar core

10.5 Surface

One projectile point was collected within the project boundary during the surface survey. The point, a Harrell/Washita type, is of black chert and is 16.85 mm long, 11.41 mm wide, 3.36 mm thick, and weighs 0.6 g (Figure10.8). Other attributes include neck width (5.8 mm), base width (11.0 mm), blade length (9.78 mm), and a shoulder-to-corner dimension of 8.0 mm. Both the base and blades are nearly straight. The tip and proximal margins are heavily rounded and polished, indicating use other than as a projectile point. Five additional projectile points were recovered during the surface survey, but they were from the area outside the project boundary and are described in Appendix M.

Figure 10.8 Surface point

10.6 Discussion

Table 10.26 lists the non-metric attributes for complete flakes and proximal flake fragments from the three excavated trenches. Proximal flake fragments are included in all categories except dorsal cortex, dorsal scar counts, and terminations. Of particular interest is how uniform the samples are, in some cases sharing identical frequencies. For example, the absence of eraillure scars is 80 percent in the samples from Trenches 2 and 3. However, there are a few subtle differences. Trench 2 has the highest frequency of lipping, diffuse bulbs, multifaceted platform remnants, feathered terminations, abraded or trimmed dorsal platform remnant margins, the fewest flakes with 100 percent dorsal cortex, and the greatest frequency of flakes with three or more dorsal flake scars.

Table 10.26 Non-metric attributes for complete flakes and proximal flake fragments

	Trench 1	Percent	Trench 2	Percent	Trench 3	Percent	Total	Percentage
Complete	668	76.6	195	71.4	203	77.2	1066	75.7
Proximal	204	23.4	78	28.6	60	22.8	342	24.3

	Trench 1	Percent	Trench 2	Percent	Trench 3	Percent	Total	Percentage
Total	**872**		**273**		**263**		**1408**	**100**
Material								
Chalcedony	301	34.5	90	33.0	114	43.3	505	35.9
Chert	385	44.2	134	49.1	109	41.4	628	44.6
Igneous	8	o.9	5	1.8	1	0.4	14	1.0
Limestone	52	6.0	24	8.8	17	6.5	93	6.6
Obsidian	1	0.1					1	.01
Orthoquartzite	12	1.4			4	1.5	16	1.1
Quartzite	103	11.8	16	5.9	16	6.1	135	9.6
Rhyolite	5	0.6					5	0.4
Siltstone	5	0.6	3	1.1	2	0.8	10	0.7
Silic. Wood			1	0.4			1	.01
Total	**872**		**273**		**263**		**1408**	**100**
Eraillure								
Absent	721	82.7	218	78.9	210	79.8	1149	81.6
Present	151	17.3	55	20.1	53	20.2	259	18.4
Lipping								
Absent	497	57.0	175	64.1	117	44.5	789	56.0
Present	375	43.0	98	35.9	146	55.5	619	44.0
Bulb								
Weak/Moderate	729	83.6	232	85.0	212	80.6	1173	83.3
Strong	143	16.4	41	15.0	51	19.4	235	16.7
Platform Remnant								
Abraded/Battered	39	4.5	16	5.8	14	5.3	69	4.9
Collapsed	122	14.0	32	11.7	28	10.6	182	12.9
Cortical	93	10.7	28	10.3	35	13.3	156	11.1
Crushed	40	4.6	9	3.3	8	3.0	57	4.0
Curved	21	2.4	3	1.1	3	1.1	27	1.9
Multifaceted	98	11.2	38	13.9	23	8.7	159	11.3
Unifaceted	459	52.6	147	53.8	152	57.8	758	53.8
Termination								
Axial	25	3.7	14	7.2	3	1.5	42	3.9
Feather	482	72.2	142	72.8	144	70.9	768	72.0
Hinge	161	24.1	39	20.0	55	27.1	255	23.9
Overshot					1	0.5	1	0.1
Preparation								
None	662	75.9	181	66.3	194	73.8	1037	73.7
Abraded	97	11.1	45	16.5	35	13.3	177	12.6
Trimmed	106	12.2	47	17.2	34	12.9	187	13.3

	Trench 1	Percent	Trench 2	Percent	Trench 3	Percent	Total	Percentage
Battered	7	0.8					7	0.5
Dorsal Cortex								
0	451	67.5	122	62.6	132	65.0	705	66.1
0-49	113	16.9	46	23.6	40	19.7	199	18.7
50-99	54	8.1	18	9.2	16	7.9	88	8.3
100	50	7.5	9	4.6	15	7.4	74	6.9
Dorsal Scar Count								
0	55	8.2	11	5.6	16	7.9	82	7.7
1	215	32.2	61	31.3	63	31.0	339	31.8
2	280	41.9	80	40.0	84	41.4	442	41.5
3	104	15.6	40	20.5	34	16.7	178	16.7
4	13	1.9	3	1.5	6	3.0	22	2.1
5	1	0.1					1	0.1
6			2	1.0			2	0.2

Table 10.27 lists the metric attribute/means recorded on complete flakes and proximal flake fragments from the three trenches. Most of the dimensions appear very similar, and in some cases nearly identical. For example, platform remnant thickness means for flakes from Trenches 1 and 3 are 3.504 mm and 3.508 mm, respectively. To explore this patterning, a one-way analysis of variance (ANOVA) was calculated. The null hypothesis states that the various attributes belong to the same statistical population, and was rejected at the 0.05 level of significance for length, midpoint thickness, maximum thickness, and weight. Looking at the means for these attributes, it is clear they are all consistently larger in the sample from Trench 2, and that flakes from Trenches 1 and 3 are more similar.

Table 10.27 Results of the ANOVA for complete flake dimensions

	Trench 1	Trench 2	Trench 3	F-Value	P-Value
Platform Thickness	3.504	3.987	3.508	2.783	0.062
StD	2.356	2.961	2.873		
Platform Width	9.314	9.861	9.068	0.959	0.384
StD	5.948	6.277	5.555		
Maximum Dimension	18.997	20.634	19.209	2.141	0.118
StD	7.795	9.126	14.881		
Length	15.501	17.893	15.608	3.539	0.029
StD	7.214	17.393	14.234		
Width	15.861	17.114	15.773	1.668	0.189
StD	7.845	7.911	12.087		
Midpoint Thickness	4.153	4.886	4.187	4.278	0.014
StD	2.564	3.286	4.422		
Maximum Thickness	4.712	5.465	4.758	3.600	0.028
StD	2.822	3.500	5.132		
Weight	1.652	2.637	1.555	4.863	0.008
StD	2.856	6.544	4.501		

The mean average dimensions of cores from the three trenches mirror the patterns seen in the flake assemblage. Although the samples are small, cores from Trench 2 are larger in all dimensions than in the samples from Trenches 1 and 3. On average, cores from Trench 1 measure 49.41 mm long (StD=12.76), 43.40 mm wide (StD=12.05), 27.33 mm thick (StD=6.08), and weigh 68.45 g (StD=47.41). Cores from Trench 2 measure 63.98 mm (StD=27.74) in maximum dimension, 52.56 mm (StD=27.97) wide, 36.74 mm (StD=15.31) thick, and weigh 208.16 g (StD=310.58). Cores from Trench 3 measure 42.24 mm (StD=20.05) in maximum dimension, 25.62 mm (StD=18.43) wide, 30.0 mm (StD=15.86) thick, and weigh 59.96 g (StD=62.01). Combined, these statistics indicate the sample of lithic debitage from Trench 2 may have been influenced by materials that were slightly larger in their unmodified, parent form. Alternatively, the assemblage from Trench 2 may represent a slightly more formal reduction trajectory with the intention of producing larger flakes and flake blanks.

Overall, the samples of complete flakes from the three trenches are remarkably similar, and some generalizations can be made about the assemblage as a whole. All stages of core reduction are represented in the sample, with a significantly greater proportion of late-stage debitage. Primary flakes, defined as having greater than 50 percent cortex, only represent 15.91 percent (n=162) of the sample of complete flakes, with only 74 exhibiting complete dorsal cortex. Secondary flakes, defined as having some cortex, but less than 49 percent, represent 18.66 percent (n=199) of the sample. Most of the flakes, 66.13 percent (n=705) lacked dorsal cortex. In addition, 20.08 percent of the lithic debitage (n=890), consisted of micro-flakes, the second most frequent class of debitage after complete flakes. The abundance of non-cortical flakes and micro-flakes is strong evidence for secondary and tertiary core reduction and tool manufacture and/or maintenance and rejuvenation.

Cores are relatively infrequent within the total assemblage, and none reflects a formal reduction strategy. Multidirectional cores are the most common (35 percent/n=7), followed by bipolar (20 percent/n=4), core tools (20 percent/n=4), tested cobbles (10 percent/n=2), and fragments (10 percent/n=2). Only one core is unidirectional, with five flake scars. Given that all multidirectional cores begin as unidirectional cores, this single example does not necessarily reflect a different reduction strategy. Similarly, hammerstones are also nearly absent from the assemblage, with a total count of only six. Many of these specimens are also difficult to place within one category or another, frequently sharing attributes of both. Given that these manufacturing-related artifact classes are composed of the same materials as the assemblage of debitage, the low overall count is likely related to the maximization of raw materials at the site. Raw materials represented in the combined core and hammerstone assemblage include chalcedony (38.46 percent/n=10), quartzite (26.92 percent/n=7), chert (23.07 percent/n=6), limestone (7.69 percent/n=2), and extrusive igneous material (3.84 percent/n=1). Cobbles that began as hammerstones may have been recycled as cores before eventually being reduced into flakes and other debitage. The general impression during this lithic analysis is the high frequency of lipping and diffuse bulbs of percussion on flakes is not necessarily related to a biface reduction trajectory. Although not measured, other attributes typically associated with biface reduction, including acute exterior platform angles and flake curvature, did not appear to be unusually prevalent. Instead, the high frequency of lipping and diffuse bulbs of percussion on flakes may be related in part to the use of less dense, workable materials as hammerstones, in addition to typical billets.

The previous statistics and observations suggest most of the assemblage represents middle and late-stages of core reduction with a considerable amount of tool production and/or retouching and maintenance of tools. However, informal modified pieces, bifaces, and projectile points only represent 1.38 percent (n=62) of the flaked-stone assemblage. Similarly, cores (n=20), projectile points (n=17), and bifaces (n=11), are relatively infrequent. This stands in sharp contrast to the preliminary results from the 1957 and 1958 LCAS excavations reported by Corley and Leslie (1960), where almost no lithic debitage of any kind was recorded. They interpret this as evidence that most of the reported tools, including 20 scrapers, 127 projectile points, 5 knives, 2 drills and 2 gravers, were manufactured elsewhere and imported to the site. However, the 1950s excavations only used ¼-inch mesh screens. Alternatively, the areas sampled during this project may represent refuse deposits or activity-specific areas outside of the primary residential zones. The area excavated by LCAS lies to the west and north of the areas tested during this project, and included at least one possible structure. A BLM assessment of the site in 1972 reports the existence of at least one room outside this area, and a total of 240 known projectile points. A TRC survey conducted in 2002 reports two possible structures and three thermal features (Condon 2002:33).

Parry and Kelly (1987) suggest that as a general trend, lithic technology becomes less formal as groups become increasingly sedentary. They propose several methods of investigation, including examining the ratio of bifaces to cores within an assemblage. For this sample, the ratio was 1.47 bifaces for every core, which fits well with their data and the known age of the site, and suggests an increasingly sedentary community. Feature 3, resting on the caliche bedrock at the bottom of Trench 1, was dated with 95.4 percent probability to A.D. 575–651. Most of the assemblage likely dates to this time frame or later. However, the percentage of tools (bifaces and projectile points) with facial retouch does not fit well with their results. Within this assemblage, 28 of the 62 tools (45.16 percent) exhibited facial retouch, and all 62 of the formal and informal tools account for only 1.38 percent of the total 4,479 flaked-stone artifacts. Compared with their data, the ratio of tools with facial retouch is unexpectedly high, and suggests a highly mobile population. In contrast, the low percentage of flaked-stone tools in the entire assemblage is even lower than what would be expected of a completely sedentary community. Even though the site has been repeatedly scoured by modern collectors, which would decrease the total percentage of tools within the assemblage, an increase in the sample of projectile points would only increase the ratio of facially retouched tools.

This suggests something different was occurring at the Boot Hill site, in what the lithic assemblage reflects regarding the characteristics Parry and Kelly (1987) associate with both high mobility and sedentism. However, there is disagreement as to what causes the trends that Parry and Kelly (1987) observed, which is essentially an argument based on mobility (Railey 2010b; Tomka 2001). The characteristics of this particular assemblage might be influenced by a combination of three factors: 1) seasonal sedentism, 2) a heavy reliance on a high-risk species, and 3) the quality of the locally available raw material.

Sedentism limits the range within which raw materials can be acquired. Chert and chalcedony nodules are locally available and can be found eroding from the underlying caliche bedrock. These can be seen in the road cut that passes through the site, and it is possible that some of the pits that have been tentatively interpreted as structures, were quarry pits. Other raw materials, including quartzites, are available as secondary deposits within the Ogallala formation gravels on the Llano Estacado. Overall, these materials can be characterized as moderately abundant, and of moderate quality, with occasional high quality pieces. At least 85 percent of the debitage assemblage was derived from these local materials, with the majority consisting of cherts and chalcedonies. The primary reduction constraint is in the small size and often spherical shape, which lends itself to a bipolar reduction strategy. This is evident in a portion of the Boot Hill assemblage. Overall, most of the assemblage is what you would expect of a semi-sedentary group heavily reliant on local materials of moderate quality for everyday tasks (Andrefsky 1989).

However, if the site occupants were also heavily dependent on a high-risk species such as bison, a reliable, bifacial technology would be advantageous, and would account in part for the large proportion of facially-flaked tools and projectile points reported from the site (Torrence 1989). Further, regardless of the mobility of a population, " tool-using contexts that require the processing of large quantities of resources in a relatively limited time favor the use of formal hafted tools" (Tomka 2001:208). Consequently, it is likely that the lithic assemblage recovered from the Boot Hill site reflects a technology focused on bison hunting, probably on the Llano Estacado, that was constrained only in part by limitations imposed by seasonal sedentism. As the production of arrow points increased over dart points, larger flake blanks, and the techniques to produce them, were no longer necessary (Railey 2010b; Tomka

2001). Given this, formal biface-oriented reduction strategies in Late Prehistoric debitage assemblages did not necessarily diminish, but may have been skewed towards smaller pieces, and therefore, became less archaeologically visible. This is likely reflected in the large proportion of micro-debitage recovered from the Boot Hill site.

11.0 Ceramic Analysis

Adriana Romero

11.1 Introduction

The analysis of ceramics recovered during the TRC testing provides a means of sorting specific pottery styles according to temporal, spatial, and oftentimes functional significance (Figure 11.1). The ceramic assemblage consists of 985 sherds of which 409 were analyzed. Miller (1990) noted that small and eroded El Paso brownware sherds are difficult to identify by type. Therefore, undecorated brownware sherds less than 3-cm in diameter were not analyzed by TRC, but all decorated sherds were analyzed. The remaining 576 sherds measured less than 3 cm and were, therefore, only quantified as specified according to TRC's approved proposal and contractual agreement. The Boot Hill field work preceded (July 2010) the ADCW approved laboratory analysis and distribution of the workshop results (Railey 2010a). However, the attributes incorporated into the final workshop coding spreadsheets and guidelines were used for the Boot Hill analysis and can be converted into the ADCW format.

As suggested by Hogan (2006), Miller (1995), and Wiseman (2002), ceramic groupings were segregated by regional traditions based on the presence or absence of surface decoration, temper type, surface texture, and rim morphology. Local pottery types include Jornada Brown and Jornada Decorated. Nonlocal pottery types include South Pecos Brown, El Paso brownware, El Paso Brown, El Paso Polychrome, El Paso Decorated, Mimbres whiteware, Playas Red, Chupadero Black-on-white, Three Rivers Red-on-terracotta, Gila Polychrome, St. Johns Polychrome, Socorro Black-on-White, and Corona Corrugated (Figure 11.1). An indeterminate category was created for sherds that could not be accurately identified. Recognized types within each group are described and relevant trends are discussed in the following sections.

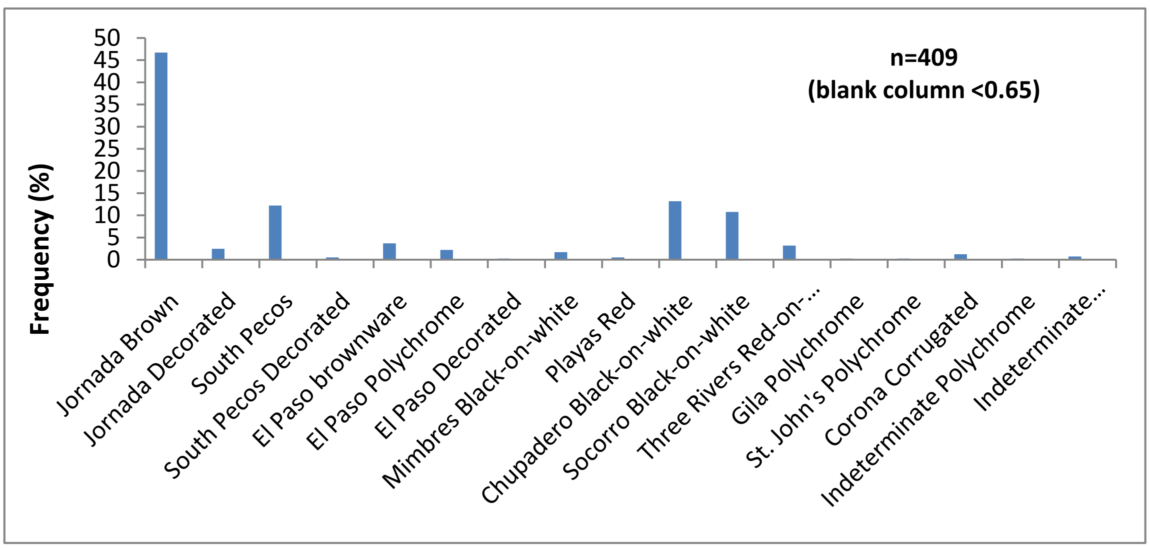

Figure 11.1 Frequency distribution of pottery types identified in the LA 32229 assemblage

11.1.1 Jornada Brown

Jornada Brown, including Jornada Decorated (0.24 percent/n=1), is regionally associated with southeastern New Mexico, particularly the Pecos River Valley, and occurs with the highest frequency in the ceramic assemblage (49.14 percent/n=201) (Figure 11.1). This unpainted pottery type is distinguished from the El Paso brownware variants by a range of brown coloring, exterior and occasional interior polish and smoothing, and fine sand or grit temper (Hill 1996, 2000; Wiseman 2003). Viewed as utilitarian ware, this pottery type dates as early as A.D. 200/400 to 1250/1350 (Hogan 2006). The combined Jornada Brown and Jornada Decorated assemblage consists of 201 sherds. Jornada Brown is associated with the Formative 1 through 7 phases of the Katz and Katz (1993) cultural sequence.

11.1.2 South Pecos Brown

South Pecos Brown is a locally manufactured pottery type that exhibits smoothed-to-polished interior and exterior surfaces, tan to blackish-orange colored paste, and slightly tapering rim profiles (Jelinek 1967:53) (Figure 11.2). Temper commonly includes feldspar and magnetite. South Pecos pottery rarely displays decoration or design reliefs, but when these are applied, they tend to take the form of broad red lines or solid red interiors (Jelinek 1967:53). South Pecos Brown is possibly a derivative of Jornada Brown and dates between A.D. 900 and 1200 (Wiseman 2003:164). The South Pecos Brown assemblage consists of 52 sherds (12.7 percent). South Pecos Brown is associated with the Formative 1 and 2 phases of the Katz and Katz (1993) cultural sequence.

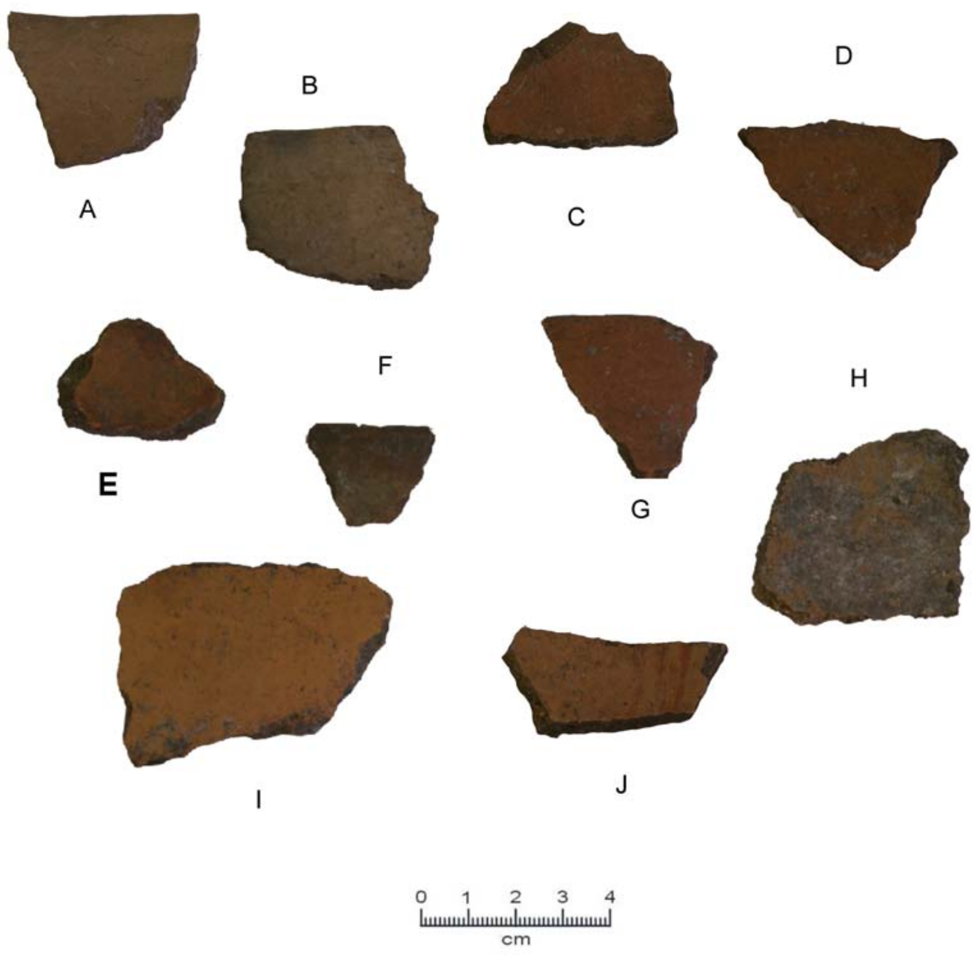

Figure 11.2 Representative Jornada Brown rim sherds, Jornada Decorated, South Pecos Brown, and South Pecos Decorated sherds

Jornada Brown rim sherds: a) Specimen 90-1, b) Specimen 50-1; Jornada Brown body sherds: c) Specimen 44-1 d) Specimen 51-1; Jornada Decorated body sherds: e) Specimen 25-5; Jornada Decorated rim sherds: f) Specimen 46-4; South Pecos Brown rim sherd: g) Specimen 41-5; South Pecos Brown body sherds: h) Specimen 46-3, i) Specimen 56-5; South Pecos Decorated body sherds: J) Specimen 13-7.

11.1.3 El Paso Brownware

El Paso brownware is a catch-all classification for Rio Grande manufactured brownwares that cannot be placed into one of three distinct brownware variants: 1) El Paso Brown, 2) El Paso Bichrome, and 3) El Paso Polychrome (Figure 11.3). El Paso brownware sherds exhibit little polish and range from lighter brown to dark brown. This pottery type is generally given a broad temporal range of A.D. 200/400 to 1450; however, when associated with one of the temporally discrete brownware variants, a more refined age is commonly assigned. The El Paso brownware assemblage consists of 15 sherds (3.67 percent) and is associated with the Formative 1through 7 phases of the Katz and Katz (1993) cultural sequence.

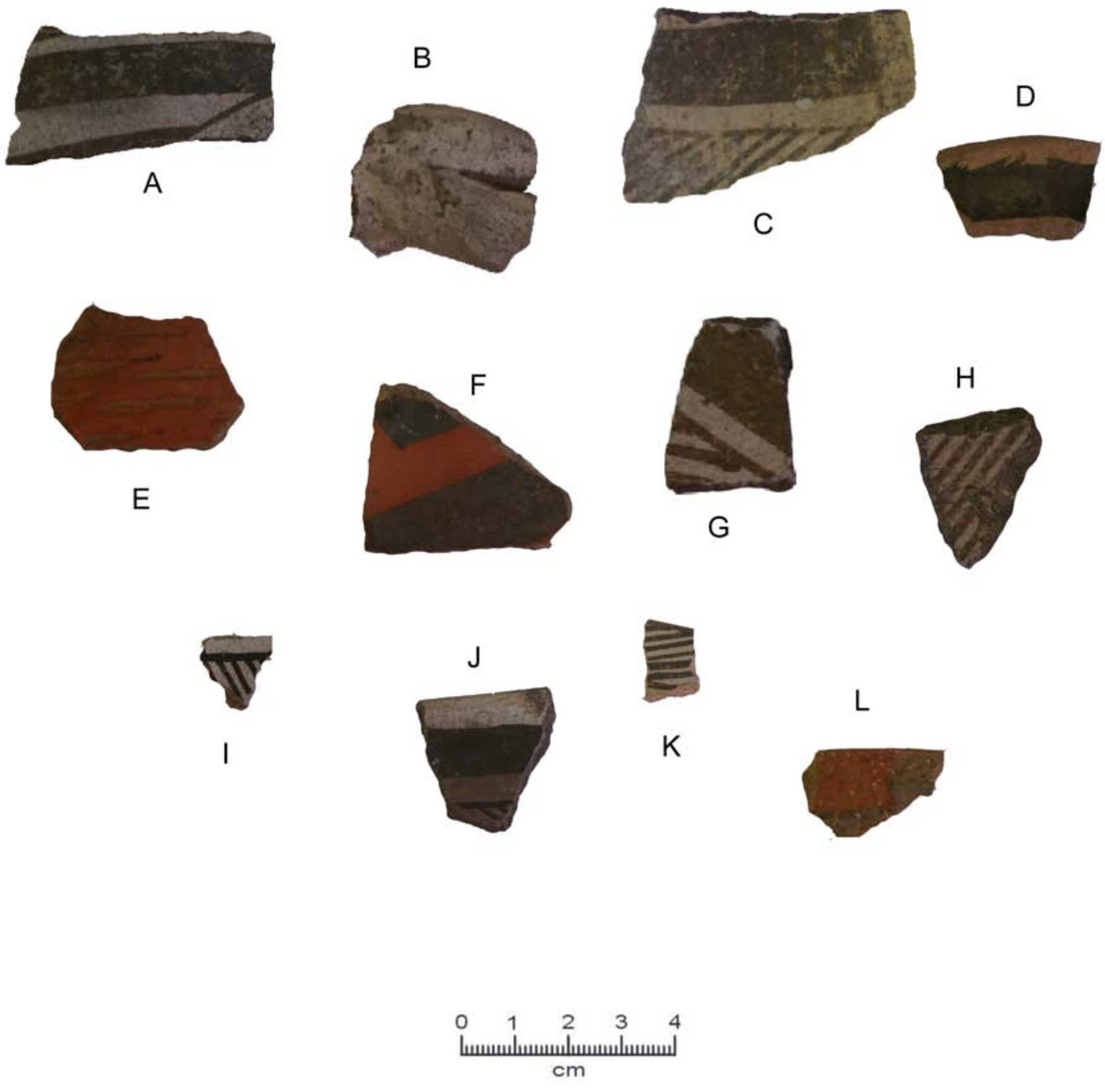

Figure 11.3 Representative nonlocal sherds from the Boot Hill site (LA 32229)

Chupadero Black-on-white: a) Specimen 35-1, b) Specimen 41-2, c) Specimen 33-1, and d) Specimen 137-1; Playas Red: e) Specimen 151-1; St. Johns Polychrome: f) Specimen 142-1; Mimbres Black-on-white: g) Specimen 13-2a and h) Specimen 13-2b; Socorro Black-on-white: i) Specimen 154-1, j) Specimen 39-3, and k) Specimen 121-1; El Paso Polychrome l) Specimen 162-1.

11.1.4 El Paso Polychrome

El Paso Polychrome is an identifying trait of the El Paso phase of the Formative period (A.D. 1200–1450) and is distinguished from El Paso Bichrome and other intrusive polychromes by a graying to brown paste, large angular to subangular quartz, feldspar, gypsum temper; and a decorated exterior surface consisting of alternating thin lines or stepped linear designs (Figure 13.3). Rims are often rounded, expanding, and flared outward from the vessel collar (Kenmotsu 2008; Runyan and Hedrick 1987). The El Paso Polychrome assemblage consists of nine sherds (2.2 percent) and is associated with the Formative 6 and 7 phases of the Katz and Katz (1993) cultural sequence.

11.1.5 El Paso Decorated

El Paso Decorated is a catch-all category into which local brownware sherds exhibiting decorative motifs are placed if they cannot be confidently identified as El Paso Bichrome or El Paso Polychrome. El Paso Decorated pottery types generally date between A.D. 1200 and 1450. A single El Paso Decorated sherd was identified in the Boot Hill assemblage (0.24 percent/n=1) and is associated with the Formative III through 7 phases of the Katz and Katz (1993) cultural sequence.

11.1.6 Mimbres Whiteware

Mimbres whiteware pottery originates in the Mimbres River Valley east of the Mimbres Mountain range and south of the Pinos Altos Mountain range. Mimbres whitewares are characterized by a light gray, dull white paste with medium to fine sand temper (Figure 13.3). Design motifs appear to be spatially and temporally sensitive (Shafer and Brewington 1999). This pottery type is identified throughout the Mogollon region and is associated with the late Mesilla and Doña Ana phases of the Formative period in the Rio Grande valley and the Formative 1 through 5 in the Pecos River valley. Based on Shafer and Brewington (1999), Mimbres pottery is subdivided into three main categories: Style I (A.D. 750–900), Style II (A.D. 880–1020), and Style III (A.D. 1010–1130). The Mimbres whiteware assemblage consists of seven sherds (1.7 percent) and is correlated with the Formative 2 through 4 phases of the Katz and Katz (1993) cultural sequence.

11.1.7 Chupadero Black-on-white

This pottery type is characterized by a dense gray to white homogeneous paste surface over which black colored hatches and solid motifs are applied (Wilson 2003) (Figure 13.3). Manufacturing of Chupadero Black-on-white pottery is thought to occur in south-central New Mexico, but sherds are found throughout the Trans-Pecos region. This pottery dates between A.D. 1050/1100 and approximately 1450/1550 and is associated with the Doña Ana and El Paso phases of the Rio Grande Formative period and the Formative 3 through 7of the Katz and Katz (1993) cultural sequence. The Chupadero Black-on-white assemblage consists of 54 sherds (13.2 percent).

11.1.8 Three Rivers Red-on-terracotta

Three Rivers Red-on-terracotta sherds occur infrequently at the Boot Hill site. This pottery type is thought to originate in south-central New Mexico and is characterized by red painted decorations over an orange to brownish-red slipped surface (Akins 2003; Wiseman 2003). This pottery dates between A.D. 1100 and 1300 and is generally represented by bowls. The Three Rivers Red-on-terracotta assemblage consists of 13 sherds (3.2 percent) and is associated with the Formative 4 through 6 phases of the Katz and Katz (1993) cultural sequence.

11.1.9 Playas Red

Playas Red is traditionally viewed as an intrusive pottery type from the Casas Grandes region of Mexico (Runyan and Hedrick 1987). This pottery type is characterized by a grayish brown to dark gray paste, medium texture temper consisting of feldspar and quartz, and smoothing of the interior and exterior surfaces (Runyan and Hedrick 1987; Wiseman 2003). A red or red-brown slip is a distinguishing trait as are the slightly inverted rims (Figure 11.3). This pottery type dates between A.D. 1150 to 1450 and is associated with the Formative 5 through 7 phases of the Katz and Katz (1993) cultural sequence. Only two Playas Red sherds (0.49 percent) were identified in the Boot Hill site assemblage.

11.1.10 St. Johns Polychrome

St. Johns Polychrome exhibits a distinctive orange-red slip on the interior and less frequently on the exterior. Design motifs include black longitudinal hatching and interlocking scrolls, with gray to cream-colored paste. This pottery originates along the western margins of the Jornada Mogollon region near St. Johns, Arizona, and dates between A.D. 1200 and 1300 (Miller 1995; Runyan and Hedrick 1987). A single sherd (0.03 percent/n=1) was identified in the assemblage, which is associated with the Formative 6 and 7 phases of the Katz and Katz (1993) cultural sequence (Figure 13.3).

11.1.11 Gila Polychrome

Gila Polychrome is associated with the Salado culture and is geographically identified with the Mogollon Rim of Arizona, southwestern New Mexico, and less frequently, west Texas. Stylistically, Gila Polychrome is identified by black-on-white decorative designs separated by bands of red slip on the interior of bowls, and black-on-white design motifs on the exterior of jars. Common design motifs include triangles, checkboards, terraces, hatching, and interlocking scrolls (Ciolek-Torrello and Lange 1990:134; Crown 1994:44). Gila Polychrome was produced from about A.D. 1300–1400 and is associated with the Formative 7 phase of the Katz and Katz (1993) cultural sequence. One sherd (0.03 percent/n=1) was identified in the Boot Hill assemblage.

11.1.12 Corona Corrugated

Corona Corrugated occurs sparsely in the Boot Hill assemblage, with five sherds (1.2 percent) identified. This pottery occurs with Chupadero Black-on-white pottery types and dates between A.D. 1225 and 1460 (Kelley 1984; Wiseman 2002). Originating in the Sierra Blanca region, Corona Corrugated exhibits indentations that point inward into the vessel and downward, resulting in a pattern of that resembles a series of continuous squares. The cultural affiliation is most commonly associated with Gran Quivera (Hayes et al. 1981), and citing Wiseman (2003:87), at Lincoln phase sites in the Sierra Blanca region. Corona corrugated is associated with the Formative 6 and 7 phases of the Katz and Katz (1993) cultural sequence.

11.1.13 Socorro Black-on-white

Socorro Black-on-white is thought to originate in south-central New Mexico. It exhibits well-polished, white slipped exterior surfaces, light gray paste, and opposed solid and hatched motifs (Opplet 2008) (Figure 11.3). This pottery dates between A.D. 950 and 1300. The Socorro Black-on-white assemblage consists of 44 sherds (10.76 percent) and is correlated with the Formative 2 through 7 phases of the Katz and Katz (1993) cultural sequence.

11.1.14 Indeterminate Ceramic Type

This category includes all pottery sherds that could not be assigned a definitive type classification. Unknown pottery is assumed to date between A.D. 200 and 1450; however, this temporal bracket is tentative. Three (0.73 percent) monochrome sherds were placed into the unknown category, in addition to one polychrome sherd (0.03 percent).

11.2 Vessel Form

Vessel form categories include the shape and portion of a jar or bowl from which the sherd originated. In order to ascertain vessel origins, sherds were categorized based on rim shape, the presence and location of decoration or slip color, curvature, vessel portion, and thickness. Standardized vessel forms were limited in extent and included bowl or jar, being distinguished from one another based on whether the orifice is restricted or unrestricted and whether or not a neck or collar is present. Unrestricted openings are defined as having an orifice diameter nearly as great, or greater, than the maximum body diameter. Restricted openings exhibit a minimum rim or neck orifice diameter substantially narrower than its maximum vessel body diameter (Bennett 1974; Rice 1987). Bowls were generally defined as open vessels with unrestricted openings, rounded or conical in shape, and relatively shallow in depth. Bowls were tentatively interpreted as noncooking ceramics used for a variety of functions and based on vessel opening were of varying sizes.

Jars were defined as restricted vessel forms oftentimes with or without necks, relatively deep in comparison to width, with or without handles (e.g., lugs), and round or conical in shape. Jars were tentatively associated with cooking functions and storage and were in all likelihood similar to neckless jars or *tecamates* and *ollas*, or wide-mouthed vessels (Miller 1995). Vessel form was initially conducted on the larger ceramic sample groups, including Jornada Brown, South Pecos Brown, El Paso brownware, Socorro Black-on-white, and Chupadero Black-on-white (Figure 11.4). Of the 201 Jornada Brown sherds analyzed, 80.1 percent (n=161) were classified as jars. The South Pecos Brown assemblage (n=52) primarily consists of jar forms (86.54 percent/n=45). Rio Grande types, consisting of El Paso brownware (n=16) and El Paso Polychrome (n=9) ceramics, yielded 16 (100 percent) and 6 (66.67 percent) jar forms, respectively. Thirty-six (66.67 percent) of the 54 Chupadero Black-on-white sherds were classified as jars. Of the 44 Socorro Black-on-white sherds, 50 percent (n=22) were identified as jars. Clearly, jars are the primary vessel form within the assemblage, with unrestricted bowl forms comprising a small percentage of the assemblage.

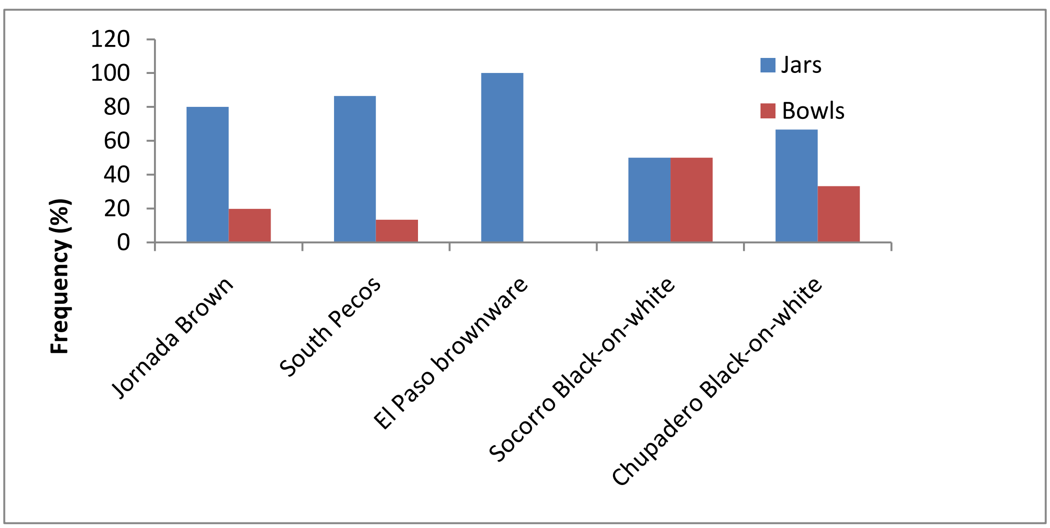

Figure 11.4 Frequency graph showing the distribution of vessel form

When the less frequently occurring pottery types are examined, a more complex picture results. For example, the Three Rivers Red-on-terracotta sherds (n=13) consist of eight bowl sherds, two jar sherds, and three indeterminate sherds. One Gila Polychrome sherd was present in the ceramic assemblage and it was classified as a bowl form. Five of the seven Mimbres Black-on-white sherds are consistent with bowl forms. This pattern is in contrast with the predominant jars represented by the other pottery types. Why the non-local, or more exotic, pottery types more commonly occur as bowls rather than the more functionally flexible jars is intriguing. This pattern is in contrast to the expected increase in bowls as sedentism became more widespread and serving vessels, rather than storage/cooking jars may have become more widespread. The high frequency of jars suggests, on a broad level, mobility continued to be the norm at the Boot Hill site.

11.3 Vessel Orifice

Although the ceramic assemblage varied in diversity, the quantity of rim sherds within each sample group was not sufficient to estimate l orifice diameters. Jornada Brown rim sherds represented 52.8 percent (n=19) of the rim sherd population, distributing the remaining 47.2 (n=17) percent amongst the other 13 sample groups.

The Jornada Brown sample group contained five rim sherds large enough for ascertaining orifice diameter. The average vessel opening is 18 cm (StD 4.77 cm) with an orifice range of 11 to 24 cm. Since the number of rim sherds was limited for the other pottery types a meaningful assessment of their vessel orifice diameters was not undertaken.

11.4 Rim Sherds

Due to the limited number of rim sherds, an alternative to the Rim Sherd Index (RSI) was calculated that classified rim sherds based solely on visibly observed traits as presented in Carmichael (1986). As proposed in Dering et al. (2001:329), basic seriation between four rim shapes: 1) pinched, 2) rounded, 3) flattened, and 4) rounded/flared, should provide a coarse-grained estimate of the temporal and cultural sequence for locally made rim sherds. According to Carmichael (1986), pinched/rounded rims with little vertical curvature are generally associated with the early Formative period. Flat rims with expanding vertical walls are tentatively associated with the middle Formative period. Curved, everted rims with a rounded and flared cross section are associated with the late Formative period.

The analysis examined 27 Jornada Brown, South Pecos Brown, Chupadero Black-on-white and El Paso Polychrome rims (Figure 11.5). Seventeen sherds were Jornada Brown rim sherds. Thirteen (76.5 percent) were classified as rounded and 23.5 percent (n=4) exhibited flattened rim profiles.

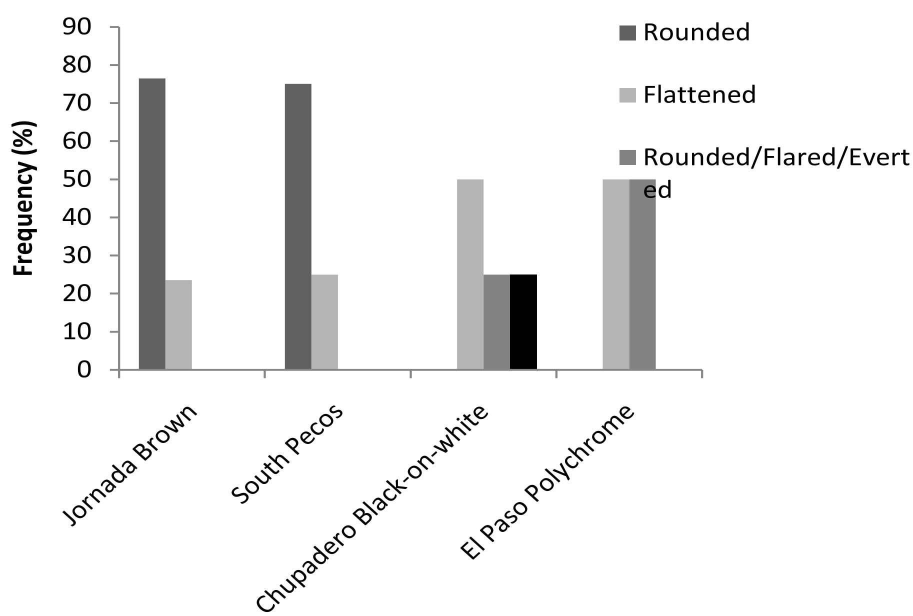

Figure 11.5 Frequency graph showing rim distributions

Four Chupadero Black-on-white rim sherds were analyzed of which two were flattened (50 percent), one was rounded/pinched (25 percent), and one was rounded/flared (25 percent). Four rim sherds were typed as South Pecos Brown of which three were rounded (75 percent) and one was flattened (25 percent).

Two El Paso Polychrome rims were analyzed of which one was flattened (50 percent) and one was rounded/flared (50 percent). Of note are the rounded/flared rim types that are more common during the later Formative period. The presence of these later rim styles possibly suggests there is more diversity within early Formative pottery forms than anticipated or these two rim forms occur later.

Based on the rim form analysis, the Jornada Brown rim sherds conform to the predicted profiles as assigned by Carmichael (1986). Finally, the presence of non-traditional rim forms within each pottery group may also reflect an early introduction, a late continuation, or an early/late pottery type that deviates from the common interpretation.

11.5 Summary

The ceramics from the Boot Hill site indicate three major points: 1) the occupation of the Boot Hill site extended throughout the Formative period until A.D. 1300/1350 with periods of more intense occupation of the site, 2) the predominant quantity of jar sherds suggests the occupants of the site were seasonally mobile rather that sedentary, and 3) the diversity, but infrequent occurrence of non-local pottery points towards local trading with minimal regional interaction or long range trade associations.

Ceramic characterization of the Boot Hill assemblage initially focused on the quantitative, such as pottery classification, rather than qualitative, which includes technological analyses, such as mineral composition or the microstructure of the clay content present in the temper. This was intentional, and measured by the scope of work outlined earlier in this report. As such, a primary goal of this project was to evaluate the range and frequency of the pottery recovered by TRC. The assemblage would provide cross dating to compare with the radiocarbon dates and other sequence dates, to provide a proxy measure based on how frequently a particular pottery type or style occurred at a particular location (Rice 1987:436). The classification system is based primarily on style, which identified 17 pottery types within the sample group of sherds measuring greater than 3 cm in minimum dimension. Overall, the ceramic assemblage reflects a range of pottery types, both local and nonlocal in origin. Local pottery types, defined as those manufactured primarily west of the Pecos River, but east of the Guadalupe Mountains, include Jornada Brown, Jornada Decorated, and South Pecos Brown.

Occurring with the most frequency in the ceramic assemblage is Jornada Brown (including ten Jornada Decorated sherds), which in much the same way as other plain brownwares, provides a relative temporal range for a given region. In this case, Jornada Brown dates between A.D. 200/400 to 1250/1350 and covers the entirety of the Formative period at the Boot Hill site. South Pecos Brown occurs with less frequency, but spans a period of 300 years (A.D. 900 to 1200). These brownwares appear to correspond stylistically with similar undecorated brownware types, including El Paso Brown, despite being manufactured in the eastern extension of the Jornada Mogollon region (Katz and Katz 1993; Miller 1995).

Within Lehmer's (1948) Jornada Mogollon culture sphere are the Rio Grande pottery types, which include El Paso Brown and El Paso Polychrome. These pottery types also occur in relative low frequencies, but reflect the transition from a plain brown, which flourished from A.D. 200 to 1000/1100, to painted wares after A.D. 800/1000 in the Rio Grande valley. The subsequent introduction of polychrome wares (A.D. 1000/1100–1450) is identified in the assemblage from the Boot Hill site. Although El Paso Polychrome occurs in low frequencies it effectively points toward a regional influence at LA 32229 post-A.D. 1000. The Rio Grande valley, including the adjacent Hueco Bolson and Tularosa Basin, fall within the traditional boundary of the Jornada Mogollon region, and holds a tentative association with the Pecos

River valley to the east, despite the general absence of locally made decorative pottery in the Pecos River valley. Moreover, the identification of clays and temper material, as suggested by Hill (2000), suggests the majority of brownware pottery was produced outside the Boot Hill area, primarily in the Sierra Blanca region or the Rio Grande area associated with El Paso.

As discussed by Hill (2000:70), the similarities and presence of pottery types within and between these two areas suggests that populations did not exist in isolation. This construct is saliently demonstrated when more exotic pottery types are discussed. The presence of pottery types northwest, far west, and far southwest of the Boot Hill site can best be explained through regional down-the- line interaction rather than direct trade. The low number of any one, nonlocal pottery type, with the exception of Chupadero Black-on-white, generally supports this interpretation. Not discounting direct use of the Pecos River as an access route, the general high diversity, low frequency of the exotics, and distance suggest that trade and exchange was indirect. Mimbres white ware dates between A.D. 750 and 1130/1150 east of the Mimbres Mountain range and overlaps chronologically with Jornada Brown, South Pecos Brown, and El Paso Brown; all pre-date what is considered the primary occupation at the Boot Hill site. Similar to Mimbres white ware, Socorro Black-on-white dates A.D. 950–1300 and also overlaps with Jornada Brown, South Pecos Brown, and El Paso Brown. Chupadero Black-on-white and Three Rivers Red-on-terracotta originate northwest of the Boot Hill site and date post-A.D. 1100, with the highest frequencies dating between A.D. 1100 and 1300. Playas Red is thought to be a product of the Casas Grande region of Mexico and also dates post-A.D. 1100, and represents a second period of intense occupation at the Boot Hill site.

Ceramics that date after A.D. 1200 tend to support the traditional interpretation of site occupation at Boot Hill (Corley and Leslie 1960). St. Johns Polychrome and Corona Corrugated reflect occupational events as early as A.D. 1200 and A.D. 1225, respectively. Gila Polychrome indicates site use after A.D. 1300, and terminating by A.D. 1400/1450. This is later than suggested by Corley and Leslie (1960). The record of site activity at Boot Hill clearly demonstrates a consistent, although not continuous, use throughout the Formative period. The diversity in the ceramic assemblage establishes a pattern of diachronic site activity that involves interaction at least on a secondary level of influence for the region. Finally, based on the distance to the Boot Hill site from points west, and intensity in the levels of production, it may be safe to suggest that the introduction of several pottery types may not have made their way to the Boot Hill site until late in the sequence or even after the *terminus ante quem* production event had passed.

Vessel form was used cautiously as a means to evaluate function in the absence of a first order context within which the pottery was used. Using the samples of Jornada Brown, 201 sherds greater than 3 cm in diameter were analyzed with attention directed towards two vessel forms, jars and bowls, as they relate to cooking and noncooking activities. Jornada Brown, South Pecos Brown, El Paso brownware, El Paso Polychrome, Chupadero Black-on-white, and Corona Corrugated all clearly demonstrate a predominant singular vessel form. Jars, including both neck and neckless forms represent the dominant form in the Boot Hill assemblage. This interpretation may relate directly to mobility with wide-mouthed, shallow vessels hindering high mobility. Jar forms, which serve a variety of functions, probably maintained a level of stable occurrence as there was a continual need for cooking and storage vessels for all periods of occupation at the Boot Hill site. In contrast, for reasons undetermined, most of the Mimbres white ware, Three Rivers Red-on-terracotta, and Gila Polychrome identified in the assemblage point toward bowls rather than jars.

On the basis of the available data, it seems vessel form is somewhat inconsistent through time with changes in size, form, and presumably function co-occurring during the late Formative period. It is suspected that vessel form can be characterized by a variety of types, including *ollas, tecomates*, and bowls. Consistency is reflected in vessel form and a relatively small-diameter orifice, suggesting narrow jar openings were more the norm rather than the exception.

12.0 Archaeofaunal Analysis

Marie E. Brown and Kenneth L. Brown

The Boot Hill (LA 32229) archaeofaunal assemblage consists of 1620 vertebrate faunal remains recovered from three manually-dug trenches during the present project. A variety of taxa is represented (Table 12.1). The following is a detailed analysis of the archaeofaunal assemblage and forms the basis for addressing several research questions.

- What animals were exploited by the site's inhabitants and which were dietary staples?
- What was the relative importance of small game in the diet?
- What was the role of bison exploitation in subsistence at the site?
- What was the relative contribution of hunting, gathering, and cultivation to the diet?
- What butchering patterns are discernible in the archaeofaunal assemblage?
- How did subsistence strategies change with the introduction of various technological innovations?
- How did subsistence strategies change in response to the increased abundance of bison beginning in the late thirteenth century?
- Did subsistence strategies change with the availability of bison?
- Is seasonal variation in the procurement of animal resources discernible?
- What do the leporid and artiodactyl indices reflect?
- Is there evidence for food stress in the faunal assemblage, such as fracturing long bones for marrow extraction and pulverizing small animals for complete consumption?

12.1 Research Methods

All of the vertebrate faunal remains recovered during the present project were examined for this analysis. No sampling was conducted. Due to the high organic content of the matrix adhering to the bones, the specimens were cleaned by wet brushing. In order to improve identifications and processing information, refits of old and recent breaks were determined whenever possible. In addition, all recently broken fragments from the same bone in a single provenience (bag) were counted as one specimen. These procedures reduced the sample size. Basic attributes recorded for each specimen—a complete bone or tooth or a fragment thereof—included the taxon, element, laterality (i.e., side), fragment and portion, weathering, burning, gnawing, and evidence of butchering and working. These data were entered directly into a Microsoft Office Excel spreadsheet. Faunal identifications were made with the aid of comparative specimens in the possession of the authors, and occasionally, published osteological references were consulted.

Taxonomic identifications were made to the lowest level of specificity (e.g., order, family, genus, species) warranted by each specimen. As a result, most specimens were identified only to a size category (e.g., medium bird, small mammal, large mammal). For birds, small birds are quail-size or smaller and medium are duck-size. For mammals, small mammals are rabbit-size, medium are coyote-size, large are pronghorn-size, and very large are bison-size. Placement of a specimen into an animal size category is somewhat subjective, based primarily on the thickness of the compact (cortical) bone, the size of the specimen, and the possible element represented. In several instances, the specific taxonomic identification—genus or species—was uncertain because of the presence of two or more osteologically similar species (e.g., deer and pronghorn, dog and coyote) in or near the project area. If the taxonomic assignment was less than certain, the modifier *cf.* (compares favorably) was used. In other cases, only the listing of alternatives (e.g., deer/pronghorn, dog/coyote) was possible.

Table 12.1 Faunal assemblage, LA 32229

Taxon	NISP	MNI
Testudinata (Turtles)	6	1
Terrapene ornata (Western Box Turtle)	11	1
Indeterminate small bird (quail-size)	4	1
Indeterminate medium bird (duck-size)	1	1
Leporidae (Rabbits, Hares)	11	
Sylvilagus audubonii (Desert Cottontail)	79	3
Lepus californicus (Black-tailed Jackrabbit)	234	7
cf. *Lepus californicus* (?Black-tailed Jackrabbit)	1	
Rodentia (Rodents)	1	
Spermophilus sp. (Ground Squirrels)	2	1
Cynomys ludovicianus (Black-tailed Prairie Dog)	6	1
Geomyidae (Pocket Gopher)	2	1
Dipodomys sp. (Kangaroo Rat)	2	1
Neotoma sp. (Woodrat)	1	1
Canis familiaris./C. latrans (Dog/Coyote)	2	1
Artiodactyla (Artiodactyls)	11	1
Antilocapra americana (Pronghorn)	22	1
cf. *Antilocapra americana* (?Pronghorn)	6	
Odocoileus/A. americana (Deer/ Pronghorn)	17	
Bison bison (Bison)	5	1
cf. *Bison bison* (?Bison)	27	
Indeterminate small mammal (rabbit-size)	271	
Indeterminate medium mammal (coyote-size)	60	
Indeterminate large mammal (pronghorn-size)	723	
Indeterminate very large mammal (bison-size)	115	
Total	**1620**	**23**

NISP = number of identified specimens
MNI = minimum number of individuals

After the variables were recorded, the number of identified specimens (NISP) was computed for each taxon and the minimum number of individuals (MNIs) was calculated for each identified species or genus (Table 12.1). The calculation of MNI values for higher taxonomic levels and for animal size classes other than mammals (e.g., small bird, medium bird) was determined by the composition of the assemblage. For example, if a specimen was identified to a taxonomic level higher than genus (e.g., Rodentia [order]) and another specimen was recorded at a lower taxonomic level within it (e.g., *Neotoma* sp.), the MNI was determined only for the lower taxonomic level. Likewise, no specific birds were identified. The MNI, therefore, was calculated for indeterminate small and medium birds. In addition, because no remains were identified specifically as either dog or coyote, the MNI for dog/coyote was calculated.

The type of MNI presented in Table 12.1 is the minimum kind. This type considers the site's assemblage as a whole and assumes that all specimens of a specific taxon could represent the same individual, regardless of provenience. As a result, the calculation of MNIs only considered taxon, element, side, portion, and age, which was based on the degree of bone fusion, and porosity—overall ossification—of bone specimens. The bones of very young mammals are distinctly spongier, or less ossified, than those of adults. Data related to tooth eruption and wear were not available. The NISP and MNI values form the basis for the faunal assemblage descriptions and interpretations.

The interpretation of any faunal assemblage is subject to several sources of probable bias. First, because of preservation factors and excavation techniques, it is impossible to recover every bone originally deposited in a site. An excavated assemblage, therefore, is by very nature a sample. In addition, it is a sample of a sample because few sites, if any, are excavated in total. Depending on where excavations occurred within a site—such as in structures, middens, refuse disposal areas, and activity areas—analysis of the recovered faunal remains can produce varying or conflicting interpretations. Sample size is another potential source of bias, particularly in small assemblages. As stated by Grayson (1984:117), “extremely small samples probably do not provide an adequate base from which statistical inferences concerning relative abundances within the target population can be made.” (The target population is the animal set exploited by a group of people [Grayson 1984:116].) Sample size is also subject to other biases.

Relative taxonomic abundances may be significantly correlated with the size of the samples from which they have been determined. Consequently, interpretations of relative abundances may prove to be primarily interpretations of the size of the samples from which the abundances have been derived (Grayson 1984:129). One measure of taxonomic abundance is richness. This refers to the number of taxa (species) that have contributed to a faunal assemblage (Cruz-Uribe 1988:180; Grayson 1984; Leonard 1989:23). Another measure sometimes used to ascertain taxonomic abundance is general diversity, which takes into account both the number of taxa present (richness) and the relative frequency of each taxon (Cruz-Uribe 1988:179). Some researchers (e.g., Grayson 1984:138–149; Leonard 1989; Leonard and Jones 1989; Meltzer et al. 1992) have shown strong correlations between richness and sample size as measured by NISP.

In the present analysis, interpretations are based on NISP, MNI, and relative percentages. The MNI is the number of animals of an identified taxon necessary to account for all the recovered bones of that taxon (Shotwell 1955:330). Although used by American paleontologists as early as the 1920s (see Grayson 1973:433, 1984:27–28), the method for determining MNI was introduced into American archaeology by White (1953). Improvements of White’s technique have occurred over the years (Bökönyi 1970; Chaplin 1971; Grayson 1973, 1979, 1984). The different methods utilized for determining MNI, however, can yield varying results for the same assemblage (see Casteel 1977a, 1977b; Grayson 1973, 1978, 1979, 1984; Horton 1984; Ringrose 1993:126–128). As a result, some researchers see little value in the use of MNI (e.g., Casteel 1977b; Turner 1980). As suggested by Horton (1984:255), “there is no single ‘best’ method, since the one that is chosen depends upon the result desired, and on the particular features of the site and excavation.” With these drawbacks in mind, MNI values are presented as a quantitative counterbalance to the NISP values. It is a means of standardizing the data. In addition, MNI values are used herein because they are relatively unaffected by differential fragmentation among species and samples and are, therefore, better for assuring comparability among indices computed for different samples (Cruz-Uribe 1988:180; Klein and Cruz-Uribe 1984). In addition, not all levels of aggregation to obtain MNI values are likely to be sensible according to site contexts and research questions. The problem of aggregation, therefore, is probably not as great as Grayson (1984) suggests (Ringrose 1993:128).

Not all recovered vertebrate archaeofaunal remains from a site are cultural. Although some researchers base intrusiveness on the presence of partial or nearly complete skeletons of animals such as small rodents (Thomas 1971; Ziegler 1973), analysts also must consider the taphonomic factors affecting the differential preservation of bones (Lyman 1984) as well as recovery techniques. Szuter (1989:209–219) presents five pieces of evidence for interpreting rodent bones. Three of these criteria are used in varying degrees in this analysis: (1) Southwestern ethnographic accounts, (2) ecological studies, and (3) archaeological evidence (including context and condition of the bones).

As indicated by the research questions, elucidation of subsistence patterns is a major focus of this analysis. Subsistence systems involve at a minimum the interaction of humans, technology, and floral and faunal resources. The study of these interactions through time and across space provides a description and an understanding of various lifeways (Lyman 1982:331). A subsistence study, therefore, requires consideration of more than just the animals. It is intimately involved with the interaction of humans—including their technology and adaptive exploitative strategies—and animals with the environment and with each other. Several diverse but related fields of research are used, including ethnography, environmental science, cultural ecology, and animal ecology.

12.2 Natural History and Ethnographic Background

The identified taxa are primarily Upper Sonoran species that occur or formerly occurred in the region, and most were widely exploited for food by both hunter-gatherers and agriculturalists. This section briefly describes the natural history of taxa identified to the level of genus or species within the faunal assemblage (Table 12.1) and summarizes ethnographic information concerning their procurement and preparation by groups in the Southwest and other areas of North America. Although the techniques described are not intended to suggest exact usage by the site's occupants, they have interesting implications for identifying procurement strategies in the archaeological record.

Primary emphasis is given to the procurement of small game. Rabbits and rodents are more abundant in arid and semi-arid habitats than large game animals, and although their procurement may have a lower return, in terms of meat, small game are generally more reliable meat resources and involve less risk and often less effort to procure. For prehistoric groups in the project area, therefore, these taxa might have been a more common dietary component than larger game. Recognition of this component of the subsistence strategy, however, poses several challenges. As described below, most of the techniques used by ethnographic groups to procure rabbits and rodents either do not require modified tools or involve the use of implements made of perishable materials. Furthermore, the methods used to prepare the game often result in fragmentation and sometimes, even the consumption of skeletal elements. The hunting, therefore, of small game, particularly taxa smaller than rabbits, will have a low visibility in the archaeological record at most sites (Brown 1997:178).

12.2.1 *Terrapene ornata* (Western Box Turtle)

The western box turtle (*Terrapene ornata*) is native to the project area and is represented in the Boot Hill archaeofaunal assemblage by 11 carapace and plastron specimens from Trenches 1 and 2. None were found in Trench 3. This turtle, which attains a carapace length of 10 to 15 cm, is a terrestrial species that can enclose itself within its shell. It prefers dry, open grasslands with soils suitable for burrowing and seldom enters wooded areas. Although not dependent on surface water, the box turtle may enter shallow pools during hot weather and is especially active during and after thunderstorms. Burrows can reach depths of 61 cm in open grasslands and some box turtles have been observed using kangaroo rat burrows. Hibernation occurs from October or November to March or April in burrows or in piles of leaves or other surface litter. This species has a population density of more than one individual per acre. Sexual maturity is reached at seven to eight years of age. A clutch of two to eight eggs is laid in late spring to early summer. If a second clutch is laid, it is smaller than the first. The box turtle is omnivorous and feeds during the daytime. Its diet consists of insects, earthworms, vegetation, and carrion (Collins 1974:95–98; Degenhardt and Christiansen 1974:30–33; Degenhardt et al. 1996:104–107; Ernst and Barbour 1972:96–102, 1989:197; Williamson et al. 1994:134). Although the box turtle is sometimes eaten, it is believed to be a source of illness (Ernst and Barbour 1972:95).

In addition, the Boot Hill assemblage contains the distal end of a rib (costal bone) of a large turtle such as a snapping turtle (*Chelydra serpentina*) or spiny softshell turtle (*Apalone spinifera*). Both species occur in the Pecos River drainage of Eddy County, are highly aquatic, and can attain carapace lengths of 45 cm

(18 inches) (Degenhardt et al. 1996:96–98, 122–124; Ernst and Barbour 1972:19, 21, 261, 265; Williamson et al. 1994:123, 125). The flesh of both species is considered delicious (Ernst and Barbour 1972:25, 265).

Turtles were consumed as dietary supplements by various groups, especially during times of food stress. Although not considered particularly desirable, the Mescalero ate turtles during times of food scarcity (Basehart 1960: 28). The type of turtle—terrestrial or aquatic—is not specified. Special techniques may have been necessary to obtain aquatic and semi-aquatic species. Some may have been caught when they ventured onto land to nest. The Cheyenne used a variety of methods for procuring aquatic turtles by hand (Grinnell 1923:I:307–308). Some were caught as they rose to the surface to breathe. "Sometimes when turtles were abundant, and only one or two men or boys were together, they tied grass and willows about their heads, and very slowly approaching a turtle at the surface, put the hands under it and caught it" (Grinnell 1923:I:307–308). The underwater locations of turtles were discerned by long lines of people wading in the water and feeling for the submerged turtles with their feet. The turtles were grasped by hand as they tried to escape or as they were held in place by a foot.

> Sometimes a circle was formed of men, women, and children, surrounding a place in the water where turtles were known to be abundant. The people closed in slowly, and sometimes the turtles all moved to the center of the circle, or some of them tried to pass through the ring of people to go to the bank [Grinnell 1923:I:307].

The turtles were then caught by hand. A similar technique was used by the Hopi (Beaglehole 1936:22). Box turtles may have been easy to procure by simply picking them up when seen.

After killing the turtles with a stone, the Miwok roasted the turtles in ashes until they split open. Then the intestines were removed (Barrett and Gifford 1933:139). The Pawnee made turtle soup (Weltfish 1977:231). After first killing the turtles by putting their heads in a fire, the Cheyenne eviscerated them while they were still in their shells. "Then a large fire was built, and the turtles were placed about it, standing up on the edges of their shells and thus roasted. Some people boiled the turtles in their shells" (Grinnell 1923:I:308). The Florida Seminole usually did not kill the turtles prior to preparation for consumption. "They merely cut off the plastron and butcher the animal alive and kicking, when it is set up before the fire and roasted in its own oven" (Skinner 1913:77). In addition, Southeastern groups ate turtle eggs (Swanton 1946:298).

Besides consumption as food, turtles have also been used as a raw material source for utilitarian and ceremonial objects and ornaments, such as carapace bowls and rattles, by a variety of peoples. The Hopi, one of many groups that used turtle shells as dance rattles, killed the turtles to be used as rattles

> by cutting the skin away from the shell and drawing the body out of the shell by the neck. The body was thrown back into the water in the belief that it would grow a new shell and so be caught again on another occasion.…The shells were brought back to the village and hung up to dry in the sun, being tested at intervals by flicking with the forefinger to determine the amount of drying advisable to produce the maximum sound. Sheep's hooves were tied to the shells to produce the completed rattle [Beaglehole 1936:23].

The Menomini often tipped arrows for use in battle with turtle claws (Skinner 1921:322). Similar uses, however, were not discerned among the turtle remains in the Boot Hill assemblage.

12.2.2 *Sylvilagus audubonii* (Desert Cottontail)

Of the three cottontail species known in New Mexico, the desert cottontail (*Sylvilagus audubonii*) is the most widespread, occurring throughout the state (Bailey 1931:54; Cockrum 1982:133; Findley et al. 1975:89). This leporid, the second most abundant specific taxon (n=79) in the faunal assemblage (Table

12.1), is found primarily at elevations below the coniferous forests, in the Lower and Upper Sonoran zones. It inhabits deserts, grasslands, brushy areas, piñon-juniper woodlands, and riparian zones. The desert cottontail also frequents cultivated fields and the dense vegetation adjoining such fields. Brush or shrubs are necessary for resting and hiding (Bailey 1931:54–60; Chapman and Willner 1978:2–3; Clark and Stromberg 1987:80; Findley 1987:57; Zeveloff 1988:92). This cottontail is normally active early in the morning and at night and subsists mainly on grasses, forbs, cacti, and shrubs (Bailey 1931:55–56; Chapman et al. 1982:102; Chapman and Willner 1978:3). Cultivated plants, including corn, are also eaten (Bailey 1931:55–56; Chapman et al. 1982:101). Much of the cottontail's water requirements are provided by its food (Bailey 1923:71–72; Chapman et al. 1982:102; Findley 1987:57; Zeveloff 1988:92).

Predation by a variety of animals—bobcats, coyotes, foxes, raccoons, skunks, raptors, snakes—is the major cause of cottontail deaths and it is the primary regulator of cottontail abundance (Chapman et al. 1982:106–107; Clark and Stromberg 1987:78–79; Ingles 1941:236; Zeveloff 1988:88, 92). The cottontail, however, is an r-selected mammal. Its high mortality rate is offset by a high reproductive rate. Breeding generally occurs from mid- or late winter through late summer. A single female may have as many as six litters of usually three to six individuals per year. The first and last litters of the year tend to be smaller. Female desert cottontail born in the spring are capable of breeding during their first summer, offsetting their low litter sizes (Chapman et al. 1982:94; Clark and Stromberg 1987:78, 81; Findley 1987:57–58; Hoffmeister 1986:131, 137; Zeveloff 1988:93).

Many peoples, such as the Jicarilla Apache (Opler 1936:207), Navajo (Hill 1938:171), Hopi (Beaglehole 1936:11–15), Havasupai (Spier 1928:108), Yavapai (Gifford 1932:205, 1936:266), Omaha (Fletcher and La Flesche 1911:104), Chippewa (Densmore 1929:44), and Kiliwa (Michelsen 1067), hunted cottontail for food and other purposes. The Mescalero hunted rabbits for their meat when large game was scarce (Basehart 1960:27–28). Cottontail were killed incidentally during communal jackrabbit hunts or drives. Because of their behavior, cottontail could be procured successfully by individual hunters. These leporids usually do not venture far from cover and when alarmed, seek shelter in brush or in burrows. Other escape behaviors consist of "freezing" (remaining motionless) and running and dodging (Ingles 1941:237–238, 249). Because cottontail "travel along open, well-defined routes" (Chapman et al. 1982:116), "wearing trails or runways in the vegetation, snow, or under brush piles" (Schwartz and Schwartz 1981:104), they are easy to find. In addition, cottontail do not run as fast, or as far, as jackrabbits. All these factors make it easier for individual hunters to procure cottontail by simple devices such as snares, traps, bow and arrows, throwing sticks, and guns.

Basin-Plateau groups used snares and bows and arrows for hunting cottontail (Steward 1938:39). The Sanpoil also killed rabbits with bows and arrows (Ray 1932:87), and the Omaha used headless arrows with sharpened shafts (Fletcher and La Flesche 1911:451). Mescalero hunting parties used surrounds and fire to hunt cottontail and jackrabbits. Hunting equipment consisted of club, stones, and bows and arrows (Basehart 1960:28). The Hopi used deadfalls and snares (Beaglehole 1936:17). Plains Cree used several types of snares, including a noose suspended from a tree. The rabbit had to put its head through the noose to reach the bait because a fence of small sticks around the snare made this the only way to reach the bait. Another snare type, a spring snare, was attached to a sapling that had been bent down. A third type of snare "consisted of a forked stick planted fork down in the ground. The noose was attached to the two arms of the fork with strands of grass. Beaters went over a tract of land and the running rabbits plunged through the nooses and were held fast" (Mandelbaum 1940:199). Among the northern Shoshone, boys hunted cottontail with dogs (Lowie 1909:185). When a rabbit was found hiding in a rotten log, the Wind River Shoshone "plugged up the hole with sagebrush and started a fire, fanning the smoke into the log" (Lowie 1924:199). The plug prevented the animal from escaping and after it stopped making noise, "the hole was uncovered and the dead rabbit was pulled out" (Lowie 1924:199).

The Chiricahua Apache and other groups dislodged rabbits from burrows with long sticks. An end was twisted into the fur and then, the animal was pulled out (Opler 1941:326). Before thrusting the stick into the hole, the Navajo pointed and abraded one end so it would catch in the fur easier. If the burrow had two openings, however, the Navajo built a fire in one and smoked out the animal. Cottontail caught in jackrabbit drives were clubbed (Hill 1938:171). The Miwok caught cottontail with nets and then broke the necks of the entangled animals. During the winter, they tracked cottontail in the snow and killed them with clubs (Barrett and Gifford 1933:182). The Yavapai shot rabbits with bows and arrows or used straight or curved throwing sticks. They also surrounded rabbits with fire and then clubbed them. As done by other groups, the Yavapai used sticks to extract rabbits from burrows. Occasionally, they used spring traps or decoyed the animals with a rabbit call made with a finger against one side of the mouth (Gifford 1932:216–217. 1936:266). The Tepehuan caught rabbits by means of many of the above methods or variations thereof (Pennington 1969:123).

After skinning and eviscerating the cottontails, the Tepehuan either roasted them on spits or boiled them (Pennington 1969:123). After removal of the skin and internal organs, the Pomo pounded the carcasses to a pulp, reducing the bones to small fragments that were easily consumed with the broiled meat (Barrett 1952:63). Before cooking the cottontail in hot ashes, the Shoshone skinned and cleaned them (Lowie 1924:197). Although the Havasupai usually roasted rabbits in ashes, they may also have used roasting pits (Spier 1928:117). The Yavapai either cooked rabbits in ashes or boiled them in pots. In addition, they preserved rabbit meat for several days by skinning the rabbits, slightly charring the carcasses, and then hanging them up. The bones were not cracked for marrow extraction (Gifford 1932:205, 1936:266). The Chippewa prepared the carcasses two ways:

> (a) The meat was removed from the bones, roasted, and pounded. The bones were then pounded with what meat remained on them. The pounded bones were boiled in a small kettle and the grease skimmed off and eaten with the pounded meat.
>
> (b) The meat was cut in pieces and dried, the bones being dried also. The bones were pounded to a powder and mixed with the dry meat and any available grease. This was eaten dry, and not boiled at the time of using [Densmore 1929:44].

Various groups also procured cottontail for uses other than subsistence. Caddo women used red-dyed rabbit skins for tying their hair behind their heads (Hatcher 1927:177). The Sanpoil used rabbit fur for caps, mittens, and blankets (Ray 1932:87). The Yavapai (Gifford 1936:272), Ute (Lowie 1924:216), and Plains Cree (Mandelbaum 1940:214) made rabbit skin blankets to wear as robes and/or use as bedding. Although many peoples only made rabbit skin robes with jackrabbit skins, some groups, such as the Havasupai (Spier 1928:188, 190) and Shoshone (Lowie 1924:216), also used cottontail skins. The Mescalero, however, considered rabbit pelts useless (Basehart 1960:28). The Yavapai used rabbit brains to dress skins (Gifford 1932:222). The Havasupai played the cup-and-pin game with either a cottontail or jackrabbit skull (Spier 1928:340).

12.2.3 *Lepus californicus* (Black-tailed Jackrabbit)

Most of the specifically identified faunal remains are those of black-tailed jackrabbit (*Lepus californicus*) (n=235) (Table 12.1), the most common jackrabbit in New Mexico. It occurs throughout the state below the ponderosa forest zone (Findley 1987:55; Findley et al. 1975:93–94). This leporid is usually found at elevations below 1,800 m (6,000 ft), in the Lower and Upper Sonoran zones (Bailey 1913:18, 33, 1931:48). It inhabits deserts and open shortgrass prairies with scattered shrubs. In addition, the jackrabbit is very adaptable to agricultural conditions. Areas of heavy brush or woods are avoided (Dunn et al. 1982:133; Findley 1987:54–55; Findley et al. 1975:93–94, Hoffmeister 1986:140–141; Zeveloff 1988:98). "They are found in mesquite, sagebrush, desertscrub, into open pinyon-juniper" (Hoffmeister 1986:141). The black-tailed jackrabbit is most common, however, in open, treeless habitats (Findley 1987:55).

The jackrabbit usually feeds at night on grasses, mesquite, herbs, and cultivated crops. Like the cottontail, the jackrabbit also obtains protein and certain B vitamins by consuming its soft droppings. Although this leporid depends on succulent or green vegetation for water, it drinks surface water when available. Daylight hours are usually spent in its form, an unlined hollow scratched into the ground. Forms are found both in the open and in dense vegetation. The breeding season extends from mid- or late winter to late summer. A single female may have as many as seven litters of two to four individuals per year. Because the black-tailed jackrabbit is an r-selected species, the yearly number and size of litters per breeding female help offset the high mortality rates. Jackrabbit predators include snakes, eagles, hawks, owls, coyotes, foxes, bobcats and skunks (Clark and Stromberg 1987:84–87; Dunn et al. 1982; Findley 1987:56; Hoffmeister 1986:141–142; Zeveloff 1988:84, 99–100).

Although some people consider jackrabbit flesh unpalatable or inferior to cottontail (e.g., Buskirk 1986:134; Castetter and Opler 1936:25; Dunn et al. 1982:137; Opler 1941:325–326; Texas Game, Fish and Oyster Commission 1945:133–134), ethnographic data indicate many groups exploited jackrabbits as food resources and as raw material sources (e.g., Beaglehole 1936:11–17; Fletcher and La Flesche 1911:104; Gifford 1932:205, 222, 226, 1936:266, 272, 299; Grinnell 1923:I:247, 1923:II:218, 269; Hill 1938:170–171; Michelsen 1967:77; Ruecking 1953:481; Spier 1928:108; Steward 1938:38–39). Jackrabbit behavior is ideal for communal hunts and drives. When alarmed, the jackrabbit may remain motionless or run away slowly or very rapidly. It can attain speeds of 30 to 35 miles per hour over short distances. A jump normally covers 1.5 to 3 m (5–10 ft), but increases to 4.6 to 6 m (15–20 ft) when the animal is speeding. It can jump as high as 1.7 m (5.5 ft) (Dunn et al. 1982:134; Findley 1987:56; Schwartz and Schwartz 1981:119). Consequently, hunting the jackrabbit with a bow and arrow is difficult. Communal efforts are more efficient.

Although the Hopi held communal rabbit hunts at irregular intervals throughout the year, such hunts usually occurred in early summer and fall when the crops needed protection from the rabbits or when rabbits were needed to feed captive eagles. The hunters formed a two-winged circle, and as they walked toward the center, they flushed the rabbits from the bushes and killed them with curved or straight, pointed throwing sticks (Beaglehole 1936:11–17). The Navajo clubbed the jackrabbits as they tried to escape the encircled area. Although the Navajo did not use nets and corrals when hunting rabbits, they used fire occasionally. After encircling the animals with fire, they were clubbed to death as the fire closed in on them (Hill 1938:170–171). The Jicarilla Apache caught jackrabbits with snares (Opler 1936:207). Basin-Plateau groups also used fire surrounds, but not very often "because desert shrubs are usually too widely spaced for a fire to spread" (Steward 1938:39). Instead, jackrabbits were driven into a large semicircular arrangement of long, low nets where the animals were killed with sticks or bows and arrows (Steward 1938:38–39). After driving them into huge nets, as much as 91 m (300 ft) long, the Paiute shot the rabbits with arrows (Lowie 1924:196–197). The Havasupai did not encircle the rabbits. Instead, they used a straight formation to drive the animals, which were then shot, never clubbed (Spier 1928:112). Communal hunts could last from several days to as much as a month (Lowie 1924:196–198; Steward 1938:97). Western farmers used large rabbit drives in the late 1800s to control jackrabbit populations (Dunn et al. 1982:138) because jackrabbits "tend to graze forage more severely than cattle" (Findley 1987:56).

After the Hopi skinned and dressed the rabbits, they cooked the meat in a pot with corn and squash (Beaglehole 1936:14). The Havasupai roasted rabbits in ashes and possibly in roasting pits (Spier 1928:117). Shoshonean groups used several methods for cooking rabbits—hot ashes and watertight baskets into which hot stones were placed to heat the contents. Some Shoshonean groups pounded the bones very fine and consumed them with the meat (Lowie 1924:196–197, 233). The Kiliwa also pulverized the bones. After removing the ribs, they ground the cooked jackrabbit spine in a small, shallow mortar until it had the consistency of thick paste, to which they added salt and then consumed it. The Kiliwa also pounded jackrabbit carcasses on metates (Michelsen 1967:76–77).

Most of the aforementioned groups made rabbit skin robes and/or blankets. Because construction techniques were similar, only that of the Plains Cree is presented:

> A rabbit was flayed by breaking through the skin at the tendons of the hind legs and the whole hide peeled back over the head. The hide was then cut in one continuous strip, three or four inches wide, and hung to dry for two days. It soon curled so that the fur was outermost on all sides. Four poles were lashed together to make a rectangular frame. A strip of hide was laced to the top of the frame and a line of perforations punched along its length. Similar strips were attached to the two vertical sides of the frame. The initial strand of fur was passed in and out of the top holes and then through one hole on the side strip where it was looped back on itself. … The "simple loop" netting technique was used. When one strand ran out, another was knotted to it [Mandelbaum 1940:214].

Jackrabbits also had other non-subsistence uses. Some Northern Shoshone men wore rabbit skin caps with several rabbit tails attached (Lowie 1909:161). Havasupai women sometimes used jackrabbit leg bone tubes as rattles on their belts (Spier 1928:188). A special whistle, made from the femur of a jackrabbit killed by an eagle, summoned eagles during the Navajo Bead Way and Eagle Way chants (Kluckhohn and Wyman 1940:33). The Miwok also fashioned whistles from jackrabbit limb bones (Barrett and Gifford 1933:214). The Havasupai cup-and-pin game used the jackrabbit skull:

> The cup and pin game…consists of a cotton-tail or jack-rabbit skull fastened to a sharply pointed twig, about 8 cm long, by a slightly longer cord.…The base of the skull is cut away, the teeth drawn, and it is boiled free of meat. The cord is tied back of the incisors. Holding the stick, the skull is swung toward the body and caught on the point. Catching by any hole scores one; any tooth hole, six; ear hole (?), ten; incisor hole, forty; and if the stick splits off in a foramen palatinum, the game is won.…Three hundred or more counters are made of soapweed leaves split into narrow pieces, 10 cm long…The side getting all the counters wins [Spier 1928:340–341].

12.2.4 *Spermophilus* sp. (Ground Squirrels)

Very few ground squirrel (*Spermophilus* sp.) remains (n=2) were recovered (Table 12.1). All are from Trench 1. Three species of ground squirrel—the Mexican ground squirrel (*S. mexicanus*), spotted ground squirrel (*S. spilosoma*), and rock squirrel (*S. variegatus*)—occur in Eddy County (Findley et al. 1975:120, 123, 126). The rock squirrel, however, is a large squirrel and the specimens are of a small, mature individual, suggesting they are one of the other two species. The preferred Mexican ground squirrel habitat consists of level grassland with cacti, mesquite, or shrubs. Sandy or gravelly soil is preferred and rocky areas are avoided (Young and Jones 1982:2). Within New Mexico, this species has been found in and adjacent to the Pecos Valley in Eddy, Lea, and Chaves counties (Findley 1987:72–73; Findley et al. 1975:120). This ground squirrel forms loose colonies, lives in burrows with an average depth of 50 cm, and may remain active year-round. Mating occurs in March and April and a litter of one to ten young (average five) is born after a gestation period of about 30 days. Diet varies seasonally, with primarily mesquite beans and leaves (the preferred foods) in the spring and insects and other small animals later in the year (Findley 1987:73; Young and Jones 1982:2–3).

The spotted ground squirrel is the most common and widespread ground squirrel in New Mexico (Findley 1987:73). It dwells in a variety of habitats, from sandy grasslands and deserts to mountain meadows. Although it occurs in grassy areas and pine woods, habitats with dry, sandy soils and sparse, shrubby vegetation are preferred. Burrows extend to a depth of 46 cm (18 inches). A round, grass-lined chamber is constructed at the end of the burrow. One litter (or possibly two—one in spring and one in summer) with four to 12 young (average seven) is born yearly. Adult size is attained in 10 to 12 weeks. Hibernation begins in late August among males and in late September among females and ends in late March. The diet of this ground squirrel includes green vegetation, seeds, forbs, cacti, grasshoppers and other insects, kangaroo rats, and lizards (Clark and Stromberg 1987:104–105; Cockrum 1982:76–77; Findley 1987:73; Findley et al. 1975:121–123; Hoffmeister 1986:179–181; Zeveloff 1988:133–134). Predators include bullsnakes, carnivores, and raptors such as red-tailed hawks (Clark and Stromberg 1987:105; Zeveloff 1988:134). The spotted ground squirrel has been reduced or extirpated in portions of its range. Because it inhabits the same areas as prairie dogs, its numbers have decreased as the result of poisoning campaigns against prairie dogs (Hoffmeister 1986:181).

Several groups hunted ground squirrel for food and other uses. Even early Euro-Americans ate these animals and sometimes used the skins for clothing (Tomich 1982:202). Basin-Plateau groups caught ground squirrels by pouring water into the burrows and capturing the animals as they tried to escape. Digging sticks or rodent skewers were used to remove them from their burrows. They were also smoked out. Away from their burrows, they were killed with deadfalls or were run down and dispatched with sticks and stones (Lowie 1924:199; Steward 1938:40). “The Tepehuan hunt five species of squirrels that are killed either because they are edible or because they prey upon newly planted corn fields” (Pennington 1969:134). Two of these species are ground squirrels that are either killed with bows and arrows or caught in a rock or basket trap (Pennington 1969:124). The Sanpoil flooded ground squirrels out of their burrows and then killed them with clubs (Ray 1932:87). The Havasupai used deadfalls to kill squirrels. “Traps are placed on the rodent trails in the fields and near storehouses to catch the squirrels and rats which root up the corn, tear their way into the storehouses, etc.” (Spier 1928:113). The Yavapai caught ground squirrels in stone deadfall traps. They also extracted them from their burrows with sticks (Gifford 1936:266–267). The Miwok hunted squirrels mostly in the winter, when they were fat. They were shot with bows and arrows or captured by dogs (Barrett and Gifford 1933:137, 183).

The Miwok (Barrett and Gifford 1933: 183) and Havasupai (Spier 1928:117) did not preserve squirrel meat but rather, prepared it for immediate consumption. If the animal was to be boiled, the Havasupai first eviscerated it and removed the skin, head, and tail. If it was to be roasted, it was only eviscerated (Spier 1928:117). The Yavapai cooked ground squirrels in an earth oven after they eviscerated and skinned them (Gifford 1936:267). After the ground squirrels were skinned and drawn, the Tepehuan roasted them either on spits or on coals (Pennington 1969:124). Great Basin peoples prepared ground squirrels for consumption by first burning off their fur in an open fire. “They might then have been pit roasted whole, sometimes eviscerated and stuffed with wild onions. Ground squirrels…were also boiled and pulverized in a mortar or on a metate” (Fowler 1986:82). Preparation of these animals included processing the bones and entrails (Fowler 1986:82).

In addition to eating the ground squirrel, the Yavapai used its skin for a tobacco bag:

> Ground squirrels taken for food, normally skins not saved. August was the best time to obtain squirrel skin for tobacco bag. Deadfall trap used, baited with prickly pear…To skin squirrel, cuts were made on inside of both hind legs and carried to anal opening. No cut made full length of abdomen. Cuts in legs later sewed, leaving opening 1½ in. in diameter for insertion of tobacco. No brains used on squirrel skin, which was held in worker’s lap or on his leg and rubbed with small stone [Gifford 1936:273].

12.2.5 *Cynomys ludovicianus* (Black-tailed Prairie Dog)

Few remains of the black-tailed prairie dog (*Cynomys ludovicianus*) (n=6) were recovered (Table 12.1). All are from Trenches 1 and 2. None are from Trench 3. Today, this species is found in the eastern half of New Mexico, but its range formerly extended into the southwestern portion of the state (Bailey 1931:120; Findley 1987:67; Findley et al. 1975:130–131). The black-tailed prairie dog is primarily an Upper Sonoran species (Bailey 1913:32, 1931:120, 123) that inhabits semi-arid shortgrass prairies with deep, well-drained soils and avoids tall grass areas, sandy soil, rocky soil, and heavy deposits of clay. It is a highly social animal that lives in very large colonies that can extend over large expanses of plains. Family groups retain some cohesion and independence within the well-organized colonies. Communication among colony members is both vocal and visual. A dome- or doughnut-shaped mound—1 to 2 m in diameter—surrounds the burrow entrance, which may extend almost vertically to a depth of 1 to 3 m before leveling off. The entrance mound prevents water from entering the burrow. The burrow system is extensive and permanent, with the nest in the deeper portion. The black-tailed prairie dog does not hibernate. Breeding occurs in winter—from late January to March—and after a gestation period of 28 to 32 days, a single litter of about four young is born. Growth lasts for about 1.5 years and females begin breeding during their second year. The diet primarily consists of grasses—seeds, leaves, awns, and stolons—but also includes plants such as prickly pear cactus, wild onion, saltbush, rabbitbrush, mesquite, scarlet globemallow, ironweed, pigweed, and plantain. The plant material provides the main water requirements. The black-footed ferret (*Mustela nigripes*), a presently endangered species, was the most specialized predator of the black-tailed prairie dog. Formerly, both species had nearly identical distributions. Other predators include eagles, hawks, owls, weasels, coyotes, foxes, bobcats, badgers, and snakes (Findley 1987:67–68; Hoffmeister 1986:194–196; Long 2002; Zeveloff 1988:145, 147). The burrowing activities of prairie dogs can severely impact buried cultural deposits if their colonies are established in a buried site.

Prairie dogs are considered food competitors of domestic livestock. Much effort, therefore, has been devoted to eradicating them from rangeland. Such programs have primarily used poisons. As a result, prairie dogs are extinct within many areas of their former range (Findley 1987:68). Conservationists and ecologists, however, consider prairie dogs as a “keystone species,” “an animal with a wide impact on the environment because of the other life forms it influences” (Long 2002:130).

> Constant foraging on plants in the colony keeps plants in a constant state of regeneration. Plants that are affected by this kind of grazing activity typically have more nutritive value than older, mature plants, generating a higher quality of food. This benefits prairie dogs but it also is a factor in attracting other grazing animals—among them bison, antelope, deer, and domestic cattle—to such a site [Long 2002:121].

Prairie dog colonies and their associated vegetation also attract a wide variety of smaller animals—raptors, songbirds, carnivores, rabbits, other rodents (e.g., kangaroo rats, pocket gophers, pocket mice, ground squirrels), snakes, lizards, turtles, toads, frogs, and insects—some of which are prey species for the others. In addition, the burrows provide shelter for other animals—toads, snakes, spiders, and a variety of insects. Burrowing owls inhabit abandoned prairie dog burrows and box turtles use them for hibernation (Long 2002:105–106, 122–130).

The Hopi used (and perhaps still use) deadfalls and snares to catch prairie dogs (Beaglehole 1936:17). Northern Shoshone boys used dogs to hunt prairie dogs (Lowie 1909:185). The Navajo dug or drowned prairie dogs out of their burrows or shot them with bows and arrows.

> Special arrows were used in hunting prairie dogs. These were unfeathered and the points had only one barb. (Formerly when arrow points were found, one barb was broken off, or bone points of this pattern were made. With the introduction of iron, points of the same type were hammered out) [Hill 1938:171].

The Navajo also used a piece of mica, placed on a split stick, to blind a prairie dog as it emerged from its burrow. It was then shot and pulled out with a barbed arrow.

> After heavy rains flood waters were directed into holes to drown out the prairie dogs.… Water was also carried to the holes for this purpose. The hole was first plugged with manure and grass, and a basin built around it. When the basin was filled, the plug was removed, allowing a large volume of water to descend into the hole at one time [Hill 1938:172].

If several frightened prairie dogs ran into the same hole, the Navajo dug them out with a digging stick. The Navajo also trapped these animals by placing nooses attached to a rock or stake at burrow entrances (Hill 1938:172). Basin-Plateau groups used similar methods. “They [prairie dogs] were either dug with a digging stick, pulled from their burrows by means of a rodent skewer, smoked out, flooded out, or killed with deadfall traps” (Steward 1938:40). The Yavapai caught prairie dogs in stone deadfall traps (Gifford 1936:266).

The Navajo generally used only one method for cooking prairie dogs. After the carcass was cleaned, the liver, lungs, and fat were placed in the body cavity and it was salted. The opening was pinned closed with twigs. “Then the hair was singed in an open fire and the animal buried in the ashes to roast” (Hill 1938:172). The Yavapai cooked prairie dogs in hot ashes after first cleaning and skinning them (Gifford 1936:266). The flesh is reportedly very greasy (Elmore 1938:152).

12.2.6 Geomyidae (Pocket Gophers)

The faunal assemblage contains very few pocket gopher (Geomyidae) remains (n=2) (Table 12.1). All are from Trench 3. The range of Jones’s pocket gopher (*Geomys knoxjonesi*) and the yellow-faced pocket gopher (*Cratogeomys castanops*) includes the project area (Davidow-Henry et al. 1989:2; Hopton and Cameron 2001:2). Formerly a subspecies of the Plains pocket gopher (*Geomys bursarius*), Jones’s pocket gopher, which is smaller than the yellow-faced pocket gopher, is restricted to deep sandy soil. Breeding occurs from late October to early April, with a 23-day gestation period. It does not hibernate and is active year-round. This pocket gopher primarily subsists on tubers, roots, and stems of a variety of plants (e.g., grasses, sunflower, yucca) (Hopton and Cameron 2001:1–2).

In areas of overlap with *Geomys*, the yellow-faced pocket gopher, a moderately large gopher, occupies the harder, shallower soils of the interfluves, while *Geomys* is most common in the soft alluvial soils of floodplains and arroyo bottoms. When not competing with *Geomys*, the yellow-faced pocket gopher prefers deep, friable soils relatively free from rocks (Davis and Schmidly 1994:130–131; Findley et al. 1952–155; Fitzgerald et al. 1994:209). The yellow-faced pocket gopher primarily subsists on roots and stems, including the outer bark on tree roots, and it also consumes crops—alfalfa, clover, and garden vegetables (Davis and Schmidly 1994:131; Fitzgerald et al. 1994:209). “The animals harvest materials either from within the tunnel system by pulling plant roots and shoots down through the soil or by venturing out above ground to forage” (Fitzgerald et al. 1994:209). Breeding occurs from February through August. One or two litters of mainly two or three young are born in fur- or grass-lined nests deep within the burrow. The nest may be as much as 1.6 m deep. Major predators consist of owls, hawks, snakes, badgers, weasels, bobcats, foxes, and coyotes (Chase et al. 1982:250; Davis and Schmidly 1994:131; Findley 1987:75–76; Fitzgerald et al. 1994:210).

The pocket gopher is a highly fossorial rodent that lives a solitary life almost entirely underground. Depending on soil conditions, burrow systems can vary from less than 30 cm to more than 1 m in depth (Hoffmeister 1986:224). In clayey soil, tunnels and mounds are smaller than in sandy soil (Davis and Schmidly 1994:130). In general, burrow systems consist of a shallow network of foraging tunnels and a deeper network containing food stores and the nest chamber (Fitzgerald et al. 1994:209). The main tunnel has been measured to depths of 1.5 m below the surface (Felthauser and McInroy 1983:557). Feeding tunnels parallel the surface and average between 10 and 30 cm deep. During winter, pocket gophers burrow through snow, depositing soil excavated from their underground burrows in the snow tunnels (Chase et al. 1982:246; Findley 1987:75; Hoffmeister 1986:225; Zeveloff 1988:161, 165). Pocket gophers mix and deepen the soil, and a single individual can displace one to three tons or more of soil annually (Kennerly 1964:428; Richens 1966:533). Thus, the impact of faunalturbation on the cultural deposits of archaeological sites containing remains of this burrower can be considerable. Several researchers (e.g., Bocek 1986, 1992; Erlandson 1984; Johnson 1989) have studied the effects of pocket gopher burrowing activities on the distribution of archaeological materials.

Ethnographic data indicate several groups ate pocket gophers, including the Gosiute Shoshone (Steward 1938:138–139), Navajo (Hill 1938:172), Tepehuan (Pennington 1969:124–125), and Plains Cree (Mandlebaum 1940:199). Basin-Plateau groups caught pocket gophers by pouring water into the burrows and capturing the animals as they tried to escape. They used digging sticks or rodent skewers to remove them from their burrows, and they also smoked them out. Outside the burrows, the pocket gophers were killed with deadfall traps or were run down and dispatched with sticks and stones (Steward 1938:40). The Plains Cree caught gophers with snares. "A sinew noose was placed over a gopher's hole. The other end of the line was held by the snarer. When a gopher appeared the line was jerked tight" (Mandelbaum 1940:199). The Gros Ventre used a similar technique (Kroeber 1908:149).

After the gophers were skinned and cleaned, the Gosiute Shoshone dried the meat without removing the bones (Steward 1938:130). The Tepehuan skinned and cleaned the gophers before they were either roasted on a spit or boiled with other meat (Pennington 1969:125). The rodents also had nonfood functions. The Navajo drank a mixture of water and a gopher stomach and flesh as a stomach ache remedy (Hill 1938:172). Such usage, however, is invisible in the archaeological record.

12.2.7 *Dipodomys* sp. (Kangaroo Rat)

The kangaroo rat (*Dipodomys* sp,) is represented by two specimens (Table 12.1), one each from Trenches 2 and 3. The ranges of three kangaroo rat species—Ord's kangaroo rat (*D. ordii*), the banner-tailed kangaroo rat (*D. spectabilis*), and Merriam's kangaroo rat (*D. merriami*)—include the project area (Best 1988:2; Findley et al. 1975:184; Garrison and Best 1990:2). Ord's kangaroo rat occurs throughout New Mexico (Cockrum 1982:101; Findley et al. 1975:175; Garrison and Best 1990:2). It is a solitary, nocturnal, desert-dwelling burrower that lives in a variety of habitats. In the northern portion of the Southwest, it lives in open piñon-juniper areas and in areas just below this zone. It occurs on alluvial fans, on flats, and in shifting sands. This rodent prefers friable soils, especially sand. Excess food is stored in shallow holes or in deep, cool underground burrows that provide protection from the heat and predators during the day when the entrances are plugged. A female may have two litters a year. The litters, consisting of two to four young, are born from February through July. The diet of the Ord's kangaroo rat primarily consists of seeds, but green leaves, buds, tubers, and insects are also eaten. Predators include owls, snakes, foxes, weasels, badgers and bobcats (Bee et al. 1981:117–118; Clark and Stromberg 1987:137–139; Findley et al. 1975:174; Hoffmeister 1986:298–299; Zeveloff 1988:181–182).

The banner-tailed kangaroo rat, the largest of the three species, occurs throughout much of New Mexico (Best 1988:2; Cockrum and Petryszyn 1992:184; Findley et al. 1975:181). It inhabits arid and semi-arid grasslands, preferring areas where grass is readily available. This kangaroo rat has an extensive burrow system, with as many as 12 openings, that provides refuge and contains food caches and nest cavities. Due to the complexity and depth of the burrow systems, heavy soils are preferred (Bailey 1931:262; Findley 1987:82–83; Findley et al. 1975:180–181; Hoffmeister 1986:306; Zeveloff 1988:186). "Large mounds, composed of soil and vegetation, up to 4 feet high and 15 feet wide, surround the burrows" (Zeveloff 1988:186). As many as three litters, each with one to four young, are born between January and August. This nocturnal rodent consumes primarily grass seeds. It is preyed upon by badgers, swift foxes, coyotes, and bobcats (Davis 1974:183; Hoffmeister 1986:307–308; Zeveloff 1988:186).

Although preferring sandy soil, when Ord's kangaroo rat occurs in the same area, Merriam's kangaroo rat is more likely found on desert pavements or other harder soils. It is usually associated with mesquite and other leguminous shrubs (Findley et al. 1975:183). Burrows are usually simple and shallow. One or two litters, of usually two to four young, are born in spring and fall. The main diet of this species consists of a variety of seeds, but forbs and shrubs are also eaten. Major predators are owls, snakes, coyotes, foxes, and badgers (Cockrum 1982:100–101; Davis 1974:185–186; Hoffmeister 1986:311–312; Zeveloff 1988:186–188).

The Navajo used several types of deadfall traps to rid their agricultural fields of kangaroo rats (Hill 1938:172–173). The Havasupai also used deadfall traps to eliminate rats from their fields and storehouses, but the type of rats is not specified (Spier 1928:113). A few groups, such as the Hopi, ate kangaroo rats (Tyler 1975:3). The Hopi caught them with deadfall traps placed around the edges of their fields (Beaglehole 1936:17). The Papago ate kangaroo rats only as a last resort (Castetter and Underhill 1935:42). The flesh of these rodents is described as white, tender, and tasting like frogs' legs or chicken (Davis 1974:188).

12.2.8 *Neotoma* sp. (Woodrat)

The woodrat (*Neotoma* sp.) is represented by a single specimen from Trench 1. Boot Hill is within or near the range of two woodrat species—the Southern Plains woodrat (*Neotoma micropus*) and the white-throated woodrat (*N. albigula*). Each tends to occupy different habitats. The Southern Plains woodrat is primarily a grassland species that tends to avoid rocky areas. This species prefers xeric or semi-arid regions with thickets of cacti, mesquite, and thornbush. Houses are constructed of sticks and spiny vegetation in the midst of cacti or thorny bushes. Oftentimes, an underground burrow system is dug. These construction methods provide protection from larger animals. Openings, at least two, near the base of the house are indicated by well-worn trails leading to them. This rodent's diet mainly consists of the flesh and fruit of cacti; however, mesquite beans and pods, fruit, seeds, and a variety of green vegetation are also eaten. Water requirements are supplied by the food eaten. Breeding generally occurs from mid- or late winter until late summer. A female may have two or more litters per year. Although litters may consist of as many as six young, the usual number is two to four. Major predators include bobcats, ringtails, foxes, coyotes, hawks, and owls (Bailey 1931:171–174; Davis 1974:218–219; Findley 1987:98–100; Findley et al. 1975:238–240).

The white-throated woodrat occurs in a variety of habitats, usually below the conifer zone. It is frequently found in piñon-juniper and is common in extensive cholla and prickly pear cactus areas. Cacti provide food and water, protection for the nest, and function as anchors for the houses. Rocky areas are also selected as house sites. Mesquite, herbs, and shrubby vegetation supply additional food. Cactus joints, sticks, thorns, and other available materials are used to construct the houses, which average about 2.5 m in diameter and about 1 m high. The nest, which is partially dug into the ground below the house, is usually constructed of grasses and is about 20 cm in diameter. It is used as a daytime retreat and to raise the young. A female may have more than one litter, usually consisting of two to four young, per year. Major predators include owls, snakes, ringtails, coyotes, badgers, bobcats, and weasels (Bailey 1931:175–180; Cockrum 1982:114–115; Davis 1974:221; Findley 1987:97–100; Findley et al. 1975:241–242; Hoffmeister 1986:406–407; Zeveloff 1988:209–210).

The woodrat is often called a "pack rat" from its habit of collecting all sorts of objects, both cultural and noncultural, and incorporating them into the den or nest. This rodent can disturb the artifact distribution patterns of a site and/or create pseudo-features (Hester and Hill 1980; Hoffman and Hays 1987). Burned woodrat houses, including contents, look suspiciously like prehistoric hearths (Hester and Hill 1980). Therefore, woodrats are a potential agent of faunalturbation at sites in which their bones are found. However, the presence of woodrat bones in a site's faunal assemblage is not necessarily indicative of intrusion. As suggested by ethnographic data, the woodrat was exploited by several groups.

The Jicarilla Apache (Opler 1936:207), Navajo (F. Bailey 1940:284; V. Bailey 1931:185; Hill 1938:173), Walapai (McGuire 1983:32), Basin-Plateau groups (Steward 1938:40, 83, 158), Kiliwa (Michelsen 1967:74), Yavapai (Gifford 1932:205, 1936:266), and Chiricahua Apache (Opler 1941:325) are among those groups that ate woodrats. This rodent was a staple in the diet of peoples in southern Texas (Hester and Hill 1980:318). Ethnographic literature also indicates the Omaha (Fletcher and La Flesche 1911:104) and Tonkawa (Newcomb 1961:139) consumed unspecified rats (possibly woodrats). The flesh of this rodent has been described as "tender, sweet, and delicious as young rabbit or quail" (Bailey 1931:180).

Basin-Plateau groups used woodrat hunting techniques similar to those for ground squirrels and prairie dogs (Steward 1938:40). The Navajo killed woodrats after digging them from their nests (Hill 1938:173). The Chiricahua worked in pairs when hunting woodrats. While one hunter poked a stick into a nest opening, the other hunter waited for the prey at the other opening. When it came out, it was shot with a headless arrow that had a sharpened shaft. Sometimes the hunters hit the woodrats with a stick when they tried to escape the nest (Opler 1941:325). The Hopi caught rats with deadfalls and snares (Beaglehole 1936:17). The Kiliwa poked a pole into the nest. When the frightened animal attempted to flee, it was stamped by a hunting companion's feet, killed with rocks, or shot with an arrow. If the woodrat refused to emerge, the nest was burned (Michelsen 1967:75). The Walapai used a hooked stick to remove woodrats from their nests (McGuire 1983:32). The Yavapai used several methods to procure woodrats. Woodrat nests in cacti or bushes were pulled apart with the curved end of 6- to 8-ft sticks. The rats were killed as they tried to escape. In addition, the hunters took the piñon nuts stored in the nests. Woodrats were also forced from their nests by poking the straight end of the long sticks into their nests. Stone deadfall traps were used, as were bows and arrows or sticks. If a hunter seized a woodrat by its neck with his bare hands, the rodent was struck against the rocks to kill it (Gifford 1932:217, 1936:266). The Tepehuan trapped woodrats with an inverted, tilted earthenware bowl "supported by a figure-four release mechanism and baited with a few grains of corn or wheat (Pennington 1969:125).

Michelsen (1967:76) provides a detailed description of the preparation of a woodrat for consumption by the Kiliwa:

> Preparations for eating are quick and efficient. First a fire is built of small branches. While the flames are high the whole animal is tossed into the fire. When the hair is well singed the rat is removed with a pair of sticks, used as tongs, and placed on a branch of fresh juniper or some similar evergreen. The skin, partially cooked, slips off cleanly and easily. The entrails are removed and the rat laid on the green boughs. After the flames of the fire have died down sufficiently the carcass is placed on the coals to roast for 10 or 15 minutes.
>
> The most remarkable part of the procedure takes place after the meat is cooked. The legs are pulled off and nibbled in the classic manner. However, the rib cage, spine and pelvis are placed on a flat rock, sometimes a metate, and thoroughly crushed with a hammerstone. The carcass, well shredded, is then eaten, bones and all.

After singing off the fur, Great Basin groups pit-roasted woodrats whole or eviscerated them and stuffed them with wild onions (Fowler 1986:82). The Yavapai prepared woodrats for consumption in several ways. They either boiled them whole or with the intestine removed. After skinning and eviscerating the woodrats, the Yavapai placed the skin in the abdominal cavity and baked the carcass under ashes. The skin was consumed as a delicacy. In addition, woodrats were preserved for short periods for later consumption. In that case, they were slightly charred after skinning and were hung in the hut in bundles of 20 or 30. They could be kept this way for a few days, and when they were to be eaten, they were boiled (Gifford 1936:266). After skinning and cleaning the woodrats, the Tepehuan roasted them either on a spit or over coals (Pennington 1969:125). The Navajo frequently ate woodrats in the early days and either baked the meat on live coals or boiled it (Bailey 1940:284; Elmore 1938:153).

Woodrats had other cultural uses. The Navajo sometimes used woodrat fur in incense (Hill 1938:173). A Pawnee subsistence strategy indirectly exploited woodrats. In the fall, women collected part of these rodents' wild bean and potato hoards, leaving a portion for the woodrat's consumption (Weltfish 1977:321, 415–416). The Yavapai also raided woodrat nests, for piñon nuts. Woodrat brains were used for skin dressing, and the skins, with the fur side in, served as winter foot wrappings for infants (Gifford 1936:257, 266, 275).

12.2.9 *Canis familiaris/C. latrans* (Dog/Coyote)

The faunal assemblage contains two dog/coyote (*Canis familiaris/C. latrans*) specimens (Table 12.1), both from Trench 2. The dog (*Canis familiaris*) is closely associated with humans. Based on a radiocarbon data of ca. 8400 B.C., the earliest known domestic dog remains in North America are from Jaguar Cave, Lemhi County, Idaho (Lawrence 1967:44, 1968:43). "Since dogs were domesticated from an Old World, not a New World stock, and since the remains discussed are of a small animal with typical dog characters, domestication must have taken place at a considerably earlier date" (Lawrence 1967:44). When humans first entered North America, therefore, they were accompanied by dogs, probably the first domesticated animal. The domestic dog probably descended from the wolf (*C. lupus*). As stated by Olsen (1985:xi):

> The wolf has perfected hunting habits that would not have been lost on early human hunters who observed their game-getting practices. Both wolves and humans were pack, or team, hunters early on, and it is likely that these similar tactics for obtaining prey were influential in bringing about the initial stages of association between these two species. This hunting association and the fact that both hominids and large canids have mutually compatible social organizations eventually led to taming and, ultimately, to domestication.

Prehistoric dog remains in North America are assigned to at least four size categories: a large wolf-like northern form, the Plains Indian dog (known in the Southwest as the large Pueblo dog), the small, short-faced Pueblo dog, and the small, long-faced Pueblo dog (Allen 1920:503; Olsen 1974:343, 1985:35). As recorded by Solis (1931:61) in the eighteenth century, the Caddo had hybrid dogs—called *jubines*—that were mixtures of dog and coyotes or wolves.

Dogs were (and in some cases still are) used by many groups for hunting, as beasts of burden, and at least occasionally as food. Although not specifically trained for hunting, the Hopi sometimes used dogs to run down game. In addition, the Hopi butchered and fed puppies or older dogs to captive eagles and hawks when rabbit meat was not available (Beaglehole 1936:8, 21). The Havasupai sometimes used dogs for hunting rabbits and deer (Spier 1928:113). The Navajo used dogs "for hunting when no ritual was involved. They were trained to track and follow wounded animals. Some were castrated. They were never eaten" (Hill 1938:97). The Navajo still use dogs to guard their sheep. The Yavapai ate dogs occasionally. They were either cooked in an earth oven or boiled. Dogs were also used to hunt fawns and wounded deer (Gifford 1932:205, 217–218, 1936:264). A unique Yavapai custom involved dogs and teeth. To ensure healthy permanent teeth, the first deciduous tooth lost by a child was either encased in food and fed to a dog or thrown toward the east by the child's father (Gifford 1936:300). The Miwok occasionally ate dogs or used them to hunt squirrels and deer. After Euro-American contact, the Miwok used dog skins for quivers (Barrett and Gifford 1933:219, 270). Among the Tepehuan, "dogs constitute an important element in individual or communal hunting, and good hunting dogs are highly prized" (Pennington 1969:119).

The coyote (*C. latrans*) is found throughout the Southwest where it occupies a wide range of habitats. "Broken country, interrupted by rocks, brush, clumps of pinyon-juniper, or other vegetation, makes excellent habitat for coyotes" (Hoffmeister 1986:462). Dens are usually dug in the ground but brush-covered slopes, riverbanks, rock ledges, hollow logs, another animal's burrow, and natural shelters also serve as den sites. Although coyotes may mate for several years, they normally do not mate for life. Breeding occurs in late winter or early spring. A litter five or six pups on average is born in the den after a gestation period of about 63 days. A female has only one litter per year. Hybrids have been reported between the coyote and the domestic dog. The coyote hunts alone or with its mate. Much of the coyote diet consists of rabbits, rodents, and carrion, but birds, deer, sheep, juniper berries, cactus fruit, and insects are also eaten. Most of the livestock killed by coyotes consists of young and infirm individuals. In an effort to protect livestock, ranchers have killed thousands of coyotes, but programs to eradicate them have generally been ineffective. The coyote is also hunted for its valuable pelt. Its major nonhuman predators are cougars and wolves (Bee et al 1981:165; Cockrum 1982:24; Findley 1987:116–117; Findley et al. 1975:281–282; Hoffmeister 1986:462–464; Zeveloff 1988:248–249).

The Yavapai ate coyotes when deer were scarce. Large deadfall traps were used to catch them. After the carcass was eviscerated and skinned, it was either cooked in an earth oven or boiled. Its marrow was not eaten (Gifford 1932:205, 216, 1936:266). Coyotes were eaten by some Plains groups, such as the Cheyenne (Grinnell 1923:I:256). Although the Tepehuan do not eat the coyote, it is hunted because it kills chickens and consumes young corn stalks. Hunting techniques include the use of bows and arrows or pit traps (Pennington 1969:127).

Coyotes were (and still are) hunted for their pelts. Although not eaten, the Hopi procured these canids for their skins, using deadfall traps (Beaglehole 1936:17–18). The Navajo used several types of deadfall traps to obtain coyote skins for the Coyote Way chant (Hill 1938:168–170). The Yavapai used coyote skins, minus the legs, for capes, robes, and blankets and also made quivers from coyote hides (Gifford 1932:226, 1936:273, 286). After drying the hides inside out, “moist earth was applied and the skin worked with the hands to soften it” (Gifford 1932:223). As a variation, the hide was softened by rubbing it with a stone and then was buried for less than a day in damp ground. Coyote hide processing did not require brains. Four or five skins were sewn together to make a robe (Gifford 1932:223, 226, 1936:273, 286). The Havasupai tracked coyotes in the snow in order to obtain their pelts for robes and bedding (Spier 1928:111). The Tepehuan used coyote skins as sleeping mats (Pennington 1969:127).

12.2.10 *Antilocapra americana* (Pronghorn)

Few definite pronghorn (*Antilocapra americana*) (n=22) and probable pronghorn (cf. *A. americana*) (n=6) remains are present (Table 12.1). Although pronghorn formerly occurred throughout the Southwest, intensive hunting greatly reduced their numbers by the early 1900s. Since that time, however, they have been expanding within their former range. Pronghorn, which were once almost as numerous as bison, inhabit arid and semi-arid grasslands, subsisting on browse such as sagebrush, buckbrush, and rabbitbrush. Prickly pear cacti, forbs, grasses, and cultivated crops are also eaten. Most, or all, of the pronghorn’s water requirements are supplied by consumed plants. Horns are present in both sexes and the sheaths are shed and replaced annually. Pronghorn congregate in large herds (e.g., 100 individuals) during the winter but disperse into smaller groups in the spring. Breeding occurs in the fall. Females give birth, usually to twins, in mid-June. The pronghorn uses its great speed—up to 60 miles per hour—to elude predators such as bobcats and coyotes (Findley 1987:144–145; Findley et al. 1975:333–334; Hoffmeister 1986:549, 551–552; Jones et al. 1985:318; Zeveloff 1988:334–336).

The pronghorn was a food resource for many North American pre-Columbian and historic peoples. The Cheyenne dug pits and built enclosures on established trails. Large numbers of pronghorn were enticed, drawn, led, or driven into these traps and killed with clubs (Grinnell 1923:I:277–290). Solitary Chiricahua Apache hunters stalked pronghorn (Opler 1941:324). Pronghorn was the Navajo’s second most important meat source. Many deer hunting techniques also served to bring down pronghorn. Animals were stalked, tracked, flushed, driven into an ambush, run down, or driven into a corral by a pair or group of Navajo hunters, but impounding was the most common method (Hill 1938:101–113, 117–131, 145–156). The Hopi also used deer hunting methods to procure pronghorn and treated the bones in a similar manner (Beaglehole 1936:4–9). The Pima stalked pronghorn (Ebeling 1986:594). During the summer and fall, the

Sanpoil, hunting singly or in pairs with bows and arrows, often found pronghorn near water holes (Ray 1932:82). The Shoshone and Crow conducted communal pronghorn drives into corrals (Lowie 1922:211; Steward 1938:34–35, 81–82). The Havasupai occasionally wore a disguise when stalking pronghorn. "The stuffed headskin of an antelope is worn on the head, while the body is painted pink and white to resemble that animal. Mimicking its actions, the hunter approaches within 10 or 15 m before he lets fly" (Spier 1928:110). The Yavapai hunted pronghorn by stalking, driving, or surrounding them. In addition to eating the meat of this animal, its marrow was also consumed (Gifford 1932:216, 1936:265).

Pronghorn also provided raw material for various items, of which only a few are presented. The Yavapai used pronghorn skins for leggings, breechcloths and drumheads, but because pronghorn skin is thin and easily torn, they did not use it for all the same purposes as deer hides (Gifford 1936:273–274, 288). The Yavapai also used pronghorn horns as flakers (Gifford 1936:287). The Havasupai made ropes from pronghorn skin (Spier 1928:146), and the Hopi used the pronghorn horn as an arrow wrench (Spier 1928:161). The Navajo made clothes from pronghorn hides, but the hides were not sturdy enough for moccasins (Hill 1938:156).

12.2.11 *Bison bison* (Bison)

The Boot Hill faunal assemblage contains definite bison (*Bison bison*) (n=5), probable bison (cf. *B. bison*) (n=27), and bison-size (n=115) remains (Table 6.1). Most, if not all, of the latter are probably bison. The bison, the largest extant terrestrial mammal in North America, was formerly the dominant mammal of the prairies. This grazer of open grasslands once numbered in the millions, but has been extirpated throughout most of its range. By 1890, fewer than 1,000 bison were left in North America. In 1884, the last recorded killing of free-ranging bison in New Mexico occurred (Findley et al. 1987:146). "Extermination of the bison was part of a United States government policy to suppress the Indian tribes that depended on them for food, clothing, and shelter. At the turn of the century, efforts were finally made to save them [bison] from extinction" (Zeveloff 1988:345). Today, almost 100,000 bison survive in public and private herds in western North America.

Although the bison is primarily a grassland species, it also inhabits forest edges and the prairie-forest transition zone. This bovid is very gregarious, living in large herds. Core herds consist of females, calves, yearlings, and two-year-olds. Older males are solitary or form small groups on the peripheries of the main herds. During the breeding season, from mid- to late summer, the males join the female-subadult herds. The bison is a K-selected species. After a gestation period of 9.5 months, a single precocial calf per breeding female is usually born in the spring. Occasionally, a female may have twins. Although sexual maturity is attained by the age of three for both sexes, males generally do not breed much until the age of six (Bee et al. 1981:229–230; Findley 1987:146; Zeveloff 1988:346–347).

Bison are efficient grazers. They are "capable of growing and maintaining good condition on less nutritious fare than domestic cattle require" (Findley 1987:146). Although grasses are preferred, sedges and brushy plants are consumed when grass is unavailable. Bison seek water each day. During droughts, however, they can go several days without water. Besides humans, major predators include wolves and grizzly bears (Bailey 1931:16; Bee et al. 1981:230; Findley 1987:146; Zeveloff 1988:346). The importance of bison as a food resource and as a raw material source for clothing, tools, and other items among various Plains peoples is well known and is not discussed herein.

12.3 The Boot Hill (LA 32229) Archaeofaunal Assemblage

The archaeofaunal assemblage recovered by TRC consists of 1620 specimens and is very fragmented. In addition, most of the assemblage exhibits some degree of erosion or corrosion. Corrosion is indicative of burial in highly acidic soils, of root etching, and/or the presence of organic acids (e.g., urine) (Andrews 1990:19) and has obscured evidence of gnawing, butchering, and modification or use. As a result, the incidence of gnawing is low (n=36, 2.2 percent), with 32 (88.9 percent) having rodent gnawing and four (11.1 percent) exhibiting carnivore gnawing. In spite of the eroded condition of the bones, the paucity of gnawing is surprising, given the presence of various rodents (Table 12.1). Butchering marks were observed on 12 specimens (0.7 percent) and include two bone flakes. Only two worked specimens, both fragments of larger bone tools, were identified.

The assemblage was recovered from three trenches (Table 6.2). Separate MNIs were calculated for each trench (Table 12.2) according to the criteria used for the assemblage as a whole. As indicated in Table 12.2, most of the assemblage (n=1162, 71.7 percent) is from Trench 1. The assemblage from each trench is discussed separately.

Table 12.2 Faunal assemblage of trenches, LA 32229

Taxon	Trench 1		Trench 2		Trench 3		Total	
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
Testudinata (Turtles)	5		1	1			**6**	**1**
Terrapene ornata (Western Box Turtle)	7	1	4	1			**11**	**2**
Indeterminate small bird (quail-size)	1	1	2	1	1	1	**4**	**3**
Indeterminate medium bird (duck-size)	1	1					**1**	**1**
Leporidae (Rabbits, Hares)	6				5		**11**	
Sylvilagus audubonii (Desert Cottontail)	31	2	35	2	13	2	**79**	**6**
Lepus californicus (Black-tailed Jackrabbit)	143	5	76	4	15	2	**234**	**11**
cf. *L. californicus* (?Black-tailed Jackrabbit)			1				**1**	
Rodentia (Rodents)	1						**1**	
Spermophilus sp. (Ground Squirrels)	2	1					**2**	**1**
Cynomys ludovicianus (Black-tailed Prairie Dog)	4	1	2	1			**6**	**2**
Geomyidae (Pocket Gopher)					2	1	**2**	**1**
Dipodomys sp. (Kangaroo Rat)			1	1	1	1	**2**	**2**
Neotoma sp. (Woodrat)	1	1					**1**	**1**
Canis familiaris./C. latrans (Dog/Coyote)			2	1			**2**	**1**
Artiodactyla (Artiodactyls)	7	1	1		3		**11**	**1**
Antilocapra americana (Pronghorn)	16	1	4	1	2	1	**22**	**3**
cf. *A. americana* (?Pronghorn)	5		1				**6**	
Odocoileus/A. americana (Deer/ Pronghorn)	12		4		1		**17**	
Bison bison (Bison)	4	1			1	1	**5**	**2**
cf. *B. bison* (?Bison)	15		6	1	6		**27**	**1**
Indeterminate small mammal (rabbit-size)	170		40		61		**271**	
Indeterminate medium mammal (coyote-size)	44		6		10		**60**	
Indeterminate large mammal (pronghorn-size)	600		73		50		**723**	
Indeterminate very large mammal (bison-size)	87		1		27		**115**	
Total	**1162**	**16**	**260**	**14**	**198**	**9**	**1620**	**39**

NISP = number of identified specimens
MNI = minimum number of individuals

12.3.1 Trench 1

As indicated above, the vast majority of the Boot Hill archaeofaunal assemblage is from Trench 1 (n=1162, 71.7 percent). Although a variety of taxa are represented, most of the Trench 1 assemblage consists of the remains of various indeterminate size mammals (n=901, 77.5 percent), of which the majority are pronghorn-size (n=600, 66.6 percent) (Table 12.2). All of the identified taxa are potentially cultural. The indeterminate turtle (Testudinata) specimens (n=5) consist of indeterminate shell (carapace/plastron) fragments. The box turtle remains (n=7) include a nuchal fragment, a complete right 11th peripheral, a nearly complete right 8th costal, a right hypoplastron fragment, and three indeterminate shell fragments. The peripheral is scorched and one of the carapace/plastron fragments is charred, with shiny black on the exterior. No cranial or limb elements are present. Although the presence of turtle is considered cultural, it is unclear as to whether turtles were procured as food resources and/or for their shells. The presence of burning on two box turtle specimens suggests this species may have been eaten. The quail-size bird bone is a long bone shaft fragment and the duck-size specimen is a proximal shaft fragment of a tibiotarsus (the "drumstick"). Based on the LCAS excavations of the 1950s, Corley and Leslie (1960:7) noted "various types and sizes of fowl." The indeterminate rodent (Rodentia) specimen is the tip of the lower incisor of a small rodent. The ground squirrel specimens (n=2) are a nearly complete maxilla and a proximal femur. The femur, a high meat value element, may represent food refuse and the maxilla, a low meat value element, may represent butchering refuse. The black-tailed prairie dog is represented by a mandible fragment, a nearly complete upper incisor, a radius shaft, and a proximal tibia shaft fragment. The mandible and tooth are low meat value elements and the radius and tibia are medium meat value elements. The former may be butchering refuse and the latter may be processing or food refuse. The woodrat specimen is a maxilla fragment, a low meat value bone that may represent butchering refuse. Ethnographic data presented above indicate these various rodents were hunted for food and other uses by several groups. Except for the two burned turtle bones, none of the remains exhibits burning, gnawing, or butchering marks.

The remaining identified taxa—leporids (cottontail and jackrabbit) and artiodactyls (e.g., pronghorn, bison)—are definitely subsistence-related animals. Most of the specifically identified remains (n=259) are those of leporids (n=180, 69.5 percent) (Table 6.2). The Leporidae category (n=6)—those leporid specimens that could not be identified confidently as either cottontail of jackrabbit—includes three tooth fragments, a scapula fragment, a metapodial fragment, and a complete first phalanx. In general, all of the major portions of the leporid skeleton—skull, trunk, foreleg, hindleg, and feet—are represented (Table 12.3, Figures 12.1 and 12.2). Both low and high meat value bones, indicative of butchering debris and food refuse, are present. The incidence of burning (n=15, 8.3 percent) and gnawing (n=19, 10.6 percent) is low, with 10 scorched, four charred, one calcined, and 19 rodent gnawed (Table 12.4). None of the leporid remains is worked or has butchering marks.

Table 12.3 Leporid skeletal elements from Trench 1, LA 32229

Element	Leporidae	Cottontail	Jackrabbit	Total
Skull:				
Nasal			2	**2**
Frontal			4	**4**
Premaxilla			1	**1**
Maxilla			2	**2**
Mandible		4	11	**15**
Palatine			1	**1**
Petrous		1		**1**
Cranial Fragment		1		**1**
Teeth – Complete		5	15	**20**
Teeth - Fragments	3		10	**13**
Trunk:				
Indet. Vertebra			1	**1**
Rib			13	**13**
Foreleg:				

Element	Leporidae	Cottontail	Jackrabbit	Total
Scapula	1	2	4	**7**
Humerus		2	7	**9**
Radius		2	13	**15**
Ulna		1	8	**9**
Hindleg:				
Innominate		1	3	**4**
Femur		3	13	**16**
Tibia		6	20	**26**
Feet:				
Metacarpals			4	**4**
Calcaneum		2	2	**4**
Metatarsals		1	7	**8**
Metapodial Fragment	1		1	**2**
1st Phalanx	1		1	**2**
Total	**6**	**31**	**143**	**180**

Table 12.4 Burned and gnawed taxa from Trench 1, LA 32229

Taxon	NISP	Burned				Gnawed		
		SC	CH	CAL	Total	R	C	Total
Terrapene ornata (Western Box Turtle)	7	1	1		**2**			
Leporidae (Rabbits, Hares)	6					1		**1**
Sylvilagus audubonii (Desert Cottontail)	31	2	1		**3**	5		**5**
Lepus californicus (Black-tailed Jackrabbit)	143	8	3	1	**12**	13		**13**
Artiodactyla (Artiodactyls)	7					1		**1**
Antilocapra americana (Pronghorn)	16			1	**1**		1	**1**
Odocoileus/A. americana (Deer/ Pronghorn)	12	1	1		**2**			
cf. *Bison bison* (Bison)	15	1			**1**			
Indeterminate small mammal (rabbit-size)	170	20	14	11	**45**	1		**1**
Indeterminate medium mammal (coyote-size)	44	3	9	8	**20**			
Indeterminate large mammal (pronghorn-size)	600	41	59	61	**161**	3	1	**4**
Indeterminate very large mammal (bison-size)	87	4	7	3	**14**	1	2	**3**
Total	**1138**	**81**	**95**	**85**	**261**	**25**	**4**	**29**

SC=scorched, CH = charred, CAL = calcined; R = rodent, C = carnivore

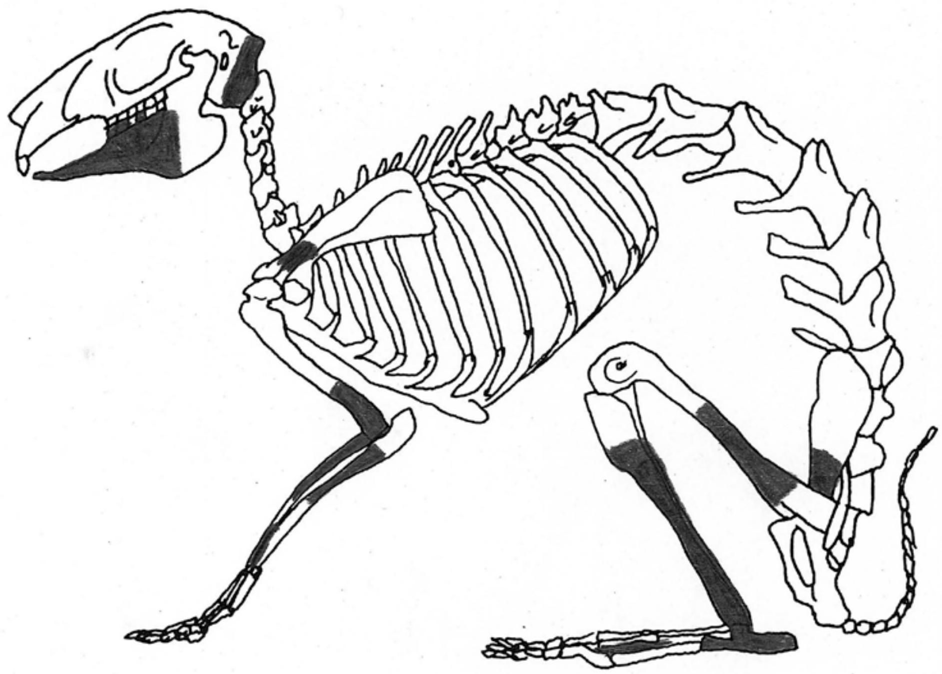

Figure 12.1 Cottontail skeletal part representation, Trench 1, LA 32229

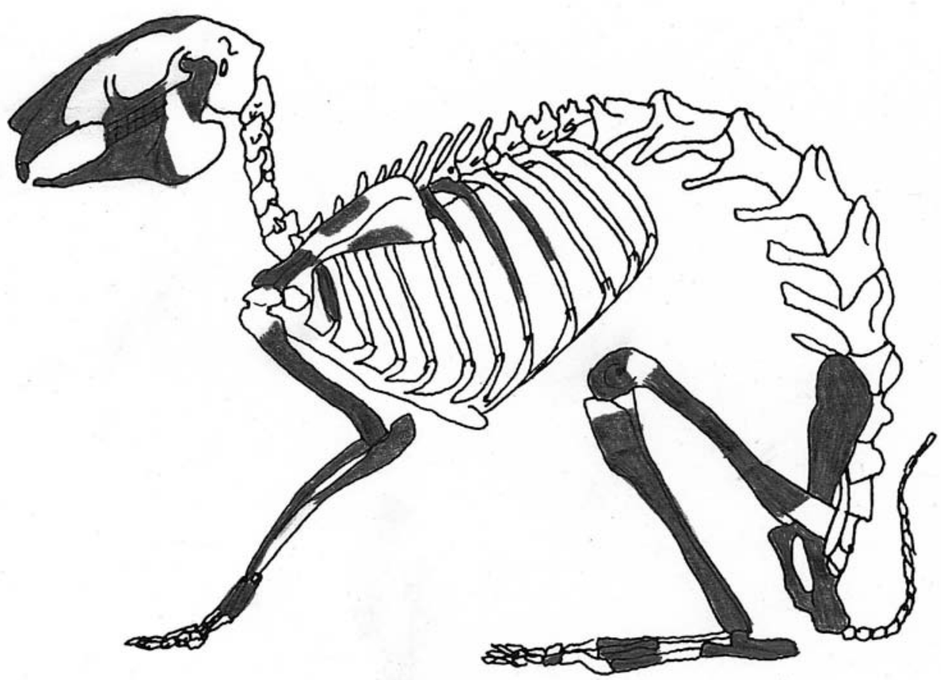

Figure 12.2 Jackrabbit skeletal part representation, Trench 1, LA 32229

Not unexpectedly, the second most numerous identified remains are those of artiodactyls (n=59, 22.8 percent). Unlike the leporids, however, the major portions of the skeleton are poorly represented (Table 12.5, Figures 12.3–12.6). The remains are very fragmented. No complete bone elements or teeth are present. The Artiodactyla remains (n=7) consist of specimens that could not be identified confidently as a specific artiodactyl (e.g., deer, pronghorn, bison) (Table 12.5, Figures 12.3). The phalanx and metatarsal fragment are of a young individual and the former exhibits rodent gnawing. Except for the tibia, a medium meat value element, the pronghorn remains (n=21) are non- (teeth) or low meat value elements that probably represent butchering and processing debris (Table 12.5, Figure 12.4). The mandible fragment has a transverse cut mark on the lateral side of the ascending ramus, just below the mandibular condyle, indicative of removal of the jaw and probable concomitant removal of the tongue. The metatarsal is a shaft fragment with an impact flake scar on the medullary cavity side of the fragment. The bone flake was probably removed when the shaft was broken to extract the marrow. A tooth fragment exhibits burning cracks and calcination, and a metapodial condyle has been gnawed by a carnivore. Because deer and pronghorn are very similar osteologically, the deer/pronghorn category (n=12) consists of those specimens that could not be identified confidently as either one. No definite deer remains, however, were identified, suggesting the specimens are probably pronghorn. A humerus shaft fragment and a thoracic vertebra fragment are the only non-tooth deer/pronghorn specimens (Table 12.5, Figure 12.5). One tooth fragment is scorched and another is charred (Table 12.4). None of the deer/pronghorn remains is worked or has butchering marks. As with the other artiodactyls, most of the bison remains (n=19) are tooth fragments (n=14, 73.7 percent) (Table 12.5, Figure 12.6). The foot bones are low meat value elements indicative of butchering debris and the rib and tibia fragments are higher meat value elements suggestive of processing (e.g., marrow extraction) debris and food refuse. A tooth fragment is scorched. The astragalus fragment exhibits parallel diagonal skinning cut marks on the medial surface. No gnawed or worked bison bones are present. The overall incidence of burning (n=4, 6.8 percent) and gnawing (n=2, 3.4 percent) among the artiodactyl remains is low (Table 12.4) and none is worked.

Table 12.5 Artiodactyl skeletal elements from Trench 1, LA 32229

Element	Artiodactyla	Pronghorn	Deer/ Pronghorn	Bison	Total
Skull:					
Squamosal		1			**1**
Mandible		1			**1**
Teeth - Fragments	5	14	10	14	**43**
Trunk:					
Thoracic Vertebra			1		**1**
Rib				1	**1**
Foreleg:					
Humerus			1		**1**
Hindleg:					
Tibia		1		1	**2**
Feet:					
Astragalus				1	**1**
Naviculo-cuboid				1	**1**
Metatarsals	1	2			**3**
Metapodial Fragment		1			**1**
1st Phalanx	1	1		1	**3**
Total	**7**	**21**	**12**	**19**	**59**

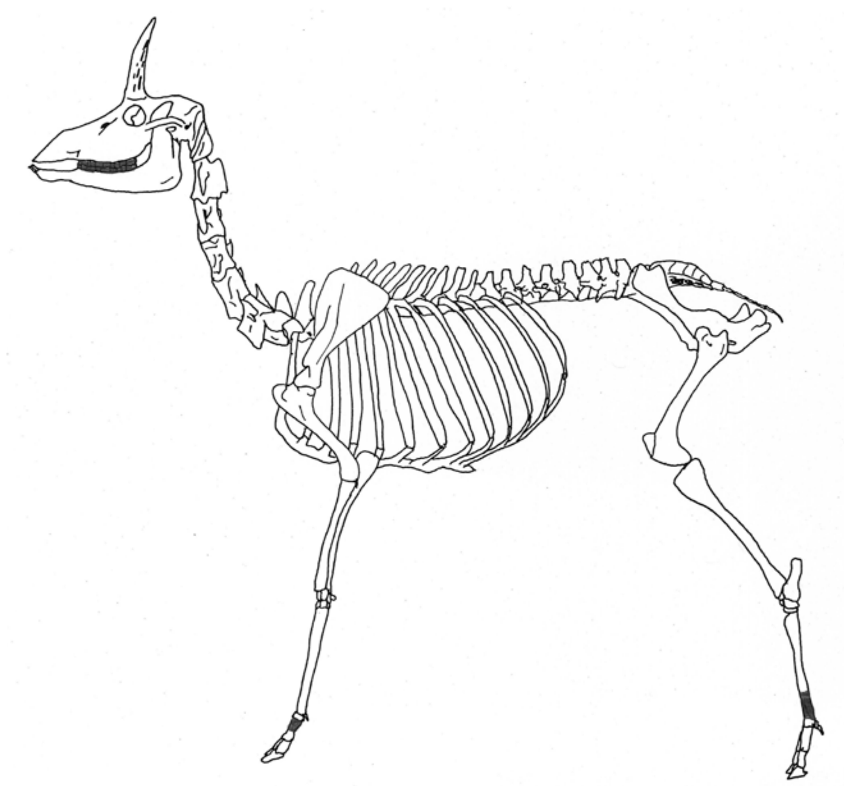

Figure 12.3 Artiodactyla skeletal part representation, Trench 1, LA 32229

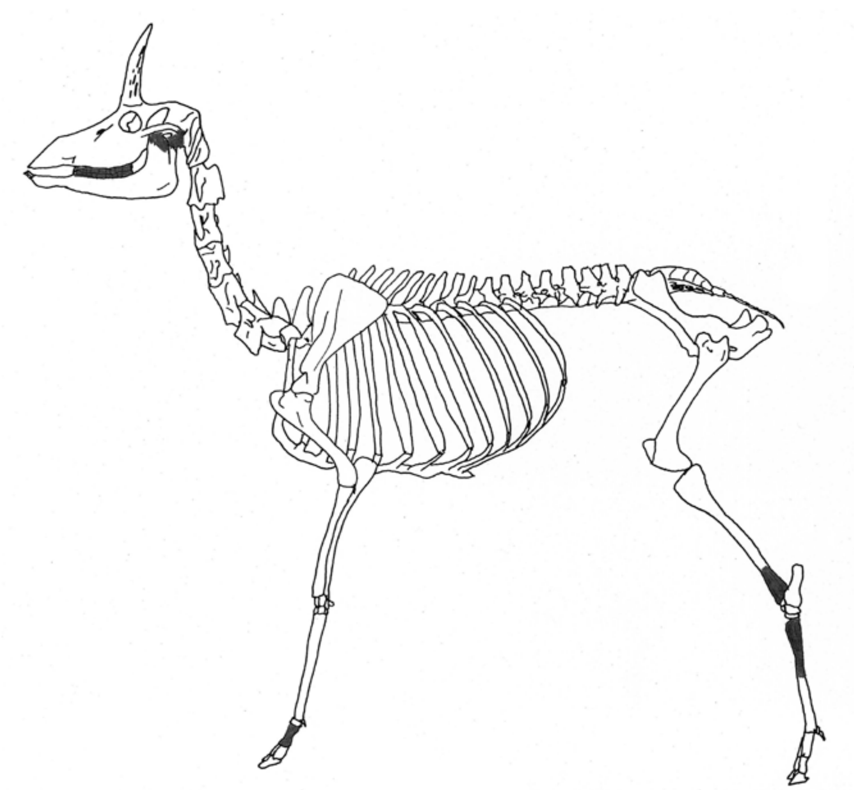

Figure 12.4 Pronghorn skeletal part representation, Trench 1, LA 32229

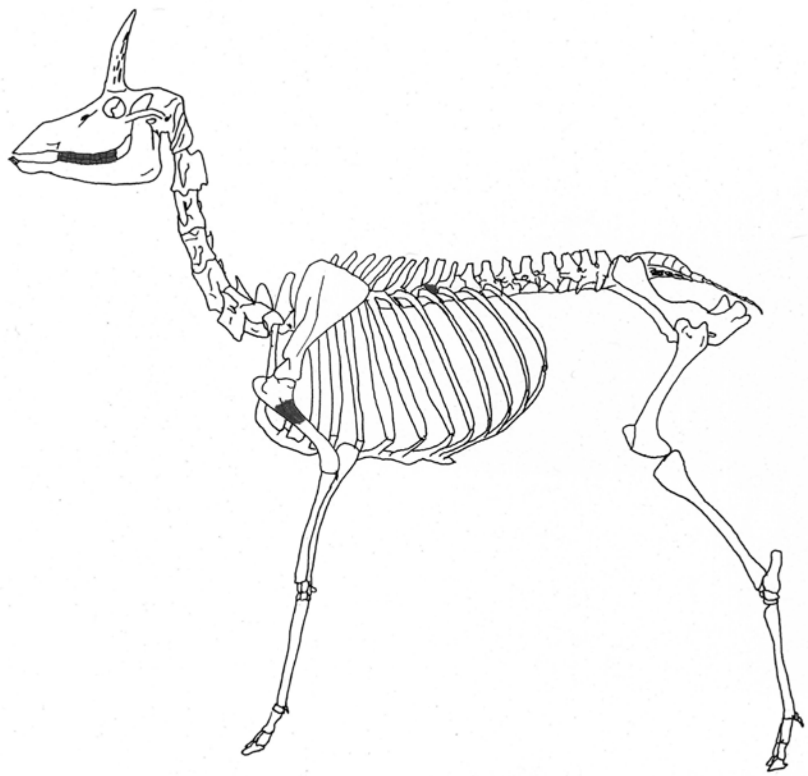

Figure 12.5 Deer/pronghorn skeletal part representation, Trench 1, LA 32229

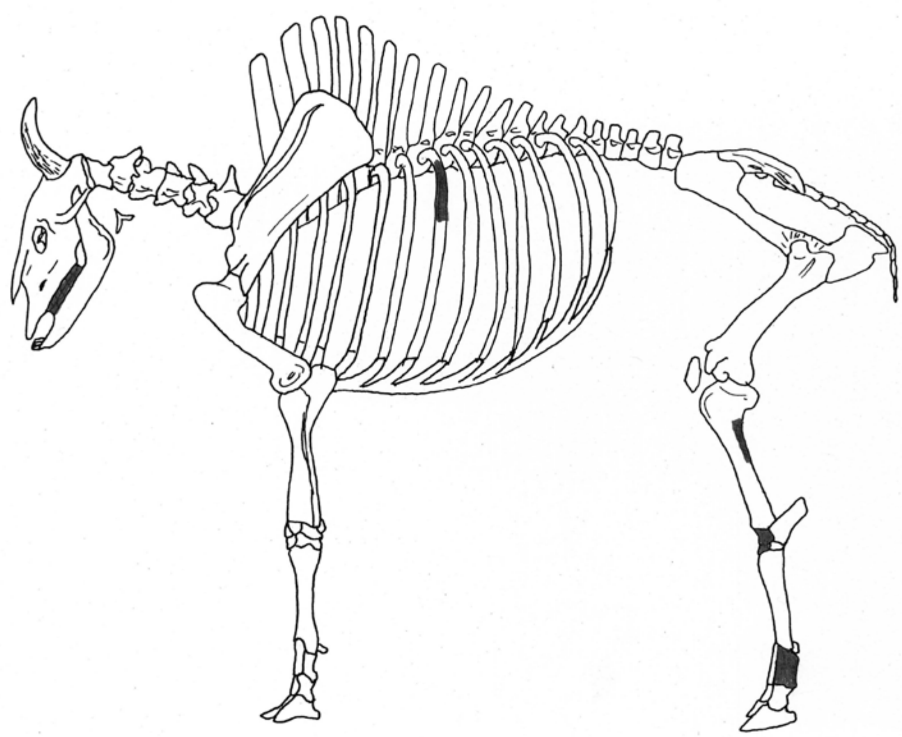

Figure 12.6 Bison skeletal part representation, Trench 1, LA 32229

The indeterminate mammal portion of the Trench 1 assemblage accounts for the vast majority of the remains (n=901, 77.5 percent) (Table 12.2). Given the paucity of rodent remains and the absence of mouse-size remains, most, if not all, of the rabbit-size specimens (n=170) are probably leporid. The incidence of burning (n=45, 26.5 percent) is high, with 20 scorched, 14 charred, and 11 calcined, but the incidence of gnawing (n=1, 0.6 percent) is extremely low, with one long bone shaft fragment exhibiting rodent gnawing (Table 12.4). None exhibits butchering marks or is worked.

The coyote-size remains (n=44) consist of a rib shaft fragment, long bone shaft fragments (n=6), and indeterminate fragments (n=37). The incidence of burning is high (n=20, 45.5 percent), with three scorched, nine charred, and eight calcined, but none is gnawed (Table 12.4). In addition, none is worked or exhibits butchering marks. The fragmented condition of the remains is suggestive of possible marrow extraction and bone grease processing.

Most of the indeterminate mammal assemblage consists of pronghorn-size remains (n=600, 66.6 percent) (Table 12.2) that probably primarily represent pronghorn. A portion of the specimens, however, may be those of bison but are not determinable as such due to extreme fragmentation. The pronghorn-size remains include two tooth fragments (one of which is a root), a vertebra fragment, and 19 rib fragments. The incidence of burning is high (n=161, 26.8 percent), with a fairly even distribution among scorched (n=41), charred (n=59), and calcined (n=61) remains (Table 12.4). One specimen has rodent gnawing and two exhibit carnivore gnawing (Table 12.4). Three specimens have probable defleshing cut marks and another specimen is a bone flake with an intact platform and bulb of percussion (Table 12.6). The distal end terminates in a hinge fracture. The bone flake was probably removed when the originating element was broken by an impact blow, possibly during marrow extraction or processing for bone grease. None of the pronghorn-size remains is worked.

The remainder of the Trench 1 archaeofaunal assemblage consists of bison-size specimens (n=87) (Table 12.2), of which most, if not all, are bison. The remains consist of long bone shaft fragments (n=19) and indeterminate fragments (n=68). The incidence of burning is moderate (n=14, 16.1 percent), with four scorched, seven charred, and three calcined (Table 12.4). One bone has rodent gnawing and two exhibit carnivore gnawing (Table 12.4). One long bone shaft fragment is a bone flake that terminates in a hinge fracture. The platform is intact. Another long bone shaft fragment has an impact flake scar on the medullary cavity side of the fragment. The flake scar terminates in a hinge fracture. The bone flake and flake scar were probably produced when the long bones were broken to extract the marrow. None of the bison-size specimens is worked.

Table 12.6 Butchered taxa from Trench 1, LA 32229

Taxon	NISP	Butchering Type				
		S	DM	DF	O	Total
Antilocapra americana (Pronghorn)	16		1		1	**2**
Bison bison (Bison)	15	1				**1**
Indeterminate large mammal (pronghorn-size)	600			3	1	**4**
Indeterminate very large mammal (bison-size)	87				2	**2**
Total	**718**	**1**	**1**	**3**	**4**	**9**

S = skinning, DM = dismembering, DF = defleshing, O=other (e.g., flake, flake scar)

12.3.1.1 Discussion

The Trench 1 faunal remains (n=1162, 71.7 percent) account for the vast majority of the Boot Hill archaeofaunal assemblage. Examination of the Trench 1 assemblage, however, indicates small animals, especially rodents (n=8, MNI=3), are underrepresented. The recovery of 25 rodent gnawed specimens attests to the presence of rodents. Although small bones, such as leporid phalanges, carpals, and tarsals, and the bones of small rodents undoubtedly fell through the screens, the paucity of rodent remains is not necessarily or entirely the result of data recovery methods. Sifting experiments by Shaffer (1992) and Shaffer and Sanchez (1994) indicate that for mammals weighing less than 140 g, such as the kangaroo rat, almost all of the skeletal elements, except for the cranium and innominates, are lost with ¼-inch sifting. "Most elements from animals weighing 71–340 g [such as the woodrat, ground squirrel, and pocket gopher] also will be missed with ¼[-inch] screening. However, these taxa are often large enough for several commonly identifiable elements to be recovered (pelves, femora, humeri, skulls, and mandibles)" (Shaffer 1992:131). For mammals weighing between 340 and 3,100 g, such as the prairie dog, cottontail, and jackrabbit, skeletal elements are well represented with ¼-inch sifting. Nevertheless, "even though many identifiable elements are recovered, other elements such as caudal vertebrae, ribs, sternae, patellae, sesamoids, podials, metapodials, and phalanges were not recovered consistently" (Shaffer 1992:131). Although the present project used screens with ⅛-inch hardware cloth, which should have increased the recovery of small animal bones, the Trench 1 rodents are represented only by five cranial elements—a maxilla (n=2), mandible (n=1), and teeth (n=2)—and three long bones (n=3)—a radius, femur, and tibia. Screening in its self, therefore, does not account for the paucity of rodent bones. Other possible factors must be considered.

Recovery from a trench may be a factor. Generally, a trench is narrow and linear and provides only a sample of the possible cultural remains present. A block excavation provides a more comprehensive view of previous occupations and allows for a greater recovery of materials. The scarcity of rodent bones, therefore, may have resulted from recovery from a trench. The eastern portion of Trench 1, however, was more like a small block excavation that was 5 m long and 2 to 4 m wide, affording a greater opportunity to recover rodent remains. If the presence of the rodents was natural, greater skeletal representation should have resulted. The rodent remains, therefore, are in large part due to cultural factors related to the site's occupants.

Ethnographic data indicate ground squirrels, prairie dogs, and woodrats were consumed as secondary meat resources by various groups (see Natural History and Ethnographic Background). The low incidence of rodent remains is probably the result of carcass preparation, consumption, and refuse disposal, with the cranial specimens representing butchering refuse and the long bones representing consumption refuse. The absence of trunk elements (e.g., vertebrae, ribs, pelves) may have resulted from preparation and consumption techniques similar to those of Great Basin peoples for ground squirrels (Fowler 1986:82) and the Kiliwa for woodrats (Michelsen 1967:76). After the carcass was cooked, with or without the head, the legs were removed and their meat was eaten. The rest of the carcass, essentially the trunk, was crushed and eaten along with its bones (see Natural History and Ethnographic Background).

On a different note, black-tailed prairie dogs do not occur naturally at the site. As indicated above, prairie dogs avoid rocky soil (see Natural History and Ethnographic Background), which is what the site contains. Thus, prairie dog carcasses—represented by both cranial and post-cranial elements—were brought to the site from a nearby area.

Elements of the entire leporid skeleton—both low and high meat value—are present, suggesting the processing and consumption of rabbits occurred near Trench 1. Except for the absence of cottontail vertebrae, ribs, and most foot elements, the skeletal part representations for cottontail and jackrabbit are similar (Table 12.3, Figures 12.1 and 12.2), suggesting similar treatment of the carcasses. Skull and foot bones are low food value elements that were probably discarded as butchering debris. The near absence of leporid vertebrae and ribs suggests the trunk was processed differently than the rest of the carcass. As indicated ethnographically (see Natural History and Ethnographic Background), these bones may have been pulverized and consumed with the meat. Tyler (1975:133) reports the grinding of rabbit bones by the Zuni. The smashing of small mammal vertebrae was documented by Steward (1941:232, 1943:304, 364) for the Shoshoni. In addition, based on the authors' experience with Cornish hens, baking or boiling small animals can soften bones such as cervical and thoracic vertebrae and ribs, allowing incidental consumption with the meat.

The leporid long bones are generally broken but much of the breakage seems to be post-depositional. In addition, most of the rabbit-size remains are long bone shaft fragments (n=141, 82.9 percent). It is doubtful that the rabbit and rabbit-size long bone specimens were processed formally for marrow or grease. Long bones may have been broken during butchering, consumption, or discard. Long bone fragmentation may also have resulted from trampling by humans and animals (Andrews 1990:8–10; Binford 1981:78; Haynes 1991:141–142,253; Lyman 1994:379, 381). Documentation of changes in bones and ethnoarchaeological and experimental contexts indicate trampling can greatly modify the fossil record from its depositional condition. Bones may be moved, broken, and scratched by trampling (Lyman 1994:381). Trampling experiments by Andrews (1990:8–10) on owl pellets (single pellets in plastic bags) containing small mammal bones resulted in the destruction of skulls, the fragmentation of mandibles, and an abundance of isolated teeth. Scapulae and innominates were partially fragmented. Although long bones, vertebrae, ribs, and foot bones tended to remain intact after six trampling episodes, examination of an assemblage of small mammal bones from a trampled (by owls and other small animals) context in a small cave indicated the absence of skulls, reduced numbers of maxillae, considerable fragmentation of most major post-cranial elements, with some loss, "but no loss or breakage of smaller elements" (Andrews 1990:10). Discounting teeth and mandibles, Table 12.3 indicates the paucity of leporid cranial elements, similar to Andrews' results. In addition, Table 12.6 shows the fragmentation of the major long bones. Except for the humerus and ulna, the bones are primarily represented by shaft fragments. Although not necessarily conclusive, the leporid skeletal part representation and long bone breakage data suggest at least some of the patterns exhibited by the remains are the result of trampling by humans and animals living on and/or crossing the site.

Table 12.7 Breakage pattern of major leporid long bones, Trench 1, LA 32229

Element/ Portion	Cottontail	Jackrabbit	Total
Humerus:			
Shaft		2	**2**
Distal	2	5	**7**
Radius:			
Proximal	1	2	**3**
Shaft	1	10	**11**
Distal		1	**1**
Ulna:			
Proximal		5	**5**
Shaft	1	3	**4**
Femur:			
Shaft	3	12	**15**
Distal		1	**1**
Tibia:			
Shaft	5	17	**22**
Distal	1	3	**4**

Based on the fusion, or lack thereof, of epiphyseal ends, one juvenile cottontail and one subadult and two juvenile jackrabbits are represented. The incidence of burning among the leporid and rabbit-size remains is moderate (n=60, 17.4 percent), with 12 (20.0 percent) calcined (Table 12.4). Although natural fires can carbonize bones, they rarely calcine bones (David 1990:75). As stated by Lyman (1994:388–389), calcination requires "longer heating times, higher temperatures, or both, relative to carbonization." Calcination requires "temperatures of over 450°C to 500°C, or heating for over three to four hours, or a combination of both" (David 1990:69). Natural conditions rarely calcine bones but can blacken them (David 1990:75). The calcined bones represent intentional discard into fire. The charred (partially or completely blackened) specimens may be associated with food preparation, such as roasting over a fire, or with discard into a fire with a reducing atmosphere.

As indicated by Table 12.5 (Figures 12.3–12.6), few elements of the artiodactyl skeleton are represented. The most numerous remains are tooth fragments (n=43, 72.9 percent), which are non-food value elements. Although the other skull (n=2) and foot (n=9) elements are low meat value bones, metapodials (metacarpals and metatarsals) have a high marrow content. The leg (n=3) and trunk (n=2) elements are higher meat value bones and the former have a high marrow content. The presence of primarily cranial and foot elements, representative of butchering debris, suggests entire artiodactyl (including bison) carcasses were brought to the site, with the animals probably procured nearby. The scarcity and fragmented condition of the metapodials, humerus, and tibia suggest leg elements were processed for marrow and possibly for bone grease. This is suggested by the pronghorn-size remains (n=600, 66.6 percent), the largest category of faunal remains from Trench 1, of which most are indeterminate fragments (n=516, 86.0 percent) but also includes long bone shaft fragments (n=62, 10.3 percent). Some of the breakage, however, may be due to trampling. The incidence of burning among the artiodactyl and pronghorn-size remains is high (n=165, 25.0 percent) and accounts for most (63.2 percent) of the burning exhibited by the Trench 1 assemblage (Table 12.4). Overall, the artiodactyl remains suggest complete carcasses were brought to the site for processing (i.e., butchering and cooking) and consumption, with further processing for marrow and possibly for bone grease.

Although it is tempting to suggest bison bones were processed for bone grease, the overall supporting data—large piles of pulverized bone or fire-cracked rock (Binford 1978:159; Quigg 1997; Vehik 1977)—are presently lacking. As stated by Vehik (1977:172), "the primary archaeological evidence for bone grease manufacturing can only be the presence of many small pieces of unburned animal bone." The bison-size remains only consist of 87 specimens—19 long bone shaft and 68 indeterminate fragments—of which 14 are burned. Supporting evidence, however, may be present in nearby unexcavated portions of the site.

12.3.2 Trench 2

Although considerably smaller than that of Trench 1, the second largest archaeofaunal assemblage was recovered from Trench 2 (n=260, 16.0 percent) (Table 12.2). As with Trench 1, all of the identified taxa are potentially cultural. The indeterminate turtle (Testudinata) specimen is the distal end of a rib (without the costal portion) of a large turtle, such as a snapping turtle (*Chelydra serpentina*). The box turtle specimens (n=4) include two costals (one complete and one nearly), a left hypoplastron fragment, and an indeterminate shell (carapace/plastron) fragment. The nearly complete costal is scorched on the interior. No cranial or limb elements are present. The quail-size bird remains (n=2) consist of a complete first phalanx and a long bone fragment. The prairie dog remains (n=2) include a proximal femur and an innominate fragment. The kangaroo rat specimen (n=1) is a complete right humerus, the ends of which are fused. All of the rodent bones are high meat value elements that probably represent food refuse. Ethnographic data presented above indicate both rodents were hunted for food and other uses by several groups. The dog/coyote specimens (n=2) consist of an upper right second molar fragment with heavy wear and a complete scapho-lunar. Except for the scorched box turtle costal, none of the remains exhibits, burning, gnawing, or butchering marks and none is worked.

Of the specifically identified remains (n=138), the vast majority are leporid (n=112, 81.2 percent). All of the major portions of the leporid skeleton are represented (Table 12.7, Figures 12.7 and 12.8). Both low and high meat value bones, indicative of butchering debris and food refuse, are present. The incidence of burning (n=5, 4.5 percent) and gnawing (n=2, 1.8 percent) is low, with three scorched, one charred, one calcined, and two rodent gnawed (Table 12.8). All are on jackrabbit remains only, as are butchering marks on a right distal humerus. Two transverse dismembering cut marks are just above the lateral condyle. No other leporid remains exhibit butchering marks and none is worked.

Table 12.8 Leporid skeletal elements from Trench 2, LA 32229

Element	Cottontail	Jackrabbit	Total
Skull:			
Frontal	1	1	**2**
Maxilla	3	3	**6**
Mandible	2	6	**8**
Jugal		3	**3**
Zygomatic	1		**1**
Teeth – Complete	20	8	**28**
Teeth - Fragments	1	5	**6**
Trunk:			
Rib		3	**3**
Foreleg:			
Scapula	2	5	**7**
Humerus		10	**10**
Radius		4	**4**
Ulna	1	3	**4**
Hindleg:			
Innominate	1	2	**3**
Femur	1	7	**8**
Tibia	1	9	**10**
Feet:			
Metacarpals		1	**1**
Calcaneum		1	**1**
Cuboid		1	**1**
Metatarsals		2	**2**
Metapodial Fragment	1	1	**2**
1st Phalanx		2	**2**
Total	**35**	**77**	**112**

Table 12.9 Burned and gnawed taxa from Trench 2, LA 32229

Taxon	NISP	Burned				Gnawed	
		SC	CH	CAL	Total	R	Total
Terrapene ornata (Western Box Turtle)	4	1			**1**		
Lepus californicus (Black-tailed Jackrabbit)	76	3	1	1	**5**	2	**2**
Indeterminate small mammal (rabbit-size)	40		4		**4**		
Indeterminate medium mammal (coyote-size)	6	1		1	**2**		
Indeterminate large mammal (pronghorn-size)	73	1	15	1	**17**	1	**1**
Total	**199**	**6**	**20**	**3**	**29**	**3**	**3**

SC=scorched, CH = charred, CAL = calcined; R = rodent

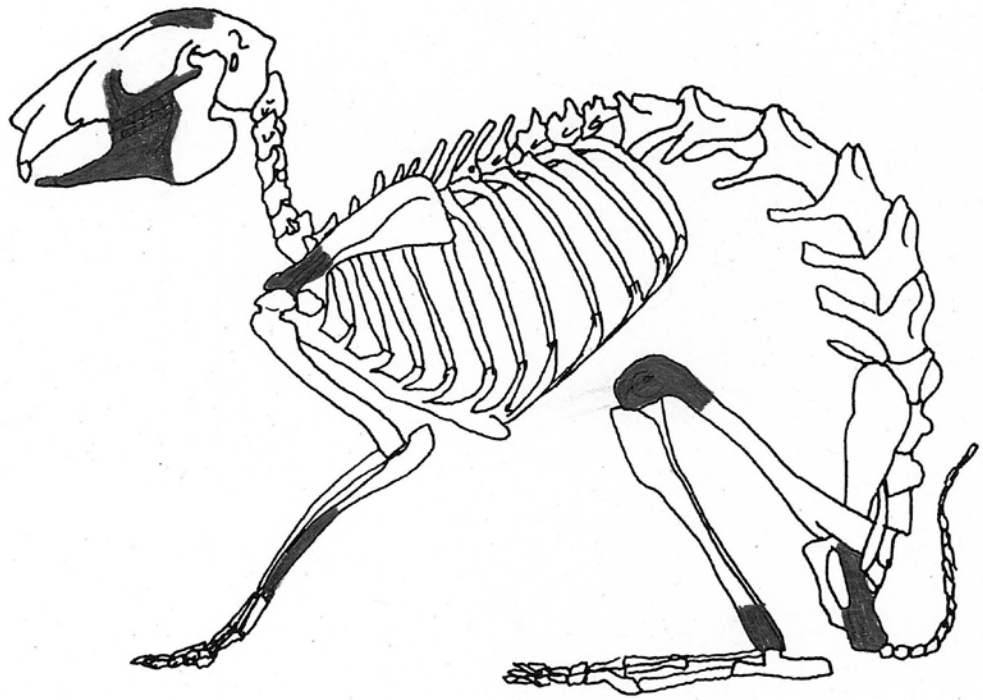

Figure 12.7 Cottontail skeletal part representation, Trench 2, LA 32229

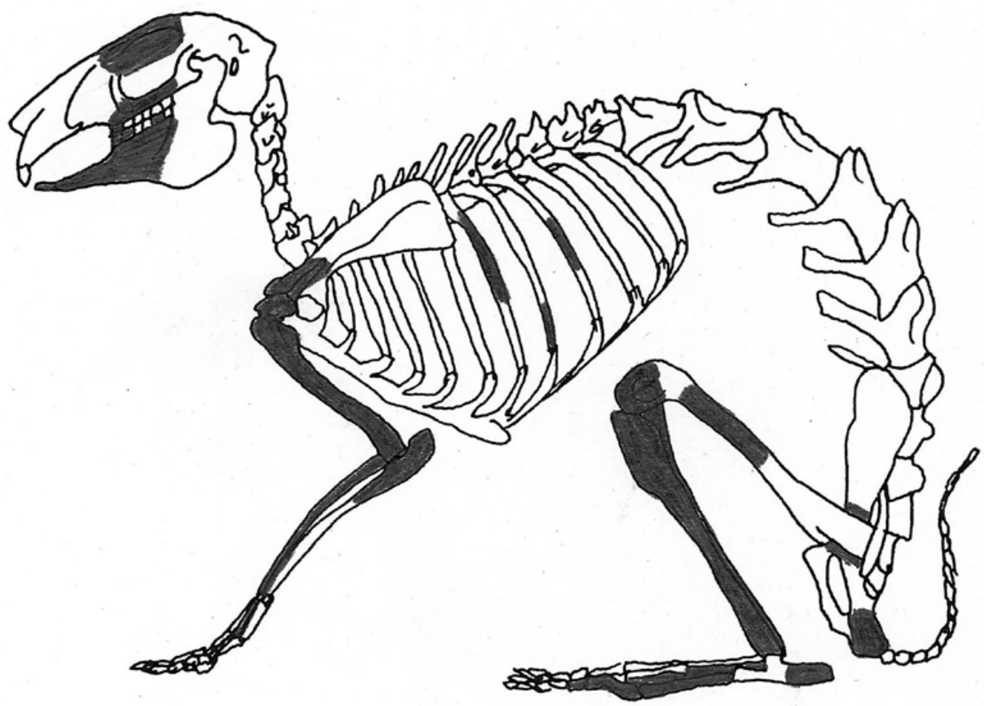

Figure 12.8 Jackrabbit skeletal part representation, Trench 2, LA 32229

Trench 2 contains few artiodactyl remains (n=16) (Table 12.2). Most are teeth (n=13, 81.3 percent), primarily fragments (Table 12.10). Artiodactyla and the probable bison are represented only by tooth fragments, but a pronghorn mandible and metapodial fragment and a deer/pronghorn vertebra fragment are also present. Except for the vertebra, which is a medium meat value element, the specimens are low meat value elements, but the metapodial has a high marrow content and was probably broken to extract the marrow. The artiodactyl remains, therefore, represent primarily butchering and processing debris. No definite deer remains were identified, suggesting the deer/pronghorn specimens are probably pronghorn. None of the artiodactyl specimens are burned, gnawed, or worked, or exhibits butchering marks.

Table 12.10 Artiodactyl skeletal elements from Trench 2, LA 32229

Element	Artiodactyla	Pronghorn	Deer/ Pronghorn	cf. Bison	Total
Skull:					
Mandible		1			**1**
Teeth - Complete		1			**1**
Teeth - Fragments	1	2	3	6	**12**
Trunk:					
Indet. Vertebra			1		**1**
Feet:					
Metapodial Fragment		1			**1**
Total	**1**	**5**	**4**	**6**	**16**

The indeterminate mammal portion of the Trench 2 archaeofaunal assemblage accounts for less than half of the remains (n=120, 45.2 percent) (Table 12.2). Most, if not all, of the rabbit-size remains (n=40) are probably leporid. Except for three indeterminate fragments, all are long bone shaft fragments (n=37, 92.5 percent), of which four (10.8 percent) are charred (Table 12.9). None of the rabbit-size remains is gnawed or worked or exhibits butchering marks.

The coyote-size remains (n=6) consist of a thoracic vertebra fragment, a long bone shaft fragment, and two indeterminate fragments. The long bone shaft is scorched and one indeterminate fragment is calcined (Table 12.9). None of the coyote-size remains is gnawed or worked or exhibits butchering marks.

Not unexpectedly, most of the indeterminate mammal assemblage consists of pronghorn-size remains (n=73, 60.8 percent) (Table 12.2). Although these remains probably primarily represent pronghorn, a small portion may be bison but is not determinable as such due to heavy fragmentation. The pronghorn-size remains mainly consist of indeterminate fragments (n=46, 63.0 percent) but include skull (n=1), mandible (n=1), rib (n=8, 11.0 percent), and long bone shaft fragments (n=17, 23.3 percent). The incidence of burning is high (n=17, 23.3 percent), with one scorched, 15 charred, and one calcined, but that of gnawing is low (n=1, 1.4 percent), with one rodent gnawed (Table 12.9). None of the remains has butchering marks, but two specimens are worked. Both are broken. One is on an indeterminate fragment that is broken longitudinally. Diagonal and longitudinal striations are on the exterior. Although speculative, the specimen may be part of an awl, possibly from the mid- or upper shaft. The second specimen consists of two pieces of a single awl but do not cross-mend. Both ends of each piece are broken. One piece is from the distal (working) end and tapers toward the tip, which is missing, and the other piece is from the mid- or upper shaft and has parallel edges. Both pieces are charred and have longitudinal striations from manufacture and polish from use.

The bison-size specimen (n=1) is an indeterminate fragment. It is not burned, gnawed, or worked and does not exhibit any butchering marks.

12.3.2.1 Discussion

Trench 2 contains a much smaller archaeofaunal assemblage (n=260, 16.0 percent) than Trench 1 (n=1162, 71.7 percent). Part of this difference is due to the fact that Trench 2 was considerably smaller, consisting of 7 units in a single row. Trench 1 consisted of 19 units, of which the western five formed a single row and the eastern 14 formed a small block. As with Trench 1, however, rodents are underrepresented in Trench 2. Although the incidence of rodent gnawing is low (n=3, 1.1 percent) (Table 12.9), it attests to the intrusive presence of rodents but no complete or nearly complete rodent skeletons were found. The rodent remains consist of an innominate fragment and two upper limb bones—a humerus and a femur—that are high meat value bones indicative of possible consumption refuse. Ethnographic data indicate prairie dogs and kangaroo rats were consumed as secondary meat resources by various groups (see Natural History and Ethnographic Background) and as mentioned previously, prairie dogs do not occur naturally at the site. The rodent remains, therefore, are considered cultural.

Although as a whole, the leporid skeleton is well represented, the cottontail skeleton is not (Table 12.8, Figure 12.7). More than half of the cottontail specimens (n=35) are teeth (n=21, 60.0 percent) and seven are other cranial elements. Trunk elements (vertebrae and ribs) are missing and only one foot element is present. The teeth and other cranial elements and the foot bone are indicative of butchering debris and the leg elements reflect consumption refuse. The absence of vertebrae and ribs probably resulted from carcass processing and consumption with the meat (see above). Except for trunk elements (no vertebrae and few ribs), all of the major portions of the jackrabbit skeleton are well represented (Figure 12.8). As with the cottontail, jackrabbit vertebrae and ribs—two of the most abundant elements in a mammalian skeleton—are underrepresented. The paucity or absence of these elements is not the result of preservation factors. Other thin-walled bones—cranial elements, scapulae, and innominates—were recovered. As suggested for the cottontail, the vertebra-rib pattern is probably attributable to carcass processing.

Due to the paucity of the artiodactyl remains and their poor skeletal representation (Table 12. 10), possibly resulting from the small size of the Trench 2 excavations, it is not possible to determine whether the pronghorn and bison were procured nearby or at a distance. The pronghorn metapodial, however, is indicative of marrow extraction. Although some of the pronghorn-size specimens may have resulted from trampling, some are probably associated with processing for marrow and possibly bone grease. This conclusion, however, is speculative.

12.3.3 Trench 3

The smallest archaeofaunal assemblage was recovered from Trench 3 (n=198, 12.2 percent), which is not surprising, considering the trench consisted of only five units. Except for the absence of turtle and some rodent taxa, the taxonomic composition of the assemblage is similar to that of the other trenches (Table 12.2). The quail-size bird specimen (n=1) is a carpometacarpus fragment that is calcined. The carpometacarpus is a low meat value element that probably represents butchering debris. The pocket gopher specimens (n=2) consist of a mandible fragment and an upper third molar. The kangaroo rat specimen (n=1) is a distal tibia. Except for the calcined bird bone, none of the specimens is burned or gnawed.

Although most of the identified remains (n=49) are leporid (n=33, 67.3 percent), the leporid skeleton is poorly represented by both cottontail and jackrabbit (Table 12.11, Figures 12.9 and 12.10). The skeletal part representations for cottontail and jackrabbit, however, are similar, suggesting similar treatment of the carcasses. Both low and high meat value elements, indicative of butchering debris and food refuse, are present. A cottontail first phalanx is scorched. Burned jackrabbit remains (n=3) consist of two scorched proximal metapodials and a calcined radius fragment (Table 12.12). Three jackrabbit specimens—a scapula, humerus, and innominate fragment—exhibit rodent gnawing (Table 12.12). In addition, a distal jackrabbit tibia has two sets of two short transverse cut marks, indicative of either skinning or dismembering, immediately above the epiphysis. None of the leporid remains is worked.

Table 12.11 Leporid skeletal elements from Trench 3, LA 32229

Element	Leporidae	Cottontail	Jackrabbit	Total
Skull:				
Maxilla		1		**1**
Mandible			1	**1**
Teeth – Complete		3		**3**
Trunk:				
Rib			1	**1**
Foreleg:				
Scapula	1		1	**2**
Humerus		1	2	**3**
Radius		1	3	**4**
Ulna		1		**1**
Hindleg:				
Innominate			1	**1**
Femur			1	**1**
Tibia	1	2	2	**5**
Feet:				
Metacarpals			1	**1**
Metatarsals		2	1	**3**
Metapodial Fragment		1		**1**
1st Phalanx	2	1	1	**4**
1st/2nd Phalanx	1			**1**
Total	**5**	**13**	**15**	**33**

Table 12.12 Burned and gnawed taxa from Trench 3, LA 32229

Taxon	NISP	Burned				Gnawed	
		SC	CH	CAL	Total	R	Total
Indeterminate small bird (quail-size)	1			1	**1**		
Sylvilagus audubonii (Desert Cottontail)	13	1			**1**		
Lepus californicus (Black-tailed Jackrabbit)	15	2		1	**3**	3	**3**
Indeterminate small mammal (rabbit-size)	61	15	13		**28**	1	**1**
Indeterminate medium mammal (coyote-size)	10	3			**3**		
Indeterminate large mammal (pronghorn-size)	50	5	7	2	**14**		
Indeterminate very large mammal (bison-size)	27		1	2	**3**		
Total	**177**	**26**	**21**	**6**	**53**	**4**	**4**

SC=scorched, CH = charred, CAL = calcined; R = rodent

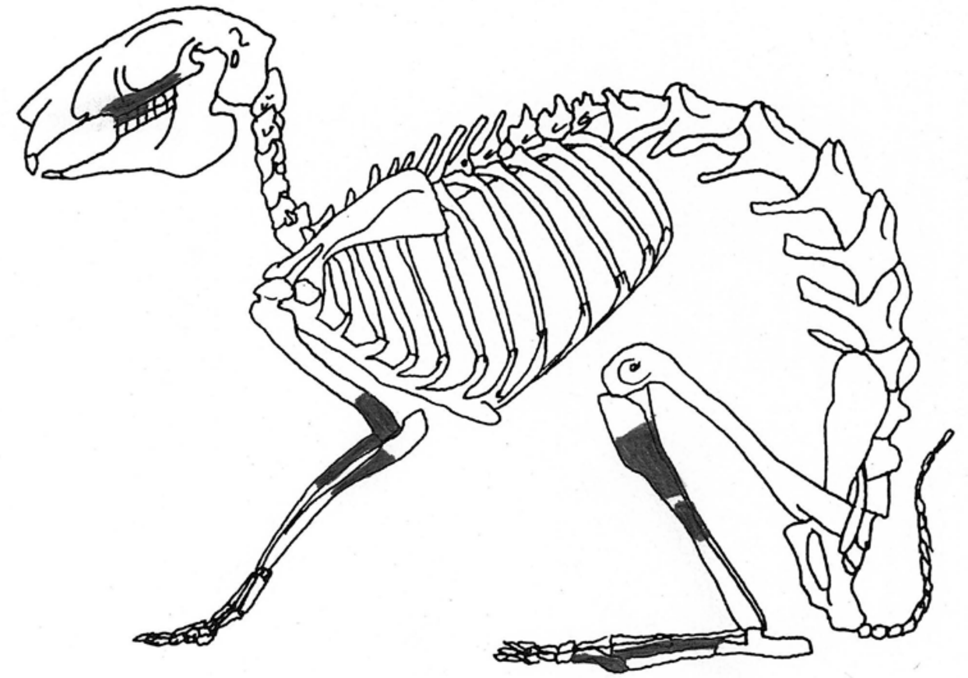

Figure 12.9 Cottontail skeletal part representation, Trench 3, LA 32229

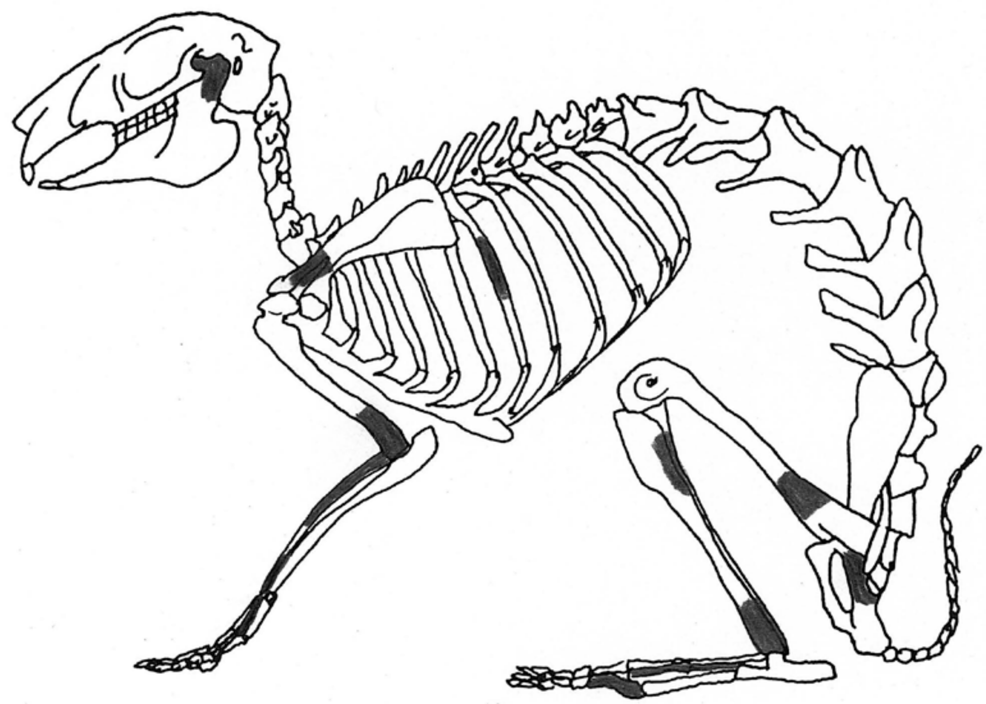

Figure 12.10 Jackrabbit skeletal part representation, Trench 3, LA 32229

Except for a bison horn core, all of the artiodactyl remains (n=13) are teeth (Table 12.13). None have any meat value. None of the artiodactyl specimens is burned, gnawed, or worked, or exhibits butchering marks.

Table 12.13 Artiodactyl skeletal elements from Trench 3, LA 32229

Element	Artiodactyla	Pronghorn	Deer/ Pronghorn	Bison	Total
Skull:					
Horn core				1	**1**
Teeth - Complete		2			**2**
Teeth - Fragments	3		1	6	**10**
Total	**3**	**2**	**1**	**7**	**13**

As with Trench 1, the indeterminate mammal portion of the Trench 3 assemblage accounts for the vast majority of the remains (n=148, 74.7 percent) (Table 12.2). Most of the rabbit-size remains (n=61) are probably leporid and consist of a complete first phalanx, indeterminate fragments (n=14), and long bone shaft fragments (n=46). The incidence of burning is high (n=28, 45.9 percent), with 15 scorched and 13 charred, but that of gnawing is low (n=1, 1.6 percent), with one rodent gnawed (Table 12.12). None of the rabbit-size remains is worked or exhibits butchering marks.

The coyote-size remains (n=10) consist of eight indeterminate fragments and two long bone shaft fragments. Three indeterminate fragments are scorched (Table 12.12). None of the coyote-size remains is gnawed or worked or exhibits butchering marks.

The pronghorn-size remains (n=50) account for about a third (33.9 percent) of the indeterminate mammal assemblage. As with the other trenches, some of the remains may be bison. The pronghorn-size remains primarily consist of indeterminate fragments (n=39, 78.0 percent) but also include long bone shaft fragments (n=11, 22.0 percent). The incidence of burning is high (n=14, 28.0 percent), with five scorched, seven charred, and two calcined (Table 12.13). None is gnawed or worked or has butchering marks.

The bison-size remains (n=27) primarily consist of indeterminate fragments (n=25, 92.6 percent) but also include two long bone shaft fragments, one of which has shallow flake scars on the exterior surface of one end. The end served as the platform. One flake scar is burinated. Although the flake scars may have resulted from trampling, it is possible that they were produced when the long bone shaft was broken, possibly for extraction of the marrow. The incidence of burning is low (n=3, 11.1 percent), with one charred and two calcined (Table 12.13). None of the bison-size remains is gnawed or worked.

12.3.3.1 Discussion

The Trench 3 archaeofaunal assemblage is the smallest (n=198, 12.2 percent) of the three assemblages. Once again, rodents are underrepresented (n=3). The low incidence of rodent gnawing (n=4, 2.0 percent) and the absence of complete or nearly complete rodent skeletons suggest the rodent remains are not intrusive. As indicated previously, ethnographic data indicate pocket gophers and kangaroo rats were consumed as secondary meat resources by various groups (see Natural History and Ethnographic Background). The rodent remains—a mandible fragment, a tooth, and a distal tibia—are low meat value portions that may represent butchering debris.

Although present in lower numbers and not as well represented as in Trenches 1 and 2 (which may be due to the smaller size of the trench), the leporid pattern basically follows that of the other trenches. Vertebrae are absent and only one rib fragment is present. The vertebra-rib pattern may be attributable to carcass processing.

The skeletal part representation of artiodactyls is very poor, with only the head represented. Except for a bison horn core, the only cranial elements are teeth, which have no meat value and are indicative of probably butchering refuse. Maxillae and mandibles were probably broken to access the marrow cavities. The presence of pronghorn- and bison-size remains indicates at least other skeletal portions were brought to the site for meat preparation and consumption and for marrow extraction—as suggested by the bison-size specimen with flake scars—and possible bone grease processing.

12.4 Seasonality

The LA 32229 faunal assemblage is indicative of a diffuse hunting strategy consisting of the procurement of both small game, particularly leporids, and larger game—pronghorn and bison. The presence of low and high meat value elements for each of these animals indicates all were available locally. Leporids, ground squirrels, prairie dogs, pocket gopher, kangaroo rats, and woodrats are r-selected species. Although they contain much less meat than deer or pronghorn, they are more reliable meat resources. They have high reproductive rates and, during good weather, breed nearly all-year in southeastern New Mexico. The high mortality rate for leporids is offset by a high reproductive rate (see Natural History and Ethnographic Background). Because of the long breeding season of leporids in southeastern New Mexico, use of ages based on long bone epiphyseal fusion rates is not a reliable method for determining seasonality. The leporid remains from LA 32229, therefore, do not lend themselves to providing reliable information about seasonality of site occupation.

Artiodactyls are K-selected species and are more susceptible to predation and environmental change compared to r-selected species. Pronghorn breed in the fall and give birth, usually to twins, in mid-June (Findley 1987:144–145; Hoffmeister 1986:549, 551–552; Zeveloff 1988:334–336). None of the pronghorn elements recovered from LA 32229 provides information about seasonality of site occupation. Many of the pronghorn specimens are tooth and enamel fragments. However, the general size, thickness, and texture of the pronghorn bone fragments are indicative of larger, probably mature or nearly mature, individuals.

During the breeding season, from mid- to late summer, bison males join the female-subadult herds. After a gestation period of about 9.5 months, a single precocial calf per breeding female is usually born in the spring. Occasionally, a female may have twins (Bee et al. 1981:229–230; Findley 1987:146; Zeveloff 1988:346–347). Unfortunately, the definitive bison remains from LA 32229 are long bone and tooth fragments that are not conducive to providing information about seasonality of site occupation. The general size, thickness, and texture of the bison bone fragments, however, are indicative of larger, probably mature or nearly mature, individuals.

12.4.1 Freshwater Mussel Shell

Freshwater mussel shell fragments were recovered from each trench. All are small unidentifiable fragments—Trench 1 (n=1, 0.28 g), Trench 2 (n=1, 0.02 g), Trench 3 (n=1, 0.21 g). Three freshwater mussels species—the Texas hornshell (*Popenaias popei*), the Pecos pearly mussel (*Cyrtonaias tampicoensis*), and the yellow sandshell (*Lampsilis teres*)—are known from archaeological sites in southeastern New Mexico (Akins 2001:47). The mussels may have been procured from the Pecos River or from nearby lakes.

12.5 Intersite Comparisons

Based upon suitable lagomorph and artiodactyl assemblages, seven sites—LA 5148, LA 34150, LA 44565, LA 68182, LA 68188, LA 116471, and LA 120945—were selected to compare with the archaeofaunal assemblage from LA 32229, Boot Hill. Because of the differences in field methods and data recovery techniques, it is difficult to generate meaningful comparisons. Studies (e.g., James

1997:386; Shaffer 1992; Shaffer and Sanchez 1994) have shown that as much as 100 percent of the fish, 95 percent of the small animals (rodents, birds, amphibians, reptiles), 86 percent of the small mammals (e.g., squirrels and chipmunks), 71 percent of the lagomorphs, and 47 percent of the medium (coyote-size) mammals are lost through use of ¼-inch screens. In comparison, no artiodactyl bones are lost using ¼-inch screen (Akins 2002:133). The present testing program at LA 32229 used screens with ⅛-inch hardware cloth, increasing recovery of small specimens. The following is a brief description of each site.

LA 5148 (Laguna Plata) has late Archaic and early through late Formative residential occupations dating from A.D. 230 to 1260. The site is on the western perimeter of Laguna Plata playa in western Lea County. The vertebrate faunal assemblage consists of 1810 specimens recovered during the 1970–1971 LCAS excavations (Brown and Brown 2010). The LCAS assemblage is primarily from three features and a large dense midden. Separate MNIs were calculated for the identified taxa in each provenience. Few faunal remains were found outside these proveniences. Most of the assemblage is from Feature 1, a pithouse that had been heavily vandalized prior to excavation (LCAS 1971:7), and its associated contiguous units. Features 2 and 3, also pithouses, include associated contiguous units. The midden assemblage is from seven noncontiguous units in the northern portion of the large midden, north of the pithouses.

LA 34150 (Townsend) is a Late Archaic to late Formative residential occupation dating from ca. 1800 B.C. to A.D. 1400. The site is on the south side of Salt Creek, about 10 miles north of Roswell and 8 miles west of the Pecos River. Excavations yielded prehistoric artifacts and features. The site assemblage was separated into five areas of which three—Townsend East Area A (Early Ceramic with some Late Archaic), Townsend East Area B (Late Ceramic) and Townsend West Pit—have assemblages suitable for comparison in the following analysis. Because the faunal assemblages are distinct for each of these loci they are maintained as separate comparative units in the following discussion (Akins 2003a:263–278).

LA 44565 (Rocky West) represents a Middle Archaic to Late Archaic camp site dating from ca. 3000 B.C. to A.D. 200. The site is along Rocky Arroyo between Carlsbad and Seven Rivers and is about 1.5 miles west of the Pecos River. As indicated by the faunal assemblage, local wildlife was consumed at the site and the refuse was discarded into a fire. Lagomorphs and small mammals dominate the assemblage (Moga 2003:111). The presence of chicken, goat, and possible sheep remains suggests the site may be a historic trash scatter with a shallowly buried prehistoric component (Moga 2003:116).

LA 68182 (Los Molinos) has Late Archaic to late Formative occupations dating from ca. 300 B.C. to A.D. 1350. The site is on the north side of the Middle Berrendo Creek, about 4 miles north of Roswell and 7.6 miles west of the Pecos River. The assemblage represents a diverse and opportunistic hunting strategy with evidence of hunting beyond the immediate site environs, but may represent an amalgamation of both because of the occupation time span involved (Akins and Moga 2004:111).

LA 68188 (Fox Place) is a late Formative residential complex dating from ca. A.D. 1150 to 1400. The site is on the east side of the Rio Hondo, about 2 miles southwest of Roswell and 10 miles west of the Pecos River. Excavations yielded a large assemblage of nearly 60,000 faunal remains, of which 25,615 specimens from 28 features were analyzed (Akins 2002:133–289). The taxonomic composition of the assemblage is very diverse, reflecting the birds, fish, and turtles living in or migrating through the area (Akins 2002:155). In addition, NISP, MNI and taxonomic richness studies have repeatedly shown a strong correlation between the size of the assemblage and the diversity of taxa identified (e.g., K. Brown and M. Brown 1998:134–149; M. Brown and K. Brown 1993:327–336). Exceptions to this association are specialized procurement sites, such as bison and pronghorn kill loci (e.g., the Garnsey bison kill site [Speth 1983] and LA 22107 [Staley et al. 1996]).

LA 116471 (Punto de Los Muertos) has occupations dating from Late Archaic through late Formative, or ca. 500 B.C. to A.D. 1400. The site, immediately northwest of Carlsbad at the east side of Living Desert State

Park, is at the western edge of the Pecos River Valley, immediately west of the river. Excavation focused on a burned midden ring (Feature 1). A sizeable faunal assemblage was recovered, much of which is burned. In addition, the fragmented and burned remains of 12 to 13 humans were recovered from the ring midden. The feature had been previously disturbed by extensive unauthorized digging which contributed to the deterioration of the faunal assemblage and context of the cultural deposits (Akins 2003b:129–130).

LA 120945 (Laguna Gatuna) is a late Formative site dating from ca. A.D. 900 to 1400. The site is situated on the south side of Laguna Gatuna, about 5 miles southeast of the Laguna Plata site. LA 120945, which is in a comparable environment as Laguna Plata, is about 33 miles east of the Pecos River and 27 miles west of the Caprock. Excavations yielded prehistoric artifacts but no discernible features (Bullock 2001; Akins 2001:46–58).

Although not used in the following analysis, the Garnsey site (LA 18399), a mid- to late fifteenth century bison kill on the eastern edge of the Pecos River Valley, about 12 miles southeast of Roswell in Chaves County, is an example of a specialized bison kill locus. The bison remains were exposed in the walls of a modern arroyo that is actively cutting into the alluvial fill of Garnsey Wash, a broad, shallow wash that drains westward into the Pecos River from a low divide at the Caprock. The local terrain consists of low, rolling plains with extensive dunes and numerous playas (Speth 1983:6–7). The Garnsey site is not used in the following assemblage comparisons because it represents a specialized activity that focused on bison procurement and processing. Interestingly, results of analyses indicate procurement was highly selective, with a high proportion of males (60 percent) compared to cows and calves (Speth 1983:160, 165). The intensity of butchering suggests food insecurity. Speth (1983:169) speculates "food insecurity may have been the norm rather than an infrequent or seasonal problem." The Garnsey bison exhibited a high rate of dental attrition and short life expectancy, in addition to subsisting, based on carbon isotope data, on extremely marginal and progressively deteriorating vegetal resources (Speth 1983:169). It is likely that during the mid-1450s the local bison populations were very vulnerable to climatic fluctuations that altered the vegetation. Bison procurement would have been variable and unpredictable from year to year, thus bison hunting would have been opportunistic (Speth 1983:170). Although LA 22107 south of LA 32229 in Lea County has a large faunal assemblage, it is not used in the following analysis because the vast majority of the assemblage consists of bison (n=1748, 77.7 percent) from a single kill and processing area (Staley 1996a:196).

Table 12.14 summarizes the taxa recovered from each of the assemblages. The taxa list is a composite of taxa listed within each of the reports. In a few instances the present taxonomic name is used rather than the former name.

Table 12.14 Summary table of site taxa

Taxon	Common Name	LA 5148 Laguna Plata LCAS 1970	LA 32229 Boot Hill	LA 44565 Rocky West	LA 68182 Los Molinos	LA 34150 Townsend East Area A: Early Ceramic w/Late Archaic	LA 34150 Townsend East Area B: Late Ceramic	LA 34150 Townsend West Pit	LA 120945 Laguna Gatuna	LA 68188 Fox Place	LA 116471 Punto de Los Muertos
Pelecypods	freshwater mussels		3			107	80		9	576	400
Crytonaias tampicoensis	Pecos pearly mussel					2					
Gastropod	snail			2							
Crayfish	crayfish									1	
Osteichthyes	Fish					7	1			443	
Salmo sp.	Trout									1	
Castostomidae	Sucker									105	
Maxostama cf. *congenstum*	Gray redhorse									226	
Cydeptus elongatus	Blue sucker									3	
Ictiobus bubalus	Small-mouth buffalofish									6	
Cyprinidae	Minnow									1	
Ictaluridae	Catfish									353	1
Ictalurus sp.	Catfish species									33	
Ictalurus punctatus	Channel catfish									205	
Ictalurus lupus	Headwater catfish									48	
Pylodictis olivaris	Flathead catfish									14	
Ameiurus sp.	Bullhead catfish									6	
Centrarchidae	Sunfish/ bass									14	
Lepamis sp.	Sunfish									45	
Micropterus cf. *punctulatus*	Spotted bass									15	
Squamata	Lizards and snakes									1	
Sauria	Lizard								2		7
Phrynosoma sp.	Horned lizards			2	3					1	
Cnemidophorus sp.	Whip-tailed lizard					1					
Ophidia	Snakes					1	5				
Colubridae	Nonvenomous snakes	1		1	7	1			2	7	2
cf. *Pituophis melanoleucus*	Gopher snake										
Crotalus atrox	Western diamondback									1	
Salienta	Frogs/ toads				3					5	
Bufonidae	Toads									4	
Spea bombifrons	Plains spadefoot toad				1					1	
Ranidae	Frogs									1	
Rana berlandieri	Rio Grande leopard frog									1	
Testudinata	Turtles and tortoises		6	1	149	7				172	62
Trionyx sp.	Softshell turtles					1					
Trionyx spineferus	Spiny softshell turtle				16					36	7
Trachemys/ Pseudomys	Slider										3
Trachemys scripta	Pond slider				2					17	8
Pseudomys gorzugi	Western river cooter				1					3	
Testudinidae	Box and water turtles				2						
Terrapene ornate	Ornate box turtle	22	11		3	5				22	

Taxon	Common Name	LA 5148 Laguna Plata LCAS 1970	LA 32229 Boot Hill	LA 44565 Rocky West	LA 68182 Los Molinos	LA 34150 Townsend East Area A: Early Ceramic w/Late Archaic	LA 34150 Townsend East Area B: Late Ceramic	LA 34150 Townsend West Pit	LA 120945 Laguna Gatuna	LA 68188 Fox Place	LA 116471 Punto de Los Muertos
cf. *Terrapene ornate*	Ornate box turtle								1		
Chrysemys sp.	Painted turtle			1							
Chrysemys picta	Painted turtle				1					100	1
Chelydridae	Snapping, musk, mud turtles				1						
Chelydra serpentina	Snapping turtle				6					154	
Kinosternon flavescens	Mud turtle				135					36	
Aves	Birds				15					796	
Branta canadensis	Canada goose									1	
Anatinae	Ducks				2						
Aix spansa	Wood duck									4	
Anatini	Surface-feeding ducks									3	
Anas discors	Blue-winged teal									3	
Anas platyrhynchos	Mallard									14	
Anas dypeata	Northern shoveler									5	
Aythyinae	Diving ducks									2	
Aythya affinis	Lesser scaup									4	
Melanitta deglandi	White-winged scoter									1	
Mergus merganser	Common merganser									13	
Cathartes aura	Turkey vulture									1	
Accipitridae	Kites, eagles, hawks, harriers			2							
Pandion haliaetus	Osprey									44	
Haliaetus leucocephalus	Bald eagle									2	
Circus cyaneus	Northern harrier									2	
Accipiter cooperii	Cooper's hawk									1	
Buteo sp.	Broad-winged hawks									2	
Buteo jamaicensis	Red-tailed hawk									2	
Buteo lagopus	Rough-legged hawk									1	
Falco sparverius	Sparrow hawk									1	
Phasianidae	Quails, partridges, pheasants			1							
Gallus gallus	Domestic chicken			1							
Colinus virginianus	Bobwhite										2
Meleagris gallopavo	Turkey				4					317	
Tetraonidae	grouse and ptarmigan									5	
Callipepla gambelii	Gambel's quail									3	1
Callipepla squamata	Scaled quail									8	1
Fulica americana	American coot				2					84	
Tympanuchus pallidicinctus	Lesser prairie chicken									18	
Columbidae	Pigeons and doves				1						
Bubo virginianus	Great horned owl									1	
Melanerpes erythrocephalus	Red-headed woodpecker									1	

Taxon	Common Name	LA 5148 Laguna Plata LCAS 1970	LA 32229 Boot Hill	LA 44565 Rocky West	LA 68182 Los Molinos	LA 34150 Townsend East Area A: Early Ceramic w/Late Archaic	LA 34150 Townsend East Area B: Late Ceramic	LA 34150 Townsend West Pit	LA 120945 Laguna Gatuna	LA 68188 Fox Place	LA 116471 Punto de Los Muertos
Passeriformes	Perching birds			1	2					1	
Eremophila alpestris	Horned lark									1	
Corvus corax	Raven									1	
medium bird	quail-size		4			2					4
large bird	duck/hawk-size		1			1					4
very large bird	turkey/goose-size	1									1
egg shell						10	2		1	120	
Leporidae	Rabbits	37	11		1					11	
Sylvilagus audubonii	Desert cottontail	166	79	63	401	129	32	41	16	2456	148
Lepus californicus	Black-tailed jackrabbit	390	234	39	163	47	17	9	12	1417	148
cf. Lepus californicus	?Black-tailed jackrabbit		1								
Rodentia	Rodents		1		9					28	
Spermophilus sp.	Ground squirrels		2		3					6	
Cynomys ludovicianus	Black-tailed prairie dog	17	6	4	291	33	17	3		998	13
Geomyidae	Pocket gophers		2		9					3	
cf. *Geomys* sp.	Pocket gopher										2
Thomomys bottae	Botta's pocket gopher										1
Pappogeomys castanops	Yellow-faced pocket gopher	8			19	4				300	2
Geomys bursarius	Pains pocket gopher				2			3		2	
Dipodomys sp.	Kangaroo rat										3
Dipodomys ordii	Ord's kangaroo rat						2	1			
Dipodomys spectabilis	Banner-tailed kangaroo rat				8	2				2	5
Cricetinae	New World mice and rats										2
Onychomys leucogaster	Northern grasshopper mouse				2		1				
Castor Canadensis	Beaver									1	3
Sigmodon hispidus	Hispid cotton rat				3					1	5
Neotoma sp.	Woodrat	1	1		10	1				11	20
Neotoma albigula	White-throated woodrat										2
Ondatra zibethicus	Muskrat				35					67	
Erethizon dorsatum	Porcupine				1					5	
Carnivora	Carnivores									2	
Canis sp.	Dogs, coyotes, wolves, foxes				28		1			158	1
Canis familiaris/C. latrans	Dog/coyote		2								
Canis lupus	Wolf									1	
Vulpes vulpes	Red fox									8	
Urocyon cinereoargenteus	Gray fox									4	
Procyon lotor	Raccoon	1			1					3	
Mustelidae	Weasels, skunks, relatives				1						
Taxidea taxus	Badger						1		1	13	

Taxon	Common Name	LA 5148 Laguna Plata LCAS 1970	LA 32229 Boot Hill	LA 44565 Rocky West	LA 68182 Los Molinos	LA 34150 Townsend East Area A: Early Ceramic w/Late Archaic	LA 34150 Townsend East Area B: Late Ceramic	LA 34150 Townsend West Pit	LA 120945 Laguna Gatuna	LA 68188 Fox Place	LA 116471 Punto de Los Muertos
Mephitis mephitis	Striped skunk				6					2	
Artiodactyla	Even-toed ungulates		11		558	18	5	40		760	4
cf. *Cervus elaphus*	Wapiti						1				
Odocoileus sp.	Deer	8			30	1	1			108	11
Odocoileus hemionus	Mule deer								1	4	
Antilocapra Americana	Pronghorn	129	22		87					1082	20
cf. *Antilocapra Americana*	Pronghorn	6	6								
Odocoileus/ Antilocapra Americana	Deer/Pronghorn	66	17								
Bison bison	Bison	3	5		45		2			239	
cf. *Bison bison*	Bison	8	7								
Bos/bison	Cow/bison				34	2				2	
Capra hircus	Domestic goat			1							
Ovis/capra	Domestic sheep/goat			15							
very small mammal	rodent-size				1						5
small mammal or bird	rodent-perching bird-size					7		2	1		
small mammal	rabbit-size	260	271	133	1099	826	118	36	72	4102	268
unknown small	rabbit-size					9	7		2		
medium mammal	coyote-size	18	60	84	2878	54	32	11	12	1959	875
large mammal	deer/pronghorn-size	624	723	30	3680	39	38	6	19	6397	5487
very large mammal	bison/wapiti-size	44	115								1
mammal	undetermined				154					1920	

The archaeofaunal remains from LA 32229, LA 5148, LA 34150 Area A, Area B, LA 44565, LA 116471, and LA 120945 have the look of garden hunting assemblages. The assemblages are dominated by small mammals, particularly leporids, and may reflect the exploitation of animals attracted to cultivated fields. The occurrence of a garden hunting assemblage highlights the importance of small game hunting during the transition from a strictly hunter-gatherer lifeway to reliance on agriculture. In contrast, the assemblage from LA 68188 and LA 34150 Townsend West Pit appear to be more intermediate or transitional between garden hunting and procurement of artiodactyls while LA 68182 is dominated by artiodactyls.

In general, as the commitment to agriculture and sedentism increased in the Southwest, the procurement of small mammals, especially leporids, assumed more importance in subsistence strategies (Szuter and Gillespie 1994). If this is the case, the archaeofaunal assemblages herein should reflect an increase in the proportion of small mammals relative to large mammals during the prehistoric time span—Archaic through late Formative—represented by the assemblages. Because the assemblages are associated with intensive agricultural development and reliance on crops, they should contain a much higher proportion of small mammals. The presence of artiodactyls is also high in LA 34150 Area A, Area B, West Pit, LA 68182, and LA 68188 (Table 12.14).

Two indices are used for inter-site comparisons (Table 12.15). First, the lagomorph index (Bayham 1982) is calculated for the 10 loci represented by seven sites. The lagomorph index is a standardized ratio for examining the proportion of cottontails to jackrabbits in an archaeofaunal assemblage. It is calculated by dividing the total number of cottontail remains (NISP) by the total lagomorph (cottontail + jackrabbit + indeterminate leporid [i.e., Leporidae]) remains (NISP). Values greater than 0.5 indicate relatively more cottontails are represented and those less than 0.5 indicate greater jackrabbit representation. The lagomorph index for LA 32229 is 0.24, which is indicative of an emphasis on jackrabbit procurement.

Second, the artiodactyl index (Bayham 1982) is calculated. This index is a standardized ratio for examining the proportion of artiodactyls to leporids in the archaeofaunal assemblages. It is calculated by dividing the total number of artiodactyl (identified artiodactyl species + indeterminate artiodactyl [i.e., Artiodactyla]) remains (NISP) by the combined total of both leporid and artiodactyl remains (NISP). Values greater than 0.5 indicate relatively more artiodactyls are represented (in a standardized ratio), while values less than 0.5 indicate more leporids (in a standardized ratio) are represented. The artiodactyl index for LA 32229 is 0.21, which is indicative of a focus on rabbit procurement, but with artiodactyls also contributing to the diet.

The leporid index (0.24) for LA 32229 indicates jackrabbit was probably the preferred small game animal. It also suggests that the vegetation in the vicinity of the site tended to be open, which was more conducive for jackrabbits (see Natural History and Ethnographic Background). In addition, the artiodactyl index (0.21) suggests a greater reliance on rabbits than on artiodactyls. As summarized by Quirt-Booth and Cruz-Uribe (1997:957), “horticulture disturbs primary vegetation, creating ‘edge zones’ (new habitats) which support a higher local density of game, particularly small species. Thus, horticulturalists will focus their hunting efforts on small mammals (i.e., leporids) easily taken in agricultural fields.” The low incidence of large mammal remains is suggestive of longer distance hunting, with pronghorn- and bison-size animals introduced into the site in a field-butchered form. If, however, the rabbit-size mammal remains are included with the leporid remains and the pronghorn- and bison-size remains are added to the artiodactyl remains, the artiodactyl index is 0.61, indicating a greater reliance on artiodactyls. Given this revised index and the site’s proximity to Mescalero Ridge and the High Plains, about a mile east, it is likely that the site’s occupants primarily hunted pronghorn and bison, which are herd species and provide a large quantity of meat per individual. Rabbits were a secondary meat resource that were probably procured opportunistically and incidental to gardening activities.

Table 12.15 Lagomorph and artiodactyl indices

Site	Lagomorph Index				Artiodactyl Index			
	Cottontail n	Jackrabbit n	Leporidae n	Index	Leporids n	Artio. n	A+L n	Index
LA 32229, Boot Hill	79	235	11	0.24	325	88	413	0.21
LA 5148, Laguna Plata (LCAS)	166	390	37	0.28	593	220	813	0.27
LA 34150, Townsend Area A: Early Ceramic with Late Archaic	129	47		0.73	176	21	197	0.11
LA 34150, Townsend Area B: Late Ceramic	32	17		0.65	49	9	55	0.16
LA 34150, Townsend West Pit	41	9		0.82	50	40	90	0.44
LA 44565, Rocky West	63	39		0.62	102	16	118	0.14
LA 68182, Los Molinos	401	163	1	0.71	565	754	1319	0.57
LA 68188, Fox Place	2456	1417	11	0.63	3884	2195	6079	0.36
LA 116471 Punto de Los Muertos	148	148		0.50	296	35	331	0.11
LA 120945 Laguna Gatuna	16	12		0.57	28	1	29	0.03

Figure 12.11 summarizes the lagomorph and artiodactyl indices. Seven loci represented at five sites—LA 34150 (Townsend Area A; Area B; West Pit), LA 44565 (Rocky West), LA 68182 (Los Molinos), LA 68188 (Fox Place), and LA 120945 (Laguna Gatuna)—have high lagomorph index values (greater cottontail than jackrabbit). In addition, LA 116471 (Punto de Los Muertos) has an index of 0.5. LA 5148 (Laguna Plata) and LA 32229 (Boot Hill) have index values below 0.3. Both sites are immediately west of the Caprock and may reflect local environmental conditions. Jackrabbit prefer open habitat, and cottontail prefer brushy, vegetated habitat.

The present assemblages exhibit a major break in the lagomorph index between 0.3 and 0.5, with LA 32229 and LA 5148 having values less than 0.3 and all other assemblages having values of 0.5 and greater. In addition to showing differences in emphasis between two genera—*Sylvilagus* and *Lepus*—as they relate to subsistence, the indices also represent different hunting strategies and are environmental indicators. The desert cottontail inhabits grasslands, brushy areas, and deserts and subsists mainly on shrubs and cacti, such as mesquite and prickly pear, but also eats grasses and herbs. The cottontail has a restricted home range of 1 to 5 acres and is normally active early in the morning and at night (Cockrum 1982:129, 133; Findley et al. 1975:87, 89; Hall and Kelson 1959:267; Schwartz and Schwartz 1981:103). A variety of methods (e.g., snares, rabbit sticks, throwing sticks, clubs, bows and arrows, nets) were used ethnographically to hunt cottontail (see Natural History and Ethnographic Background).

The black-tailed jackrabbit is most common in open, treeless habitats (Findley 1987:55) and usually feeds at night on grasses, mesquite, and herbs but also eats cultivated crops. The size of the jackrabbit home range is dependent upon the availability of food, cover, and water and varies, therefore, from 4 to 75 ha. Jackrabbits are more easily obtained with communal hunts and drives, using nets and clubs (see above).

The artiodactyl indices for LA 68182 (Los Molinos) (0.57) and LA 34150 (Townsend West Pit) (0.44), and to a lesser extent for LA 68188 (Fox Place) (0.36) is noteworthy, suggesting artiodactyl hunting was a primary subsistence strategy. LA 120945 (Laguna Gatuna) has a very low artiodactyl index (0.03), indicative of greater reliance on the procurement of leporids, as do LA 116471 (Punto de Los Muertos) (0.11), LA 44565 (Rocky West) (0.14), and LA 34150 (Townsend Area A [0.11] and Area B [0.16]).

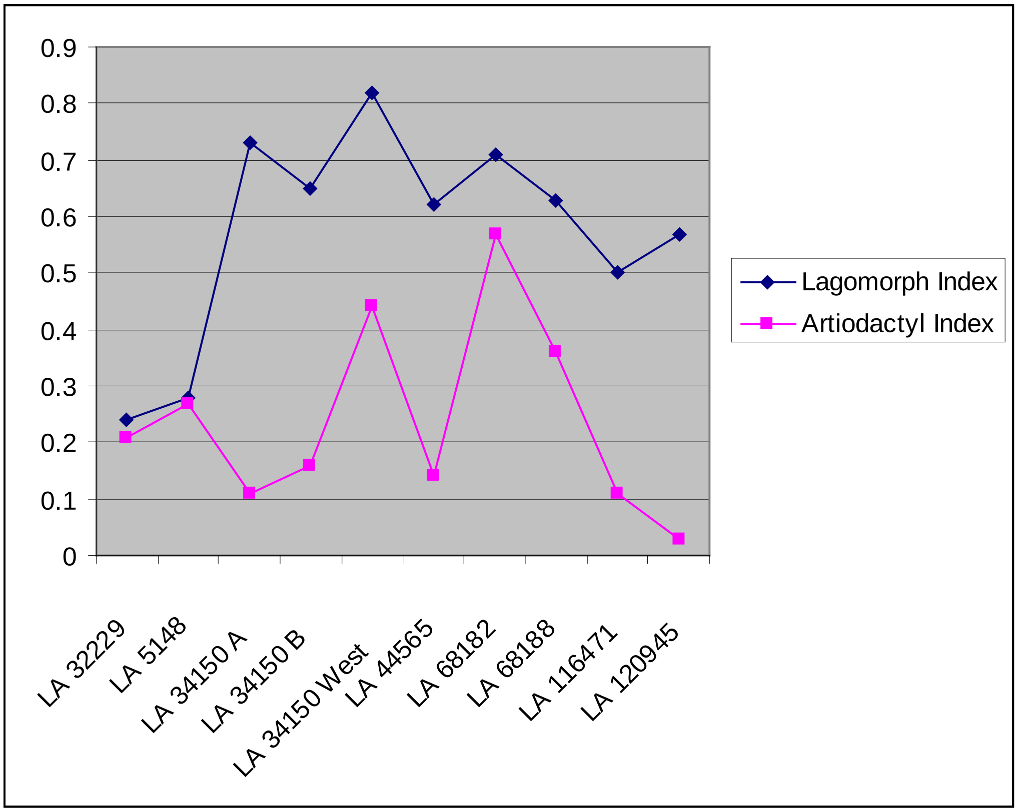

Figure 12.11 Lagomorph and artiodactyl indices summary graph

12.6 Conclusions

The archaeofaunal assemblage from Boot Hill (LA 32229) consists of 1610 vertebrate faunal remains recovered during the present project. A series of research questions were posed at the beginning of this chapter and form the basis for the following conclusions.

What animals were exploited by the site's inhabitants and which were dietary staples?

All of the specifically identified taxa are probably cultural (Table 12.1) and except for dog/coyote, all probably contributed to the diet of the site's inhabitants. The paucity of rodent remains suggests their occasional inclusion in the diet as meat supplements, possibly during times of food stress. Ethnographic data document the use of prairie dogs, woodrats, pocket gophers, and turtles as dietary supplements by a variety of groups (see Natural History and Ethnographic Background). Staple meat resources consisted of leporids (jackrabbits and cottontails) and artiodactyls, especially pronghorn. Bison was available, at least occasionally. The absence of definite deer remains suggests this artiodactyl was not a dietary staple.

What was the relative importance of small game in the diet?

The leporid index of 0.24 indicates jackrabbit was the primary small game. The artiodactyl index is 0.21, indicative of hunting that focused on the procurement of rabbits rather than artiodactyls. If, however, the revised artiodactyl index of 0.61, which incorporates the rabbit-, pronghorn-, and bison-size remains, is used, a greater reliance on artiodactyls is indicated. It is likely that the site's occupants primarily hunted pronghorn and bison, herd species that provide a large quantity of meat per individual. Rabbits were secondary meat resources that were probably procured opportunistically in the immediate vicinity of the site.

What was the role of bison exploitation in subsistence at the site?

Based on the assemblage as a whole, only one bison is represented. Considering each trench separately, however, three bison are represented. Only 32 bison and 115 bison-size remains are present. The paucity of bison and bison-size remains suggests hunting did not focus on the procurement of bison. Bison were probably hunted opportunistically, as they were drawn to nearby playas and springs. The presence of both low and high meat value elements suggests bison were procured nearby. Bison probably provided a welcome addition to the regular meat diet—pronghorn and rabbits. The fragmented condition of the bones reflects processing for marrow and possibly for bone grease.

What was the relative contribution of hunting, gathering, and cultivation to the diet?

No cultigens were identified in the pollen and flotation samples (Holloway Appendix xx). However, FTIR analysis of sherds and ground stone artifacts suggests cucurbits (gourd, pumpkin, squash) and possibly goosefoot (or yucca) were processed (Logan Appendix xx). Starch residue confirms the processing of little barley through grinding and boiling (Perry Appendix xx). The paucity of botanical evidence suggests hunting was of primary importance at LA 32229, with gathering and possible limited horticulture supplementing the diet.

What butchering patterns are discernible in the archaeofaunal assemblage?

The incidence of rodents is low and few rodent taxa are present (Table 12.1). The low incidence of rodent remains is probably the result of carcass preparation, consumption, and refuse disposal, with cranial specimens representing butchering refuse and long bones representing consumption refuse. The absence or paucity of trunk elements (e.g., vertebrae, ribs, pelves) may have resulted from preparation and consumption techniques. After the carcass was cooked, with or without the head, the legs were removed and their meat was eaten. The rest of the carcass, essentially the trunk, was crushed and eaten along with its bones (see Natural History and Ethnographic Background).

A similar pattern is postulated for the leporids. Skull and foot bones are low food value elements that were probably discarded as butchering debris. The near absence of leporid vertebrae and ribs suggests the trunk was processed differently than the rest of the carcass. As indicated ethnographically (see Natural History and Ethnographic Background), these bones may have been pulverized and consumed with the meat. The rabbit and rabbit-size long bones are generally broken but much of the breakage seems to be post-depositional. It is doubtful that the rabbit and rabbit-size long bone specimens were processed formally for marrow or grease. Although long bones may have been broken during butchering, consumption, or discard, fragmentation may also have resulted from trampling by humans and animals (Andrews 1990:8–10; Binford 1981:78; Haynes 1991:141–142,253; Lyman 1994:379, 381). Both low and high meat value elements, indicative of on-site butchering, processing, and consumption refuse, are present.

Artiodactyls are primarily represented by skull and foot elements—low meat value bones. Metapodials (metacarpals and metatarsals), however, have a high marrow content. In addition, the leg elements are higher meat value bones, which also have a high marrow content. The presence of primarily cranial and foot elements, representative of butchering debris, suggests entire artiodactyl (including bison) carcasses were brought to the site, with the animals probably procured nearby. The scarcity and fragmented condition of the metapodials and fore- and hindleg elements suggest these bones were processed for marrow and possibly for bone grease. No complete artiodactyl long bones are present. Both low and high meat value elements, indicative of on-site butchering, processing, and consumption refuse, occur.

How did subsistence strategies change with the introduction of various technological innovations?

Because of the absence of a firm chronology of the site stratigraphy and associated artifacts, discernment of subsistence strategy changes associated with the introduction of various technological innovations is currently not possible.

How did subsistence strategies change in response to the increased abundance of bison beginning in the late thirteenth century?

The presence of playas and springs in the vicinity of LA 32229 suggests bison and other game were undoubtedly attracted to the area. The paucity of bison and bison-size remains at LA 32229 itself, therefore, indicates bison were not necessarily killed at the site, but in the general vicinity. The presence of foreleg and hindleg elements suggests the distance was not unduly far. These bones are high meat value elements that also have high marrow content. The broken condition of the bones suggests processing for marrow and possibly for bone grease. Overall, the faunal remains are indicative of local, probably opportunistic hunting.

Leporids are r-selected species. Although they contain much less meat than artiodactyls, they are more reliable meat resources. Leporids are not as adversely affected by hunting pressures as are artiodactyls. In addition, rabbits and other small mammals could have been easily procured by women and children using a variety of simple techniques (e.g., traps, deadfalls, snares, rabbit sticks). In general, however, artiodactyls (especially pronghorn) were procured locally as the opportunity presented itself. The presence of low and high meat value elements suggests much, if not all, of the carcasses were brought to the site or, in the case of bison, were initially butchered at the nearby kill locus. The subsistence strategies observable in the faunal assemblage from each trench are essentially the same. Changes associated with an increased abundance of bison are not discernible.

Did subsistence strategies change with the availability of bison?

No increased availability of bison is discernible in the archaeofaunal assemblage. Based on the faunal assemblage from each trench, the animals hunted and the processing of carcasses remained unchanged. Hunting focused on the procurement of leporids and artiodactyls, primarily pronghorn. Leporids dominate in all three trenches. Hunting of artiodactyls, including bison, was probably opportunistic, as the animals were attracted to nearby playas and springs. Based on limited testing data, subsistence strategies did not change with the availability of bison.

Is seasonal variation in the procurement of animal resources discernible?

As indicated above, because of the long breeding season for leporids in southeastern New Mexico, use of ages based on long bone epiphyseal fusion rates is not a reliable method for determining seasonality. The LA 32229 leporid remains, therefore, do not lend themselves to providing reliable information concerning seasonality of site occupation. In addition, the artiodactyl remains are not appropriate for providing information about seasonality. Seasonality, therefore, is not discernible in the faunal assemblage.

What do the leporid and artiodactyl indices reflect?

The leporid index of 0.24 indicates jackrabbits predominate and the artiodactyl index of 0.21 indicates the presence of more rabbits than artiodactyls. This suggests a garden hunting strategy. The low incidence of large mammal remains is suggestive of longer distance hunting, with pronghorn- and bison-size animals introduced into the site in a field-butchered form. If, however, the rabbit-size mammal remains are included with the leporid remains and the pronghorn- and bison-size remains are added to the artiodactyl remains, the artiodactyl index is 0.61, indicating a greater reliance on artiodactyls. Given this revised index and the site's proximity to Mescalero Ridge and the High Plains, about a mile east, it is likely that the site's occupants primarily hunted pronghorn and bison, which are herd species and provide a large quantity of meat per individual. Rabbits were a secondary meat resource that were probably procured opportunistically and incidental to gardening activities.

Is there evidence for food stress in the faunal assemblage, such as fracturing long bones for marrow extraction and pulverizing small animals for complete consumption?

The skeletal part representation for rabbits and rodents suggests similar processing. As mentioned previously, the absence or paucity of trunk elements (e.g., vertebrae, ribs, pelves) may have resulted from preparation and consumption techniques. After the carcass was cooked, with or without the head, the legs were removed and eaten. The trunk bones may have been pulverized and consumed with the meat. This would have made consumption of the torso easier, rather than having to pick out all of the little bones. In addition, baking or boiling small animals can soften bones such as cervical and thoracic vertebrae and ribs, allowing incidental consumption with the meat. Although this pattern may represent food stress, ethnographic data (see above) suggest this was a normal, easy way to process and consume small animals.

The artiodactyl, pronghorn-size, and bison-size remains, on the other hand, reflect a different pattern. All of the artiodactyl long bones have been broken. The metapodials and long bones have a high marrow content. The scarcity and fragmented condition of metapodials and fore- and hindleg elements suggest these bones were processed for marrow and possibly for bone grease. However, the overall supporting data for bone grease processing—large piles of pulverized bone or fire-cracked rock (Binford 1978:159; Quigg 1997; Vehik 1977)—are presently lacking but may be present in nearby unexcavated portions of the site. Extraction of marrow and processing for bone grease do not necessarily indicate food stress. These processes are also associated with the production of pemmican, a high energy food that can be stored for extended periods. The data do not necessarily indicate the site occupants were experiencing food stress.

13.0 Radiocarbon Dating

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Chronology was established through relative dating of diagnostic artifacts and absolute-dating radiocarbon analysis. In particular, accelerator mass spectrometry (AMS) were conducted on one feature (n=1, Feature 3), three soil horizons (n=3), and four levels from excavation Unit 3 in Trench 1 in an attempt to establish a more refined chronometric sequence for the site and its environs. Although the SOW required a minimum of four radiometric dates be obtained from the highly organic enriched soils on the hill top, additional sediment samples were submitted from geomorphological contexts (Localities 1–3).

The radiocarbon dates were processed through the CALIB Radiocarbon Calibration Software program (CALIB) which standardized the calibration curve for all radiocarbon assays (M. Stuiver, P. J. Reimer, and R. Reimer 2011). Eight samples (5 charcoal, 3 sediments) were submitted for radiocarbon dating (Table 13.1). Also included in the table is a radiocarbon date derived from sediments from the CR 220 road cut in 1990. The samples were targeted for AMS dating to bracket the occupation episodes for LA 32229 and correlate with the relative dates of the diagnostic artifacts. Based on results of the radiocarbon data, at least one general occupation event is associated with the site.

The sample from Feature 3 was collected from a small carbon stain encountered during testing. This stain was the only architectural remnant excavated during testing. The AMS analysis yielded a conventional age of 1440±25 B.P. with a calibrated, 2-sigma age range of A.D. 575–651 (UGA 7608). This age estimate falls within Katz and Katz's (1993) Formative 1 phase. This age is in keeping with the depositional history of this portion of the site.

The nature of the anthrogenic soil, a true dark earth, in the vicinity of Trench 1 at the Boot Hill site is unusual in this landscape. The behavioral and natural processes responsible for its formation and its spatial implications warrant further investigation. Middens of this nature are unusual in that it lacks significant quantities of burned rock and it is aerially extensive. Although the initial geoarchaeological impression of this deposit is that it is heavily mixed (Chapter 9), an attempt was made to test the age of the structure of the deposit through AMS radiocarbon ages obtained from pieces of charcoal collected from levels 1, 2, 4, and 5 within Unit 3 of Trench 1. The deposits in the top 20–30 cm of the soils clearly is mixed and of doubtful integrity (Table 13.1). The AMS dates are of substantially older age than those from the lower levels. However, the results do suggest that some areas of deeper deposit may have integrity and are not mixed. The AMS dates from the lower two levels retain their stratigraphic chronology and suggest they may retain their spatial integrity. While the dates obtained during this testing phase *suggest* this might be the case, the degree to which such deposits with integrity exist, and their extent is still undetermined. Should they exist, a larger scale excavation would be required to uncover such deposits and extract any data they contain.

The six radiometric dates associated with the main site are indicative of a more intensive site occupation during the Formative period, particularly from about A.D. 575, the Formative 1, through the early Formative 6 period, and abandonment of the site by A.D. 1225. This is a critical time period in southeastern New Mexico prehistory, with availability of cultigens, climatic change (Little Ice Age), changes in available herd animals (e.g., bison and pronghorn), and technological adaptations (e.g., bow-and-arrow and ceramics). For intersite comparative purposes, the AMS dates acquired for the Laguna Plata site are included in Table 13.1.

Table 13.1 Accelerator mass spectrometer data for LA 32229 and culturally associated dates from Laguna Plata (LA 5148)

Laboratory Number.	Feature Number.	Material	13C/12C	pMC	C^{14} Age B.P.	CALIB 2-Sigma Age Range	Cultural Affiliation
Beta 39193	(1990) CR 220 road cut	Sediment			1290±90	A.D. 600–900 A.D. 917–966	Formative 1–2
UGA-7608	Trench 1, TU 1.3, Feature 3	Charcoal	-24.1‰	83.58	1440±25	A.D. 575–651	Formative 1
UGA-8336	Trench 1, TU 1.3, Level 5	Charcoal	-24.6‰	84.66	1340±25	A.D. 654–719 A.D. 742–769	Middle Formative 1–Early Formative 2
UGA-8337	Trench 1, TU 1.3, Level 4	Charcoal	-24.4‰	89.70	870±25	A.D. 1047–1089 A.D. 1121–1139 A.D. 1149–1224	Late Formative 3–Early Formative 6
UGA-8338	Trench 1, TU 1.3, Level 2	Charcoal	-24.4‰	87.70	1050±25	A.D. 899–919 A.D. 962–1025	Formative 2–3
UGA-8339	Trench 1, TU 1.3, Level 1	Charcoal	-24.1‰	83.89	1410±30	A.D. 591–665	Formative 1
UGA-7609	Locality 3	Sediment	-17.6‰	85.56	1250±25	A.D. 678–784 A.D. 786–827 A.D. 839–864	NA
UGA-7610	Locality 1	Sediment	-15.7‰	77.64	2030±25	152–150 B.C. 110 B.C–A.D. 29 A.D. 38–51	NA
UGA-7611	Locality 2	Sediment	-21.0‰	33.42	8800±30	8166–8123 B.C. 7975–7739 B.C.	NA
LA 5148	**Laguna Plata Site**						
UGA-6724	Feature 2	Charcoal	-24.9‰		1740±25	A.D. 240–359 A.D. 363–381	Archaic 4
UGA-7215	Feature 3-Past A	Charcoal	-22.8‰		870±28	A.D. 1045–1094 A.D. 1120–1141 A.D. 1147–1225 A.D. 1233–1241 A.D. 1247–1251	Formative 3–6
UGA-6725	Feature 3-Post C	Charcoal	-25.7‰		900±25	A.D. 1042–1107 A.D. 1117–1210	Formative 3–5
UGA-6723	Feature 6	Charcoal	-24.7‰		1670±25	A.D. 262–280 A.D. 326–426	Archaic 4
UGA-7214	Trench 6 off-site	Bison bone	-8.90‰		280±27	A.D. 1515–1598 A.D. 1617–1665 A.D. 1785–1793	Proto-Historic Historic

When the chronometric data from LA 32229 are compared to comprehensive radiocarbon datasets provided by Railey, Rissetto, and Bandy (2009) then the occupation of LA 32229 occurs immediately prior to and immediately after the peak periods of occupation in the region (Figure 13.1). Assigning an arbitrary 200-year time increment, the 95 percent confidence level indicates increased occupation in the region as early as 50 B.C., peaking around A.D. 750, and declining by A.D. 1750. The cumulative-age peak, as shown by the radiocarbon age histogram, indicates a range of more intense occupation at the Boot Hill site between A.D. 575 and 1225 with abandonment after 1225.

This occupation distribution differs somewhat from Railey, Rissetto, and Bandy (2009:50) and the variation observed at LA 5148, which lends more support to the Railey, Rissetto, and Bandy (2009) distribution (Table 13.1, Figure 13.1). The absence of a chronometric dated Archaic 4 (A.D. 1–500) occupation at the Boot Hill site may be attributed to several factors, among which is there is an earlier Archaic IV presence at the site elsewhere, such as near one of the arroyos (e.g., Locality 1) (152–150 B.C., 110 B.C.–A.D. 29, A.D. 38–51). In addition, there is the possibility of a Paleoindian presence as expressed by the proboscidean tusk fragment that was dated in Locality 2 (8166–8123 B.C., 7975B.C.). However, the tusk fragment may represent secondary deposition, consequently the later date. The additional radiometric date from Locality 3 (Table 16.1) yielded additional support for Formative 1 through 2 occupation of the site.

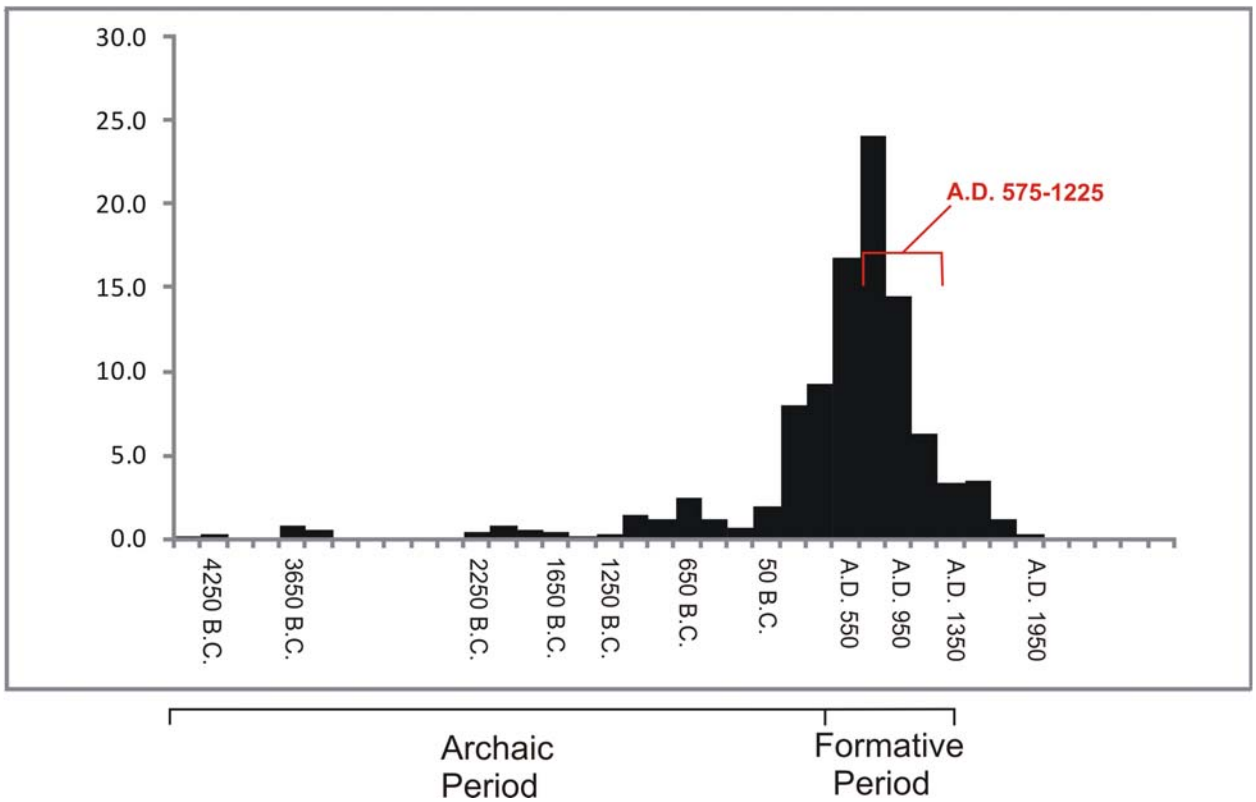

Figure 13.1 Summed probability graph for the southeastern New Mexico region

(modified from Railey, Rissetto, and Bandy [2009]) (Boot Hill radiocarbon dates in red)

Current research carried out by Railey, Rissetto, and Bandy (2009) and aggressive radiocarbon sampling conducted by Lord and Reynolds (1985), Staley (1996b), Wiseman (2003), and recent work by Simpson (2010) there is becoming a more reliable chronometric control of the archaeological record in southeastern New Mexico. However, nearly 55.9 percent (n=124) of the conventional radiocarbon dates acquired several years ago (see Railey, Rissetto, and Bandy (2009:Appendix I) have standard errors greater than 50 years. As stated throughout Hogan (2006), good radiocarbon dating in southeastern New Mexico requires not only careful collection and meticulous chemical and radiometric analysis, but also consideration of the biochemistry of the carbon source. Moreover, pursuing a more aggressive regimen of sampling data from suitable contexts throughout the region may provide an elevated level of chronometric control and further our understanding of the region.

The recent dating of 48 features at seven sites in the Mescalero Sands yielded dates associated with early Archaic through late Formative occupations. The 48 dates include 10 Archaic I, 6 Archaic III, 7 Archaic IV, 10 Formative I, 15 Formative II, 1 Formative III, 4 Formative IV, and 2 Proto-historic-Present features (Simpson 2010:302). These sites in the Mescalero Sands retained fairly stable surfaces that were occupied repeatedly from the Archaic through the middle Formative periods. Periods of most intense occupation appear to have occurred from about 5500–2000 B.C., around 1000 B.C., from about A.D. 1 to 950, a short period of abandonment of the region followed by more intense occupation of the region from about A.D. 1075 to 1125 and abandonment again until after A.D. 1400. These earlier dates of occupation in the region tend to correlate with the interpretations for the Laguna Plata site (see above), from A.D. 200/400–1100 and A.D. 1100–1300, but do not necessarily correlate with the later dates. The more intensive Formative I and II occupations, represented by 25 radiocarbon dates, correspond more closely with the occupations expressed at the Boot Hill site (Table 16.1). Obviously, there needs to be refinement in the chronology for the region. Although informative and helpful, the conventional and AMS dates from the seven excavated sites in the Mescalero Sands (Simpson 2010) exhibit standard errors of ±40 (42 percent of 48 dates) to ±60 (35 percent of 48 dates) while those recently acquired for the Boot Hill and Laguna Plata sites have been ±25 to ±30. Unfortunately, the higher resolutions are not conducive to better chronometric control and further work needs to be done.

14.0 Conclusions

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This chapter summarizes the results of the investigations and assesses them in terms of the research issues outlined in Chapter 4. The summary data are followed by a discussion that integrates research issues into an interpretation of prehistoric land use. The research issues are predicated in part upon our current understanding of the culture history of the Jornada Mogollon region and the characteristics specific to LA 32229. The fundamental research objective of the testing project was to map the spatial limits of the primary occupation area, including surface artifacts and features, to discern the location of the LCAS (1957 and 1958) excavations, to carry out limited test excavations, and to analyze recovered materials in order to summarize the status of the archaeological data from the site. The second objective was to develop a geophysical map identifying subsurface features and anomalies associated with LA 32229. The third objective was to identify the soil sequence at the site and to correlate the contextual integrity of the cultural deposits with the site's depositional context. The latter two objectives provided the necessary data for evaluating spatial diversity and land-use patterns at LA 32229 and for correlating these data to current models of prehistoric mobility and adaptation. The ultimate value of this project is the providing of relevant data for determining future research efforts and data recovery strategies at LA 32229 and similar sites in the region. The research topics identified include the following: chronology and cultural affiliation, site structure, assemblage diversity, technology, subsistence patterns, land use patterns, and regional interaction.

14.1 Chronology and Cultural Affiliation

Establishing the site chronology involved using both AMS dated loci and diagnostic artifacts. This strategy integrated type correlates that included relative dates provided by diagnostic ceramics and projectile point assemblages. Cross typing of artifacts against the radiocarbon assays strengthened the interpretation for site occupation and provided a link between temporal and material correlates with regard to diagnostic artifact types.

14.1.1 AMS Dates

AMS dates were acquired for one feature (Feature 3), three soil horizons (n=3), and four levels from excavation Unit 3 in Trench 1 in an attempt to establish a more refined chronometric sequence for the site and its environs. The radiocarbon dates were processed through the CALIB Radiocarbon Calibration Software program (CALIB) which standardized the calibration curve for all radiocarbon assays (M. Stuiver, P. J. Reimer, and R. Reimer 2011). Eight samples (5 charcoal, 3 sediments) were submitted for radiocarbon dating (Table 13.1). Also included in the table is a radiocarbon date derived from sediments from the CR 220 road cut in 1990. Based on results of the radiocarbon data for the organically rich soil, at least one general occupation event is associated with the site.

Feature 3 was the only architectural remnant excavated during testing. AMS yielded a conventional age of 1440±25 B.P. with a calibrated, 2-sigma age range of A.D. 575–651 (UGA 7608). This age estimate falls within Katz and Katz's (1993) Formative 1 phase. This age is in keeping with the depositional history of this portion of the site. The nature of the anthrogenic soil, a true dark earth, in the vicinity of Trench 1 at the Boot Hill site is unusual in this landscape in that it lacks significant quantities of burned rock and it is aerially extensive. The initial geoarchaeological impression of this deposit is that it is heavily mixed (Chapter 9). The AMS dates from the surface are of substantially older age than those from the lower levels. However, the results do suggest that some areas of deeper deposit may have integrity and are not mixed. The AMS dates from the lower two levels (Levels 4 and 5) retain their stratigraphic chronology and suggest they may retain their spatial integrity. While the dates obtained during this testing phase *suggest* this might be the case, the degree to which such deposits with integrity exist, and their extent, is still undetermined. Should they exist, a larger scale excavation would be required to uncover such deposits and extract any data they contain. The six radiometric dates associated with the main site are indicative of a more intensive site occupation during the Formative period, particularly from ca. A.D. 575, the Formative 1, through the early Formative 6 period, and abandonment of the site by A.D. 1225 (Figure 14.1).

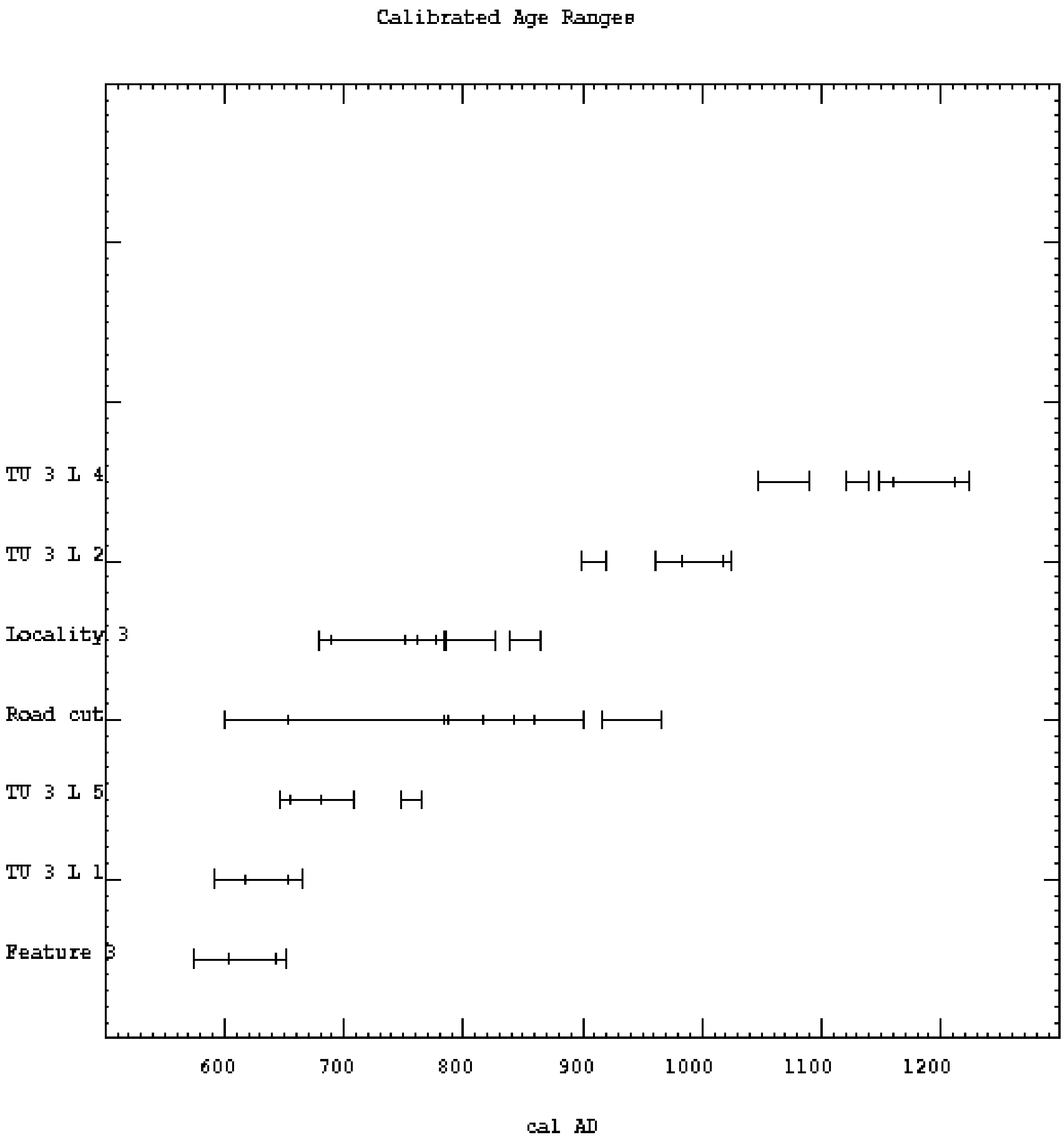

Figure 14.1 Calibrated AMS dates for LA 32229 (does not include dates for geomorphological loci)

The recent dating of 48 features at seven sites in the Mescalero Sands yielded dates associated with early Archaic through late Formative occupations. The 48 dates include 10 Archaic 1, six Archaic 3, seven Archaic 4, 10 Formative 1, 15 Formative 2, one Formative 3, four Formative 4, and two Proto-historic-Present features (Simpson 2010:302). These sites in the Mescalero Sands retained fairly stable surfaces that were occupied repeatedly from the Archaic through the middle Formative periods. Periods of most intense occupation appear to have occurred from about 5500 to 2000 B.C., ca. 1000 B.C., from ca. A.D. 1 to

950, a short period of abandonment of the region followed by more intense occupation of the region from ca. A.D. 1075 to 1125, and abandonment again until after A.D. 1400. These earlier dates of occupation in the region tend to correlate with the interpretations for the Laguna Plata site (see above), from A.D. 200/400 to 1100 and A.D. 1100 to 1300, but do not necessarily correlate with the later dates. The more intensive Formative 1 and 2 occupations, represented by 25 radiocarbon dates, correspond more closely with the occupations expressed at the Boot Hill site (Table 13.1). Obviously, there needs to be refinement in the chronology for the region. Although informative and helpful, the conventional and AMS dates from the seven excavated sites in the Mescalero Sands (Simpson 2010) exhibit standard errors of ±40 (42 percent of 48 dates) to ±60 (35 percent of 48 dates) while those recently acquired for the Boot Hill and Laguna Plata sites (Condon et al. 2010a) have been ±25 to ±30. Unfortunately, the higher resolutions are not conducive to better chronometric control and further work needs to be done.

14.1.2 Ceramics

Seventeen pottery types were identified. Local types include Jornada Brown and Jornada Decorated. Nonlocal types include South Pecos Brown, El Paso brownware, El Paso Brown, El Paso Polychrome, El Paso Decorated, Mimbres whiteware, Playas Red, Chupadero Black-on-white, Three Rivers Red-on-terracotta, Gila Polychrome, St. Johns Polychrome, Socorro Black-on-White, and Corona Corrugated. An indeterminate category was created for sherds that could not be accurately identified.

The ceramic assemblage consists of 409 analyzed sherds and provides a relative age estimate for site use. Occurring with the most frequency in the ceramic assemblage is Jornada Brown, which, in much the same way as other plain brownwares, provides a relative temporal range for a given region. In this case, Jornada Brown dates between A.D. 200/400 and 1250/1350 and covers the entirety of the Formative period at the Boot Hill site. South Pecos Brown occurs with less frequency, but spans a period of 300 years (A.D. 900–1200). These brownwares appear to correspond stylistically with similar undecorated brownware types, including El Paso Brown, despite being manufactured in the eastern extension of the Jornada Mogollon region (Katz and Katz 1993; Miller 1995).

Within Lehmer's (1948) Jornada Mogollon culture sphere are the Rio Grande pottery types, which include El Paso Brown and El Paso Polychrome. These pottery types also occur in relatively low frequencies, but reflect the transition from a plain brown, which flourished from A.D. 200 to 1000/1100, to painted wares after A.D. 800/1000 in the Rio Grande valley. The subsequent introduction of polychrome wares (A.D. 1000/1100–1450) is identified in the assemblage from the Boot Hill site. Although El Paso Polychrome occurs in low frequencies it effectively points toward a regional influence at LA 32229 post-A.D. 1000. The Rio Grande valley, including the adjacent Hueco Bolson and Tularosa Basin, fall within the traditional boundary of the Jornada Mogollon region, and holds a tentative association with the Pecos River valley to the east, despite the general absence of locally made decorative pottery in the Pecos River valley. Moreover, the identification of clays and temper material, as suggested by Hill (2000), suggests the majority of brownware pottery was produced outside the Boot Hill area, primarily in the Sierra Blanca region or the Rio Grande area associated with El Paso.

Mimbres white ware dates between A.D. 750 and 1130/1150 east of the Mimbres Mountain range and overlaps chronologically with Jornada Brown, South Pecos Brown, and El Paso Brown; all pre-date what is considered the primary occupation at the Boot Hill site. Similar to Mimbres white ware, Socorro Black-on-white dates from A.D. 950 to 1300 and also overlaps with Jornada Brown, South Pecos Brown, and El Paso Brown. Chupadero Black-on-white and Three Rivers Red-on-terracotta originate northwest of the Boot Hill site and date post-A.D. 1100, with the highest frequencies dating between A.D. 1100 and 1300. Playas Red is thought to be a product of the Casas Grande region of Mexico and also dates post-A.D. 1100, and represents a second period of intense occupation at the Boot Hill site.

Ceramics that date after A.D. 1200 tend to support the traditional interpretation of the occupation at the Boot Hill site (Corley and Leslie 1960). St. Johns Polychrome and Corona Corrugated reflect occupational events as early as A.D. 1200 and A.D. 1225, respectively. Gila Polychrome indicates site use after A.D. 1300, and terminating by A.D. 1400/1450. This is later than suggested by Corley and Leslie (1960). The record of site activity at Boot Hill clearly demonstrates a consistent, although not continuous, use throughout the Formative period.

14.1.3 Projectile Points

Seventeen projectile points were recovered from Trenches 1, 2 and 3 and one was collected from the surface within the project area. Seven are classified as Harrell/Washita variants (Justice 2002:289; Turner and Hester 1993:217). Justice (2002:298) dates this style between A.D. 1150 and 1300/1500, and it has been previously reported at the Boot Hill site (Corley and Leslie 1960).

Four projectile points are classified as Fresno variants (Justice 2002:266–267). Various date ranges have been proposed for this style, with all occurring after A.D. 800 and as late as 1750 (Dorshow et al. 2000; Justice 2002; Railey 2002). One projectile point is tentatively classified as a Perdiz variant with smaller than average tangs/barbs, or as an Edwards point. The former dates from A.D. 1200 to 1500, and the later from A.D. 900 to 1040 (Turner and Hester 1993).

One projectile point resembles a Livermore style. Justice (2002:231) associates the Livermore point type to the Guadalupe Mountains of New Mexico and provides an age range of A.D. 100–800. Two projectile points are classified as San Pedro variants (Justice 2002:202). The San Pedro variant traditionally coincides with the Late Archaic period, extending into the early Formative period (Carmichael 1986; Condon et al. 2008). Four projectile points are lenticular forms or point fragments that cannot be accurately assigned to a specific type.

The projectile point assemblage recovered during the present project indicates a late Archaic through late Formative period occupation of the Boot Hill site. The projectile point assemblage supports the ceramic assemblage, and extends the site occupation into the late Archaic period. The collection of diagnostic projectile points by local collectors over the past decades and through excavations by the LCAS has undoubtedly skewed the results of the present collection, with the smaller arrow points being recovered while the larger Archaic dart and spear points, being more easily recognized, having been collected.

14.1.4 Summary

Results of the chronometric analyses suggest the radiocarbon ages from Feature 3 and Trench 1 is compatible with an aggrading depositional environment. The radiocarbon age of the vicinity of Trench 1 places the age of this site locus during the Formative period, specifically the Formative 1 through 6. The ceramic assemblage supports this interpretation while the projectile point assemblage suggests a Late Archaic presence.

Current research carried out by Railey et al. (2009) and aggressive radiocarbon sampling conducted by Lord and Reynolds (1985), Staley (1996a), Wiseman (2003), and recent work by Simpson (2010) is providing a more reliable chronometric control of the archaeological record in southeastern New Mexico. However, nearly 55.9 percent (n=124) of the conventional radiocarbon dates acquired several years ago (see Railey et al. 2009:Appendix I) have standard errors greater than 50 years. As stated in Hogan (2006), good radiocarbon dating in southeastern New Mexico requires not only careful collection and meticulous chemical and radiometric analysis, but also consideration of the biochemistry of the carbon source. Moreover, pursuing a more aggressive regimen of sampling data from suitable contexts throughout the region may provide an elevated level of chronometric control and further our understanding of the region.

14.2 Site Structure

Analyses conducted in conjunction with the first research domain provided the framework for addressing two subsequent research domains: 1) site context and 2) site structure. Site context refers to the state in which archaeological deposits are encountered and how the relationship between artifact and environment can be used to interpret past human behavior. The ability to address the second research question is partially, if not wholly, dependent on the answer to the first. Site structure refers to the distribution of artifacts and features within a site and the functional, temporal, and spatial patterns associated with these material remains (Hodder and Okell 1978; Schiffer 1976; Simek 1989). The fundamental objective of pattern recognition is identifying limited activity areas or special-task loci as defined by a specific tool kit or the co-occurrence of artifact classes in an effort to interpret prehistoric adaptive strategies (Schiffer 1976; Simek 1989). Following Simek (1989:59), the application of point provenience techniques is valid only if the distributional structure, or contextual integrity of a site, indicates specific behavioral events may be preserved. Results of test excavations indicate the uppermost 20 to 30 cm in the vicinity of Trenches 1 and 3 is disturbed, while Trench 2 is the location of the LCAS 1957–1958 excavations. Therefore, depositional processes associated with LA 32229 do not provide an increased level of preservation for the surface materials.

Therefore, statistically meaningful interpretations are unlikely to be forthcoming from the piece-plotted surface artifacts and the nine features recorded within the project boundary. Using the Kernel Density application in ArcGIS, a raster map was generated that graphically displays the density of points, in this case, artifacts and features, within the site boundary. This tool calculates a non-parametric estimate of site density by subdividing the bounded environment into individual cells, or kernels (Silverman 1986). Provenience points (e.g., artifacts) that fall within each raster cell/kernel are counted and the values added (Silverman 1986). A smoothed curved surface is placed over each point, resulting in a contour map reflecting density of cells in relation to the bounded environment, LA 32229. Density values are greatest, reflect the highest frequency, along the line, and diminish as they move away from the line. This is graphically displayed in the transition from a dark blue to lighter-blue color. The raster map was then overlaid on an aerial map of the site and correlated to square meters (Figure 14.2).

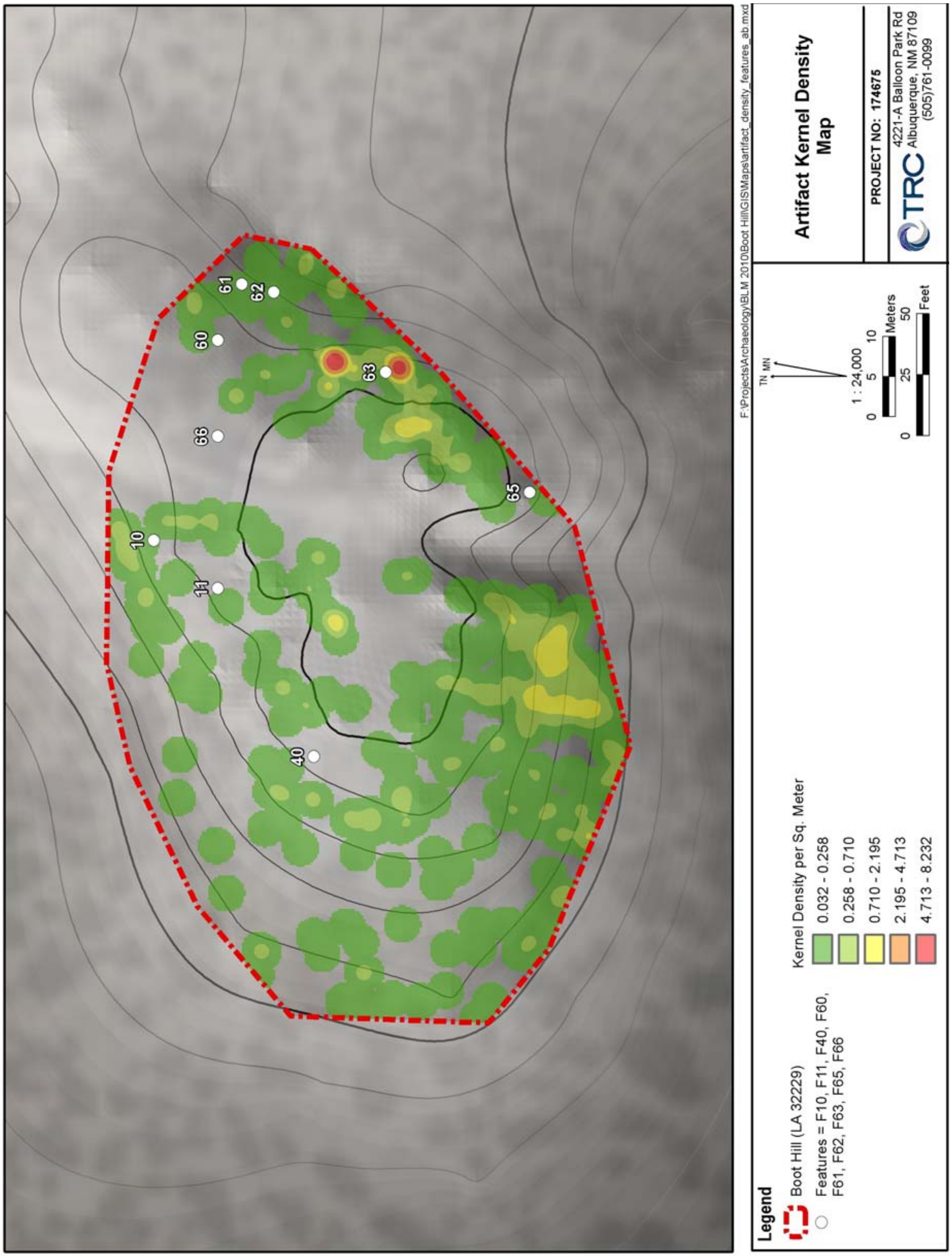

Figure 14.2 Kernel Density map for LA 32229

Artifact clustering in general is associated with a rich organic deposit interpreted as an Ab soil horizon/anthrosol. The densest artifact clustering is in the eastern margin of the site, which is a point that overlooks a major arroyo and is nearest to Bogle Tank. Results of the test excavations in Trench 1 indicate artifacts within the upper 20 to 30 cm of the anthrosol probably do not retain contextual integrity as a result of past excavation activities. Results of the geophysical survey and the lower deposits exposed during testing in Trench 1 suggest the presence of buried intact cultural deposits within the anthrosol.

The results of the kernel density map effectively illustrate artifact clusters are west and east of Square Lake Road. The well-developed anthrosol likely blankets buried cultural deposits, resulting in a low frequency of surface features. Surface artifacts are most prevalent in the eastern portion of the site, in the area of Trench 3. A greater density of artifacts is noted in the south-central portion of the site, immediately west of Square Lake Road. This may be attributed to erosion of the anthrosol, exposing the underlying cultural deposits, or from past collectors' excavations. None of the nine features occurs on the highest terrain, but are on the slightly lower terrain below the hill crest. Their occurrence may be attributed to exposure from erosion of the anthrosol.

14.2.1 Summary

With regard to the patterning and differential use of space at LA 32229, there is a distinction in the placement of features around the elevated ridge. While the interpretation of spatial patterning and probable use of space offers a tool in a comparative context, several cautions are warranted. Problems are inherent in the sample size effect and in the interpretation of culture versus nature as causal factors in spatial patterning. The extensive disturbances to the uppermost layers of the anthrosol across the site diminish the usefulness of spatial patterning techniques. In addition, until the formation of the extensive anthrosol across the site is better understood, the relationship of the cultural remains within the anthrosol cannot be more accurately reconstructed.

14.3 Assemblage Diversity

14.3.1 Lithics

Current archaeological research into the organization of flaked-stone technology has provided several intriguing insights into the relationship between raw material selection, core reduction strategies, and tool function (Miller 2007; Odell 2004; Tomka 2001). Raw material analysis for the Jornada Mogollon region, including the Boot Hill area, has shown a strong trend for the selection of locally available tool stone, as well as a general decrease in stone quality through time (Carmichael 1986; Mauldin 1986; Miller 2007; Whalen 1977). In turn, variability in material type, as defined by artifact assemblages, has been tentatively linked to modifications in lithic reduction strategies, shifts in mobility, and changes in subsistence patterns. It can be argued that on a local scale, the frequency of specific stone types within Archaic and Formative assemblages is providing information concerning forager and collector site types rather than about stone selection and material procurement. Tool stone selection may be symptomatic of broader socioeconomic and organization shifts within a region.

Tool stone, including chalcedony, chert, obsidian, and quartzite, are available as secondary river deposits in the vicinity of the Boot Hill site. Despite an abundance of stone sources, knapable stone does not occur consistently across the landscape. Even within a specific outcrop, stone quality may differ substantially. Among Archaic and Formative period populations, two stone procurement strategies may have been employed. The first strategy infers purposeful movement across the landscape with the goal of acquiring knapable stone. This direct procurement strategy may have played a significant part in accessing rock outcrops or secondary gravel deposits. The second strategy stands in contrast to the first, and suggests that hunter-gatherer groups balanced the need for tool stone with edible resource acquisition. This embedded strategy employed an encounter, or a 'use what was immediately available' approach to tool manufacture.

These strategies are not to be viewed as mutually exclusive, but as flexible options that shifted as needs changed through time.

Lithic artifacts documented during the TRC testing represent a variety of raw material textures and morphologies (Table 14.1). Chert is the most dominant material identified within the excavated assemblage, comprising 43.2 to 50.2 percent within the three trenches. Chalcedony is the second most abundant material, comprising 34.5 to 44.6 percent. Quartzite (5.4–11.8 percent) and limestone (3.1–6.0 percent) are the other prominent raw material types. Rare materials include igneous, orthoquartzite, rhyolite, siltstone, obsidian, and silicified wood. Material preference is probably determined by availability, in addition to other factors, including abundance, access, and suitability for intended tasks.

Table 14.1 Raw material counts for debitage

Material	Trench 1 (n/%)	Trench 2 (n/%)	Trench 3 (n/%)
Chalcedony	301/ 34.5	285/ 36.9	317/ 44.6
Chert	385/ 44.2	388/ 50.2	307/ 43.2
Igneous	8/ 0.9	6/ 0.8	4/ 0.6
Limestone	52/ 6.0	45/ 5.8	28/ 3.1
Orthoquartzite	12/ 1.3		5/ 0.7
Quartzite	103/ 11.8	52/ 5.4	46/ 6.5
Rhyolite	5/ 0.6	2/ 0.3	1/ 0.1
Siltstone	5/ 0.6	3/ 0.4	2/ 0.3
Obsidian	1/ 0.1	1/ 0.1	1/ 0.1
Silicified wood		1/ 0.1	
Totals	**872**	**773**	**711**

Projectile points (17 excavated, 1 surface) are predominately made of chert (n=13, 72.2 percent), with lesser materials being chalcedony (n=3, 16.7 percent), quartzite (n=1, 5.6 percent), and limestone (n=1, 5.6 percent). Bifaces mirror projectile points, with chert (n=6, 60 percent) dominating, and lesser frequencies of chalcedony (n=2, 20 percent), quartzite (n=1, 10 percent), and silicified wood (n=1, 10 percent). Hammerstones are represented by quartzite (n=5, 83.3 percent) and chalcedony (n=1, 16.7 percent). Cores consist predominately of chalcedony (n=9, 45 percent), followed by chert (n=6, 30 percent), quartzite (n=2, 10 percent), limestone (n=2, 10 percent), and igneous material (n=1, 5 percent). Ground stone items are predominately sandstone (n=22, 75.9 percent) with some granite (n=6, 20.7 percent) and limestone (n=1, 3.5 percent).

14.3.2 Ceramics

The ceramics from the Boot Hill site indicate three major points: 1) the occupation of the Boot Hill site extended throughout the Formative period until A.D. 1300/1350, with periods of more intense occupation of the site, 2) the predominance of jar sherds suggests the occupants of the site were seasonally mobile rather that sedentary, and 3) the diversity, but infrequent occurrence of non-local pottery points towards local trading with minimal regional interaction or long-range trade associations. Overall, the ceramic assemblage reflects a range of pottery types, both local and nonlocal in origin. Local pottery types, defined as those manufactured primarily west of the Pecos River, but east of the Guadalupe Mountains, include Jornada Brown, Jornada Decorated, and South Pecos Brown.

Occurring with the most frequency in the ceramic assemblage is Jornada Brown (including 10 Jornada Decorated sherds), which in much the same way as other plain brownwares, provides a relative temporal range for a given region. In this case, Jornada Brown dates between A.D. 200/400 to 1250/1350 and covers the entirety of the Formative period at the Boot Hill site. South Pecos Brown occurs with less frequency, but spans a period of 300 years (A.D. 900–1200). These brownwares appear to correspond stylistically with similar undecorated brownware types, including El Paso Brown, despite being manufactured in the eastern extension of the Jornada Mogollon region (Katz and Katz 1993; Miller 1995).

Within Lehmer's (1948) Jornada Mogollon culture sphere are the Rio Grande pottery types, which include El Paso Brown and El Paso Polychrome. These pottery types also occur in relatively low frequencies, but reflect the transition from a plain brown, which flourished from A.D. 200 to 1000/1100, to painted wares after A.D. 800/1000 in the Rio Grande valley. The subsequent introduction of polychrome wares (A.D. 1000/1100–1450) is identified in the assemblage from the Boot Hill site. Although El Paso Polychrome occurs in low frequencies, it effectively points toward a regional influence at LA 32229 post-A.D. 1000. The Rio Grande valley, including the adjacent Hueco Bolson and Tularosa Basin, fall within the traditional boundary of the Jornada Mogollon region, and holds a tentative association with the Pecos River valley to the east, despite the general absence of locally made decorated pottery in the Pecos River valley. Moreover, the identification of clays and temper material, as suggested by Hill (2000), suggests the majority of brownware pottery was produced outside the Boot Hill area, primarily in the Sierra Blanca region or the Rio Grande area associated with El Paso.

Vessel form was used cautiously as a means to evaluate function in the absence of a first order context within which the pottery was used. Examining two vessel forms, jars and bowls as they relate to cooking and noncooking activities, Jornada Brown, South Pecos Brown, El Paso brownware, El Paso Polychrome, Chupadero Black-on-white, and Corona Corrugated all clearly demonstrate a predominant singular vessel form. Jars, including both neck and neckless forms, represent the dominant form in the Boot Hill assemblage. This interpretation may relate directly to mobility, with wide-mouthed, shallow vessels hindering high mobility. Jars, which serve a variety of functions, probably maintained a level of stable occurrence as there was a continual need for cooking and storage vessels for all periods of occupation at the Boot Hill site. In contrast, for reasons undetermined, most of the Mimbres white ware, Three Rivers Red-on-terracotta, and Gila Polychrome in the assemblage point toward bowls rather than jars.

On the basis of the available data, it seems vessel form is somewhat inconsistent through time with changes in size, form, and presumably function co-occurring during the late Formative period. It is suspected that vessel form can be characterized by a variety of types, including *ollas, tecomates*, and bowls. Consistency is reflected in vessel form and a relative small diameter orifice, suggesting narrow jar openings were more the norm rather than the exception.

14.3.2.1 Summary

In summary, the ubiquitous preference for chert and chalcedony across the entire assemblage is the result of availability and occurrence of the Ogallala formation associated with the Caprock margin of the Southern High Plains (Haskell 1977; Holliday 1997). While other materials are used, their occurrences might be limited to several factors, including access, quality, and functional response to environmental needs. The preference for fine-grained material types precludes the need for course-grained tool stone that does not produce a finer cutting edge. Moreover, the low occurrence of quartzite and rhyolite may support the premise of an embedded collection strategy that primarily relied on raw material that was nearby or could be acquired opportunistically during the course of other activities. The few obsidian items may have found their way to LA 32229 through trade and exchange or as the result of a chance find. There are no obvious trading networks or extensive contacts with populations outside of the region based on the use of tool stone. This is in keeping with current models of prehistoric land use for the region that suggest stone was procured from local gravel sources and accessible outcrops.

The Boot Hill ceramics indicate western and southern contacts. The paucity of most of the imported ceramic types suggests contact was minimal, but nonetheless, did exist at some level. There appears to have been a stronger social contact with groups in the Rio Grande valley in the El Paso area, based on the greater occurrence of El Paso Brown wares. This pattern has been reflected elsewhere in nearby sites east of the Pecos River, such as Laguna Plata (Condon et al. 2010a).

14.4 Organization of Technology: Features

Features are traditionally viewed as unmovable material reflections of human behavior and for the purposes of this project are used as one method to define site activity (Condon et al. 2007, 2008). In this section, features were evaluated by form and functional elements associated with resource processing, secondary artifact deposits, and with architecture. These three feature classes addressed the technological facilities identified during the project.

Miller and Kenmotsu (2004) provide a cumulative frequency graph correlating radiocarbon distributions and feature types across the Jornada Mogollon region between A.D. 200 and 1600 (Figure 18.7). The distribution pattern shows a prominent trend in the use frequency of small burned-rock features and small hearth features (i.e., pits with an absence of thermal rock) prior to A.D. 1000. An increase in rock-lined features and trash/storage features is noted for the same region post-A.D. 800. Medium and large burned-rock feature frequencies display an undulating pattern of peaks and valleys up to A.D. 1200, after which a definitive decline in the frequency of these feature types is observed for west Texas and southern New Mexico (Miller and Kenmotsu 2004:252).

Hearths and roasting pits, which may require a pit to be excavated in order to successfully accomplish the processing task, present several scenarios illustrating different models of feature construction. Although several common denominators co-occur in almost every example provided by the authors, the necessity for correct height-depth dimension is as significant an attribute as whether thermally conductive stone is layered below or above the resource to be processed. In an archaeological context, pit morphology becomes critical if the most salient component of the feature, that is thermally altered rock, is removed from its principal location. As a result, archaeologists commonly encounter a loose scatter or moderate aggregation of burned-caliche cobbles in loose (or direct) association with a basin-shaped pit. The contextual integrity of the burned-rock has much to do with the rate of deflation and erosion present within a given environment. Site-formation processes also play a prominent role in the vertical deflation and infilling of the pit. However, the pit element is a static phenomenon whereas the lifecycle of the burned rock is dynamic. Of the two feature components, the morphology of the pit usually has the characteristics that were present immediately after construction, during the functional activity, and after abandonment (Condon et al. 2008).

Features identified during TRC's testing at the Boot Hill site were subjectively defined based initially on the presence or absence of two technological attributes, burned rock and/or a definable pit. The presence or absence of burned-caliche cobbles is self-explanatory. Characteristics of a pit included carbon-stained sediments with charcoal, ash, and oxidized soils. It should be noted that the presence or absence of a pit was based on a trowel test that determined depth below ground surface. In the presence of contextual integrity, these feature attributes were viewed as sufficient on a nominal scale of measurement to build inferential statements on their past use at LA 32229. The present project documented only nine features in which four feature types were identified. Of the nine features recorded within the project boundary, all consist of burned caliche (Table 14.2). They probably represent hearths.

Table 14.2 Feature types and frequencies recorded during the site survey

Feature Type	Quantity	Percent
Burned caliche cluster	2	22.2
Burned caliche concentration	2	22.2

Feature Type	Quantity	Percent
Burned caliche scatter	3	33.3
Burned caliche scatter w/stain	2	22.2
Total Feature Quantity	**9**	**100.0**

There is a noticeable absence of storage features at LA 32229. This may be the result of the limited subsurface testing, but in general, the documented features do not appear to be storage related. This is not surprising, as portable storage in the form of jars or baskets may have been more convenient for mobile populations. It should also be noted that quantifying storage pits is typically difficult if the morphology and internal characteristics of the pit do not conform to the traditional definition of a storage pit that is bell shaped or steep-sided with depth. Finally, the number of discernible features within the project boundary at LA 32229 is such as to infer a moderate-to-high level of site use. The similarity in feature types suggests commonality in function that is more akin to small hearths rather than large processing features. Large roasting pits, as defined by burned-rock middens, annular rock rings, and crescent middens of burned rock, are absent. Their absence suggests processing of resources, such as agave, may not have been a focus at the site. More likely, the environmental conditions were not favorable to the flourishing of this resource and subsequently, it is not present in the archaeological record.

14.5 Subsistence Patterns

An understanding of prehistoric economies that evolved locally in the Jornada Mogollon region is essential in determining the relationship between prehistoric cultures and the environment. For the Jornada Mogollon region, and in particular those populations occupying lands east of the Pecos River, resource specialization and plant domestication has been ephemerally identified, with horticulture a viable, but undefined, alternative to a foraging and collecting adaptation strategy by A.D. 1150/1200. Shifts in plant and animal utilization are broadly linked to changes in climate, most notable in precipitation. The measure of adaptation is found in the interaction between cultures and their environments, or cultural ecology.

The adaptive-dynamic approach to cultural ecology is defined as the coping mechanisms employed by a culture that allows for adjustments on social and environmental levels, thus facilitating a continuation of the culture. Those features that allow the cultural system to continue will be maintained, while those less suited will be abandoned. Therefore, cultures are dynamic, when needs cannot be satisfied by one system, a subsystem is likely to originate through the adaptive actions of individuals or social groups (Bennett 1976:255). Changes in resource procurement can be viewed through two dynamic processes—adaptive drift and adaptive selection.

Adaptive drift consists of the movement or decision making of a cultural system, in this case hunter-gatherer populations, in a certain direction due to the preservation of a cultural style or traditional precedent. Changes in subsistence are brought about by an interaction of factors, such as the introduction or development of new technologies, changes in resource availability, seasonal shift in the quality of resources, and social responses to change (Church et al. 2009:8–11). As such, the initial factor in examining prehistoric subsistence involves identifying available resources and changes in the resources diachronically.

Adaptive selection refers to the development of a sustained yield system through a series of experiments with natural resources. Experimentation, combined with particular behavioral styles, is suited to the emerging techniques and culture change (Bennett 1976:294). On a regional level, adaptive selection may be used to help understand the shift in emphasis from non-domesticated plants and animals to a subsistence strategy focused on cultivated plants. The economic orientation that emerged as a result of drift and selection during the Late Archaic and Formative periods was highly differentiated, consisting of more than one species exploited and more than one method for acquiring food. As such, acquiring food, whether it was plant or animal, was dependent on a series of variables, including seasonal availability and relative importance in the diet. Adaptive selection and, ultimately, adaptive drift are hypothesized through the increased exploitation of medium to large animals after the introduction of bow and arrow technology, the dominance of non-domesticated plants, selective access to cultigens, and the hunting of small animals, suggesting mobile hunter-gatherers on a seasonal basis continued to exploit certain productive ecosystems. The resulting analyses provide the datasets by which these models can be tested.

14.5.1 Palynological

Three pollen samples, all from Trench 1, were processed. Chemical extraction of pollen samples was conducted at the Palynology Laboratory at Texas A&M University, using a procedure designed for semi-arid Southwestern sediments. The method, detailed in Appendix B, specifically avoids use of such reagents as nitric acid and bleach, which have been demonstrated experimentally to be destructive to pollen grains (Holloway 1981).

Sample 1 was from a marl deposit and its assemblage contained 490 grains/g total pollen concentration values but was based on a pollen sum of only 19 grains. This assemblage was significantly weathered. *Pinus edulis* type, and *Artemisia* pollen (26 grains/g) were present in trace amounts only and were based on single grain occurrences. Cheno-am pollen (258 grains/g) was very low with high amounts of low spine Asteraceae pollen (181 grains/g). Thus, only the most resistant grains were recovered from this assemblage.

Sample 2 was from a Pleistocene gleyed clay deposit and it contained only 216 grains/g total pollen concentration. A pollen sum of only 5 grains was present. *Pinus edulis* type (130 grains/g) was present in very low amounts. The only other taxon recovered was *Artemisia* (86 grains/g).

Sample 3 contained a statistically valid count of 302 grains and a total pollen concentration value of 37,414 grains/g. No identification of this deposit was made although this sample was older than either of the previous samples. This sample may represent a paleosol. Only 15 marker grains were encountered during counting, which significantly elevated the pollen concentration values. *Pinus edulis* (10,035 grains/g) and *Pinus ponderosa* type (5079 grains/g) were both present in large amounts, in addition to a single occurrence of *Juniperus* pollen (124 grains/g). Chemo-am (12,017 grains/g), Poaceae (867 grains/g), low (2602 grains/g) and high spine Asteraceae and *Artemisia* (743 grains/g each) were all very high. In addition, pollen of Cactaceae, *Sphaeralcea* (124 grains/g each), a larger than normal grass pollen (496 grains/g), and *Ephedra* (3345 grains/g) were also present. This suggests the presence of a piñon-juniper stand along with interspersed open desert scrub grassland components. The pollen concentration values of this type of plant community were significantly elevated which is probably due to compaction of the stratigraphic unit. This unit may have been present for a much longer period of time, but the unit was compressed and consolidated by the younger deposits overlying it.

14.5.1.1 Conclusion

The pollen spectra recovered from the Boot Hill site is quite different from the macrofloral assemblage. The pollen concentration values are quite high and given the high values of *Pinus*, it is thought that this assemblage reflects the presence of a Late-glacial piñon-juniper association. It is possible, if not probable, that this sedimentary layer represents the later portion of the Pleistocene period, when this area of eastern New Mexico and far west Texas were dominated by piñon-juniper woodlands (Bryant and Holloway 1985).

Bryant and Holloway (1985) have summarized many of the pollen records from West Texas and extending into eastern New Mexico. Based on original records by Hafsten (1961), Oldfield and

Schoenwetter (1975), the pollen assemblages suggested an area dominated by conifers by at least 15,000 years ago. This was a fairly large area around the southern edge of the Llano Estacado (Bryant and Holloway, 1985). The pollen assemblage from LA 32229 was not completely dominated by conifer pollen but the samples did contain very high pollen concentration values.

Thus, this single sample may possibly correlate with the Vigo Park Interval (Oldfield and Schoenwetter, 1975) which was characterized by less than 50 percent arboreal pollen and was considered a brief warming and drying trend during this portion of the West Texas Late-glacial (Bryant and Holloway, 1985). The interpretation of this single sample as reflecting a piñon-juniper association is more consistent with the interpretations of Martin and Mehringer (1965) who interpreted the Late-glacial from this area as more widespread conifer parklands (Bryant and Holloway 1985).

Another interpretation is based on the ethnographic literature. According to the Mescalero Apache, historically, "Pine was regarded as superior for firewood for starting a fire; often bundles of pine were carried as a part of plains camping equipment to supplement the meager firewood resources of that area" (Basehart 1960:47). If this practice has antiquity associated with it, then the high pine pollen content at LA 32229 may not be unexpected. The high pine pollen counts may represent preferential use of pine for use in hearth fires in antiquity.

14.5.2 Macrofloral

Four flotation samples were processed by Quaternary Services. A flotation sample was collected from Trench 1, Feature 3. This sample (FS 84) contained only *Prosopis* spp. (mesquite) charcoal and smaller unidentified charcoal fragments. This likely represents locally available fuel wood. It is suspected that Feature 3 may have been much more recent than the pollen samples collected from this same trench. If the pollen samples were labeled in sequence, then the upper two samples consisting of marl and the Pleistocene gleyed clay must be closer in age to terminal Pleistocene, and are in no way related to the flotation sample collected from Feature 3, even though they were collected from the same trench.

The sample from Trench Unit 1.6 (FS 89) was collected from level 4. The assemblage contained *Prosopis* spp. charcoal and small unidentified charcoal fragments. Snail shells were also present. The sample from Trench Unit 2.5 (FS 60) was collected from level 3. This assemblage contained both *Prosopis* spp. charcoal, charcoal of cf. *Larrea tridentata* (creosotebush), and small unidentified charcoal fragments. This is consistent with the modern vegetation of the area. The sample from Trench 3 (FS 163) was collected from Unit 5. The assemblage contained *Prosopis* spp. charcoal, small unidentified charcoal fragments, and snail shells.

Taken together, the flotation samples are all consistent with the modern vegetation consisting of *Prosopis* spp., *Larrea tridentata,* and various grasses. This suggests that fuel wood was obtained locally and that both *Prosopis* spp., and perhaps *Larrea tridentata* were used. The macrobotanical data are dominated by the presence of *Prosopis* spp. charcoal, which seems to be the most common taxon. The sample from Trench Unit 2.5 also contained a charcoal type, which compared favorably to that of *Larrea tridentata*. This suggests a much more open and sparse vegetation cover than the piñon-juniper association indicated by the pollen samples.

14.5.2.1 Conclusions

The flotation samples were taken from Feature 3 and three trench units. The assemblages were fairly consistent in being dominated by *Prosopis* spp. charcoal. This argues for the dominance of *Prosopis* spp. as a local fuel source and further suggests a similar plant community at present and during the prehistoric occupation. FS 60 (Trench Unit 2.5) contained a second charcoal type, which, while not conclusive, compared favorably with the anatomy of *Larrea tridentata*. If verified, this further supports the use of locally available fuel woods.

14.6 Starch Grain Analysis

Eight artifacts were selected for starch grain analysis. The sample included a metate fragment, two ground stone tools, and five ceramic sherds. All artifacts were collected and bagged separately without washing. The artifacts were sampled using a clean, sonic toothbrush that was applied to the used surfaces of the metate and ground stone artifacts and to the inside surfaces of the ceramic sherds. The wash water was then collected in vessels. The effluent from the cleaning was allowed to settle overnight. Then, the settled material was centrifuged for 10 minutes at 1000 RPM to pellet out the solids. The solid materials were then subject to a heavy liquid flotation using Cesium chloride (CsCl) at a density of 1.8 g/cm^3 to separate the starch grains from the sediment matrix. The material collected from the flotation was rinsed and centrifuged three times with reverse-osmosis filtered water to ensure that the CsCl was completely removed from the solution. At this point, the pellet from the final centrifugation was placed on a clean glass slide with a small amount of water/glycerin solution. Slides were scanned with a Zeiss Universal compound microscope for polarized light at 200X, and identifications were made at 400X using standard methods. Digital images were captured at 800X using a Micropublisher 3.3 camera and software.

A total of 14 intact starch grains, all of lenticular form, were recovered from the sampled artifacts (Table 14.3). Damaged starches were common, with morphological changes typical of both heating and grinding (Figure 14.3). Because the assemblage contained so many damaged starch grains, it is difficult to determine their source with absolute confidence. The morphologies of the intact starches, however, are typical of the Triticeae group, and are consistent with those of little barley (*Hordeum pusillum*). This tentative identification does not preclude the possible presence of other grasses that create similar forms of starch, including wildrye (*Elymus* spp.).

Lenticular starches may be derived from little barley. An “X” indicates that a type of processing damage was noted in the assemblage. Heating damage indicates exposure to temperatures typical of cooking, but the type of heating (boiling, parching, etc.) cannot be determined. Boiling damage is consistent with the type of morphological changes that occur when starch grains are heated in an aqueous medium.

Table 14.3 Starch remains recovered from the Boot Hill site

FS #	Artifact	Provenience	Lenticular starch	Grinding damage	Heating damage	Boiling damage	Total
108	Metate	TU 3.2.2					**0**
36	Gstone	TU 2.3.3	2	X			**2**
54	Gstone	TU 2.4.1	4			X	**4**
9	Ceramic	TU 1.4.1	1			X	**1**
24	Ceramic	TU 1.4	5	X	X		**5**
108	Ceramic	TU 3.2.2			?		**0**
96	Ceramic	TU 1.4.6					**0**
59	Ceramic	TU 2.5.2	2		X		**2**
Total	**8**		**14**	**X**	**X**	**X**	**14**

14.6.1.1 Ground Stone

Three ground stone artifacts were analyzed. The metate fragment (FS 108) yielded no starch remains, but starch was recovered from two other ground stone tools. Two lenticular grains were recovered from FS 36, and grinding damage was noted as well. This type of damage indicates the artifact was used for grinding grain. FS 54 yielded four lenticular starches, and damage from boiling was observed in the assemblage. This damage could indicate the use of the tool as a boiling stone, or the processing of previously boiled grain with the artifact.

14.6.1.2 Ceramic Sherds

Five ceramic sherds were analyzed, of which three yielded intact starch remains. A single lenticular grain was recovered from FS 9, and boiling damage was also noted. This damage indicates the vessel was used to cook grain in a liquid medium. FS 24 had the largest number of starch grains of the analyzed samples with five lenticular starch grains recovered. Both grinding damage and unidentifiable damage from heating were also observed, indicating the vessel was used for cooking grain that had been previously processed by grinding. FS 59 yielded two starch grains, and unidentifiable damage from heating was present. This damage indicates the vessel was used to cook grain. FS 108 contained what appear to be highly degraded residues of cooked starches. The damage is so severe, however, that a positive identification cannot be made. FS 96 was free of starch remains.

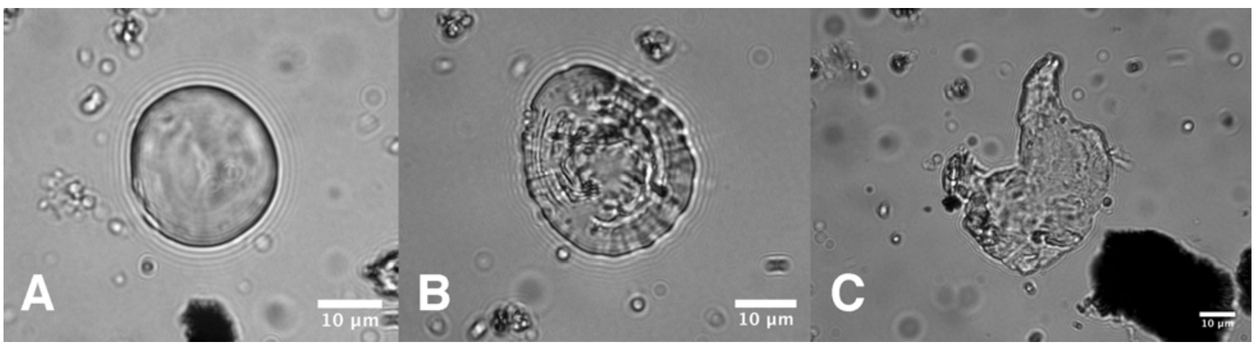

Figure 14.3 Starch remains from the Boot Hill site

A. Lenticular starch grain from ground stone tool FS 54. B. Starch grain subject to grinding and heating, from ceramic sherd FS 24. C. Gelatinized starch subject to boiling from ground stone tool FS 54.

14.6.2 Conclusions

The starch remains provide solid evidence that the ground stone tools were used for grinding grain, and the ceramic vessels were used for cooking. The starch assemblage is derived from indigenous grasses, and possibly from little barley. Thus, the grain was very likely either collected or produced locally and then processed into flour or meal that was cooked onsite. If future research is planned for the Boot Hill site, ground stone artifacts and ceramic sherds appear to be reliable sources of starch residues.

14.7 Fourier Transform Infrared Spectroscopy (FTIR) Residue Analysis

Three ceramic sherds and three ground stone fragments were submitted for organic residue analysis. Samples were tested for organic residues using Fourier Transform Infrared Spectroscopy (FTIR) to gain information regarding diet and tool function (Appendix F, Table 1). It is a commonly accepted practice in archaeological studies to reference ethnographically documented plant uses as indicators of possible or even probable plant uses of the specimens submitted for FTIR analysis. The ethnobotanical literature provides evidence for the exploitation of numerous plants in historic times, both by broad categories and by specific example. Evidence for exploitation from numerous sources can suggest widespread utilization, and strengthens the possibility that the same or similar resources were used prehistorically. Ethnographic sources outside the study area have been consulted to permit a more exhaustive review of potential uses for each plant.

Ethnographic sources document that for some plants the historic use was developed and carried from the past. A plant with medicinal qualities very likely was discovered in prehistoric times and the usage persisted into historic times. There is likely, however, to have been a loss of knowledge concerning the utilization of plant resources as cultures moved from subsistence to agricultural economies and/or were introduced to European foods during the historic period. The ethnobotanical literature serves only as a guide, indicating the potential for utilization prehistorically—not as conclusive evidence that the resources were used. Pollen and macrofloral remains, when compared with the material culture, can become indicators of use. Plants represented by organic residues are discussed in order to provide an ethnobotanical background for discussing the remains.

14.7.1 Native Plants

14.7.1.1 Agavaceae (Agave Family)

Agavaceae are perennial plants that are typically found in the foothills and lower mountain areas of the Southwest (Castetter et al. 1938:79). Members of the agave family were used in a variety of food and fiber applications by native peoples of the Southwest. The crowns of *Agave* (agave, century plant, mescal) species were commonly collected and roasted in pits. Roasted agave could be consumed immediately, or further prepared by boiling or pounding into a paste. Fermented agave beverages were a later introduction to the Southwest, by way of Mexico and Mesoamerica. Fibers from members of the Agavaceae family, especially those of *Yucca* species, were used to make cloth, sandals, baskets, rope, and a variety of other utilitarian items. Roots of *Yucca* species have high saponin content and were processed by groups throughout the Southwest to produce a soap for washing. *Yucca* species were also a source of edible seeds and fleshy fruits. (Bell and Castetter 1941; Castetter et al. 1938:78; Ebeling 1986:468–474; Luomala 1978).

14.7.1.2 *Xanthium* (Cocklebur)

Xanthium (cocklebur) is a common weedy annual found throughout the United States, especially in dry areas, old fields, along roadsides, around alluvial washes and creek banks, and on beaches. The fruit is a pod, about one inch long, that is covered with stiff, hooked barbs and often called a bur. The inner seeds can be parched and ground into flour. Shields (1984:59) notes that cocklebur was "employed by early desert people in remedies." Crushed, boiled pods have analgesic, diuretic, and antispasmodic effects, and have been used for diarrhea, excess sweating, and painful urination; however, large quantities or constant use can have toxic effects. Mature leaves can be used to treat shingles, skin and bladder infections, and to stop the bleeding of cuts and abrasions. A leaf tea was used as a diuretic and to treat cystitis (Krochmal and Krochmal 1973:236–237; Moerman 1998:602; Moore 1990:23; Shields 1984:59).

14.7.2 Cultigens

14.7.2.1 *Cucurbita* (Squash/Pumpkin/Gourd)

Cucurbita (squash/pumpkin/gourd) is noted as one of the most important New World crops and, along with corn and beans, belongs to what Ford (1981) has called the *Upper Sonoran Agricultural Complex* (Cordell 1984:171). These crops were the first to be cultivated everywhere in the Southwest. Fresh squash were cut into pieces, boiled, baked, or roasted whole in ashes. Squash and pumpkins also were cut in coils or strips that were dried for future use. Blossoms were used to season soup or were fried in grease and used as a delicacy in combination with other foods. Seeds also were roasted and eaten or used to oil piki stones. Gourds were dried and made into cups, ladles, dippers, ceremonial rattles, and used for other purposes (Cordell 1984:178; Cushing 1920:561; Elmore 1944:79; Robbins, et al. 1916:100–102; Vestal 1952:46–47; Whiting 1939:93).

14.7.3 Discussion

LA 32229 is along the face of the caprock on a small hill. Local vegetation consists of *Prosopis* (mesquite), *Larrea tridentata* (creosotebush), and grasses (Poaceae). Results of the FTIR analysis are presented by level.

14.7.3.1 Level 4

The ceramic sherd from Level 4 (FS 94) yielded peaks representing major categories (functional groups) of compounds (4000–1500 wave number), as well as specific compounds noted in the fingerprint region (1500–400 wave numbers) of the spectrum. The functional group peaks indicate the presence of absorbed water and fats/oils/lipids and/or plant waxes (Appendix F, Table 2). Peaks within the fingerprint region represent the presence of aromatic rings; aromatic esters; proteins including nucleic acids; the amino acid glutamate; calcium carbonate; calcium oxalates; pectin; cellulose and carbohydrates; and the polysaccharide galactoglucomannan.

The best match for this signature was with calcium carbonate for several peaks, which are characteristic peaks of calcium carbonate. This is consistent with alkaline sediments in the area (Appendix F, Table 3). The presence of this amino acid might represent either natural decomposition of faunal remains or possibly animal processing. Calcium oxalates are present in many plants, often in the form of crystals, particularly in agave, yucca, members of the Cactaceae (cactus family), and members of the Chenopodiaceae (goosefoot family). Some edible plants that contain calcium oxalates include legumes (leaves and pods), goosefoot (and spinach) greens (leaves), the fruits of saltbush, and cactus fruits and epidermal tissue. Peaks representing galactoglucomannan are common for this project and their significance will not be discussed for each sample. The presence of these polysaccharides suggests the woody and fibrous tissue of coniferous plants (Gymnosperms) are contributing to the signal. These compounds probably are attributable to plants growing in the local environment or possibly wood that was burned as fuel.

14.7.3.2 Level 3

A ground stone fragment (FS 36) from Level 3 yielded peaks representing functional group compounds, including absorbed water and amines. Other peaks identified in the fingerprint range indicate the presence of aromatic rings; aromatic esters; protein; the amino acids lysine and leucine; calcium carbonate; calcium oxalates; pectin; starch; cellulose and carbohydrates; and the polysaccharides glucomannan and galactoglucomannan. Good matches with foods were not made for the entire signature obtained from this sample; however, matches with raw *Cucurbita* (gourd/pumpkin/squash) flesh and raw *Agave* leaf skin were made.

Gourd/pumpkin/squash was matched representing glucomannan. This polysaccharide is found in the fibrous tissues of dicotyledons, of which *Cucurbita* is a member, and this match suggests the possibility that gourd, pumpkin, and/or squash might have been ground with this artifact. Since glucomannan is found in many dicots, this peak is not considered to be specific enough to interpret processing cucurbits with this ground stone.

Processing agave, or perhaps its close relative yucca, with the ground stone also is suggested by matches with agave references for a calcium oxalate. Although the calcium oxalate peaks matched with plants (agave/yucca) known to contain calcium oxalate, the presence of this compound in other plants raises the possibility that other calcium oxalate-rich plants might have been processed with this ground stone. The inability to distinguish between calcium oxalate crystals found in different species using FTIR, makes it impossible to identify the specific plants contributing to the peak, although the match with agave suggests this plant probably is present in the sample. Since calcium oxalates are found in other locally growing plants, including members of the Chenopodiaceae and Cactaceae families, these plants also might be contributing to the calcium oxalate peak even though matches with these references were not made with this peak, or any other portion of the spectrum.

Lysine peaks also are common for this project and their significance will not be reiterated for each sample. This amino acid is found in gourds and squash, as well as legumes and meat. Although none of the peaks for these samples were matched directly with these references, the presence of lysine suggests members of the Cucurbitaceae, legumes, and/or meat probably are contributing to the samples. Matches with gourd/pumpkin/squash were made in other portions of the spectrum for all samples in which lysine peaks are present. The amino acid leucine was identified in this sample. The presence of this compound suggests nuts, seeds, and/or meat are contributing to the signal.

The environmental signal was visible in this sample by matches with peaks characteristic of calcium carbonate and deteriorated cellulose and carbohydrates. Although cellulose in the sample probably represents the natural breakdown of plant matter in the sediments from which the ground stone was recovered, the presence of cellulose also might indicate processing other plants that have deteriorated to the point they are no longer visible by their general cellulose signature.

Peaks representing amines, which are produced naturally by the breakdown of amino acids through the decomposition of plant and animals materials (Guch and Wayman 2007:176), might be attributable to either the cultural and/or environmental components of the sample's signature, as these compounds are not unique to cultural activities or natural processes.

14.7.3.3 Level 2

Two ground stone fragments recovered from Level 2 (FS 47 and FS 73) were tested for organic residues. The first ground stone fragment (FS 47) yielded functional group peaks indicating the presence of absorbed water, amines, and fats/oils/lipids and/or plant waxes. Peaks within the fingerprint range of the spectrum represent saturated esters; protein; the amino acids lysine and serine; pectin; humates; and the polysaccharide glucomannan.

Matches with raw *Cucurbita* (gourd/pumpkin/squash) flesh for protein/lipid peaks and charred *Xanthium* (cocklebur) seeds also for protein/lipid peaks suggest gourd/pumpkin/squash flesh and/or cocklebur seeds (or closely related marshelder seeds) were ground with this stone. The match with raw cucurbit flesh is considered to be very general and probably unlikely for use of this ground stone. The more general nature of the compounds indicated by these peaks also might suggest processing other plants rich in proteins and lipids that are not visible in matches with this signature. Although no good matches were made, the presence of this amino acid supports seed processing and also suggests nuts and meat might be contributing to the signal.

A glucomannan peak was not matched. The presence of this polysaccharide might be attributable to *Cucurbita* in the sample; however, without a match to this peak for gourd, pumpkin, or squash, glucomannan in the sample also could be attributable to the presence of fibrous tissues from other dicots and coniferous plants. A combination of cultural activities and natural processes probably resulted in peaks representing amines. The second ground stone fragment (FS 73) from Level 2 yielded peaks representing functional group compounds, including absorbed water and fats/oils/lipids and/or plant waxes.

Other peaks in the fingerprint range indicate the presence of aromatic and saturated esters; proteins including nucleic acids; the amino acid glutamate; calcium carbonate; pectin; cellulose; and the polysaccharides glucomannan and galactoglucomannan. A match with peaks characteristic of calcium carbonate was the only match made with the signature from FS 73. This match suggests the presence of a strong environmental signal in the sample representing this artifact. Woody and fibrous tissues from conifers and dicots are contributing to the signal; however, in the absence of matches, the specific flora species cannot be identified.

A ceramic sherd (FS 37) from Level 2 also was examined for organic residues. The sample yielded functional group peaks indicating the presence of absorbed water and fats/oils/lipids and/or plant waxes. Peaks within the fingerprint region of the spectrum representing aromatic esters; protein; the amino acid glutamate; calcium carbonate; calcium oxalate; cellulose and carbohydrates; and the polysaccharide glucomannan also were identified.

A weak match with raw *Cucurbita* (gourd/pumpkin/squash) flesh suggests possibility of processing gourd, pumpkin, or squash. Repetitive matches with raw gourd/squash suggest the possibility that wild gourds have grown in this area and contributed to the environmental signal. Alternatively, it is possible that the peaks representing glucomannan have a different origin and are matching only with this single reference.

Calcium oxalates in the sample might indicate native plants rich in these crystals, including *Agave*, *Yucca*, *Opuntia* (prickly pear cactus), *Cylindropuntia* (cholla cactus), and/or various members of the Chenopodiaceae, such as *Atriplex* (saltbush) and *Chenopodium* (goosefoot), were contained in the vessel. However, it also is possible this compound reflects the deterioration of plant matter from local vegetation.

Other matches with peaks characteristic of calcium carbonate and deteriorated cellulose and carbohydrates attest to the presence of the local environmental signal in the sample. As stated above, cellulose also might indicate non-specific plant processing using the ceramic vessel represented by this sherd.

14.7.3.4 Surface

A ceramic sherd (FS 156) collected from the surface yielded peaks representing functional group compounds including absorbed water and fats/oils/lipids and/or plant waxes. Peaks within the fingerprint range indicate the presence of aromatic and saturated esters; protein; the amino acids lysine and serine; pectin; cellulose; and the polysaccharides rhamnogalacturonan, arabinogalactan, glucomannan, and galactoglucomannan.

These peaks were matched with raw *Cucurbita* (gourd/pumpkin/squash) flesh, suggesting gourd, pumpkin, or squash might have been contained in the vessel represented by this ceramic sherd or, as stated above, that this signal is pervasive at this site. The amino acid serine, suggests nuts, seeds, and meat also might be contributing to the signal. However, in the absence of matches with this peak, the specific floral and/or faunal species present cannot be identified. Serine in the sample probably is attributable to the local environmental signal.

14.7.4 Conclusions

As a whole, the FTIR record for the ceramic and ground stone recovered from all levels at LA 32229 suggests the processing of gourd/pumpkin/squash, agave, and perhaps other native plants rich in calcium oxalates, such as yucca, saltbush, goosefoot, and prickly pear cactus. Processing seeds, perhaps cocklebur or the closely related marshelder, was suggested only for one ground stone sample (FS 47) recovered from Level 2. All, but two samples (FS 47 and FS 156), exhibited strong environmental signals evidenced by matches with calcium carbonate and deteriorated cellulose.

14.8 Faunal Analysis

The archaeofaunal assemblage consists of 1620 specimens and is very fragmented. In addition, most of the assemblage exhibits some degree of erosion or corrosion. Corrosion is indicative of burial in highly acidic soils, of root etching, and/or the presence of organic acids (e.g., urine) (Andrews 1990:19) and has obscured evidence of gnawing, butchering, and modification or use. As a result, the incidence of gnawing is low (n=36, 2.2 percent), with 32 (88.9 percent) having rodent gnawing and four (11.1 percent) exhibiting carnivore gnawing. In spite of the eroded condition of the bones, the paucity of gnawing is surprising, given the presence of various rodents. Butchering marks were observed on 12 specimens (0.7 percent) and include two bone flakes. Only two worked specimens, both fragments of larger bone tools, were identified.

The assemblage was recovered from three trenches. Most of the assemblage (n=1162, 71.7 percent) is from Trench 1. Examination of the Trench 1 assemblage indicates small animals, especially rodents (n=8, MNI=3), are underrepresented. If the presence of the rodents was natural, greater skeletal representation should have resulted. The rodent remains, therefore, are in large part due to cultural factors related to the site's occupants. The low incidence of rodent remains is probably the result of carcass preparation, consumption, and refuse disposal, with the cranial specimens representing butchering refuse and the long bones representing consumption refuse. The absence of trunk elements (e.g., vertebrae, ribs, pelves) may have resulted from preparation and consumption techniques similar to those of Great Basin peoples for ground squirrels (Fowler 1986:82) and the Kiliwa for woodrats (Michelsen 1967:76).

Elements of the entire leporid skeleton—both low and high meat value—are present, suggesting the processing and consumption of rabbits occurred near Trench 1. Except for the absence of cottontail vertebrae, ribs, and most foot elements, the skeletal part representations for cottontail and jackrabbit are similar, suggesting similar treatment of the carcasses. Skull and foot bones are low food value elements that were probably discarded as butchering debris. The near absence of leporid vertebrae and ribs suggests the trunk was processed differently than the rest of the carcass, possibly pulverized and consumed with the meat.

Few elements of the artiodactyl skeleton are represented. The most numerous remains are tooth fragments (n=43, 72.9 percent), which are non-food value elements. Although the other skull (n=2) and foot (n=9) elements are low meat value bones, metapodials (metacarpals and metatarsals) have a high marrow content. The leg (n=3) and trunk (n=2) elements are higher meat value bones and the former have a high marrow content. The presence of primarily cranial and foot elements, representative of butchering debris, suggests entire artiodactyl (including bison) carcasses were brought to the site or processed nearby, with the animals probably procured nearby. The scarcity and fragmented condition of the metapodials, humerus, and tibia suggest leg elements were processed for marrow and possibly for bone grease. This is suggested by the pronghorn-size remains (n=600, 66.6 percent), the largest category of faunal remains from Trench 1, of which most are indeterminate fragments (n=516, 86.0 percent) but also includes long bone shaft fragments (n=62, 10.3 percent). The incidence of burning among the artiodactyl and pronghorn-size remains is high (n=165, 25.0 percent) and accounts for most (63.2 percent) of the burning exhibited by the Trench 1 assemblage. Overall, the artiodactyl remains suggest complete carcasses were brought to the site for processing (i.e., butchering and cooking) and consumption, with further processing for marrow and possibly for bone grease.

Although it is tempting to suggest bison bones were processed for bone grease, the overall supporting data—large piles of pulverized bone or fire-cracked rock (Binford 1978:159; Quigg 1997; Vehik 1977)—are presently lacking. As stated by Vehik (1977:172), "the primary archaeological evidence for bone grease manufacturing can only be the presence of many small pieces of unburned animal bone." The bison-size remains only consist of 87 specimens—19 long bone shaft and 68 indeterminate fragments—of which 14 are burned. Supporting evidence, however, may be present in nearby unexcavated portions of the site.

Trench 2 contains a much smaller archaeofaunal assemblage (n=260, 16.0 percent) than Trench 1 (n=1162, 71.7 percent). Part of this difference is due to the fact that Trench 2 was considerably smaller, consisting of 7 units in a single row. Trench 1 consisted of 19 units, of which the western five formed a single row and the eastern 14 formed a small block. As with Trench 1, however, rodents are underrepresented in Trench 2. Although the incidence of rodent gnawing is low (n=3, 1.1 percent), it attests to the intrusive presence of rodents but no complete or nearly complete rodent skeletons were found. The rodent remains, therefore, are considered cultural.

Although as a whole, the leporid skeleton is well represented, the cottontail skeleton is not. More than half of the cottontail specimens (n=35) are teeth (n=21, 60.0 percent) and seven are other cranial elements. Trunk elements (vertebrae and ribs) are missing and only one foot element is present. The teeth and other cranial elements and the foot bone are indicative of butchering debris and the leg elements reflect consumption refuse. The absence of vertebrae and ribs probably resulted from carcass processing and consumption with the meat. Due to the paucity of the artiodactyl remains and their poor skeletal representation, possibly resulting from the small size of the Trench 2 excavations, it is not possible to determine whether the pronghorn and bison were procured nearby or at a distance. The pronghorn metapodial, however, is indicative of marrow extraction.

The Trench 3 archaeofaunal assemblage is the smallest (n=198, 12.2 percent) of the three assemblages. Once again, rodents are underrepresented (n=3). The low incidence of rodent gnawing (n=4, 2.0 percent) and the absence of complete or nearly complete rodent skeletons suggest the rodent remains are not intrusive. Although present in lower numbers and not as well represented as in Trenches 1 and 2 (which may be due to the smaller size of the trench), the leporid pattern basically follows that of the other trenches. The skeletal part representation of artiodactyls is very poor, with only the head represented. Except for a bison horn core, the only cranial elements are teeth, which have no meat value and are indicative of probable butchering refuse. The presence of pronghorn- and bison-size remains indicates at least other skeletal portions were brought to the site for meat preparation and consumption and for marrow extraction.

The LA 32229 faunal assemblage is indicative of a diffuse hunting strategy consisting of the procurement of both small game, particularly leporids, and larger game—pronghorn and bison. The presence of low and high meat value elements for each of these animals indicates all were available locally. Leporids, ground squirrels, prairie dogs, pocket gopher, kangaroo rats, and woodrats are r-selected species. Although they contain much less meat than deer or pronghorn, they are more reliable meat resources. Because of the long breeding season of leporids in southeastern New Mexico, use of ages based on long bone epiphyseal fusion rates is not a reliable method for determining seasonality.

Artiodactyls are K-selected species and are more susceptible to predation and environmental change compared to r-selected species. Pronghorn breed in the fall and give birth, usually to twins, in mid-June (Findley 1987:144–145; Hoffmeister 1986:549, 551–552; Zeveloff 1988:334–336). None of the pronghorn elements recovered from LA 32229 provides information about seasonality of site occupation. Many of the pronghorn specimens are tooth and enamel fragments. However, the general size, thickness, and texture of the pronghorn bone fragments are indicative of larger, probably mature or nearly mature, individuals.

During the breeding season, from mid- to late summer, bison males join the female-subadult herds. After a gestation period of about 9.5 months, a single precocial calf per breeding female is usually born in the spring. Occasionally, a female may have twins (Bee et al. 1981:229–230; Findley 1987:146; Zeveloff 1988:346–347). Unfortunately, the definitive bison remains from LA 32229 are long bone and tooth fragments that are not conducive to providing information about seasonality of site occupation. The general size, thickness, and texture of the bison bone fragments, however, are indicative of larger, probably mature or nearly mature, individuals.

14.9 Summary

Subsistence models, such as the one presented in Chapter 4, assume that populations living in a semiarid environment will use resource procuring strategies that will maximize their return in habitats that provide the broadest resource base available. The Boot Hill site, being immediately west of the Caprock, is in the ecotone between the desert scrub to the west and the relative homogeneity of the Llano Estacado to the east. With the numerous springs along the base of the Caprock and scattered playas throughout the desert coppice dunes, it is easy to envision the productivity of the Boot Hill environs and why it attracted mobile populations (Haskell 1977:320).

Jelinek (1967), Katz and Katz (1985b), Speth (2004), and Wiseman (2003) have contributed to our understanding of regional subsistence, each providing insight into prehistoric landscape use in southeastern New Mexico. Within each of their models, the relationship between wild and domesticated plants, as well as the role of bison, in the realm of culture change is discussed. For the Sierra Blanca region and the Middle Pecos valley, a trend towards an increasing emphasis on medium-to-large mammals, including bison, is assigned for the Formative period (Driver 1985; Jelinek 1967). Maize recovered from Bloom Mound and the Henderson sites (Rocek and Speth 1984) tentatively suggests the contribution of a horticulturalist economy at these late Formative period sites. With regard to the role of bison hunting, Speth and Parry (1980) suggest an alternative subsistence pattern that questions the abundance and predictability of bison during the Formative period. Wiseman's (1985 cf. from Sebastian and Larralde 1989:81) evidence from the Rocky Arroyo site indicates fish and mussels may have contributed to the diet of the inhabitants. Finally, for the region east of the Pecos River, which directly relates to the Boot Hill site, Sebastian and Larralde (1989:82) summarize previous models by Corley (1965), Leslie (1979), Stuart and Gauthier (1984), and Speth (1983) that outline a subsistence pattern that does not include agriculture or a dependence on domesticated foods. In fact, other elements indicative of sedentary land use, or at least short-term sedentism at any one locus, such as pit houses and surface room blocks, have been identified. Yet, the subsistence strategies suggest a mixed resource, hunting and gathering economy.

Despite the significant regional accomplishments, a clear understanding of the role that subsistence played in the regional prehistory of southeastern New Mexico is lacking. Sebastian and Larralde (1989:82) and more recently, Miller and Kenmotsu (2004:247), summarize the issue:

> Observed changes in architectural complexity and formality, combined with the location of settlement in relation to hydrologically favorable topographic zones, have been taken as evidence of increasing agricultural dependence and reduced settlement mobility during the Formative period.
>
> While it can be logically surmised that agriculture played a greater role in regional subsistence economies during the late Formative period, than in preceding periods, the extent or proportion of agricultural production in the diet remains unclear.

While it is clear that subsistence patterns have a significant, even determinant, effect on human behavior, especially in semiarid environments, it is unclear which attributes shape the procurement decisions of mobile populations inhabiting the project area. Using the data gleaned from the Boot Hill testing project in relation to a model of cultural ecology, several inferences are developed to address this issue.

The macrofloral analysis identified *Prosopis* sp. (mesquite) as one of the species associated with providing the dominant fuel for fires that contributed to the formation of the anthrosol at the Boot Hill site. Access to mesquite would have been facilitated in areas were water was accessible, in particular, arroyos or along playa margins. While the macrobotanical evidence provided limited evidence of plant use, starch grain analysis provided a more refined data set. The tentative identification of *Hordeum pusillum* (little barley) points toward the targeting of specific non-domesticated seed-bearing plants. In addition, these plants were processed through grinding, boiling, and cooked in ceramic vessels in fluid forms.

The faunal assemblage provides the most robust data set towards interpreting subsistence at the Boot Hill site. Eleven identified species, including reptiles, birds, and mammals of small, medium, and large varieties are identified in the assemblage. Table 12.1 provides the summary data for species ubiquity. When overall frequency is examined, small mammals occur with elevated frequency, with *Sylvilagus audubonii* (desert cottontail) and *Lepus californicus* (black-tailed jackrabbit) the primary species present. There is a general paucity in diversity, particularly in the absence of small rodents. Larger mammals, primarily *Antilocapra americana* (pronghorn) and large mammal-size bone, comprise a substantial portion of the assemblage providing evidence for the exploitation of a primary resource. *Bison bison* (bison), although identified, comprises a small part of the assemblage.

As discussed in Chapter 4, the diet-breadth model of optimal foraging is based on a the premise that resources that provide the greatest return with the lowest amount of effort will rank higher and be desired over resources that offer lower return rates or greater effort to acquire (Bettinger 1991; Madsen and Schmitt 1998). The correlating assumption suggests that humans make these decisions daily, whether consciously or subconsciously. The inclusion of lower-ranked resources is generally based on availability of one or more low ranked species in the absence of other higher-ranked resources. For example, in the absence of pronghorn and bison, rabbits or grasshoppers may be added to the list of desirable resources. The resulting dynamic is the shift from hunting large mammals to smaller mammals and plant and seed collecting. As plant domestication becomes a factor, adaptive selection allows populations to shift from seeds as the primary food source to harvested crops, as long as the net return does not fall below the critical threshold for survival. The increasing reliance on a cultigen offers control of a resource, but limits movement of a population. Diversity and the balancing factor are expressed through the availability of non-domesticated food sources. Using this reasoning, the ranking of resources identified during the current testing project should, with the absence of cultigens, primarily include artiodactyls and lagomorphs as the leading ranked resources. Bison reflect the least dominant species of artiodactyls, which although returns a greater caloric intake, can be unpredictable. This unpredictability is suggested by the presence, but not predominance, of bison at the Boot Hill site. Table 14.4 summarizes the subsistence ranking according to net caloric intake/handling time.

When the primary resources identified at the Boot Hill site are assessed, *Lepus californicus* (black-tailed jackrabbit) and *Sylvilagus audubonii* (desert cottontail) would be ranked high in order of availability, although artiodactyls would be taken when the opportunity was presented. Smaller mammals, as well as *Terrapene ornata* (Western box turtle) may be more opportunistic rather than a primary staple of the inhabitants' diet. Plant species, such as *Elymus salinus* (wild rye) appear to be higher ranked than other plant resources. For instance, *Porceae* (grass seed), although not identified in the analyses, was in all likelihood, available at Boot Hill. *Prosopis* sp. (mesquite) in a similar fashion, was present, but in low quantities and in ambiguous context with regard to consumption. *Zea mays* (maize) provides a comparable caloric intake to wild rye, but was not identified.

Table 14.4 Post-encounter return rates for common resources in the Jornada Mogollon

Resource Species	Common Name	kcal/hour
Bison bison	bison	5,920–11,950
Odocoileus hemonius	deer	17,971–31,450
Antilocapra americana	pronghorn	15,725–31,450
Agave lechuguilla	lechuguilla	730
Lepus sp.	jackrabbit	8,983–15,400
Atriplex canescens	fourwing saltbush seeds	1,033–1200

Resource Species	Common Name	kcal/hour
Elymus salinus	rye grass seeds	921–1238
Oryzpsis hymenoides	Indian rice grass seeds	301–392
Chenopodium rhadinostachyum	goosefoot seeds	652
Helianthus annuus	sunflower seeds	467–504
Typha latifolia	cattail roots	128–267
Zea mays (one ear)	maize kernels	711–1,133
Prosopis sp.	mesquite pods	1,733 –2,522
Opuntia sp.	prickly pear cactus	2,175
Portulaca sp.	purslane seeds	3,049–3,910
Yucca sp	yucca seeds	3,900
Brassicaceae	mustard seed	1,307
Amsinckia	fiddleneck seed	3,049–3,910
Poaceae	grass seed	575
Atriplex/Sarcobatus	fourwing saltbush	1,033
Hordeum jubatum	Foxtail barley	138–273

Bettinger 1991; Dering et al. 2001; Kelly 1995; Bohrer 2006, Table 18.8.

The abundance of resources in the Boot Hill site environment suggests the hunting of small mammals provided a consistent resource base, but opportunistic hunting of medium to large mammals also made an important contribution to the diet. Bison outweighs the value of any other hunted resource, with the exception of herd mammals, such as pronghorn, which can be acquired in large numbers during a single hunting event. The large number of pronghorn-size bone specimens implies reliance upon this resource.

Seasonal availability is a primary factor in resource selection regardless of ranking. Resource stress does not seem to figure into the subsistence pattern at the Boot Hill site, suggesting the environment was favorable with active springs supplying fresh water, attracting the local flora and fauna. The procurement of readily available faunal and floral species in large enough quantities may have outweighed the advantages that a predictable, but unstable and tethered food source, such as maize, offered. Due to the availability of wild game and plant species, *Zea mays* (maize) may not have been considered for contribution to the diet through either trade or horticulture. However, the off-site growing of cultigens in suitable environmental niches within the Boot Hill environs may have been a feasible alternative.

The adaptive hunter-gatherers of the Late Archaic through Formative period would have adjusted their resource selection and scheduling to meet the seasonally available resources. Climate and precipitation would have played a critical role in acquiring resources. During the summer rainy season, floral resources would have been more abundant and use of nearby playa basins and seasonal springs and seeps would have experienced their greatest activity. Artiodactyls would have provided a larger resource, but would have probably been infrequent and would have been acquired opportunistically. Small game, such as cottontail and jackrabbit, were consistently available. Absent from the site is evidence of large-scale plant processing, storage, and horticulture, suggesting the transition from a mixed resource economy to a horticultural economy was gradual or did not occur. Adaptive drift is recognized through increased hunting of medium and large game after the introduction of bow and arrow technology.

This is tentatively evidenced at the Boot Hill site where artiodactyls (i.e., pronghorn and bison) may represent a critical component of the subsistence economy. Adaptive selection is generally absent, as expressed by the continuation of a hunting and gathering economy during the Formative period, even though there was access to cultigens and horticulture. As a precaution, one should remember that much of the subsistence record recovered from the Boot Hill site is from a mixed context within an anthrosol of which the entirety of the Formative period is collapsed within a meter of sediment. This is further complicated by the mixing of the uppermost strata resulting from many decades of digging by local collectors. Therefore, only a broad interpretation of the subsistence economy can be developed diachronically. In conclusion, it is difficult to discern a change in subsistence from the Late Archaic through the Formative periods, indicating a continuation of Archaic resource selection and practices at the Boot Hill site.

14.10 Land-Use Patterns

This section addresses land use as it specifically relates to LA 32229. Following the model and the research issues discussed in Chapter 4, land-use patterns are not clearly defined for the Archaic period and only partially expressed for the Formative period. An argument can be made that due to generations of artifact collecting at this site, a clear picture of land use is an impossible task (Haskell 1977). It is believed that site use during the Middle and Late Archaic periods mimics Formative period land use strategies at the Boot Hill site. This interpretation was presented in Stuart and Gauthier (1984:290) and later by Katz and Katz (1993:I-121), who stated:

> There are striking similarities between the topographic situations of Formative sites [n=1,379 sites with Formative period components recorded in ARMS database in 1993] with those of the preceding Archaic period. In both periods, more than half of the recorded sites are located in only four topographic situations. In the Formative period, 65% of the sites are located in blowouts and dunes, and on ridges or benches. The first three situations are shared with Archaic sites; the Archaic preference for hill slope is shifted slightly to a Formative preference for benches.

An interpretation of group settlement and mobility is structured around Hard's (1983, 1986, 1990) and Mauldin's (1983, 1986) bi-seasonal models for the Formative period, which can be extended back to include the Late Archaic. This model suggests that shifts in settlement can be viewed as cultural adjustments or adaptations to seasonally related environmental conditions. Hard (1983), Mauldin (1986), Miller and Kenmotsu (2004), Kenmotsu et al. (2008), and more recently Condon et al. (2008, 2010b, 2010c) have argued that diachronic shifts in settlement during the Late Archaic and Formative period (A.D. 200/400–1450) are in part a result of seasonal variability and related changes in resource congruence within the region.

Seasonal variance for the Jornada Mogollon region is accentuated by severe drought conditions lasting from A.D. 940 to 1040, followed by above average rainfall between A.D. 1040 and 1125. Between A.D. 1125 and 1140/50 and A.D. 1205 to 1305 below average rainfall again characterized the region. From A.D. 1300 to 1400 the project area experienced increasing above average precipitation levels, suggesting a period of resource abundance existed during this time span (Grisino-Mayer et al. 1997). These trends in precipitation support the concept of highly adaptive populations that practiced a land-use strategy that was in large part influenced by environmental conditions, rather than population pressure. Moreover, climatic variation may act as a critical factor instigating the movement of populations along a continuum of high mobility and short-term sedentism, always accentuated by logistical forays. This interpretation is presented in spite of population aggregation and agricultural reliance identified throughout much of the Southwest during the Formative period.

Adaptive strategies, which subsume seasonal adjustments, become more salient during periods of increased stress or during periods of increased abundance. Thus, the construct of adaptation is the process by which populations maintain homeostasis through responsive changes in their states, structures, or compositions in the face of both short-term and long-term environmental fluctuations (Rappaport 1971). This shift is further substantiated through an analysis of architecture and subsistence. As previously noted, significant differences in structure size exists between circular or oval-shaped pit houses within the greater Jornada Mogollon region (Condon and Hermann 2008; Gilman 1991; Hard 1983). Pit houses found along the alluvial fans differ markedly from those identified in the valley and basin low lands. There appears to be a difference in terms of invested labor when basin structures are compared to structures found on upland settings. This pattern may have relevance to southeastern New Mexico, where Speth and LeDuc (2007:45) suggest architectural variability may be the product of differing ethnicity or perhaps seasonality.

Settlement strategies for east of the Pecos River follow a continuum of seasonally influenced land-use patterns, characterized primarily by mobility rather than sedentism and a broad-based resource focus rather than a growing reliance on agriculture. Hill's (2000) excavations at Macho Dunes and Wiseman's (2002) research at The Fox Place site both indicate group mobility and a mixed-resource economy. In a similar scenario to LA 5148, Hill (2000:38) dates three ephemeral pit houses between A.D. 665 and 885. The Laguna Plata site (Condon et al. 2010a) has pit houses that are similar in size and morphology to the Macho Dunes structures, but lack the internal hearth or additional floor features identified by Hill (2000:31). Structures at both sites lack depth and labor investment, with the Laguna Plata structures exhibiting shallow depressions and no clear indication of subsurface excavation to create walls or substantial support systems for structure infrastructure (Condon et al. 2010a). Comparative structures are associated with Whalen's (1994:139) Class 2/3 site type at the Turquoise Ridge site in El Paso County, Texas, which is characterized by small, shallow pit houses. The Keystone Dam site (EPCM 2:33), a Late Archaic habitation site in El Paso County, Texas also revealed similar ephemeral pit house configurations (O'Laughlin 1980). In comparison, these sites differ in many aspects, but have at least one characteristic in common, limited duration occupation.

Wiseman (2002:25) excavated 11 of 13 pit houses at The Fox Place site, which all date much later: A.D. 1270 to 1315, A.D. 1345 to 1390, and A.D. 1410 to 1420. Unlike architecture in the Rio Grande valley, the morphology and general structural elements appear to remain somewhat static over the course of the Formative period. This suggests consistency in land use, mobility, and possible group size despite shifts in technology and social structure in areas surrounding the eastern margins of the Jornada Mogollon region. Exceptions are generally rare, but may be reflected at the Henderson and Bloom Mound sites where short-term sedentism seems to have taken hold. Despite a more established social organization and architectural intensification at both sites, which date between A.D. 1250 and 1400 (Speth and LeDuc 2007:45), most residential sites in the Roswell and Carlsbad area appear less labor intensive and of short-term duration. As suggested by Wiseman (2003) and Speth and LeDuc (2007), the causal factors surrounding the shift in architecture from pit houses to room block may be difficult to identify, as no single factor may be to blame. At present, settlement patterns for southeastern New Mexico appear to be nonlinear, with many settlement characteristics transgressing time, with minor shifts occurring in response to resource availability, changing climate, and possibly, developing territorialism and encroachment from the east (Speth and LeDuc 2007).

Land-use studies for southeastern New Mexico have identified adaptive strategies that are dynamic and variable within a diverse, and at times, marginal environment (Condon et al. 2008; Railey et al. 2009; Speth and LeDuc 2007; Wiseman 2003). As such, the archaeological record of the eastern extension of the Jornada Mogollon is highly variable, but has a distinct signature unlike other portions of Lehmer's (1948) Jornada Mogollon region. Although interaction and similarities occur between the regions, Corley's (1970) proposed extension of the Jornada Mogollon 150 miles eastward to encompass southeastern New Mexico south and east of Roswell, New Mexico may have been premature. As additional data becomes available, this area exhibits attributes that are consistent for areas east of the Pecos and do not parallel the traditional Jornada Mogollon region as defined by Lehmer (1948). Based on the current data, settlement patterns and land-use studies indicate a highly mobile, mixed-resource economy that did not embrace horticulture or long-term sedentism, although, in all likelihood, recognized both innovations.

14.10.1 Land-Use at LA 32229

Occupations at LA 32229 appear to reflect a continuation of adaptation that transitioned from the Archaic period into the Formative period, with technologies including the bow and arrow and ceramic production. The present testing project did not yield any evidence of cultigens. This transition suggests an extended sequence of similar adaptations east of the Pecos River valley that continued relatively unaltered until at least A.D. 1400/1450. The current suite of subsistence data recovered from LA 32229 tentatively identifies the use of little barley (*Hordeum pusillum*). Faunal analysis provides a more definitive view into exploited resources, as the western box turtle (*Terrapene ornata*), desert cottontail (*Sylvilagus audubonii*), black-tailed jackrabbit (*Lepus californicus*), pronghorn (*Antilocapra americana*), and bison (*Bison bison*) remains are present at the site. This mixture of resources indicates an environment that was diverse and able to support a multitude of species. In addition, the multiple habitats identified with the Boot Hill environs supports an interpretation of resource congruence, where multiple resources were predictable and accessible to human populations. Accessibility to potable water afforded by the presence of spring vents along the base of the Caprock provided this much-needed resource for all other resources and an added attraction for the inhabitants of the site. Within the broader settlement scope, the Boot Hill locale may represent a multi-component residential base camp from which logistical diurnal activities, such as resource procurement, could be anchored. This interpretation suggests the Boot Hill site was occupied through time on a seasonal or discontinuous schedule. The number of small-hearth features and presence of a large deep anthrosol documented throughout the site attest to heavy domestic site use. Feature data compiled by Katz and Katz (1993:122) note that features across the region tend to be similar in form, regardless of ecozone, topography, and temporal affiliation. Based on the feature data, activities tended to be conducted outside of structures, suggesting a favorable climate and available resources. If this model is correct, then the primary occupations at Boot Hill during the Late Archaic and Formative periods may have benefitted from above average precipitation and a wide range of exploitable resources.

The period from 750 B.C. to A.D. 800 experienced a general increase in temperature, with the culmination of a severe warming trend occurring from A.D. 900 to 1200 (Condon et al. 2010b, 2010c; Grissino-Mayer et al. 1997; Prentiss and Chatters 2003). This “Little Climatic Optimum” of the Southwest experienced fluctuating periods of extreme precipitation and aridity. Four periods of drought and four corresponding periods of above-average rainfall were documented for southeastern New Mexico during this period. The periods of drought include A.D. 710 to 720, A.D. 940 to 1040, A.D. 1140 to 1190, and A.D. 1210 to 1230. The periods of above-average rainfall include A.D. 740 to 840, A.D. 900 to 920, A.D. 1060 to 1120, and A.D. 1320 to 1330 (Church and Sale 2003:28; Grissino-Mayer et al. 1997:61).

The chronometric data from Feature 3 and Levels 1, 2, 4, and 5 in Trench 1, and the road cut overlap the periods of both above and below average rainfall. It is conceivable that LA 32229 may have acted as an oasis during periods of drought, where inhabitants would have exploited a limited range of resources. During periods of above average rainfall, the site environs offered a plethora of resources. Although no definitive structures have been excavated at Boot Hill, the extensive anthrosol and results of testing in Trenches 1 and 3 strongly suggest the possibility of nearby structures. It is likely the construction of any structures would have involved little labor investment and were, in all likelihood, constructed and used during cool weather months, perhaps during fall or spring.

14.10.2 Summary

Based on the results of testing, LA 32229 may have served as a residential site or base camp during the Archaic and Formative periods. The re-occupation and density of the artifact assemblage attests to the importance of this site locale to regional hunter-gatherer groups. Although no discernible pit houses have been excavated at the site, it is likely that ephemeral pit houses are present in the well-developed anthrosol that extends across the site. The location of LA 32229 on the landscape appears to have considered a combination of suitable topography, access to reliable water, and the exploitation of a mixed-resource economy. This community is most identifiable during the Formative period and reflects a continuing adaptive strategy during periods of affluence and environmental stability. At present, the Archaic and Formative period occupations at LA 32229 appear primarily seasonal in form, yet influenced by fluctuating environmental conditions and shifting demographics. Mobility is recognized as highly flexible, with occupational duration determinant on a number of variables within the hunter-gatherer continuum.

Doleman (2005:131) discusses this concept with regard to the Late Archaic period in south-central New Mexico. However, this construct of flexibility can easily be extended to the Formative period. Doleman (2005:131) argues that spatial structure (i.e., distance between viable biotic zones, climate, water availability, and resource productivity) is broadly reflected in a decrease in the number of resource options in a region and may have played a significant role in the continuance of the hunter-gatherer adaptation. Of equal interest is the subsequent premise that this land-use strategy resulted in an increase in scale and frequency in residential movements, possibly impeding the development of agriculture, but establishing a clearly discernible archaeological footprint across the region (Doleman 2005:132). As an alternative, one can view the lands east of the Pecos River as spatially challenged, but productive, as the Boot Hill subsistence data indicate. Seasonal or cyclical movement to these choice areas may have played a significant role in regional settlement patterns.

For the Late Archaic and Formative periods, hunter-gatherer populations reduced systemic risk by undertaking and maintaining loose trade networks, managing group size, and practicing what Doleman (2005:119, cf. Yellen 1977) terms behavioral plasticity. As long as the population of a given hunter-gatherer group, or even a regional population, remained below the carrying capacity threshold (i.e., the ability of the environment to support a population), a given adaptive strategy would remain unchanged, despite the introduction of innovative technology. In southeastern New Mexico, specifically east of the Pecos River, this is reflected in reoccupation and extended stays at specific locales that provided access to multiple resources (e.g., the Boot Hill, Laguna Plata, Burro Tanks, and Indian Hill sites), and the establishment of intra- and inter-regional contacts (Figure 14.4). The result of behavioral plasticity, coupled with high mobility, is the rejection of socio-complexity and a hierarchal establishment for the region, which may have been developing in the Hondo River valley and the Sierra Blanca highlands, and which was present in the Rio Grande valley by the late Formative period. With an adaptive strategy that was flexible and reliant on a mixed resource economy, need for agriculture (i.e., farming) and consequently sedentism, was ignored or, at best, superficially accepted. Trade networks may have provided access to domesticated plants, such as maize, but in the case of Boot Hill, it does not appear in the archaeological record. As a result, resource acquisition remained flexible and diverse, possibly relying on social networks as a mechanism for access to domesticated plants, rather than adopting horticulture.

While there may be diachronic differences in procurement at the Boot Hill site, we are currently unable to offer evidence of a change from a foraging/hunting to a sedentary/collecting, agricultural-based strategy. If our interpretation is correct, we may never identify the agricultural reliance demonstrated in other parts of the Southwest, east of the Pecos River, including LA 32229. Although this testing project resulted in a reasonable attempt to understand the broader settlement system associated with LA 32229, additional research will be required before a more accurate interpretation of site use can be established.

14.11 Regional Interaction

Within the eastern extension of the Jornada Mogollon region, extensive trade networks have yet to be clearly defined and are only indirectly evidenced through intrusive pottery types, nonlocal tool stone, and exotic marine shell (Condon et al. 2008; Hill 2000; Wiseman 2003). Prior to the Formative period, the identification of nonlocal tool stone, such as the presence of Alibates silicified dolomite, chert from the Edwards Plateau formation, and Quitaque, or Tecovas jasper, were the most readily recognized, although uncommon, nonlocal materials encountered in southeastern New Mexico (Holliday 1997). The near absence of nonlocal materials between 5200 B.C. and A.D. 500 may be attributed to low populations, frequent settlement movements, sporadic unplanned episodes of local exchange, and marginal group interaction. Evidence to the contrary may be found, not in pottery or tool stone, but in food resources, such as maize.

Research at Fresnal Shelter (LA 10101) and High Rolls Cave (LA 114103) in Otero County, New Mexico may point toward the presence of maize from Mexico by at least 1250/1200 B.C. (Lentz 2006:223). After A.D. 750 and the firm entrenchment of ceramic technology, regional interaction is inferred by the presence of nonlocal pottery, most notably Mimbres white ware and El Paso brownware variants from west of the Rio Grande, Red Mesa Black-on-white from northwestern New Mexico, and later polychrome pottery from as far south as Chihuahua, Mexico (Hogan 2006:6-45). Despite evidence of regional interaction, quantifying trade and exchange is much more difficult for the region. Following Renfrew (1969), trade and exchange are used in the broadest sense as the reciprocal traffic, exchange, or movement of material goods through peaceful human agency (cf. Stewart 1989). Internal and external factors, including social and political dynamics, play a critical part in the organization of trade and exchange. As such, two models of trade and exchange are presented here: broad-based networks and focused networks.

Broad-based networks are characterized by hand-to-hand down-the-line exchange and nebulous exchange relationships for the region. Trade items are broadly distributed and generally exhibit gradually declining frequencies with increasing distance from artifact/material sources. Broad-based networks are extensive and may not be controlled by or restricted to formalized relationships between groups. Determining what items and how much of an item is exchanged is determined by the particular needs of a group and not directed by the nature of the exchange system itself (Stewart 1994). Exchanged items are not necessarily held in great esteem, are used in the same manner as locally derived counterparts, and are discarded in both ritual (sacred) and domestic context (Stewart 1989:65). Locally, this construct is demonstrated in the recovery of exotic items in burial and caching contexts, as well as from trash pits. On a fundamental level, artifacts are circulated through a series of exchanges that are nonlinear, operate on a personalized level of relationship, and do not operate as a support to a social hierarchy. While ritual or ceremony may operate at some level during the exchange, it does not relate to the general use of the artifacts. This decision-making correlates to a model of sequential hierarchies that function in a flexible manner and which take advantage of aggregated communities (Johnson 1982; Miller et al. 2009). These communities form, aggregate, and disperse as part of the larger cultural system that can include being part of a more established Puebloan system.

Focused networks, defined by Stewart (1989), contain few contacts and commonly include a large number of artifacts. They are often associated with complex societies and ritual and, in the Southwest, are exemplified by complex polities, such as Casas Grandes and Chaco Canyon. Given the hierarchal socio-political substructure of these complex states, it is likely that high-ranking individuals or groups subsidized long-range trading expeditions and linking into established trade systems (LeBlanc 1989:195). Focused exchange may have occurred immediately after the planting season (spring), when groups may have been more sedentary and inhabited easily identifiable settlements (Stewart 1989). A case for interregional contact can be made for the Formative period and particularly for the late Formative period in the Rio Grande valley, where the sedentary nature of the Puebloan system and an agricultural based subsistence, coupled with marked territoriality, embraced the benefit of trade and exchange. Despite evidence to the contrary, the Formative period remains enigmatic in southeastern New Mexico (Condon et al. 2010b).

Within the greater Jornada Mogollon culture sphere, which takes into account the community structure and interaction among regional populations, including kinship relations, the influence of the Puebloan system identified in the Rio Grande valley, at least in part, is linked to more established polities, such as Casas Grandes to the southwest, and judging from the high frequency of El Paso-base ceramics, to the Boot Hill region as well. However, sedentism may not be measured in the same manner in the Pecos River valley, where an absence of Puebloan architecture is the norm, and high mobility may preclude the establishment of centralized trade centers. Despite more intense occupation between A.D. 1100 and 1300 in the Jornada Mogollon region, the low efficiency and high transport cost of direct trade may have weakened the social relationships between the Pecos River valley and trade centers to the west (Whalen and Minnis 2001:195). Considering this interpretation, the advantage of broad-based nonlinear trade and exchange during the late Formative period at the Boot Hill site may be more realistic than focused relationships and would explain the low frequency, but relatively high diversity of nonlocal artifacts.

During the current testing project, 17 pottery types were identified, of which two are considered local and 15 are considered nonlocal. Local pottery types include Jornada Brown and Jornada Decorated. Nonlocal pottery types include South Pecos Brown (plain and decorated), El Paso brownware, El Paso Brown, El Paso Polychrome, El Paso Decorated, Mimbres whiteware, Playas Red, Chupadero Black-on-white, Three Rivers Red-on-terracotta, Gila Polychrome, St. Johns Polychrome, Socorro Black-on-White, and Corona Corrugated. An indeterminate category contains sherds that could not be accurately identified.

The diversity of intrusive pottery types suggests interaction with areas adjacent to the Pecos River and those along the far western extension of the Jornada Mogollon and beyond (e.g., St. Johns Polychrome). More regionalized pottery types include Jornada Brown and South Pecos Brown. Three Rivers Red-on-terracotta, Corona Corrugated, and Chupadero Black-on-white also originate in the northern Jornada Mogollon region characterized by the Sierra Blanca Mountains (Hill, cf. Peterson 2001; Runyan and Hedrick 1987; Wiseman 2003). Socorro Black-on-white is associated with the Rio Grande valley in Socorro County. El Paso brown ware variants, including El Paso Brown, and El Paso Polychrome are associated with the Rio Grande valley of west Texas and the Tularosa Basin of New Mexico (Miller 1995; Miller and Kenmotsu 2004). Mimbres white ware is tentatively sourced to the Mimbres valley west of the Rio Grande River, while St. Johns Polychrome is associated with northwestern New Mexico. Gila Polychrome is associated with southwestern New Mexico. Playas Red is traditionally associated with northern Chihuahua, Mexico (Figure 14.5).

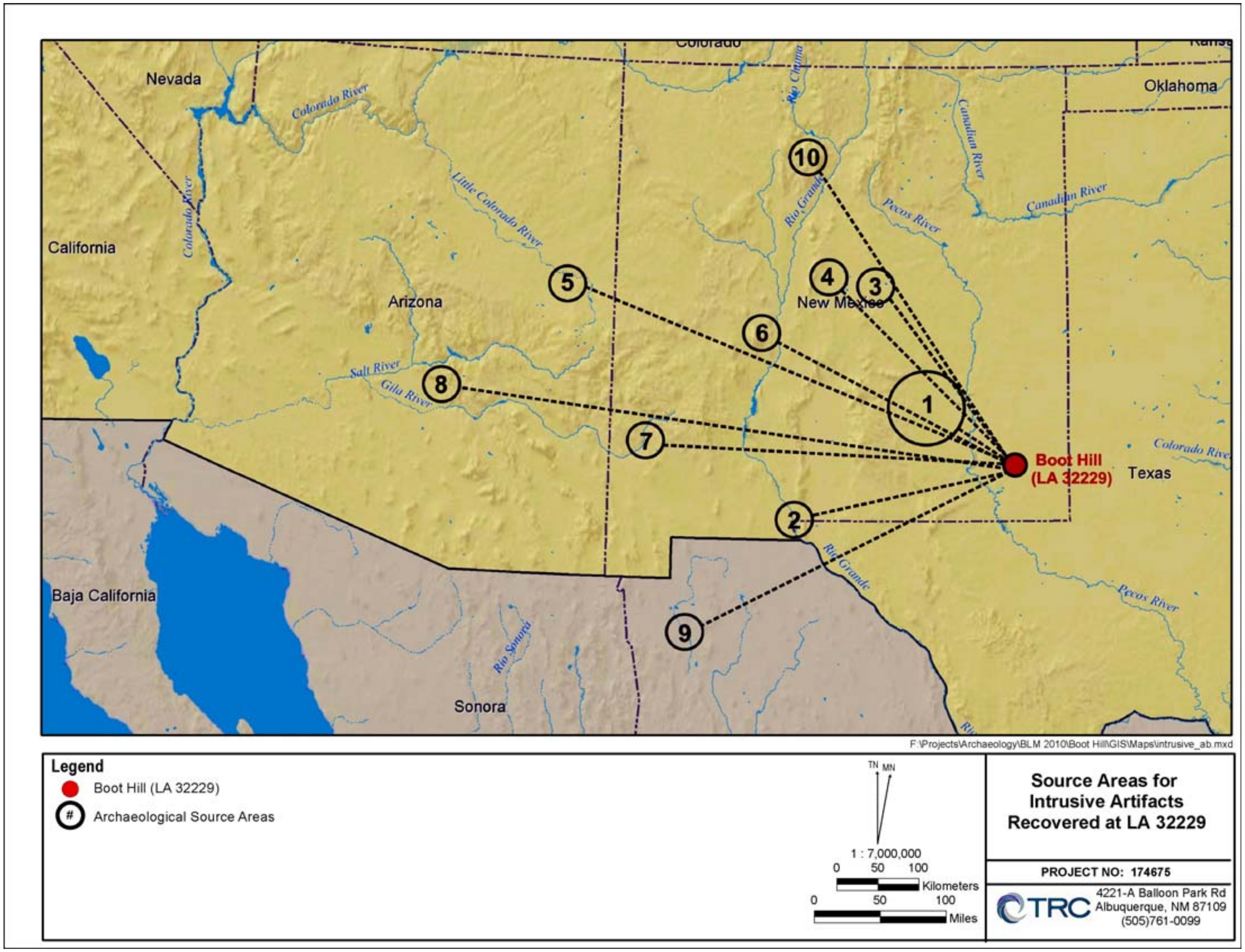

Figure 14.5 Source areas for intrusive artifacts recovered at LA 32229

1) Jornada Brown, Jornada Decorated, South Pecos Brown, and Corona Corrugated; 2) El Paso brownware, El Paso Brown, El Paso Polychrome, and El Paso Decorated; 3) Three Rivers Red-on-terracotta; 4) Chupadero Black-on-white; 5) St. Johns Polychrome; 6) Socorro Black-on-white; 7) Mimbres Black-on-white; 8) Gila Polychrome; 9) Playas Red; and 10) Valles Calderas obsidian source.

Included in the discussion on trade and exchange is the identification of rhyolite at LA 32229 from the Jemez Mountain range of north-central New Mexico. The presence of a nonlocal lithic material indicates possible long-range transport from the Valles Caldera outcrops of Cerro Toledo Rhyolite and Valles Rhyolite (Shackley 2005). The general morphology and size of the cobbles, as well as the flaking and cutting properties of rhyolite, made this desired tool stone a transportable commodity. Three artifacts were submitted for XRF analysis. Two sources in the Jemez Mountains are indicated—Cerro Toledo Rhyolite and Valles Rhyolite (Table 14.5) (Shackley 2005). Valles Rhyolite has been found as far south as Albuquerque, but in very small nodules (< 16 mm) and in proportions well below 1 percent (LeTourneau and Shackley 2009; Shackley 2010).

Table 14.5 XRF analysis, elemental concentrations for the samples.

Sample	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
1	501	11568	204	9	48	173	57	Valles Rhyolite
2	425	9459	181	5	45	165	54	Valles Rhyolite
3	614	10697	239	6	69	184	104	Cerro Toledo Rhy

Measurements in parts per million (ppm).

Nonlocal artifacts, recovered during test excavation, are characterized by a low frequency count for any single artifact type. El Paso Brown (n=15), El Paso Polychrome (n=9), El Paso Decorated (n=1), Mimbres whiteware (n=7), Three Rivers Red-on-terracotta (n=13), Corona Corrugated (n=5), Gila Polychrome (n=1), St. Johns Polychrome (n=1), and Playas Red (n=2) all occur in very low frequency. The higher frequency of pottery attributed to the El Paso region of Texas (El Paso Brown) may suggest a more established social relationship with this region. Chihuahuan ware, including Playas Red, further strengthens a network connecting Casas Grandes with southeastern New Mexico. This is in keeping with trade system models proposed by LeBlanc (1999) and Whalen and Minnis (2001) and suggests Casas Grandes served as a possible clearinghouse for pottery and other items moving northeast. Examining the distribution of Boot Hill pottery, a pattern of east moving trade items is demonstrated. In fact, the artifact assemblage indicates an almost total absence of materials moving west from the Southern High Plains or from central Texas. While the absence may be misleading, in that perishable items may have been traded, such as bison meat or hides (see faunal analysis), the pattern is intriguing and begs the question as to the relationship between populations inhabiting LA 32229 and those to the east. This same pattern was observed at the Laguna Plata site (LA 5148) (Condon et al. 2010a).

14.11.1 Summary

Evidence of regional trade at LA 32229 can be found in intrusive pottery and tool stone. Whether this interaction is buffered through a broad network of trade and exchange or is the result of direct interchange along trade routes is unclear. The presence of pottery types sourced to the west of the project area further suggests interaction with populations within and peripheral to the Jornada Mogollon region. As noted by Kenmotsu et al. (2008), the role that regional interaction plays in the adaptive strategies carried out in the Jornada Mogollon region suggest a higher level of importance than previously allotted. It is suggested that, for the Formative period in southeastern New Mexico, the development of interregional trade and exchange systems is illuminated by the introduction of pottery, population increase, and seasonal aggregation of populations into general core areas, such as LA 32229. Questions relating to the interaction and exchange of trade goods and ideas between the Rio Grande and Pecos River valleys merit attention and future inquiry.

15.0 Current Research Assessment: Settlement, Subsistence, Technology, and Regional Interaction

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This section addresses the research questions in Chapter 4. The questions pertain to four research topics: 1) settlement, 2) subsistence, 3) technology, and 4) regional interaction. While each of the research domains is tentatively viewed as a separate entity, each is interrelated and some have overlapping explanations. Because the only evidence TRC acquired of Archaic period occupation at the Boot Hill site was in the form of a few San Pedro and Livermore projectile points with no associated AMS dates or probable associated floral, faunal, or other features, the following questions focus on the Formative period.

15.1 Settlement

Hypothesis 1: *Formative period use of the Boot Hill site will exhibit evidence for a warm-weather, residential pattern of mobility. These occupations may exhibit use of ephemeral shelters, increased assemblage density and diversity, and increased frequency in ground stone artifacts.*

Hard (1983) argued for more intense use of low-lying environments during the Formative period, specifically after A.D. 600 for the Jornada Mogollon region. Climatic conditions prior to A.D. 940 suggest average and above average annual precipitation and corresponding environmental stability would have provided optimum resource availability on a seasonal basis. With environmental stability is the expected flourishing of plant and animal communities, or at the very least, the development of ecozones supporting the proliferation of species. The Boot Hill site is in an ecotone where nearby springs and seeps at the base of the Caprock supported a diversity of plant and animal communities.

The diagnostic artifact assemblage dating to the Formative period suggests multiple occupations at the Boot Hill site. A large number of projectile points indicate hunting was probably a major activity, as indicated by the faunal assemblage. Feature 3, a small soil stain representing a probable hearth, yielded an age range of A.D. 575 to 651 (UGA 7608), dating it to the Formative 1 period.

The Boot Hill site may have served as a residential site or base camp during the Formative period. The site re-occupation and density of the artifact assemblage attest to the importance of the site to regional hunter-gatherer groups. Although no pit houses have been excavated, their presence is likely in the well-developed anthrosol. The anthrosol, which is more than one meter thick, attests to the presence of, or processing of, huge quantities of C3 plant material. The presence of mesquite in the flotation and pollen samples collected during testing suggests mesquite is one source of carbon for the anthrosol. Another possible source may be the processing of large quantities of acorns from the shinnery oak (Shelley, personal communication 2011), but this has not been tested. Trenches 1 and 3 exposed portions of the anthrosol that suggest the possible presence of nearby structures or large buried features of undetermined function.

Site occupation appears to have targeted areas of that provided suitable topography, access to reliable water, and exploitation of a mixed resource economy. This community is most identifiable during the Formative period and reflects a continuing adaptive strategy during periods of affluence and environmental stability. At present, the Formative period occupations at the Boot Hill site appear primarily seasonal, yet were influenced by fluctuating environmental conditions and shifting demographics. Mobility is recognized as highly flexible with occupational duration based upon a number of variables within the hunter-gatherer continuum.

15.2 Technology

Hypothesis 1: *During periods of resource abundance, groups will exhibit a tool kit composed of multifunctional flaked stone tools indicative of a core/flake reduction strategy used to exploit a mixed resource base.*

Hypothesis 2: *In the face of lithic abundance, we would expect to find a multidirectional approach emphasizing a series of reduction strategies with regard to tool manufacture.*

Hypothesis 3: *Mobile hunter-gatherer groups will use informal slab metates and cobble manos to process both faunal and floral resources.*

Hypothesis 4: *Ceramics will be comprised mostly of jars that serve both a cooking and transportable storage function.*

Hypothesis 5: *Feature morphology and construction will reflect limited-use domestic hearths rather than formal rock-lined pits or annular rock-ring roasting pits.*

Technological issues are addressed through the range of artifacts identified at the Boot Hill site and indirectly linked to site activities and site use. The Boot Hill site contained a variety of artifacts, including thousands of pieces of lithic debitage, but a low frequency of cores, flaked stone tools, hammerstones, and few ground stone items. Ceramics were recovered throughout the site. Features were consistent in form and function and occur around the side slope of the ridge rather than on top of the ridge.

Raw material selection points toward a preference for chert and chalcedony across the entire assemblage and is the result of availability and occurrence of the Ogallala formation associated with the Caprock margin of the Southern High Plains (Haskell 1977; Holliday 1997). While other materials are used, their occurrence might be limited to several factors, including access, quality, and functional requirements. The preference for fine-grained material types may have resulted from the need for good cutting and butchering implements (e.g., pronghorn and bison hunting and butchering). The paucity of obsidian makes it unclear whether it found its way to the Boot Hill site through trade and exchange or as the result of a chance find. Concurrent with this is the interpretation that no obvious trading networks or extensive contact with populations outside of the region existed with regard to tool stone. This is in keeping with current models of prehistoric land use for the region that suggest stone was procured from local gravel sources and accessible outcrops.

The debitage analysis indicates a variety of reduction techniques were used, and equally critical, that stone conservation and tool maintenance did not play pivotal roles in the structure of technological organization at the site. As noted by Miller (2007), Condon et al. (2010b, 2010c), and more recently by Railey (2010b), reduction techniques used during the Formative periods appear to fall between a formal biface-oriented reduction strategy and one that is best described as an informal core/flake trajectory. Moreover, material conservation does not seem to play a major role in tool maintenance at many sites within the Boot Hill region, suggesting that access to tool stone was not necessarily a problem.

The core assemblage is reflective of the debitage assemblage in that both fit the profile of expected early through late reduction of core/flake technologies. The frequent occurrence of multidirectional cores suggests a reduction strategy that is flake oriented, random, opportunistic, and in all likelihood, expedient rather than formalized. Using the mean core size and mean flake length, there is a pattern that almost precludes biface-oriented reduction, suggesting that flaked stone tools, specifically projectile points, may have been made from a core/flake technology rather than a bifacial core trajectory. This is in keeping with a Formative period organizational strategy that emphasizes the bow and arrow rather than larger atlatl or spear technology.

This interpretation is supported by the projectile point analysis, which suggests a subtle, yet distinguishable, pattern that segregates dart from arrows points. However, the more critical question focuses on the perceived shift in technology for the region. For the southeastern New Mexico region, this implication suggests the possible knowledge and use of multiple technologies through time. The more acceptable age range for the shift from atlatl dart to the manufacture of arrow points in the southeastern New Mexico region is between A.D. 500 and 700 (Railey 2010b:266). While Fresno, Scallorn, and Harrell types traditionally reflect arrow points, the general wide age range associated with point types prior to the late Formative period does not provide much assistance in narrowing this transition in technology. The flaked stone tool assemblage, including informal and bifacial tools, consists of a relatively small sample group.

Grinding implement raw materials, almost exclusively sandstone and granite, would have been easily obtained from nearby outcrops. Metate types are indeterminate, represented by small fragments. Manos are also fragmented, but two complete one-hand types were recovered. Absent are formal ground stone types, such as trough metates, which are documented in increasing frequencies as agriculture began to become a primary activity. These types of formal grinding tools are typically associated with extended occupations and maize processing, and were not expected at the Boot Hill site. The general informal slab metates correspond with seed processing and highly mobile populations (Adams 1999; Hard 1983).

Occurring with the most frequency in the ceramic assemblage is Jornada Brown (including ten Jornada Decorated sherds), which in much the same way as other plain brownwares, provides a relative temporal range for a given region. In this case, Jornada Brown dates between A.D. 200/400 and 1250/1350 and covers the entirety of the Formative period at the Boot Hill site. South Pecos Brown occurs with less frequency, but spans a period of 300 years (A.D. 900–1200). These brownwares appear to correspond stylistically with similar undecorated brownware types, including El Paso Brown, despite being manufactured in the eastern extension of the Jornada Mogollon region (Katz and Katz 1993; Miller 1995).

Within Lehmer's (1948) Jornada Mogollon culture sphere are the Rio Grande pottery types, which include El Paso Brown and El Paso Polychrome. These pottery types also occur in relative low frequencies, but reflect the transition from a plain brown, which flourished from A.D. 200 to 1000/1100, to painted wares after A.D. 800/1000 in the Rio Grande valley. The subsequent introduction of polychrome wares (A.D. 1000/1100–1450) is identified in the assemblage from the Boot Hill site. Although El Paso Polychrome occurs in low frequencies it effectively points toward a regional influence at LA 32229 post-A.D. 1000. The Rio Grande valley, including the adjacent Hueco Bolson and Tularosa Basin, fall within the traditional boundary of the Jornada Mogollon region, and holds a tentative association with the Pecos River valley to the east, despite the general absence of locally made decorative pottery in the Pecos River valley. Moreover, the identification of clays and temper material, Hill (2000), suggests the majority of brownware pottery was produced outside the Boot Hill area, primarily in the Sierra Blanca region or the Rio Grande area associated with El Paso.

As discussed by Hill (2000:70), the similarities and presence of pottery types within and between these two areas suggests that populations did not exist in isolation. This construct is saliently demonstrated when more exotic pottery types are discussed. The presence of pottery types northwest, far west, and far southwest of the Boot Hill site can best be explained through regional down-the-line interaction rather than direct trade. The low number of any one, nonlocal pottery type, with the exception of Chupadero Black-on-white, generally supports this interpretation. Not discounting direct use of the Pecos River as an access route, the general high diversity, low frequency of the exotics, and distance suggest that trade and exchange was indirect. Mimbres white ware dates between A.D. 750 and 1130/1150 east of the Mimbres Mountain range and overlaps chronologically with Jornada Brown, South Pecos Brown, and El Paso

Brown; all pre-date what is considered the primary occupation at the Boot Hill site. Similar to Mimbres white ware, Socorro Black-on-white dates A.D. 950–1300 and also overlaps with Jornada Brown, South Pecos Brown, and El Paso Brown. Chupadero Black-on-white and Three Rivers Red-on-terracotta originate northwest of the Boot Hill site and date post-A.D. 1100, with the highest frequencies dating between A.D. 1100 and 1300. Playas Red is thought to be a product of the Casas Grande region of Mexico and also dates post-A.D. 1100, and represents a second period of intense occupation at the Boot Hill site.

Ceramics that date after A.D. 1200 tend to support the traditional interpretation of site occupation at Boot Hill (Corley and Leslie 1960). St. Johns Polychrome and Corona Corrugated reflect occupational events as early as A.D. 1200 and A.D. 1225, respectively. Gila Polychrome indicates site use after A.D. 1300, and terminating by A.D. 1400/1450. This is later than suggested by Corley and Leslie (1960). The record of site activity at Boot Hill clearly demonstrates a consistent, although not continuous, use throughout the Formative period. The diversity in the ceramic assemblage establishes a pattern of diachronic site activity that involves interaction at least on a secondary level of influence for the region. Finally, based on the distance to the Boot Hill site from points west, and intensity in the levels of production, it may be safe to suggest that the introduction of several pottery types may not have made their way to the Boot Hill site until late in the sequence or even after the *terminus ante quem* production event had passed.

Vessel form was used cautiously as a means to evaluate function in the absence of a first order context within which the pottery was used. Using the samples of Jornada Brown, 201 sherds greater than 3 cm in diameter were analyzed with attention directed towards two vessel forms, jars and bowls, as they relate to cooking and noncooking activities. Jornada Brown, South Pecos Brown, El Paso brownware, El Paso Polychrome, Chupadero Black-on-white, and Corona Corrugated all clearly demonstrate a predominant singular vessel form. Jars, including both neck and neckless forms represent the dominant form in the Boot Hill assemblage. This interpretation may relate directly to mobility with wide-mouthed, shallow vessels hindering high mobility. Jar forms, which serve a variety of functions, probably maintained a level of stable occurrence as there was a continual need for cooking and storage vessels for all periods of occupation at the Boot Hill site. In contrast, for reasons undetermined, most of the Mimbres white ware, Three Rivers Red-on-terracotta, and Gila Polychrome identified in the assemblage point toward bowls rather than jars.

On the basis of the available data, it seems vessel form is somewhat inconsistent through time with changes in size, form, and presumably function co-occurring during the late Formative period. It is suspected that vessel form can be characterized by a variety of types, including *ollas*, *tecomates*, and bowls. Consistency is reflected in vessel form and a relatively small-diameter orifice, suggesting narrow jar openings were more the norm rather than the exception.

Nine burned caliche features indicative of hearths were documented within the project area. The number of discernible features is indicative of moderate-to-high levels of site activity. The similarity in feature type suggests commonality in function that is more akin to small hearths rather than large processing features. The paucity of large processing features may relate to a scarcity of resources that would necessitate the processing of resources on a large scale. The large roasting pits, defined as burned-rock middens, annular rock rings, and crescent middens of burned rock, are absent. This absence may suggest processing of resources, such as agave, may not have been a primary activity. More likely, environmental conditions were not favorable for this resource and, therefore, it is not present in the archaeological record.

15.3 Subsistence

Hypothesis 1: *Due in part to increased aridity and population pressure, Formative period use of the Boot Hill site will reflect broad-spectrum resource acquisition of perishable and nonperishable resources that are reflected in the seasonal exploitation of small game and seed-bearing plant species.*

Hunter-gatherers of the Formative periods adjusted their resource selection and scheduling to seasonally available resources. During the summer rainy season, floral resources would have been more available. Based on current floral availability, it is expected that mesquite beans and seeds from acacia, yucca, amaranth, chenopod, sunflower, and drop seed would have provided a food source that could have been consumed immediately after processing or stored for future use. Bison would have provided an infrequent, but valued food source; however, within the site region, pronghorn and small game, such as cottontail or jackrabbit, would have been the most available. Undoubtedly, changes in exploitation over the last 3,000 years can be accounted for by the relationship between climate, resource diversity, and population pressure. Major transitions from a mixed-resource economy that exploited a broad spectrum of seasonally based resources, however, are gradual in nature and ephemerally present in the archaeological record. Several characteristics of Formative period subsistence strategies are more expressive than others. For instance, the increased value of seed-bearing plants is evidenced by increased frequencies of ground stone implements. Storage, both transportable (e.g., jars and baskets) and fixed (e.g., storage pits) infer that nonperishable resources were becoming increasingly important as a means of delayed-economic return in anticipation of cold-weather resource scarcity.

When the primary resources identified at the Boot Hill site are assessed, *Lepus californicus* (black-tailed jackrabbit) and *Sylvilagus audubonii* (desert cottontail) are the dominant resources, although artiodactyls reflect a significant resource, particularly pronghorn, with bison also probably acquired on an opportunistic basis. Smaller reptiles, as well as *Terrapene ornata* (Western box turtle), may have been more supplemental rather than a primary staple of the inhabitants' diet. Plants, such as *Hordeum pusillum* (little barley), were exploited. *Prosopis* sp. (mesquite) was present, based on flotation and pollen. The absence of *Zea mays* (maize) suggests horticulture did not contribute to the subsistence of the site occupants.

The abundance of resources in the Boot Hill site environs suggests the hunting of small mammals provided a consistent resource, but that opportunistic hunting of medium to large mammals, including pronghorn and occasionally bison, commonly occurred. Seasonal availability was probably a major factor in resource selection. Climate and precipitation would have been critical components for available resources. It is possible that the occupying groups revisited the same locale within a yearly residential round. The site occupants practiced a broad-spectrum subsistence strategy that in all likelihood targeted seasonally available resources that provided a relatively high return rate. Higher ranked species were acquired opportunistically, as indicated by the faunal assemblage.

15.4 Intra-regional and Inter-regional Interaction

Hypothesis 1: *During periods of prolonged residential occupation and seasonal resource incongruence, foraging groups will exhibit elevated inter-regional interaction, resulting in a moderate to high presence of nonlocal artifact types.*

Exchange and interaction on a regional scale was primarily evaluated through nonlocal pottery types tentatively seen as markers of regional interaction. Whether this interaction was buffered through a broad network of trade and exchange or was the result of direct interchange along trade routes is unclear. The frequency of pottery associated with the Sierra Blanca highlands points toward a relationship northwest of the Boot Hill site. Direct or indirect interaction with the Henderson and Bloom Mound sites, or even the pit house settlement of The Fox Place site (LA 68188), all of which demonstrate temporally contemporaneous components (i.e., between A.D. 1250–1400) (Speth and LeDuc 2007:45) is suggested.

The presence of pottery types sourced to the west of the project area further suggests some cultural linkage with populations within and peripheral to the greater Jornada Mogollon region. Alternatively, no evidence for interaction with populations on the Plains was identified. As noted by Kenmotsu et al. (2008), the role that regional interaction plays in the adaptive strategies carried out in the Jornada

Mogollon region suggests a higher level of importance than previously allotted. It is further suggested that for the Formative period in southeastern New Mexico, the development of cultural interaction is promoted by the seasonal aggregation of populations into a recognized locale, one in which trade and exchange are facilitated. The Boot Hill site, with its sweeping vista, nearby freshwater springs, and diverse resources may have served as one such locality. Access to hunter-gatherer groups, allowing the fortuitous and deliberate alike the opportunity for interaction on a limited basis, was in all likelihood afforded during their occupation at the Boot Hill site.

15.5 Regional Interaction

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TRC's recent testing at the Boot Hill and Laguna Plata sites has resulted in a wide variety of data sets, including AMS dates indicative of periodic site occupations and possible regional abandonment as a result of climatic events. The apparent absence of occupation, either at the site or regional level, may be attributed to a variety of causes. These periods of reduced site usage east of the Pecos River and west of the Caprock raises some interesting questions, especially since the population of the eastern Jornada Mogollon probably reached its maximum during this period. Interestingly, the ceramic and lithic data from both the Boot Hill and Laguna Plata sites do not exhibit any evidence of Plains influence or contact. In contrast, there is evidence in the ceramic assemblages of contact with groups to the southwest and west, with stronger associations to peoples along the Rio Grande in the El Paso area.

The Boot Hill and Laguna Plata sites are in the ecotone between the Llano Estacado to the east and the desert grasslands to the west. Their location near the base of the Caprock places them among the springs and seeps of the Caprock, in addition to the numerous playas throughout the landscape. The following is a model to consider for future research regarding what is sometimes interpreted as seasonal abandonment of the area along the base of the Caprock.

An ethnographic historic account and model from the northern Midwest with possible application to the west face of the Caprock is introduced herein. Although care is required when applying ethnographic models from different cultural and environmental contexts, the following is offered as a scenario for contemplating the west Caprock to desert interface. In the upper Midwest, a close relationship existed between the Sisseton and Wahpeton bands of the Santee Dakota. The Sisseton and Wahpeton occupied the Minnesota River Valley above Shakopee, having major villages at Two Woods Lake (in present-day South Dakota) and at Lac qui Parle, Big Stone Lake, and Lake Traverse (in present-day Minnesota) by the early 1800s (Pond 1908). The Sisseton and Wahpeton, along with other Santee bands, followed a seasonal cycle of subsistence activities. Although they were nomadic hunters much of the year, some Sisseton and Wahpeton groups had permanent villages consisting of bark houses. These villages were occupied during part of the spring and summer when maize was planted or harvested. Subsistence activities during the rest of the year consisted of hunting mammals and waterfowl, fishing, and gathering a variety of berries, roots, and tubers. In the course of these activities, a variety of habitats were exploited—lakes, streams, prairies, and deciduous forests.

Although the bison had moved westward, abandoning most of Minnesota by the mid-1830s, the Sisseton and Wahpeton from the upper Minnesota River area, due to possession of horses, were able to pursue the bison onto the Plains. The majority of the Santee, though, were forced to shift their emphasis from bison to deer meat and hides. The hunting of deer within the prairie-forest border of Minnesota brought the Santee into conflict with the Chippewa.

By the late eighteenth century, the Chippewa occupied the coniferous forest of northern Minnesota and northwestern Wisconsin, and the Santee occupied prairie regions on the Minnesota and upper Mississippi rivers. Due to continuing Dakota-Chippewa hostilities, Hickerson (1962, 1965, 1970) has suggested that the prairie-forest ecotone functioned as a buffer zone between the two groups from about 1780 to 1850. "The buffer zone comprised territory on the frontiers between tribes which, except for communal drives, was normally unoccupied. Such lands could not be entered in safety except by war parties or large hunting parties prepared at a moment's notice for war" (Hickerson 1965:43).

In addition, the character and shape of the buffer zone, extending diagonally (southeast to northwest) from the Chippewa River in west-central Wisconsin to the Red River Valley in western Minnesota, was influenced by the distribution of deer within the prairie-forest border (Hickerson 1965). In general, deer prefer open forests with a great variety of browse, shunning mature coniferous or broad-leaf forests, boggy areas, and grassy areas without tree cover. "In Minnesota the buffer zone coincides generally with the transition zone between biotic provinces and the areas of highest deer populations" (Watrall 1968:83).

Deer were an important element of the subsistence strategies of the Dakota and Chippewa. Maintenance of the buffer zone (i.e., warfare) acted as a deterrent to heavy hunting within the zone by Dakota and Chippewa. As a result, the supply of deer within it remained high, suggesting that the buffer zone was purposefully maintained as a reservoir for deer. "The effect of warfare, then, was the regulation and preservation of a supply of deer in and near the buffer zone for the use of Indians hunting in bands, often at great risk of their lives" (Hickerson 1965:62).

This scenario, proposed by Hickerson (1965) for the Dakota and Chippewa, concerned the maintenance and harvesting of a reliable supply of deer. The Llano Estacado and area from the Caprock to the Pecos River would have been ideal habitat for pronghorn and bison. The area immediately west of the Caprock, with its springs, seeps, and numerous playas, would have provided an oasis for wildlife and vegetation throughout this otherwise arid territory.

Sites similar to Boot Hill that have been tested or excavated in the playa setting include LA 5148 (Laguna Plata), which has late Archaic and early through late Formative residential occupations dating from A.D. 230 to 1260. The site is on the western perimeter of Laguna Plata playa in western Lea County (LCAS 1971). LA 120945 (Laguna Gatuna) is a late Formative site dating from ca. A.D. 900 to 1400. The site is situated on the south side of Laguna Gatuna, about 5 miles southeast of the Laguna Plata site. LA 120945, which is in a comparable environment as Laguna Plata, is about 33 miles east of the Pecos River and 27 miles west of the Caprock (Bullock 2001; Akins 2001). The Garnsey site (LA 18399), a mid- to late fifteenth century bison kill on the eastern edge of the Pecos River Valley, about 12 miles southeast of Roswell in Chaves County, is an example of a specialized bison kill locus. The bison remains were exposed in the walls of the alluvial fill of Garnsey Wash, a broad, shallow wash that drains westward into the Pecos River from a low divide at the Caprock. The local terrain consists of low, rolling plains with extensive dunes and numerous playas (Speth 1983:6–7).

The springs and seeps near the base of the Caprock, in addition to the numerous playas scattered across the landscape, would have created numerous ecotones that may have functioned as little oases. It is postulated that this area was not barren, but rather resource-rich and would have been used on a regular basis by more than one community—possibly by several different nearby communities. The area immediately west of the Caprock would have been ideally suited as a no-man's land, except for those times when certain resources were needed or ready for harvesting, such as pronghorn, or seasonal plants. It is postulated that evidence of horticulture will be found in agricultural fields associated with the playas. Future researchers are encouraged to submit ground stone implements from Formative period occupations for starch residue analysis. Although macrobotanical evidence of cultigens may not be discernible, starch grain residues may be preserved. Ideally, cultigens would have been planted in fields surrounding playas known to retain moisture throughout the growing season. The crops could be planted and left to grow and mature until harvest time. Consequently, nearby sites, like Boot Hill and Laguna Plata, would have archaeological expressions of seasonality (i.e., spring planting, fall harvesting). Therefore, it is recommended further geomorphological and botanical investigations be conducted in playa basins or their immediate perimeters. It is suspected that if playas were targeted for growing cultigens, the placement of the fields in relation to the playa will have a cultural pattern or consistency once it is recognized. As an example, prehistoric sites associated with playas within the Cimarron National Grassland in southwestern Kansas were nearly always associated with the northern or northeastern perimeter of the playa, i.e., downwind of the playa basin. This would be the ideal camp placement for hunting parties waiting for game attracted to a playa micro-environment (e.g., water, forage) (Brown 1979).

It is expected that sites in the Caprock area will be small specialized hunting and gathering camps. Because of their specialized focus and short-term use, with the exception of ceramics and the presence of arrow points, they will likely be easily confused with Archaic occupations. A consideration for the end of the Formative occupation of the region between the Caprock and the Pecos River is the arrival of the Apache (see Culture History).

16.0 Recommendations and Management Concerns

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TRC Environmental, Inc., Albuquerque, New Mexico under contract with the BLM-CFO, conducted the required archaeological and geomorphologic investigations at the Boot Hill site (LA 32229), Eddy County, New Mexico. Under the BLM's Permian Basin Mitigation Program, Task Order 04 was done to provide a more comprehensive interpretative assessment of the Boot Hill site. The archaeological investigations conducted to fulfill these obligations yielded significant information towards addressing regional research issues as they pertain to the Boot Hill site. The results of the present testing project offer insights into managing the cultural resources and future activities at the site. This testing project documented cultural context, inventoried and excavated features, mapped and collected artifact assemblages, and recovered chronometric data from a feature and four levels in Trench 1 in the anthrosol in the main part of the site. This has illuminated several directions to pursue regarding future research.

First is geoarchaeological investigation. The upland portion of the site is primarily situated within Hall's (2002a) Unit 2, and this deposit has witnessed extensive human alteration. The deposits present in the core of the site near Trench 1 have been extensively altered by human activity and are quite correctly classified as anthrosols. The documentation of the organic matter distribution in the cores indicates that although there is some variation in the depth distribution of organic carbon, in most profiles the organic enrichment is present throughout the entire solum (all of Unit 2) and this can only happen with extensive mixing of the deposit, either as part of prehistoric land use, post-depositional disturbance, or a combination of both. The organic enrichment of <400-year-old Unit 3 deposits in the core of the site suggests that post-depositional bioturbation was one of the major factors in this process, and that with more time, the Unit 3 deposits would eventually be incorporated into the anthrosol by non-human agency.

The nature of the anthrogenic soil at the Boot Hill Site, a true *dark earth*, is curious in this landscape. The behavioral and natural processes responsible for its formation and the spatial implications of this deposit merit further investigation. The work here demonstrated the magnitude of the organic carbon enrichment, but barely scratched the surface of understanding this deposit, either as an oddity in this edaphic landscape (in isolation, if you will) or from a more comprehensive perspective that places the formation of this deposit, and others like it, into a broader behavioral context.

The geophysical survey showed this technology has tremendous potential for aiding management of archaeological sites (Kvamme et al. 2006a). Several variables must be considered in order to maximize that potential. Geophysical methods have the advantage of being non-invasive, relatively inexpensive, fast, efficient, and remarkably accurate. However, each of these depends on additional variables such as site type, environmental setting (e.g., soils, geology), surface obstacles (e.g., vegetation, excessive metallic debris), and operator experience. The geophysical survey of the Boot Hill site yielded information that would not have been possible with any other method. Specifically, we now have a better understanding of the spatial distribution of potential features (both horizontal and vertical), which can be used for further interpretations about past cultural activity when compared to data from similar archaeological sites. Approximately 100 anomalies were identified using GPR (n=39) and magnetometer (n=61) technology.

The artifact assemblage provided insight into hunter-gatherer activities and technologies and augmented the chronometric data. Future research should continue to identify and refine the periods of greater site occupation through more exacting radiocarbon testing. In addition to submitting charred seeds and wood charcoal for radiocarbon dating, other methods such as archaeomagnetic, thermoluminescence, optically stimulated luminescence, and infrared stimulated luminescence dating may prove useful.

The ceramic assemblage has potential to yield additional information. Further compositional analysis of ceramics using Neutron Activation Analysis (NAA) will not only enhance the database for the region, but will also provide insight into the economic organization and mobility strategies at the Boot Hill site.

Also of interest is the subsistence data, which has yielded valuable information for future research. The tentative identification *Hordeum pusillum* (little barley) suggests a seasonally focused flora procurement strategy. The absence of cultigens, particularly *Zea mays* (maize), adds to a negative database that can be better evaluated on a regional level. Identifying what resources were exploited through time and how these resources were processed will provide an important factor in considering future research. It is suggested that ground stone implements be subjected to starch grain analysis to ascertain the presence of cultigens. Recent investigations by TRC at nearby sites have had excellent results in extracting maize starch residue from ground stone when no other macrobotanical evidence of maize was recovered from the sites (Brown and Brown 2011).

The testing strategy was purposefully limited in extent to help establish a framework for future research and to demonstrate the utility of key analytical methods. TRC believes the testing, geophysical survey, and geoarchaeological investigations fulfilled the goals of this project. Future research at the Boot Hill site in particular, and within the Permian Basin in general, can move beyond documentation, towards developing a detailed and refined regional synthesis of prehistoric and early historic occupations.

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Appendix A: Radiocarbon Assay Data

The University of Georgia

Center for Applied Isotope Studies

RADIOCARBON ANALYSIS REPORT

October 27, 2010

Adriana Y.Romero
TRC Environmental
5400 Suncrest Drive, Suite D-1
El Paso, TX 79912

Dear Mrs. Romero

Enclosed please find the results of ^{14}C Radiocarbon analyses and Stable Isotope Ratio $\delta^{13}C$ and analyses for the samples received by our laboratory on October 7, 2010.

UGAMS #	Site #	Sample #	Material	$\delta^{13}C$,‰	pMC	±	^{14}C age, years BP	±
7608	LA32229	86	charcoal	-24.1	83.58	0.24	1440	25
7609	LA32229	1	sediment	-17.6	85.56	0.25	1250	25
7610	LA32229	2	sediment	-15.7	77.64	0.23	2030	25
7611	LA32229	3	sediment	-21.0	33.42	0.12	8800	30

The charcoal sample was treated with 5% HCl at the temperature 80°C for 1 hour, then it was washed and with deionized water on the fiberglass filter and rinsed with diluted NaOH to remove possible contamination by humic acids. After that the sample was treated with diluted HCL again, washed with deionized water and dried at 60°C.
The sediment sample was treated with 1N HCl to remove any carbonates, after that the samples was filtered on fiberglass filter, washed with deionized water and dried at 105°C.
For accelerator mass spectrometry analysis the cleaned sample was combusted at 900°C in evacuated / sealed ampoules in the presence of CuO.
The resulting carbon dioxide was cryogenically purified from the other reaction products and catalytically converted to graphite using the method of Vogel *et al*. (1984) Nuclear Instruments and Methods in Physics Research B5, 289-293. Graphite $^{14}C/^{13}C$ ratios were measured using the CAIS 0.5 MeV accelerator mass spectrometer. The sample ratios were compared to the ratio measured from the Oxalic Acid I (NBS SRM 4990). The sample $^{13}C/^{12}C$ ratios were measured separately using a stable isotope ratio mass spectrometer and expressed as $\delta^{13}C$ with respect to PDB, with an error of less than 0.1‰. The quoted uncalibrated dates have been given in radiocarbon years before 1950 (years BP), using the ^{14}C half-life of 5568 years. The error is quoted as one standard deviation and reflects both statistical and experimental errors. The date has been corrected for isotope fractionation.

Sincerely,

Dr.Alexander Cherkinsky

Appendix B: Macrobotanical and Pollen Analyses

**Pollen and Macro-botanical Identification of Samples from LA 32229,
Eddy County, New Mexico**

Report Submitted To:
Ken Brown
TRC Solutions
221 Balloon Park Rd NE #A
Albuquerque, NM 87109-5809

Report Submitted By:
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Quaternary Services Technical Report Series
Report Number 2011-01
January 2011

Introduction

A total of 3 soil samples for pollen extraction and analysis and 4 samples for flotation analysis were sent to Quaternary Services. These samples were collected in conjunction with a Testing Project in Eddy County, New Mexico conducted by TRC Environmental. The site is located at an elevation of 4086'AMSL near an intermittent stream in the Loco Hills, in Eddy County, New Mexico. The site is from an unknown Prehistoric Cultural affiliation and age. The modern Vegetation of the site area contains *Prosopis* spp., *Larrea tridentata* (Creosote Bush), and various grasses.

METHODS AND MATERIALS

Palynological Extraction

Chemical extraction of pollen samples was conducted at the Palynology Laboratory at Texas A&M University, using a procedure designed for semi-arid Southwestern sediments. The method, detailed below, specifically avoids use of such reagents as nitric acid and bleach, which have been demonstrated experimentally to be destructive to pollen grains (Holloway 1981).

From each pollen sample submitted, 25 grams (g) of soil were sub-sampled. Prior to chemical extraction, two tablets of concentrated *Lycopodium* spores (18,583 ± 500 marker grains per tablet) were added to each sub-sample. The addition of marker grains permits calculation of pollen concentration values and provides an indicator for accidental destruction of pollen during the laboratory procedure.

The samples were treated with 3 percent Hydrochloric Acid (HCl) overnight to remove carbonates and to release the *Lycopodium* spores from their matrix. After neutralizing the acid with distilled water, the samples were allowed to settle for a period of at least three hours before the supernatant liquid was carefully poured off and discarded. Additional distilled water was added to the supernatant, and the mixture was swirled and then allowed to settle for 10 seconds. The liquid was then carefully poured off and saved in a second beaker. This procedure was repeated a total of three times to ensure that all pollen would be freed from the matrix that remained in the original beaker. The sand and small rocks remaining in the beaker were then discarded. If any clay particles remained in the matrix, the matrix material was placed into a 50 ml centrifuge tube, a solution of Darvan (a detergent) was added and the tube was sonicated in a Delta D-9 Sonicator for no longer than 15 seconds because occasionally, longer sonication can damage some of the most fragile pollen grains. After sonication, the contents of the centrifuge tube were placed in a beaker and the decanting process was repeated three times. We have found that a short sonication will disperse small clods of clay, thus releasing any potential pollen into suspension. All of the saved, suspended fine fraction was decanted through a screen with openings of 150µ. All material passing through the screen was concentrated using centrifugation mesh screen into a second beaker. This procedure, repeated at least three times, removed lighter materials, including pollen grains, from the heavier fractions.

The fine fraction was treated with concentrated (48%) Hydrofluoric Acid (HF) overnight to remove silicates. After completely neutralizing the acid with distilled water, the samples were treated with a concentrated wash of HCl. This procedure removed any potential fluorosilicates that often form during the HF process. The HCl wash was repeated several times until the solution remained clear after centrifugation. The samples were then washed twice in distilled water.

The samples were dehydrated in glacial acetic acid in preparation for acetolysis. Acetolysis solution (acetic anhydride: concentrated sulfuric acid in 9:1 ratio) following Erdtman (1960), was added to each sample. Centrifuge tubes containing the solution were heated in a heating block at 180^{o} F for approximately 8 minutes, then cooled for an additional 8 minutes before centrifugation. Each sample was then washed and removal of the acetolysis solution with glacial acetic acid followed by two washes with distilled water. Centrifugation at 2,000 RPM for 90 seconds dramatically reduced the size of the sample, yet from periodic examination of the residue, did not remove fossil palynomorphs. The samples were dehydrated in glacial acetic acid in preparation for acetolyis. Acetolysis solution (acetic anhydride: concentrated sulfuric acid in 9:1 ratio) following Erdtman (1960), was added to each sample. Centrifuge tubes containing the solution were heated in a boiling water bath for approximately 8 minutes and cooled for an additional 8 minutes before centrifugation and removal of the acetolysis solution with glacial acetic acid followed by distilled water. Centrifugation at 2,000 RPM for 90 seconds dramatically reduced the size of the sample, yet from periodic examination of the residue, did not remove fossil palynomorphs.

Heavy density separation ensued using zinc bromide ($ZnBr_2$), with a specific gravity of 2.00, to remove much of the remaining detritus from the sample pollen. After 10 minutes of centrifugation at 2,000 RPMs, the light fraction was removed and diluted with 95% ETOH in a ratio of distilled water (10:1) and then concentrated by centrifugation. The samples were then washed repeatedly in distilled water until neutral. The residues were then rinsed in a 5% solution of potassium hydroxide (KOH) for less than one minute, which is effective in removing the majority of the unwanted alkaline soluble humates. This was followed by a wash with concentrated HCl, which is essential to remove the remaining dissolved materials that are not water-soluble. Next, the samples were washed with distilled water. That process was repeated until the solution was clear.

Although all of the previous procedures will effectively remove most of the unwanted matrix materials, none of these actions seem to have much effect on charcoal, which is inert. Unfortunately, we have yet to discover any procedure that will effectively remove charcoal from pollen samples without harming either the fossil pollen or removing some of it as well.

The residues were rinsed in Ethanol (ETOH) stained with safranin-O, rinsed twice with ETOH, and transferred to 1-dram vials with ETOH. The samples were mixed with a small quantity of glycerine and allowed to stand overnight for evaporation of the remaining ETOH. The storage vials were capped and were returned to TRC Environmental Inc. at the completion of the project.

A drop of the polliniferous residue was mounted on a microscope slide for examination under an 18 X 18 mm cover slip sealed with fingernail polish. The slide was examined using 200X or 100X magnification under an aus-Jena Laboval 4 compound microscope. Occasionally, pollen grains were examined using either 400X or 1,000X oil immersion to obtain a positive identification to either the family or genus level.

Abbreviated microscopy was performed on each sample in which either 20 percent of the slide (approximately four transects at 200X magnification) or a minimum of 50 marker grains were counted. If warranted, full counts were conducted by counting to a minimum of 200 fossil grains. Regardless of which method was used, the uncounted portion of each slide was completely scanned at a magnification of 100X for larger grains of cultivated plants such as *Zea mays* and *Cucurbita,* two types of Cactus (Platyopuntia and Cylindropuntia), and other large pollen types such as members of the Malvaceae, or Nyctaginaceae families.

For those samples warranting full microscopy, a minimum of 200 pollen grains per sample were counted as suggested by Barkley (1934), which allows the analyst to inventory the most common taxa present in the sample. All transects were counted completely (Brookes and Thomas 1967), resulting in various numbers of grains counted beyond 200. Pollen taxa encountered on the uncounted portion of the slide during the low magnification scan are tabulated separately.

Total pollen concentration values were computed for all taxa. In addition, the percentage of Indeterminate pollen was also computed. Statistically, pollen concentration values provide a more reliable estimate of species composition within the assemblage. Traditionally, results have been presented by relative frequencies (percentages) where the abundance of each taxon is expressed in relation to the total pollen sum (200+ grains) per sample. With this method, rare pollen types tend to constitute less than 1 percent of the total assemblage. Pollen concentration values provide a more precise measurement of the abundance of even these rare types. The pollen data are reported here as pollen concentration values using the following formula:

$$\mathbf{PC = \frac{K * \sum_p}{\sum_L * S}}$$

Where: PC = Pollen Concentration

K = *Lycopodium* spores added

$\sum_p$ = Fossil pollen counted

$\sum_L$ = *Lycopodium* spores counted

S = Sediment weight

The following example should clarify this approach. Taxon X may be represented by a total of 10 grains (1 percent) in a sample consisting of 1,000 grains, and by 100 grains (1 percent) in a second sample consisting of 10,000 grains. Taxon X is 1 percent of each sample, but the difference in actual occurrence of the taxon is obscured when pollen frequencies are used. The use of "pollen concentration values" are preferred because it accentuates the variability between samples in the occurrence of the taxon. The variability, therefore, is more readily interpretable when comparing cultural activity to noncultural distribution of the pollen rain.

Variability in pollen concentration values can also be attributed to deterioration of the grains through natural processes. In his study of sediment samples collected from a rockshelter, Hall (1981) developed the "1000 grains/g" rule to assess the degree of pollen destruction. This approach has been used by many palynologists working in other contexts as a guide to determine the degree of preservation of a pollen assemblage and, ultimately, to aid in the selection of samples to be examined in greater detail. According to Hall (1981), a pollen concentration value below 1000 grains/gm indicates that forces of degradation may have severely altered the original assemblage. However, a pollen concentration value of fewer than 1000 grains/g can indicate the restriction of the natural pollen rain. Samples from pit structures or floors within enclosed rooms, for example, often yield pollen concentration values below 1000 grains/g.

Pollen degradation also modifies the pollen assemblage because pollen grains of different taxa degrade at variable rates (Holloway 1981, 1989; Holloway and Bryant 1983). Some taxa are more resistant to deterioration than others and remain in assemblages after other types have deteriorated completely. Many commonly occurring taxa degrade beyond recognition in only a short time. For example, most (ca. 70 percent) Angiosperm pollen has either tricolpate (three furrows) or tricolporate (three furrows each with pores) morphology. Because surfaces erode rather easily, once deteriorated, these grains tend to resemble each other and are not readily distinguishable. Other pollen types (e.g. Cheno-am) are so distinctive that they remain identifiable even when almost completely degraded.

Pollen grains were identified to the lowest taxonomic level whenever possible. The majority of these identifications conformed to existing levels of taxonomy with a few exceptions. For example, Cheno-am is an artificial, pollen morphological category which includes pollen of the family Chenopodiaceae (goosefoot) and the genus *Amaranthus* (pigweed) which are indistinguishable from each other (Martin 1963). All members are wind pollinated (anemophilous) and produce very large quantities of pollen. In many sediment samples from the American Southwest, this taxon often dominates the assemblage.

Pollen of the Asteraceae (Sunflower) family was divided into four groups. The high spine and low spine groups were identified on the basis of spine length. High spine Asteraceae contains those grains with spine length greater than or equal to 2.5µ while the low spine group have spines less than 2.5µ in length (Bryant 1969; Martin 1963). *Artemisia* pollen is identifiable to the genus level because of its unique morphology of a double tectum in the mesocopial (between furrows) region of the pollen grain. Pollen grains of the Liguliflorae are also distinguished by their fenestrate morphology. Grains of this type are restricted to the tribe Cichoreae ,which includes such genera as *Taraxacum* (dandelion) and *Lactuca* (lettuce).

Pollen of the Poaceae (Grass) family are generally indistinguishable below the family level, with the single exception of *Zea mays*, identifiable by its large size (ca 80ɥ), relatively large pore annulus, and the internal morphology of the exine. All members of the family contain a single pore, are spherical, and have simple wall architecture. Identification of non-corn pollen is dependent on the presence of the single pore. Only complete or fragmented grains containing this pore were tabulated as members of the Poaceae.

Clumps of four or more pollen grains (anther fragments) were tabulated as single grains to avoid skewing the counts. Clumps of pollen grains (anther fragments) from archaeological contexts are interpreted as evidence for the presence of flowers at the sampling locale (Bohrer 1981). This enables the analyst to infer possible human behavior.

Finally, pollen grains in the final stages of disintegration but retaining identifiable features, such as furrows, pores, complex wall architecture, or a combination of these attributes, were assigned to the Indeterminate category. The potential exists to miss counting pollen grains without identifiable characteristics. For example, a grain that is so severely deteriorated that no distinguishing features exist, closely resembles many spores. Pollen grains and spores are similar both in size and are composed of the same material (Sporopollenin). So that spores are not counted as deteriorated pollen, only those grains containing identifiable pollen characteristics are assigned to the Indeterminate category. Thus, the Indeterminate category contains a minimum estimate of degradation for any assemblage. If the percentage of Indeterminate pollen is between 10 and 20 percent, relatively poor preservation of the assemblage is indicated, whereas Indeterminate pollen in excess of 20 percent indicates severe deterioration to the assemblage.

In those samples where the total pollen concentration values are approximately at or below 1000 grains/g, and the percentage of Indeterminate pollen is 20 percent or greater, counting was terminated at the completion of the abbreviated microscopy phase. In some cases, the assemblage was so deteriorated that only a small number of taxa remained. Statistically, the concentration values may have exceeded 1000 grains/gm. If the species diversity was low (generally these samples contained only pine, Cheno-am, members of the Asteraceae (Sunflower) family and Indeterminate category, counting was also terminated after abbreviated microscopy even if the pollen concentration values slightly exceeded 1000 grains/g.

Floatation Methodology

The samples were subjected to physical flotation by personnel of TRC Environmental Inc., El Paso, TX, according to their methodology. The light fraction was collected and dried separately. After drying completely, the material was placed in labeled zip-loc bags prior to analysis. The heavy fraction was also collected, air dried, and placed in labeled zip-loc bags.

The contents of the light fraction were measured (volume) and then examined using a Meiji stereoscopic zoom microscope (7X-45X magnification). Wood charcoal specimens were examined using a modification of the snap method of Leney and Casteel (1975) in order to expose fresh transverse surfaces. These are necessary since often soil particles fill the vessel elements of the wood charcoal, obscuring the characteristics necessary for identification. Identifications of wood charcoal and seed materials were based on published reference materials (Martin and Barkley 1961, Montgomery 1977, Panshin and Dezeeuw 1980, Schopmeyer 1974), as well as comparisons with modern reference specimens.

Results and Discussion

The results of the pollen analysis are presented in Table 1 and include both raw counts and the calculated pollen concentration values. Percent frequency tabulations were not requested. The results of the flotation analyses of these samples are presented in Table 2. The individual results are presented below by Area and Feature.

Trench 1

Three pollen samples were submitted from this trench. Sample 1 was taken from a marl deposit and the assemblage contained 490 grains/g total pollen concentration values but was based on a pollen sum of only 19 grains. As might be expected, this assemblage was significantly weathered. *Pinus edulis* type, and *Artemisia* pollen (26 grains/g) were present in trace amounts only and were based on single grain occurrences. Cheno-am pollen (258 grains/g) was very low with high amounts of low spine Asteraceae pollen (181 grains/g). Thus, only the most resistant grains were actually recovered from this assemblage.

Sample 2 was taken from a Pleistocene gleyed clay dposit and contained only 216 grains/g total pollen concentration. A pollen sum of only 5 grains was present from this assemblage. *Pinus edulis* type (130 grains/g) was present in very low amounts from this level. The only other taxon recovered was *Artemisia* (86 grains.g).

Sample 3 contained a statistically valid count of 302 grains and contained a total pollen concentration value of 37,414 grains/g. No identification of this deposit was made although TRC Environmental Inc. indicated that this sample was older than either of the previous samples. Thus, it may represent a paleosol although I would suspect that this would have been identified. Only 15 marker grains (Table 1) were encountered during counting which significantly elevated the pollen concentration values. *Pinus edulis* (10,035 grains/g) and *Pinus ponderosa* type (5079 grains/g) were both present in large amounts, along with a single occurrence of *Juniperus* pollen (124 grains/g). Chemo-am (12,017 grains/g), Poaceae (867 grains/g), low (2602 grains/g) and high spine Asteraceae and *Artemisia* (743 grains/g each) were all very high. Additionally, pollen of Cactaceae, *Sphaeralcea* (124 grains/g each), a larger than normal grass pollen (496 grains/g) and *Ephedra* (3345 grains/g) were also present. This suggests the presence of Piñon-Juniper stand along with interspersed open desert scrub grassland components. The pollen concentration values of this type of plant community were significantly elevated which I suspect is due to compaction of the stratigraphic unit. This unit may have been present for a much longer period of time but the unit was compressed and consolidated by the younger deposits overlying it.

A flotation sample was also recovered from Trench 1 from TU 1.3, taken from Feature 3. This sample (FS 84) contained only *Prosopis* spp. charcoal and smaller charcoal fragments. I suspect that feature 3 may have been a thermal feature although it was not identified. This likely represents locally available fuel wood sources. I suspect that feature 3, may have been much more recent than the pollen samples taken from this same trench. If the pollen samples are labeled in sequence, then the upper 2 samples consisting of marl and the Pleistocene gleyed clay must be closer in age to terminal Pleistocene, and thus are in no way related to the flotation sample of Feature 3, even though taken from the same trench.

Trench 1.6

FS 89 was taken from this trench from level 4. The assemblage contained *Prosopis* spp. charcoal and small charcoal fragments. Snail shells were also present in the assemblage.

Trench 2.5

FS 60 was taken from this trench from level 3. This assemblage contained both *Prosopis* spp. charcoal, charcoal of cf. *Larrea tridentata* (Creosote Bush), and small charcoal fragments. This is consistent with the modern vegetation of the area.

Trench 3

FS 163 was taken from TU 3.5 from this trench. The assemblage contained *Prosopis* spp. Charcoal, small charcoal fragments, and snail shells.

Taken together, the flotation samples are all consistent with the modern vegetation consisting of *Prosopis* spp., *Larrea tridentata* and various grasses. This suggests that fuelwood was obtained locally and that both *Prosopis* spp., and perhaps *Larrea tridentata* charcoal were utilized. These assemblages suggest a much sparser environment.

The macrobotanical data are dominated by the presence of *Prosopis* spp. Charcoal, which seems to be the most common taxon. The sample from Trench 2.5 also contained a charcoal type which compared favorably to that of *Larrea tridentata*. This suggests a much more open and sparse vegetation cover than the Piñon-Juniper association indicated by the pollen samples.

TRC environmental has indicated that the pollen samples from Trench 1 were in stratigraphic sequence with sample 3 at the bottom, underlying the Marl and Pleistocene Gleyed Clay deposits. Thus, this sample should be estimated as Late-glacial in age.

Bryant and Holloway (1985) have summarized many of the pollen records from west Texas and extending into eastern New Mexico from this area. Based on original records by Hafsten (1961), Oldfield and Schoenwetter (1975) the pollen assemblages suggested an area dominated by conifers by at least 15,000 years ago. This was a fairly large area around the southern edge of the Llano Estacado (Bryant and Holloway 1985). The pollen assemblage from LA 32229 was not completely dominated by conifer pollen but the sample did contain very high pollen concentration values.

Thus, this single sample may possibly correlate with the Vigo Park Interval (Oldfield and Schoenwetter 1975) which was characterized by less than 50% arboreal pollen and was considered a brief warming and drying trend during this portion of the West Texas Late-glacial (Bryant and Holloway 1985). The interpretation of this single sample as reflecting a Piñon-Juniper association is more consistent with the interpretations of Martin (1964) and Martin and Mehringer (1965) who interpreted the late-glacial from this area as more widespread conifer parklands (Bryant and Holloway).

Thus, the single sample from the base of Trench 1, would be interpreted as a possible paleosol from this early period and as such, unrelated to the macro-botanical (flotation) samples submitted from site LA 32229. This makes the most sense in this situation as the pollen and macro-botanical data are suggesting completely different vegetational communities. The local area in the vicinity of site LA 32229 is essentially devoid of arboreal components and certainly no communities that would produce pollen concentration values of 37,000 grains/g. While stands of Piñon-Juniper are present in scattered locations at slightly higher elevations within 20–50 miles or so, more dense stands capable of producing this high pollen concentration values are located much farther west and north.

By interpreting this sample layer as a potential paleosol, the combination of data does fit together. The pollen assemblage was potentially from a Late-glacial conifer parkland or woodland, which would account for the extremely high pollen concentration values. Moreover, the position of this layer is consistent with the overlying Pleistocene deposits of Marl and Gleyed clay, likely deposited at the terminal Pleistocene.

Conclusions

The flotation samples were taken from 4 separate trenches from this site. The assemblages were fairly consistent in being dominated by *Prosopis* spp. charcoal. This argues for the dominance of *Prosopis* spp. as a local fuel source and further suggests a similar plant community at present as that during the Prehistoric occupation. FS 60 (Trench 2.5) contained a second charcoal type, which while not conclusive, did compare favorably with the anatomy of *Larrea tridentata*. If verified, this further supports the acquisition of locally available fuel woods.

The pollen spectra recovered from this site is quite different. The pollen concentration values are quite high and given the high pollen concentration values of *Pinus*, it is thought that this assemblage reflects the presence of a Late-glacial Piñon-Juniper association. It is possible, if not probable, that this sedimentary layer represents the later portion of the Pleistocene Period when this area of eastern New Mexico and far west Texas were dominated by Piñon-Juniper Woodlands (Bryant and Holloway 1985).

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Table 1: Results of Pollen Analysis, LA 32229, Eddy County, New Mexico

Bag #	Area	Type	Period	Age	*Pinus*	*P. pond.*	*P. edulis*	*Juniperus*	Poaceae	Cheno-am	Cheno-am af.
Raw Counts											
samp 1	Locality 1	marl	Unk	Unk	1	0	1	0	0	10	0
samp 2	Locality 1	Gleyed Clay/Pleistocene	Unk	Unk	3	0	3	0	0	0	0
samp 3	Locality 1	N/A	Unk	Unk	122	41	81	1	7	97	0
Concentration Values											
samp 1	Locality 1	marl	Unk	Unk	26	0	26	0	0	258	0
samp 2	Locality 1	Gleyed Clay/Pleistocene	Unk	Unk	130	0	130	0	0	0	0
samp 3	Locality 1	N/A	Unk	Unk	15114	5079	10035	124	867	12017	0

Table 1: Results of Pollen Analysis, LA 32229, Eddy County, New Mexico

Bag #	Aster. hs.	Aster. ls	*Artemisia*	Liguliflorae	Cactaceae	*Ephedra*	Indeterminate	*Sphaeralcea*	lg grass
Raw Counts									
samp 1	0	7	1	0	0	0	0	0	0
samp 2	0	0	2	0	0	0	0	0	0
samp 3	6	21	6	0	1	27	9	1	4
Concentration Values									
samp 1	0	181	26	0	0	0	0	0	0
samp 2	0	0	86	0	0	0	0	0	0
samp 3	743	2602	743	0	124	3345	1115	124	496

Table 1: Results of Pollen Analysis, LA 32229, Eddy County, New Mexico

Bag #	Sum	Total	marker	% Indeterminate	trans	tot trans	mark/slide	*Lycopodium* added	Weight (gms)
Data									
samp 1	19	490	72	0	5	23	331.2	37166	20

Table 1: Results of Pollen Analysis, LA 32229, Eddy County, New Mexico

Bag #	Sum	Total	marker	% Indeterminate	trans	tot trans	mark/slide	*Lycopodium* added	Weight (gms)
samp 2	5	216	43	0	24	24	43	37166	20
samp 3	302	37414	15	2.98	6	24	60	37166	20

Table 1: Results of Pollen Analysis, LA 32229, Eddy County, New Mexico

	Based on Counts and Low Magnification Scan of Slide		
Bag #	**Onagraceae**	**lg grass**	**Max. Potential Concentration**
Raw Counts			
samp 1			
samp 2			
samp 3	1	4	
Concentration Values			
samp 1	0.00	0.00	25.81
samp 2	0.00	0.00	43.22
samp 3	123.89	495.55	123.89

Table 2: Results of Floation, LA 32229, Eddy County New Mexico

Bag #	Unit	Area	Level	Feat.	Period	Age	Vol	Light	%Recovery	Charcoal	Contaminants	Notes
60		Trench 2.5	3		unk.	unk.		150		CF. *Prosopis*; cf. *Larrea*	ucpd,S	40% charred
84	TU 1.3	Trench 1	1	3	unk.	unk.		15		CF; *Prosopis*	ucpd	30% charred
89		Trench 1.6	4		unk.	unk.		175		CF; *Prosopis*	ucpd, S	30% charred
163	TU 3.5	Trench 3	2		unk.	unk.		125		CF; *Prosopis*	ucpd, S	30% charred

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Appendix C: Diatom Analysis

PALEOENVIRONMENTAL ANALYSIS OF DIATOMS AND ASSOCIATED MICROFOSSILS FROM SEDIMENTS ASSOCIATED WITH THE BOOT HILL SITE (LA 32229), EDDY COUNTY, NEW MEXICO

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INTRODUCTION

This report presents the results of a paleoenvironmental analysis of diatoms and associated microfossils in three sediment samples from the Boot Hill site (LA 32229), Eddy County, New Mexico (Table 1). The site is on a small hill just west of the Caprock (Mescalero Ridge). The area is in far southeastern New Mexico.

Diatoms are unicellular, photosynthetic algae distinguished by the possession of a silica cell wall. They can be found living in a wide variety of natural and man-made terrestrial and aquatic habitats, including seeps, wet walls, dry and damp soil, springs, streams, creeks, sloughs, fresh and saline lakes, rivers, ponds, marshes, lagoons, estuaries, bays, and oceans. Most are cosmopolitan, found in many parts of the world under similar environmental conditions, and many species have predictable environmental requirements and pollution tolerances that directly affect diatom species composition.

Diatoms, which can be readily identified to species, are the most taxonomically diverse and well-studied algal group found in streams and lakes. A large and growing body of information exists on the range of ecological tolerance of many common taxa (see Winsborough 2010 for summary). Large diatom data sets from various parts of the world have shown that living diatom communities provide reliable analogs for estimates of past salinity, depth, trophic (nutrient) level, pH, habitat, size and seasonality, and (indirectly) climate. Since diatoms are sensitive to so many physical and chemical parameters, and are often found in large numbers in sedimentary deposits, they are well-suited for use in paleoenvironmental reconstruction.

Aquatic diatoms include free-floating (live suspended in the water column) planktonic species, and benthic species associated with sediment, microbial mats, drifting mats of filamentous algae, and rooted vegetation on the floor of a stream or lake. Motile benthic forms glide through mud, and others are firmly attached to macrophytes or larger algae, rocks, and sand, and attached to molluscs, turtles, and fish. Related to the benthic diatoms, in terms of overlapping habitats, are the aerial diatoms (commonly found living exposed to air) or sediment diatoms that are adapted to damp or dry habitats.

METHODS

Sediment samples were cleaned of organic material and soluble minerals in preparation for microscopic analysis by boiling first in hydrogen peroxide and then in nitric acid. The oxidized, decalcified material was rinsed repeatedly until a pH of about 7 was reached. A few drops of the cleaned material was air-dried onto 22 x 22-mm cover glasses and mounted onto glass slides using NAPHRAX© a synthetic resin with a high index of refraction, developed to aid in resolving the details of diatom cell wall morphology. One slide of each sample was scanned in its entirety at 1500x, and all diatoms, diatom fragments, and associated microorganisms were recorded.

RESULTS AND DISCUSSION

Samples 1 and 2 lacked microfossils. Sample 3, however, contained diatoms as well as an assortment of other microfossils. These are listed in Table 2, along with the counts for each. In Sample 3, there were four diatom taxa that could be identified to species. Two more were incomplete and corroded and could be identified only to genus. Five diatom fragments were recorded but could not be identified further. The four identified diatoms, in order of abundance, include *Hantzschia amphioxys* (Ehrenberg) Grunow, *Luticola mutica* (Kützing) D. G. Mann, *Craticula cuspidata* (Kützing) D. G. Mann, and *Hantzschia virgata* (Roper) Grunow (Table 2). These diatoms are illustrated in Figures 1 through 11. References consulted to obtain the following information are included in the bibliography.
Three of the four species are tolerant of a wide range of organic and inorganic pollution, often being reported from eutrophic water with substantial amounts of inorganic nutrients, such as nitrogen,

phosphorus, silica, and carbon. There is no data about the pollution tolerance of *Hantzschia virgata*. All four are benthic, shallow water or aerial taxa, have prostrate growth forms, are motile, prefer a pH from near circumneutral to slightly or very alkaline, and tolerate elevated concentrations of organically bound nitrogen. *Hantzschia amphioxys* and *Craticula cuspidata* are found typically in fresh-brackish water (less than 500mg/l chloride, less than 0.9% salinity), *Hantzschia virgata* is found in muddy sands of shallow fresh water of high conductivity, saline water, salt works, and brackish and marine water. It lives between the grains of intertidal beach sand and migrates vertically when the tide ebbs. *Luticola mutica* is typical of brackish-fresh water (500-1000mg/l chloride, 1.8-1.9% salinity). *Luticola* is characteristic of continuously high oxygen concentrations, *Hantzschia amphioxys* prefers fairly high oxygen and *Craticula cuspidata* needs only moderate oxygen. *Hantzschia amphioxys* and *Luticola mutica* occur mainly on wet and moist or temporarily dry places, whereas *Craticula cuspidata* is an aquatic mud species, designed to withstand increasingly saline water and periodic drying. The *Surirella* and *Synedra* taxa are both aquatic, benthic, shallow water species but they were broken and corroded fragments and could have been transported from a nearby lake or stream, or even eroded from a fossil lacustrine deposit. *Surirella* is found on muds in shallow water, and *Synedra* attaches to any firm, submerged substrate.

In addition to diatoms, pollen grains, phytoliths, and chrysophyte cysts were in Sample 3. These were recorded along with the diatoms and photomicrographs of representative examples are provided on the plates on the chance that they may contain useful paleoecological information or possible evidence of resource procurement. These include chrysophyte cysts (Figures 12–14), phytoliths (Figures 15–19), and pollen (Figure 20). Pollen and phytoliths were recorded because they can provide evidence of plants used as a food source, as well as those used for other purposes, such as grass or reeds used for baskets, medicinal plants, and plant material used for dyes or pigments (Bullock, 2001). The pollen and phytolith records are by no means meant to be comprehensive, only to provide supplemental information to the palynologist.

Chrysophyte cysts (also called statospores or stomatocysts) are used to track changes in paleosalinity. Cysts are resting stages of members of the algal class Chrysophyceae and the wall of the statospore is siliceous. They are found primarily in freshwater lakes that are low in nutrients and lakes that periodically or seasonally dry out. The cysts allow the algae to survive droughts and other adverse conditions. There were not enough cysts in these samples to imply anything other than that there was water nearby that may have been low in nutrients and dried out.

In conclusion, the diatoms found in this sample suggest that the soil where the sediment samples were collected was often damp, but not submerged for long periods of time. *Hantzschia amphioxys* was unusually abundant, indicating that the conditions were very good for growth, meaning damp mud or soil, in a location with adequate illumination for photosynthesis. If the habitat had been submerged for any significant length of time there would probably have been some evidence of an aquatic component to the diatom assemblage, and fewer aerial diatoms. It is unlikely that the absence of aquatic diatoms is the result of selective preservation due to dissolution or breakage, because *Luticola* is a small, delicate diatom and the specimens found were complete and uncorroded.

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LIST OF ILLUSTRATIONS

Diatoms and representative examples of associated microfossils from LA32229, Sample 3
Scale bar length = 10μ. All photomicrographs are taken at 1000x unless otherwise noted.

Plate 1:
1. *Craticula cuspidata* (Kützing) D.G. Mann, central portion, part of left side missing
2. *Craticula cuspidata* (Kützing) D.G. Mann, same cell, end portion
3. *Craticula cuspidata* (Kützing) D.G. Mann, same cell, entire valve @400x
4. *Hantzschia amphioxys* (Ehrenberg) Grunow
5. *Hantzschia virgata* (Roper) Grunow, part of a complete cell
6. *Hantzschia virgata* (Roper) Grunow, same cell @400x
7. *Hantzschia amphioxys* (Ehrenberg) Grunow
8. *Surirella* sp. fragment

Plate 2:
9. *Luticola mutica* (Kützing) D.G. Mann
10. *Luticola mutica* (Kützing) D.G. Mann
11. *Luticola mutica* (Kützing) D.G. Mann
12. Chrysophyte cyst
13. Chrysophyte cyst
14. Chrysophyte cyst

Plate 3:
15. Cross-shaped phytolith
16. Rondel phytolith
17. Blade phytolith
18. Saddle-shaped phytolith
19. Bilobate phytolith
20. Possible pollen grain @400x

TABLE 2

DIATOMS AND OTHER MICROFOSSILS FOUND IN SEDIMENT SAMPLE # 3

FROM LA 32229, EDDY COUNTY, NEW MEXICO

Fossil Type	Name or description	Number Found
Diatom	*Hantzschia amphioxys* (Ehrenberg) Grunow	245
Diatom	*Hantzschia virgata* (Roper) Grunow	1
Diatom	*Luticola mutica* (Kützing) D.G. Mann	24
Diatom	*Craticula cuspidata* (Kützing) D.G. Mann	2
Diatom	*Surirella* sp.	1
Diatom	*Synedra* sp.	1
Diatom	Unidentified diatom fragments	5
Pollen	Unidentified pollen grains	2
Algae	Chrysophyte spores	9
Phytolith	Cross-bodied and bilobate	6
Phytolith	Blade-shaped	12
Phytolith	Saddle-shaped	31
Phytolith	Miscellaneous unidentified	65

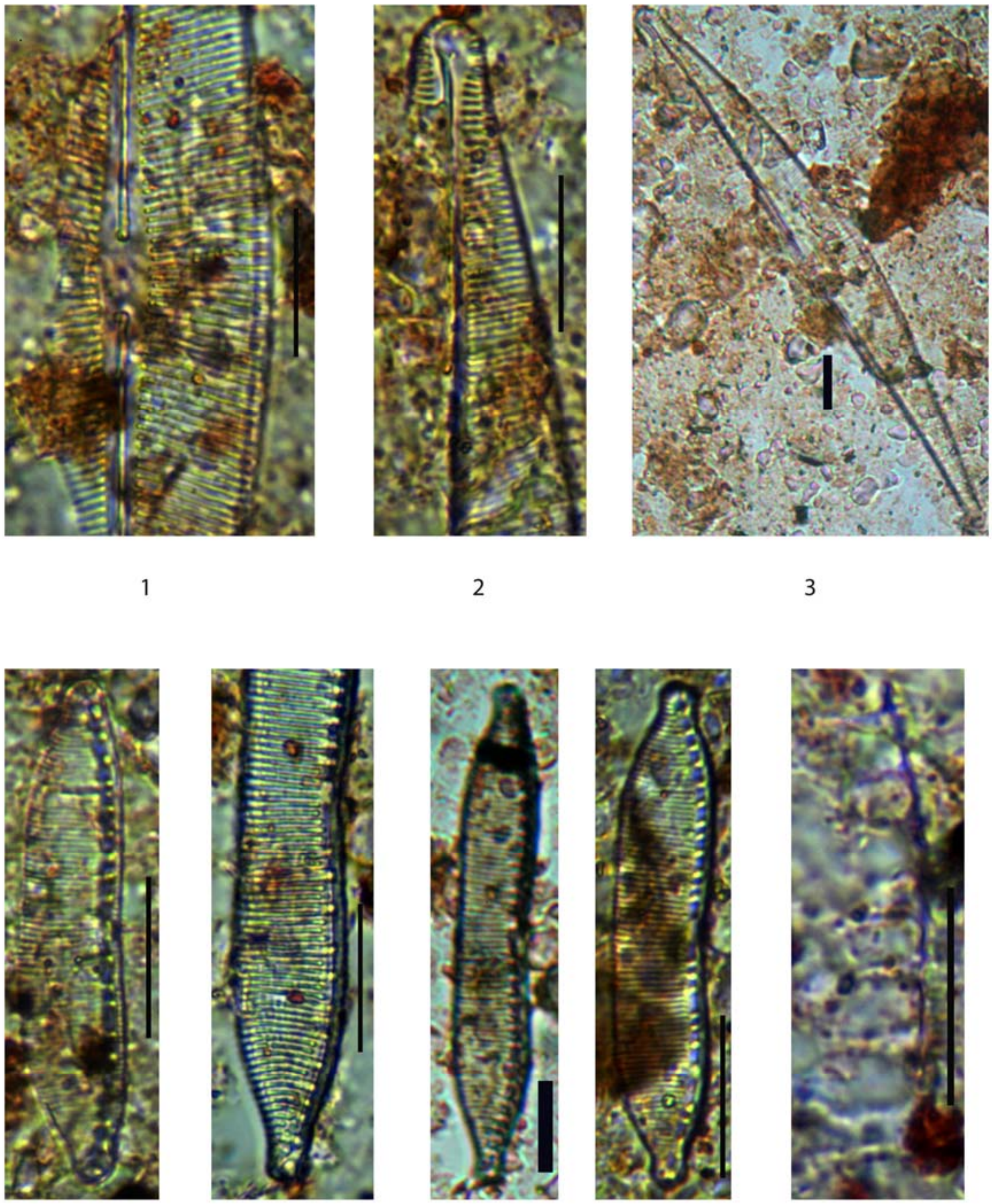
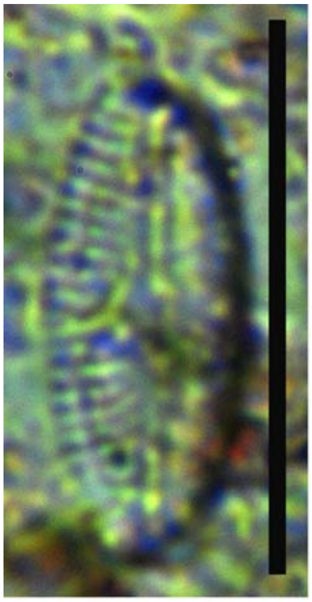


Plate 1



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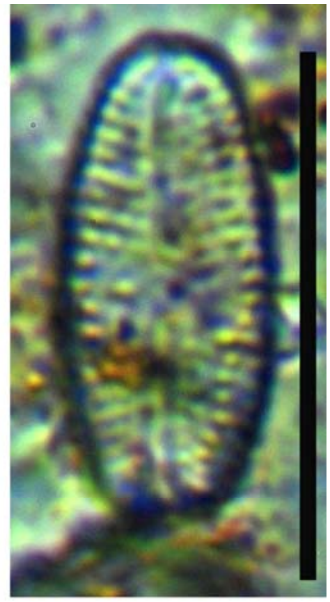

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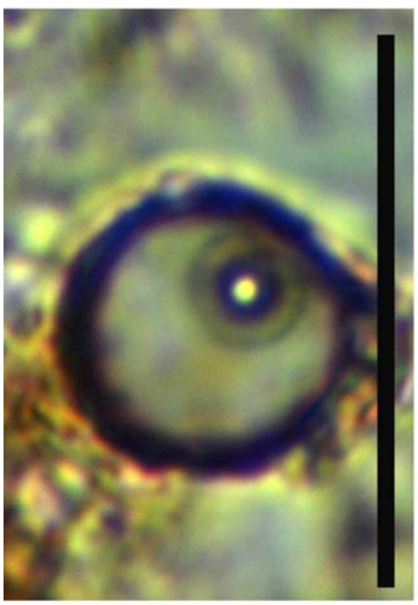

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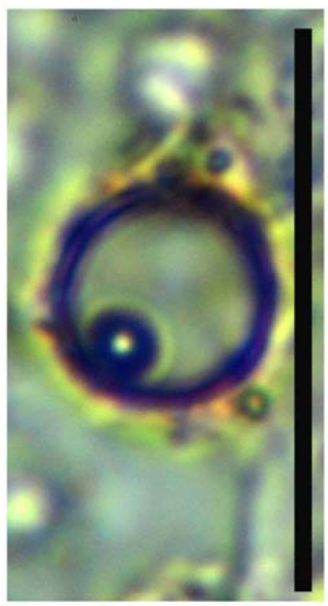

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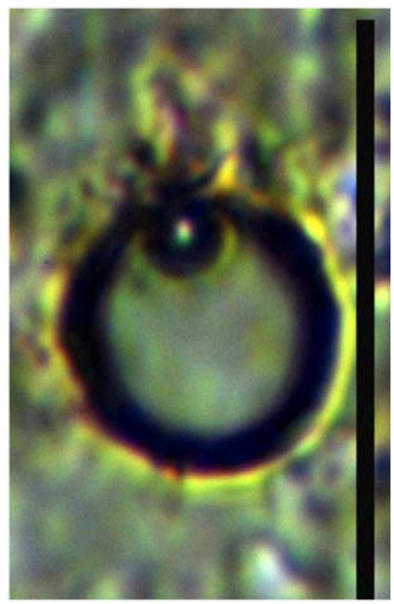

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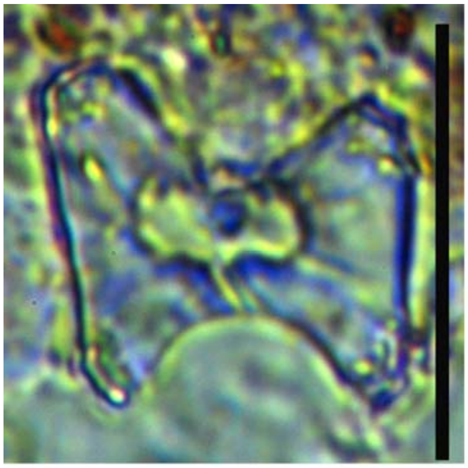
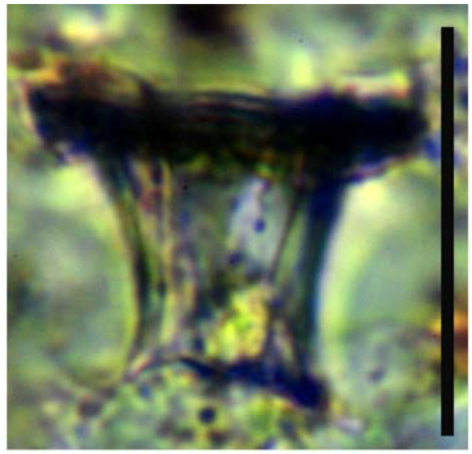
Plate 2



15



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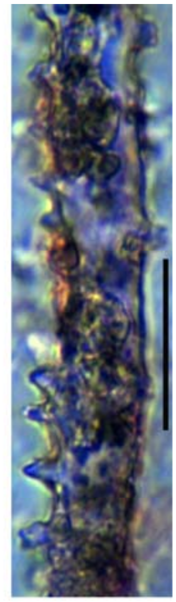

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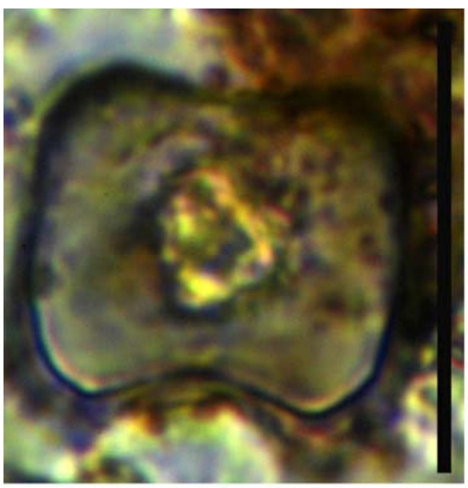
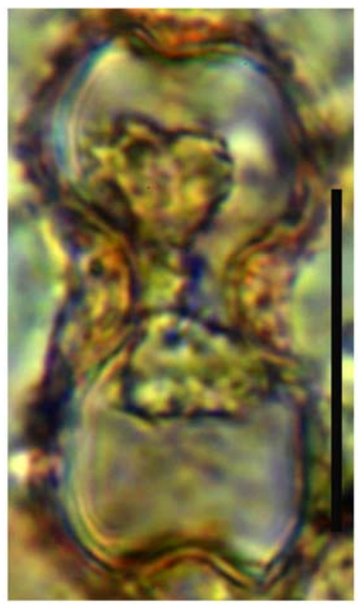


18



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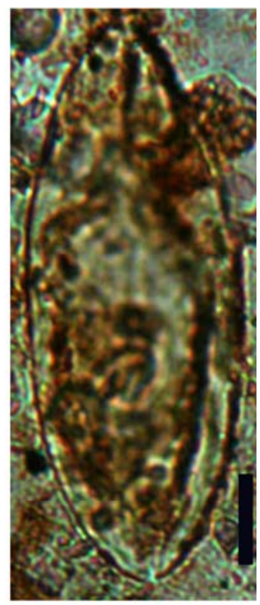

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Plate 3

Appendix D: Stable Isotope Analysis

Colorado Plateau Stable Isotope Laboratory
-- Results for Peter Condon, TRC Environmental --
CPSIL report# FY11-088 (27 soils)

Sample	Date	Position	Mass	CO2 Ampl	N2 Ampl	CO2 Area	N2 Area	$\delta^{13}C$	$\delta^{15}N$	%C	%N	C/N	Comments
			(mg)	(volts)	(volts)	(V/s)	(V/s)	(‰)	(‰)				
Sample 1	3-Jan-11	36	59.343	9.43	2.22	274.70	49.67	-20.23	7.91	3.16	0.15	21.67	
Sample 2	3-Jan-11	40	59.395	9.22	2.11	253.61	44.07	-20.22	8.39	2.91	0.13	22.55	
Sample 2	3-Jan-11	41	60.553	9.15	2.10	250.57	43.99	-20.24	8.58	2.82	0.13	22.32	
Sample 3	3-Jan-11	42	60.209	11.75	2.87	347.34	59.76	-20.16	8.36	3.93	0.17	22.78	
Sample 4	3-Jan-11	43	59.242	7.80	1.67	205.02	35.24	-20.10	8.14	2.36	0.10	22.80	
Sample 5	3-Jan-11	44	59.803	8.95	2.08	243.78	43.79	-19.91	8.05	2.78	0.13	21.82	
BH1-1	3-Jan-11	45	75.586	1.84	0.65	43.10	14.70	-21.99	5.94	0.39	0.03	11.49	
BH1-10	3-Jan-11	46	75.212	2.61	0.90	62.32	20.26	-18.26	8.07	0.56	0.05	12.05	
BH1-9	3-Jan-11	47	74.253	2.19	0.75	51.81	16.97	-18.23	7.63	0.48	0.04	11.97	
BH1-5	3-Jan-11	48	75.755	3.56	1.16	86.59	26.16	-19.08	7.61	0.78	0.06	12.97	
BH1-7	3-Jan-11	49	75.118	3.30	1.09	80.00	24.77	-18.91	6.76	0.73	0.06	12.65	
BH1-11	3-Jan-11	50	75.187	2.43	0.89	57.76	19.97	-18.23	7.61	0.52	0.05	11.34	
BH1-6	3-Jan-11	52	75.466	2.77	0.92	65.53	20.60	-18.81	8.29	0.59	0.05	12.47	
BH1-6	3-Jan-11	53	75.479	2.80	0.93	66.26	20.68	-18.76	7.57	0.60	0.05	12.55	
BH1-4	3-Jan-11	54	75.386	3.12	1.01	75.25	22.81	-19.18	7.03	0.68	0.05	12.93	
BH1-8	3-Jan-11	55	74.379	2.61	0.88	62.08	19.83	-18.49	7.12	0.57	0.05	12.27	
BH1-2	3-Jan-11	56	74.557	3.01	1.05	72.10	23.45	-19.40	6.99	0.66	0.05	12.05	
BH1-3	3-Jan-11	57	75.807	3.51	1.21	84.72	26.88	-19.25	6.88	0.76	0.06	12.35	
BHC6-8	3-Jan-11	58	75.210	4.77	1.11	117.35	24.25	-19.92	7.87	1.06	0.06	18.96	
BHC6-2	3-Jan-11	59	66.107	4.08	0.90	98.13	19.45	-20.94	8.12	1.01	0.05	19.77	
BHC6-6	3-Jan-11	60	74.109	7.69	1.85	210.60	41.27	-19.64	7.86	1.94	0.10	20.00	
BHC6-4	3-Jan-11	61	75.280	5.16	1.18	128.06	25.72	-20.06	7.50	1.16	0.06	19.51	
BHC6-5	3-Jan-11	62	75.310	5.80	1.39	146.01	30.23	-19.90	8.35	1.32	0.07	18.93	
BHC6-10	3-Jan-11	64	75.095	4.29	1.23	104.68	26.84	-19.24	9.63	0.95	0.06	15.28	
BHC6-10	3-Jan-11	65	75.187	4.70	1.34	116.07	29.40	-19.20	8.23	1.05	0.07	15.47	
BHC6-3	3-Jan-11	66	74.034	5.43	1.26	135.37	27.14	-20.36	9.44	1.25	0.06	19.55	
BHC6-7	3-Jan-11	67	74.682	4.72	1.18	114.88	25.47	-19.70	7.01	1.05	0.06	17.67	
BHC6-11	3-Jan-11	68	74.796	2.05	0.68	47.78	14.98	-19.69	8.61	0.44	0.03	12.50	
BHC6-1	3-Jan-11	69	74.285	5.71	1.39	143.25	29.91	-20.75	9.46	1.31	0.07	18.77	
BHC6-9	3-Jan-11	70	75.226	7.26	1.70	193.40	37.30	-20.78	8.24	1.75	0.09	20.32	
			min	**1.84**	**0.65**	**43.10**	**14.70**	**-21.99**	**5.94**	**0.39**	**0.03**	**11.34**	
			max	**11.75**	**2.87**	**347.34**	**59.76**	**-18.23**	**9.63**	**3.93**	**0.17**	**22.80**	
Drift and linearity standards													
NIST peach leaves	3-Jan-11	3	1.946	5.44	1.47	137.48	32.44	-26.07	2.24	46.07	2.89	15.95	
NIST peach leaves	3-Jan-11	13	1.985	5.61	1.51	141.29	32.95	-25.98	2.00	46.27	2.87	16.10	
NIST peach leaves	3-Jan-11	25	2.011	5.69	1.51	143.59	33.37	-25.96	2.11	46.35	2.87	16.13	
NIST peach leaves	3-Jan-11	37	2.036	5.83	1.55	147.80	34.22	-25.89	2.19	47.04	2.91	16.18	
NIST peach leaves	3-Jan-11	39	1.961	5.57	1.51	138.27	32.37	-26.27	2.26	45.86	2.86	16.04	
NIST peach leaves	3-Jan-11	51	1.961	5.63	1.51	139.83	32.52	-26.02	1.86	46.35	2.87	16.14	
NIST peach leaves	3-Jan-11	63	1.999	5.81	1.54	144.31	33.25	-25.96	1.95	46.79	2.88	16.25	
NIST peach leaves	3-Jan-11	72	5.994	14.86	5.31	472.59	104.23	-26.12	2.26	46.66	2.89	16.15	
NIST peach leaves	3-Jan-11	73	4.995	12.84	4.28	387.97	86.13	-26.01	1.76	46.32	2.89	16.01	
NIST peach leaves	3-Jan-11	74	4.000	10.75	3.37	304.83	68.26	-26.02	1.83	46.14	2.89	15.96	
NIST peach leaves	3-Jan-11	75	2.995	8.45	2.50	223.59	51.45	-26.07	1.92	46.40	2.94	15.79	
NIST peach leaves	3-Jan-11	76	1.991	5.83	1.58	143.35	33.48	-26.14	2.13	46.64	2.91	16.03	
NIST peach leaves	3-Jan-11	77	1.500	4.44	1.17	105.41	25.19	-26.25	2.01	46.78	2.92	16.02	
NIST peach leaves	3-Jan-11	78	0.998	2.97	0.77	68.18	16.57	-26.22	2.19	47.01	2.90	16.20	
NIST peach leaves	3-Jan-11	79	0.499	1.44	0.37	31.97	8.24	-26.01	1.72	45.94	2.90	15.83	
			min	**1.44**	**0.37**		**avg**	**-26.07**	**2.03**	**46.44**	**2.89**	**16.05**	
			max	**14.86**	**5.31**		**sd**	**0.11**	**0.19**	**0.37**	**0.02**	**0.13**	

Colorado Plateau Stable Isotope Laboratory
-- Results for Peter Condon, TRC Environmental --
CPSIL report# FY11-088 (27 soils)

Sample	Date	Position	Mass	CO2 Ampl	N2 Ampl	CO2 Area	N2 Area	$\delta^{13}C$	$\delta^{15}N$	%C	%N	C/N	Comments
			(mg)	(volts)	(volts)	(V/s)	(V/s)	(‰)	(‰)				
Isotope calibration standards													**Expected**
IAEA CH6	3-Jan-11	80	1.243	3.29		76.54		-10.44		42.08			**d13C = -10.45**
IAEA CH7	3-Jan-11	81	0.749	4.06		95.38		-32.18		85.83			**d13C = -32.15**
IAEA N1	3-Jan-11	82	0.315		1.76		38.14		0.34		20.68		**d15N = 0.43**
IAEA N2	3-Jan-11	83	0.320		1.82		39.08		20.65		20.86		**d15N = 20.41**
Elemental calibration standards													
Acetanilide	3-Jan-11	84	0.815	3.71	2.39	85.83	49.75	-33.86	-0.83	71.28	10.42	6.84	**C/N = 71.09/10.36 = 6.86**
BBOT	3-Jan-11	85	0.807	3.73	1.46	86.38	30.42	-26.49	-10.46	72.42	6.47	11.19	**C/N = 72.53/6.51 = 11.14**
Cystine	3-Jan-11	86	0.963	1.79	3.11	39.88	65.43	-16.51	8.66	30.15	11.57	2.60	**C/N = 29.95/11.61 = 2.57**
Methionine	3-Jan-11	87	1.011	2.58	2.65	58.12	55.49	-25.14	-1.27	40.11	9.36	4.28	**C/N = 40.21/9.39 = 4.28**
Sulfanilamide	3-Jan-11	88	0.744	1.95	3.40	43.66	71.41	-28.91	-1.63	41.66	16.35	2.55	**C/N = 41.84/16.27 = 2.57**
Cyclohexanone	3-Jan-11	89	0.616	2.00	3.49	44.51	73.07	-26.97	-3.58	50.81	20.20	2.51	**C/N = 51.79/20.14 = 2.57**
Nicotinamide	3-Jan-11	90	0.594	2.18	3.81	48.86	79.68	-33.06	-1.53	57.36	22.84	2.51	**C/N = 59.01/22.94 = 2.57**
Secondary check standards													
NIST pine needles	3-Jan-11	91	5.952	15.51	2.05	501.30	38.85	-26.16	0.46	50.24	1.14	44.17	
NIST apple leaves	3-Jan-11	92	3.009	8.60	1.84	229.16	38.38	-26.93	0.64	47.32	2.21	21.44	
NIST tomato leaves	3-Jan-11	93	2.945	6.73	2.45	169.05	51.49	-27.02	3.84	35.98	2.99	12.03	
NIST bovine liver	3-Jan-11	94	0.975	3.06	2.77	70.42	58.27	-21.68	7.66	49.55	10.19	4.86	
NIST mussel tissue	3-Jan-11	95	0.999	2.45	2.14	56.04	45.40	-18.54	7.47	39.31	7.77	5.06	
Caffeine - Aldrich	3-Jan-11	96	0.485	1.49	3.95	32.82	83.25	-39.04	-3.38	48.31	29.23	1.65	
Soil standards													
B2150	3-Jan-11	97	12.126	4.72	1.49	114.70	31.65	-20.07	4.78	6.45	0.45	14.20	**C/N = 6.40/0.45 = 14.15**
NIST 2710	3-Jan-11	98	19.623	3.73	1.53	88.96	32.91	-24.98	4.91	3.09	0.29	10.59	**C/N = 3.10/0.29 = 10.57**
NIST 2711	3-Jan-11	99	40.705	4.48	1.47	106.44	31.23	-16.99	7.38	1.78	0.13	13.36	**C/N = 1.77/0.13 = 13.31**
B2152	3-Jan-11	100	60.038	4.63	1.69	111.11	35.76	-26.83	6.73	1.26	0.10	12.18	**C/N = 1.27/0.10 = 12.27**

Appendix E: Starch Grain Analysis

Starch Analysis of Eddy County Site LA 32229
Boot Hill

Prepared by:

Linda Perry
The Foundation for Archaeobotanical Research in Microfossils
PO Box 37
Fairfax VA 22038

Introduction to Starch Grain Analyses

Archaeobotanical investigators are constantly seeking new methods by which previously unobtainable data can be recovered. Among archaeologists who work in regions characterized by the poor preservation of organic remains, the analyses of starch granules have proven particularly useful in accessing the residues of starchy root and tuber crops that have previously been invisible in the archaeological record (Bryant 2003; Coil et al. 2003; Fullagar et al. 1998; Hall et al. 1989; Iriarté et al. 2004; Loy et al. 1992; Pearsall et al. 2004; Perry 2001, 2002a, 2004, 2005, 2007; Perry et al. 2006, 2007; Piperno and Holst 1998; Piperno et al. 2000). These residues have proven to be tenacious survivors in harsh climates, and their preservation on the surfaces of lithic tools that were used in the processing of starch-bearing plants occurs consistently in archaeobotanical investigations (Iriarté et al. 2004; Pearsall et al. 2004; Perry 2001, 2002a, 2004, 2005, 2007; Perry et al. 2006, 2007; Piperno and Holst 1998; Piperno et al. 2000).

Investigations of the starchy remains of plant foods on the surfaces of archaeological lithic tools began with simple analyses using chemical reagents that identified the residues in question as plant-derived storage starch (Bruier 1976) rather than animal tissue. Within the last fifteen years, however, archaeologists have been successfully employing morphological criteria to identify plant taxa. The methods are almost identical to those used in the analysis of phytolith microfossils.

Just as different plants produce characteristically shaped leaves, flowers, and seeds, different genera and species make starch grains that are distinctive to and diagnostic for each taxon. The anatomical features that distinguish the starch of one species of plant from another have been noted by botanists (e.g., Denniston 1904; MacMasters 1964; Reichert 1913), and their methods have been expanded by archaeobotanists who are now able even to distinguish wild from domesticated species in some plant families (Iriarté et al. 2004; Pearsall et al. 2004; Perry 2001, 2002a, 2004; Piperno et al. 2000). Basic physical features that are comparable between modern reference specimens and archaeological samples can be viewed using a light microscope and include gross morphological features such as shape and faceting, the location of and appearance of the hilum, and presence and patterning of lamellae (Iriarté et al. 2004; Loy 1994; Pearsall 2004; Perry 2004; Piperno and Holst 1998; Piperno et al. 2000). Fissuring and other internal patterning have also proven to be useful criteria for identification. The successful identification of starch granules relies upon the viewing of each granule in three dimensions to gain an accurate assessment of its morphological features.

Because starch granules differ morphologically between plants, their distinctive characteristics can often allow identification to the level of genus or species in archaeological samples (e.g., Iriarté et al. 2004; Pearsall et al. 2004; Perry 2001, 2002a, 2004, 2005, 2006, 2007a, 2007b; Piperno and Holst 1998; Piperno et al. 2000). The method has proven particularly useful in identifying the remains of plant tissues that would not usually be preserved as macroremains, such as the remnants of root and tuber crops (Bryant 2003; Coil et al. 2003; Fullagar et al. 1998; Hall et al. 1989; Iriarté et al. 2004; Loy et al. 1992; Pearsall et al. 2004; Perry 2001, 2002a, 2004, 2005; Piperno and Holst 1998; Piperno et al. 2000). This role of starch analysis as a tool for revealing the significance of plant foods in the archaeobotanical record also adds to our understanding of the pre-contact significance of starchy seed crops like maize (*Zea mays*).

In a citation of preliminary results from an ongoing study, the archaeological remains of maize starch have been extracted from 2000 year-old obsidian artifacts from the Honduran site of Copán (Haslam 2003, 2004). The starchy residues of maize were also successfully recovered and identified from a migmatite milling stone from Cueva de los Corrales 1 in Argentina (Babot and Apella 2003). In this case, the grinding stone was found to have multiple purposes, including the grinding of burnt bone, presumable for a non-food purpose. Starch analyses of groundstone artifacts from Real Alto have supported previously published phytolith studies that indicate the great antiquity of maize in Ecuador, and its role in subsistence during the Formative period (Pearsall et al. 2004). Seventeen examined artifacts from Real Alto yielded concentrations of maize starch granules ranging from one to more than ten granules per sampled tool. Other Neotropical studies have resulted in the recovery of more complex assemblages of starches.

Archaeologists have recovered starch granules from maize, beans (*Phaseolus* sp.), and *Canna* from the Los Ajos mound complex in Uruguay (Iriarté et al. 2004). Maize starch granules were reported from three groundstone tools including one mano and two milling stone bases. Concentrations of maize starches ranged from two to eleven granules on tools from contexts dating from 3600 years before present to about 500 years before present (Iriarté et al. 2004: supplementary information). The starch data were combined with phytolith evidence and, together, these results introduce compelling evidence for the early development of a mixed subsistence economy in this region of South America. In other regions of the Neotropics, starch analysis has been an essential tool in defining similar subsistence patterns that included the exploitation of root and tuberous food plants.

Starch granules of maize, manioc (*Manihot esculenta*), both wild type and domesticated yams (*Dioscorea* spp.), and arrowroot (*Maranta arundinacea*) have been recovered from edge ground cobbles and grinding stone bases collected from the Aguadulce rock shelter as well as the sites of Monagrillo, La Mula, and Cerro Juan Diaz in Panama (Piperno and Holst 1998; Piperno et al. 2000). Edge ground cobbles are characterized by faceting that is hypothesized to have resulted from the processing of root crops against larger grinding stone bases (Ranere 1975), and the analyses of the residual remains of plant tissues supports this hypothesis. However, the use of the milling stones does appear to have been more complex than previously believed. Maize remains were recovered from all twelve artifacts that bore starch (Piperno et al. 2000). The numbers of starch granules of maize per artifact ranged from one to twenty-five per artifact. Two starch granules of arrowroot occurred on a single artifact, manioc starch granules were recovered from three artifacts (one, five, and eight granules), and yam starch granules were found on the surfaces of three of the artifacts (two, three, and sixteen granules) (Piperno et al. 2000). These investigations resulted in the recovery of the oldest evidence for root and tuber crop cultivation in the Neotropics, with radiocarbon dates spanning from 5,000 to 7,000 years before present.

Starch granules of maize, yams, and arrowroot have also been recovered from twelve flake and three groundstone tools collected from Pozo Azul Norte 1 and Los Mangos del Parguaza in Venezuela (Perry 2001, 2002a, 2004, 2005). These sites date from the middle first century AD to contact. As in the above-cited set of studies, maize remains were recovered from every examined artifact and ranged in number from two to fifty-one per artifact. Additionally, four granules of yam starch were recovered from two flake tools, four flake tools yielded four granules of guapo (*Myrosma* sp.) starch, and seven starch granules from arrowroot were collected from five tools, one of which was a groundstone artifact. These findings were significant in that five of the examined artifacts were chosen for study due to their hypothetical function as microlithic grater flakes from a manioc specific grater board. The evidence indicated a more complex function of these tools that did not include the processing of manioc.

More recent investigations have led to the recovery of direct evidence for contact between the highland Peruvian Andes and the lowland tropical forest to the east (Perry et al. 2006). This contact and interaction had been a significant component of Andean theory for decades, but direct evidence had been elusive until starch microfossils of arrowroot were collected from both sediment samples and lithic tools at the mid-elevation site of Waynuna (Perry et al. 2006). Further, the discovery and cataloging of a microfossil will allow for the recovery and understanding of the origins and subsequent dispersals of chili peppers (Perry et al. 2007), plants whose histories are poorly understood due to the lack of preservation of macroremains in the archaeobotanical record. Remains of these plants have been successfully recovered throughout the Americas from ceramic sherds, lithic tools, and sediment samples dating from 6250 BP to European contact.

Understanding the relationship between residues and artifacts

Early work on starch remains from Panamanian sites used stepwise analysis to support the direct association between starchy residues on tools and the tools' use (Piperno et al. 2000). These studies demonstrated that starch grains were not present in sediments adhering to stone tools or on unused parts of the lithics, but they did occur in the cracks and crevices of the tools on used surfaces, thus indicating that the residues were the result of the tools' use and not environmental contamination. Similar experiments have been undertaken independently by other researchers, and the results were equivalent.

In a study of obsidian artifacts recovered from an open air site in Papua New Guinea, the frequency of starch granules recovered from stone artifacts was compared to that present in the soil matrix immediate to the tool (Barton et al. 1998). The frequency of starch granules was found to be much higher on used artifacts than in the surrounding soil. Thus, the conclusion was drawn that the tools were not contaminated by environmental starch sources. Further, use-wear analyses were used in combination with the soil and starch analyses to assess the degree of association of starchy residues with the used surfaces of tools (Barton et al. 1998). The researchers found that, indeed, the occurrence of starch granules was highly correlated with obsidian tools that bore use-wear and was not correlated with unused tools.

In a study of starch residues occurring on stone pounding tools from the Jimmium site in north central Australia, the starch forms in soil samples were compared to those extracted from the artifacts (Atchison and Fullagar 1998). It was found that, although starch granules did occur in the soil matrices surrounding the tools, they were of different size and shape than those present on the pounding stones, and, therefore, are probably not from the same plant source. This result was interpreted as evidence that the tools had not been contaminated by soil-borne starches.

Another method for assessing whether or not starch residues are culturally deposited involves the analysis of control samples from non-cultural contexts surrounding a site. If different types of starches, or different concentrations of starches, or no plant residue whatsoever are recovered from the control samples than are recovered from the artifacts undergoing testing, then one can be more secure that the residues are the remains of prehistoric food processing (Brieur 1976).

In addition to the study of association of microfossils with tool use, experimentation with processing methods has also been undertaken. In Argentina, a researcher replicated ancient Andean methods of food processing and found that each different process resulted in diagnostic damage to starch granules in plant tissues including potato tubers (*Solanum tuberosum*) and quinoa seeds (*Chenopodium* spp.) (Babot 2003). Modern plant materials were subjected to freeze-drying, dehydration, roasting, charring, desaponification (a process particular to the preparation of quinoa), and grinding. It was found that fragments of starches that would probably otherwise be identified as unknowns or non-starches are actually damaged starches. Further, with careful analysis, researchers can link damage patterns with processing techniques (Babot 2003). Experimentation with various cooking techniques have resulted in similar conclusions: cooked starches are identifiable as such, and different cooking techniques yield different patterns of damage (Henry et al. 2009).

Archaeobotanists have focused their energies upon honing their methods toward the effective recovery of and identification of residual starch granules to understand plant use and processing. Studies have resulted in an impressive assemblage of various suites of starchy food plants, both wild and domesticated, raw and cooked. At this juncture in time, more studies are being undertaken and starch remains are being successfully recovered. What we now lack are baseline data as to how and why different plant materials may or may not adhere to stone tools. Thus, we are not yet able to understand issues such as intensity of use based upon numbers of recovered grains, or the history of a tool based upon the numbers of species of plants recovered from its surface. Linda Perry has obtained funding and will be performing experiments over the next year in the hopes of gaining an understanding of these issues.

Methods

The methods of starch grain analysis can be distilled down into a few simple tasks. These tasks include removing the archaeological material from the artifact, placing it on a glass slide, and observing the residue using a light microscope. The analysis amounts to a careful cleaning of each artifact and examination of the material that was collected during cleaning. If the cleaning results in a relatively large quantity of sediment, the microfossils must be separated from the matrix so that they can be clearly viewed via microscopy. This step is completed with a heavy liquid flotation. Detailed methods are as follows.

Eight artifacts were chosen for analysis. Included in the sample were a metate fragment, two groundstone tools and five ceramic sherds. All artifacts were collected and bagged separately without washing. Washing is a traditional step in the collection and curation of artifacts, but it will remove some of the residues that are of interest to archaeologists.

The artifacts were sampled using a clean, sonic toothbrush that was applied to the used surfaces of the metate and groundstone artifacts and to the inside surfaces of the ceramic sherds. The wash water was then collected in vessels.

The effluent from the cleaning was allowed to settle overnight, then the settled material was centrifuged for ten minutes at 1000 RPM to pellet out the solids. The solid materials were then subject to a heavy liquid flotation using Cesium chloride (CsCl) at a density of 1.8 g/cm^3 to separate the starch grains from the sediment matrix.

The material collected from the flotation was rinsed and centrifuged three times with reverse-osmosis filtered water to ensure that the CsCl was completely removed from the solution. At this point, the pellet from the final centrifugation was placed on a clean glass slide with a small amount of water/glycerin solution. Slides were scanned with a Zeiss Universal compound microscope for polarized light at 200x, and identifications were made at 400x using standard methods. Digital images were captured at 800x magnification using a Micropublisher 3.3 camera and software.

Results and Discussion

A total of 14 intact starch grains, all of lenticular form, were recovered from the sampled artifacts (Table 1). Damaged starches were common, with morphological changes typical of both heating and grinding occurring (Figure 1). Because the assemblage contained so many damaged starch grains, it is difficult to determine their source with absolute confidence. The morphologies of the intact starches, however, are typical of the Triticeae group, and are consistent with those of little barley (*Hordeum pusillum*). This tentative identification does not preclude the possible presence of other grasses that create similar forms of starch, including wildrye (*Elymus* spp.)

Table 1: Starch remains recovered from the Boot Hill site. Lenticular starches may be derived from little barley. An “X” indicates that a type of processing damage was noted in the assemblage. Heating damage indicates exposure to temperatures typical of cooking, but the type of heating (boiling, parching, etc.) cannot be determined. Boiling damage is consistent with the type of morphological changes that occur when starch grains are heated in an aqueous medium.

Sample	**Artifact**	**Provenience**	**Lenticular starch**	**Grinding damage**	**Heating damage**	**Boiling damage**	**Total**
108	Metate	TU 3.2.2					**0**
36	Gstone	TU 2.3.3	2	X			**2**
54	Gstone	TR 2.4.1	4			X	**4**
9	Ceramic	TR 1.4.1	1			X	**1**
24	Ceramic	TU 1.4 F2	5	X	X		**5**
108	Ceramic	TU 3.2.2			?		**0**
96	Ceramic	TU 1.4.6					**0**
59	Ceramic	TU 2.5.2	2		X		**2**
Total	**8**		**14**	**X**	**X**	**X**	**14**

Groundstone artifacts: Three groundstone artifacts were analyzed.

The metate fragment (#108) yielded no starch remains, but starch was recovered from two other groundstone tools.

Two lenticular grains were recovered from artifact #36, and grinding damage was noted as well. This type of damage indicates the artifact was used for grinding grain.

Artifact #54 yielded four lenticular starches, and damage from boiling was observed in the assemblage. This damage could indicate the use of the tool as a boiling stone, or the processing of previously boiled grain with the artifact.

Ceramic sherds: Five ceramic sherds were analyzed, and three yielded intact starch remains.

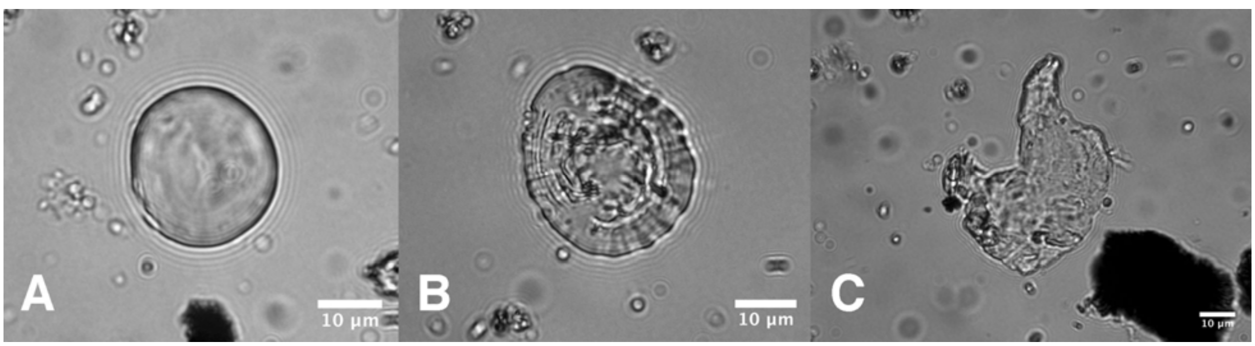
A single lenticular grain was recovered from sherd #9, and boiling damage was also noted. This damage indicates that the vessel was used to cook grain in a liquid medium.

Sherd #24 had the largest number of starch grains in the analyzed samples with five lenticular starch grains. Both grinding damage and unidentifiable damage from heating were also observed, indicating that the vessel was used for cooking grain that had been previously processed by grinding.

Sherd #59 yielded two starch grains, and unidentifiable damage from heating was present. This damage indicates that the vessel was used to cook grain.

Sherd #108 contained what appear to be highly degraded residues of cooked starches. The damage was so severe, however, that I am hesitant to make a secure identification. Sherd #96 was free of starch remains.

Figure 1: Starch remains from the Boot Hill site. A. Lenticular starch grain from groundstone tool #54. B. Starch grain subject to grinding and heating, from ceramic sherd #24. C. Gelatinized starch subject to boiling from groundstone tool #54.



Summary and Conclusions

The starch remains provide solid evidence that the groundstone tools were used for grinding grain, and the ceramic vessels were cooking implements. The starch assemblage is derived from indigenous grasses, and possibly from little barley. Thus, the grain was very likely either locally collected or produced and then processed into flour or meal that was cooked onsite. If future research is planned for the Boot Hill site, both groundstone artifacts and ceramic sherds appear to be reliable sources of starch residues.

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Appendix F: FTIR Residue Analysis

ORGANIC RESIDUE (FTIR) ANALYSIS OF SAMPLES FROM SITE LA 32229, EDDY COUNTY, NEW MEXICO

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INTRODUCTION

Three ceramic sherds and three groundstone fragments from site LA 32229 in Eddy County, New Mexico were submitted for organic residue analysis. Samples will be tested for organic residues using Fourier Transform Infrared Spectroscopy (FTIR). Organic residue analysis will be used to gain information regarding diet and tool function.

METHODS

FTIR (Fourier Transform Infrared Spectroscopy)

A mixture of chloroform and methanol (CHM) was used as a solvent to remove lipids and other organic substances that had soaked into the surface of the ceramic and stone. This mixture is represented in the FTIR graphics as CHM. The CHM solvent and sample were placed in a glass container, and allowed to sit, covered, for several hours. After this period of time, the solvent was pipetted into an aluminum evaporation dish, where the CHM was allowed to evaporate. This process leaves the residue of any absorbed chemicals in the aluminum dishes. The residue remaining in the aluminum dishes was then placed on the FTIR crystal and the spectra were collected. The aluminum dishes were tilted during the process of evaporation to separate the lighter from the heavier fraction of the residue. The lighter and heavier fractions are designated upper (lighter fraction) and lower (heavier fraction) respectively in the subsequent analysis.

FTIR is performed using a Nicolet 6700 optical bench with an ATR and a diamond crystal. The sample is placed in the path of a specially encoded infrared beam, which passes through the sample and produces a signal called an "inferogram." The inferogram contains information about the frequencies of infrared that are absorbed and the strength of the absorptions, which is determined by the sample's chemical make-up. A computer reads the inferogram and uses Fourier transformation to decode the intensity information for each frequency (wave numbers) and presents a spectrum.

FTIR (FOURIER TRANSFORM INFRARED SPECTROSCOPY) REVIEW

Infrared spectroscopy (IR) is the study of how molecules absorb infrared radiation and ultimately convert it to heat, revealing how the infrared energy is absorbed, as well as the structure of specific organic molecules. Infrared spectroscopy has been experiencing a renaissance for identifying organic substances during the past few decades. It is currently considered one of the more powerful tools in organic and analytical chemistry. One of the primary advantages to the FTIR is that it measures all wave lengths simultaneously. It has a relatively high signal-to-noise ratio and a short measurement time. Each peak in the spectrum represents either a chemical bond or a functional group.

Since molecular structures absorb the vibrational frequencies or wavelengths of infrared radiation, the bands of absorbance can then be used to identify the composition of the materials under study. In the case of the current research, the portion of the electromagnetic spectrum between 4000-400 wave numbers is used for identifying organic materials. Carbohydrates, lipids, proteins, and other organic molecules are associated with specific wave number bands (Isaksson 1999:36-39).

The infrared spectrum can be divided into two regions--the functional group region and the fingerprint region. These two groups are recognized by the effect that infrared radiation has on the respective molecules of these groups. The functional group region is located between 4000 and approximately 1500 wave numbers. The molecular bonds display specific characteristic vibrations that identify fats, lipids, waxes, lignins, proteins, carbohydrates, etc. The fingerprint region, located below 1500 wave numbers, is influenced by bending motions, which further identify the molecules present.

Using the FTIR, it is possible to identify different types of organic compounds and eventually recognize different types of materials such as plant or animal fats or lipids, plant waxes, esters, proteins, carbohydrates, and more. Specific regions of the spectrum are important in identifying these compounds.

The results of the identification of specific wavelengths can be compared with commercial or laboratory-created analytical standards to identify the specific types of bonds present in different materials. By combining the results of the analysis of individual samples with all of the reference materials in the PaleoResearch Institute (PRI) library, the percent match with individual reference items can be displayed. For instance, plant lipids or fats are identifiable between 3000-2800 wave numbers. A match might be obtained on this portion of the spectrum with nuts such as hickory, walnut, or acorn, or with animal fats or corn oil. Recovery of high level matches with several types of nuts (in this example) indicates that nuts were processed. If the match with the PRI library is with meats, then the fats matched are more consistent with those produced by meat than plant parts, such as nuts.

Samples containing many compounds are more difficult to identify – and many archaeological samples are complex mixtures. Multi-purpose artifacts, such as groundstone, which could have been used to crush or grind a variety of foodstuffs, or ceramic cooking vessels, which are expected to have been used to cook many different foods, might present a mixture problem. Mixtures sometimes have many absorption bands that overlap, yielding only broad envelopes of absorption and few distinctive features. FTIR analysis is expected to be particularly valuable in examining fire-cracked rock (FCR), for which few other means of analysis exist, since the fats, lipids, waxes, and other organic molecules contained in liquids that seep out of the food being processed become deposited on the rocks during the baking process. Once again, these rocks might have been present in more than one cooking episode, thus having the potential to yield a complex signature. The PRI extraction method gently removes these organic molecules from the groundstone, ceramics, and/or rocks so that they can be measured with the FTIR and subsequently identified.

Organic molecules from sediments can be extracted and the sediments then characterized. This has the potential to be very useful in identifying signatures of the remains responsible for a dark horizon. For instance, if the dark horizons are the result of decaying organic matter (plant or animal), the FTIR will yield a signature of decaying organic remains. If the dark horizons are the result of blowing ash from cultural features, the FTIR signature will be considerably different. This is an affordable technique for making distinctions between horizons and identifying cultural horizons.

Carbohydrates

Carbohydrates are a product of photosynthesis in green plants. This group of compounds is the most abundant found on earth. Carbohydrates is a term that encompasses three main groups of compounds: 1) sugars, 2) starches, and 3) fibers. To elaborate, sugars include the simple carbohydrates found in table sugar, honey, natural fruit sugars, and molasses. Starches and complex carbohydrates are present in legumes, grains, vegetables, and fruits. Fibers, including cellulose, hemicellulose, and pectin, are present in whole grains, legumes, vegetables, and fruits (Garrison and Somer 1985:13). Dietary carbohydrates provide energy for bodily functions, including our ability to digest and absorb other foods. They are the body's preferred source of energy, although proteins and lipids also may be converted to energy. Carbohydrates are so important that an inadequate intake may result in nutritional deficiencies such as ketosis, energy loss, depression, and even loss of essential body protein. On the other hand, excess intake of carbohydrates causes obesity and dental decay.

To understand carbohydrates and their detection with the FTIR, it is important to know that they are formed of carbon atoms coupled to "hyrates," such as water, resulting in empirical formulas of $C_nH_{2n}O_n$ where "n" represents the number of atoms for C, H, and O, respectively. "Biochemically, carbohydrates are polyhydroxy alcohols with aldehyde or ketone groups that are potentially active" (Garrison and Somer 1985:13). Since carbohydrates are classified according to their structure and the FTIR detects the bonds between molecules, we will review the simple sugars (monosaccharides), multiple sugars (oligosaccharides), and complex molecules (polysaccharides) that are made up of simple sugars.

Polysaccharides

These complex starchy compounds follow the empirical formula: $C_6H_{10}O_5$. They are not sweet, do not crystallize, and are not water soluble. Simply defined, polysaccharides are complex carbohydrates found in plants as starch and cellulose, and in animals as glycogen. Because the FTIR detects the bonds between atoms in molecules, it is important to know that polysaccharides are formed of repeating units of mono- or disaccharides that are joined together by glycosidic bonds. Polysaccharides are often heterogeneous. The slight modifications of the repeating unit results in slightly different wave number signatures on the FTIR. Types of polysaccharides are descriptive and include storage (starches and glycogen), structural (cellulose and chitin), acidic (containing carboxyl groups, phosphate groups, and/or sulfuric ester groups), neutral (presumably without the acid features), bacterial (macromolecules that include peptidoglycan, lipipolysaccharides, capsules and exopolysaccharides), and more. The study of polysaccharides is an ever growing field and industry, since polysaccharides are important to proper immune function, bowel health, and a host of other factors that are important in human health. At present there is no comprehensive study of which plants and animal parts contain which polysaccharides. Research into this field is currently growing at a rapid pace. Some highlights for the purpose of our discussions are presented below.

Storage Polysaccharides

Storage polysaccharides are digestible polysaccharides. Starch and glycogen are the two primary groups of these polysaccharides (Wardlaw and Insel 1996:80-81).

Starch

Starch is the primary digestible polysaccharide in the human diet, and the most important carbohydrate food source (Murray, et al. 2000:155; Wardlaw and Insel 1996:80). Starch is composed of long chains of glucose units. "Cooking increases the digestibility of...starches...making them more soluble in water and thus more available for attack by digestive enzymes" (Wardlaw and Insel 1996:80). Amorphous starch granules encased in cell walls burst free when cooked because the granules absorb water and expand. The two primary constituents of starch are amylose and amylopectin, both of which are a source of energy for plants and animals (Murray, et al. 2000:155; Wardlaw and Insel 1996:80). When the glucose chains are long and straight, the starch is labeled amylose. If the chains are short and branched, they are amylopectin. Shorter chains of glucose (dextrin) are the intermediate product of the hydrolysis of starch. Glucan, which is often found in association with pectin, resides in the cell walls of plants and trees and many forms of bacteria and fungi (Stephen 2006). Most people are familiar with beta glucans, which are a diverse group of molecules that occur commonly in the cellulose of plants, bran of cereals, cell walls of baker's yeast, and certain fungi, mushrooms, and bacteria. Some beta glucans may be useful as texturing agents and soluble fiber supplements. Beta glucans derived from yeast and medicinal mushrooms have been used for their ability to modulate the immune system.

Structural Polysaccharides

Structural polysaccharides, which are also known as dietary fiber, are indigestible by humans and other animals. Structural polysaccharides are primarily composed of cellulose, hemicellulose, pectin, gum, and mucilage (Wardlaw and Insel 1996:82). "The only noncarbohydrate components of dietary fiber are lignins, which are complex alcohol derivatives" (Wardlaw and Insel 1996:82). Lignins are complex alcohol derivatives that make up the non-carbohydrate components of insoluble plant fibers (Wardlaw and Insel 1996:82). As such, they cannot be digested by the enzymes animals produce (Carlile 1994). Lignin is found in all plants and is an important component of the secondary cell walls (Lebo, et al. 2001; Martone 2009; Wardlaw and Insel 1996:82). One of the important functions of lignin is to provide support through strengthening of the xylem cells of wood in trees (Arms 1995; Esau 1977; Wardrop 1969). In linking plant polysaccharides, lignin provides strength to the cell walls and by extension to the entire plant (Chabannes, et al. 2001). Because cellulose and chitin provide structural support to plants and animals they are not water soluble. Cellulose, hemicellulose, and pectin are all comprised of simple sugars, and their differences are defined by the various inclusions, exclusions, and combinations of these sugars, as well as how the sugars are bonded, and the molecular structure of the sugars of these polysaccharides.

Cellulose

Cellulose is comprised of a long linear chain of glucose, whereas hemicellulose consists of shorter branched chains of simple sugars in addition to glucose, including especially xylose, but also mannose, galactose, rhamnose, and arabinose (Crawford 1981; Updegraff 1969). Pectin, however, may be found in either a linear or branched form of simple sugars that is primarily composed of rhamnose.

Hemicellulose

Hemicellulose resides in the cell wall structures of many plants, particularly grain and vegetable plants, and is a component of both insoluble and soluble fibers (Wardlaw and Insel 1996:82). Some specific hemicelluloses include galactan, galactoglucomannan, glucomannan, glucuronoxylan (GX), and xyloglucan (Walker 2006; Wilkie 1985).

Galactoglucomannan. Galactoglucomannan is a primary component of the woody tissue of coniferous plants (Gymnosperms) (Bochicchio and Reicher 2003).

Glucomannan. Glucomannan, which may be very concentrated in some roots or corms and in the wood of conifers and dicotyledons (dicots), is a soluble fiber used to treat constipation by decreasing fecal transit time (Bochicchio and Reicher 2003; Marzio 1989).

Pectin, Gums, and Mucilages

Pectin, gums, and mucilages are soluble fibers found inside and around plant cells that help "glue" them together (Wardlaw and Insel 1996:82). Pectin is a structural heteropolysaccharide and common substance found in many plants (apples, plums, gooseberries, and citrus) often used for its gelling or thickening action. Plant derived gums and mucilages such as gum arabic, guar gum, and locus bean gum are also used for this same purpose. Arabinan, arabinogalactan, arabinoglucuronoxylan, and rhamnogalacturonan are some examples of these types of polysaccharides (Wilkie 1985).

Arabinogalactan. Arabinogalactan is a sugar found in plant carbohydrate structures, particularly gums and hemicelluloses. One of arabinogalactan's many functions is to bond with proteins to repair damage when it occurs to a plant or its parts (Nothnagel 2000).

Rhamnogalacturonan. Rhamnogalacturonans are specific pectic polysaccharides that reside in the cell walls of all land plants, and result from the degradation of pectin (Willats, et al. 2001). They are visible by the presence of peaks at 1150, 1122, 1070, 1043, 989, 951, 916, 902, 846, and 823 wave numbers.

Esters

Esters are an important functional group because they are present as flavoring agents in food and are components of biological compounds such as fats, oils, and lipids. In an ester, the basic unit of the molecule is known as a carbonyl. The presence of the double peak between 3000 and 2800 wave numbers identifies the presence of the aldehyde functional group, which is present in fats, oils, lipids, and waxes.

There are two important groups of esters, saturated esters and aromatic esters. Aromatic esters take their name from their ability to produce distinctive odors and are present as flavoring agents in food. In contrast, saturated esters do not produce distinctive odors. Esters are expressed in the FTIR spectrum by three distinct peaks ("the rule of three") located at approximately 1700, 1200, and 1100 wave numbers, and a fourth peak in the region between 750 and 700 wave numbers, which represents the CH_2 bend associated with aromatic esters.

The first peak for saturated esters falls in the 1750-1735 range, the second peak lies between 1210 and 1160, and the third peak sits between 1100 and 1030. Saturated esters have a unique peak to acetates at 1240. This band can be very strong in the signature. The first peak for aromatic esters falls in the range between 1730 and 1715, the second peak between 1310 and 1250, and the third peak between 1130 and 1100 (Smith 1999:110-112). Distinguishing between saturated and aromatic esters, which are both components of foods, is easy if all three bands are present, since they occupy different wave number regions.

Lipids

Lipids that are solid at room temperature are called "fats," and those that are liquid at room temperature are referred to as "oils" (Wardlaw and Insel 1996:108). Both forms of lipids can be detrimental, as well as beneficial, to human health. Consumption of certain animal fats rich in saturated fatty acids can lead to heart disease, while ingesting omega-3 fatty acids such as EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) found in fish and other plant sources are essential to good health.

Fatty Acids

Fatty acids are found in most lipids in the human and animal body, as well as in the lipids in foods (Wardlaw and Insel 1996:108). Long chains of carbons bonded together which are then bonded to hydrogens define the structure of fatty acids (Wardlaw and Insel 1996:109). A fatty acid is considered saturated if the carbons are connected by single bonds. Saturated fatty acids are high in animal fats. If the carbon chain has one double bond between two of the carbons, then the fatty acid is monounsaturated. If there are two or more double bonds between carbons, then the fatty acid is polyunsaturated.

Essential Fatty Acids

Essential fatty acids, are those lipids critical to human health, such as omega-3 and omega-6 fatty acids, alpha-lineolic acid, and linoleic acid, that cannot be created within the body and must be obtained from dietary sources (Wardlaw and Insel 1996:110-111). These essential fatty acids are part of "vital body structures, perform vital roles in immune system function and vision, help form cell membranes, and produce hormone like compounds," and are necessary to maintain good health (Wardlaw and Insel 1996:111). Diets high in essential fatty acids, like omega-3 and omega-6, reduce the risk of heart attacks because they minimize the tendency for blood to clot (Wardlaw and Insel 1996:112). Fish oils contain high concentrations of omega-3 and omega-6 fatty acids and may be administered as a dietary supplement.

Proteins

The human body uses protein from dietary plant and animal sources to form body structures and other constituents (Wardlaw and Insel 1996:152). "Proteins contribute to key body functions, including blood clotting, fluid balance, production of hormones and enzymes, vision, and cell growth and repair" (Wardlaw and Insel 1996:152). This constant regulation and maintenance of the body requires thousands of different types of proteins that are not all available within the body (Wardlaw and Insel 1996:152). The majority of the building blocks for these proteins, which are also known as amino acids, are produced by plants.

Amino Acids

Within the body, amino acids are linked to form the necessary proteins, making them not only essential for life, but key to nutrition. Amino acids can be combined in a multitude of ways to create a vast variety of proteins. Differences between these proteins are distinguished by the unique arrangements of amino acids. Proteins are created through a process called translation, in which amino acids are added, one-by-one, to form short polymer chains called peptides, or longer chains called polypeptides or proteins (Rodnina 2007). The order in which the amino acids are added is determined by the genetic code of the mRNA template, which is a copy of an organism's genes (Creighton 1993). Amino acids are divided into standard and non-standard types.

Standard Amino Acids

There are twenty (20) naturally occurring amino acids on earth called standard amino acids (Creighton 1993). These amino acids are encoded by the standard genetic code and are found in all forms of life (Creighton 1993). The standard amino acids are broken down into two different types, essential and nonessential.

Essential Amino Acids

Eight of the standard amino acids are considered "essential amino acids" because they are necessary for normal human growth and cannot be synthesized by the human body (Young 1994). Essential amino acids must be obtained from food sources, and include histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine (Furst and Stehle 2004; Reeds 2000; Wardlaw and Insel 1996:154).

Leucine. Leucine is used in the liver, adipose tissue, and muscle tissue. In adipose and muscle tissue, leucine aids in the formation of sterols, and slows the degradation of muscle tissue by increasing the synthesis of muscle proteins (Combaret, et al. 2005; Rosenthal, et al. 1974). Common sources of leucine in the diet include beef, fish, shellfish, nuts and seeds, eggs, and legumes.

Lysine. Lysine is important for calcium absorption, building muscle, recovering from injuries or illnesses, and the production of hormones, enzymes, and antibodies (Nelson and Cox 2005). Plants that contain significant amounts of lysine include legumes, gourds/squash, spinach, amaranth, quinoa, and buckwheat (Wardlaw and Insel 1996:158). Other dietary sources of lysine include beef, poultry, pork, fish, eggs, and dairy.

Nonessential Amino Acids

The majority of the standard amino acids are considered "nonessential," meaning that under normal circumstances these amino acids can be manufactured by the human body and are not required in the diet. However, some amino acids that are normally nonessential may become an essential part of the diet for a person whose health has been compromised

(Wardlaw and Insel 1996:155). Nonessential amino acids include alanine, arginine, asparagine, aspartate (aspartic acid), cysteine, glutamate (glutamic acid), glutamine, glycine, proline, serine, and tyrosine (Furst and Stehle 2004; Reeds 2000)(Wardlaw and Insel 1996:154).

Glutamate. Glutamate, or glutamic acid, is an important molecule in cellular metabolism. It is the most abundant excitatory neurotransmitter in the nervous system of mammals (Nelson and Cox 2005). Glutamate is found in dairy products, eggs, and all meats, such as beef, pork, poultry, wild meats, and fish (Reeds, et al. 2000).

Serine. Serine is important in metabolic function (Nelson and Cox 2005). It serves as a neuronal signal by activating N-methyl-D-aspartate (NMDA) receptors in the brain and helps to build muscle tissue (Mothet, et al. 2000). Common sources of serine in the diet are beef, eggs, nuts and seeds, legumes, and milk.

Nucleic Acids

Millions of proteins exist in all living organisms to assist with the daily functions of these complex systems. Proteins are produced and assembled locally to exact specifications, and a large amount of information is necessary to properly manage the system. This information is stored in a set of molecules called nucleic acids. Nucleic acids not only contain the genetic instructions for the proper development and functioning of living organisms, but also play a role in copying genetic information to protein (Saenger 1984). The most common examples of nucleic acids are DNA (deoxyribonucleic acid) and RNA (ribonucleic acid).

ETHNOBOTANIC REVIEW

It is a commonly accepted practice in archaeological studies to reference ethnographically documented plant uses as indicators of possible or even probable plant uses in prehistoric times. The ethnobotanic literature provides evidence for the exploitation of numerous plants in historic times, both by broad categories and by specific example. Evidence for exploitation from numerous sources can suggest widespread utilization, and strengthens the possibility that the same or similar resources were used in prehistoric times. Ethnographic sources outside the study area have been consulted to permit a more exhaustive review of potential uses for each plant. Ethnographic sources document that with some plants, the historic use was developed and carried from the past. A plant with medicinal qualities very likely was discovered in prehistoric times and the usage persisted into historic times. There is, however, likely to have been a loss of knowledge concerning the utilization of plant resources as cultures moved from subsistence to agricultural economies and/or were introduced to European foods during the historic period. The ethnobotanic literature serves only as a guide indicating that the potential for utilization existed in prehistoric times--not as conclusive evidence that the resources were used. Pollen and macrofloral remains, when compared with the material culture (artifacts and features) recovered by the archaeologists, can become indicators of use. Plants represented by organic residues will be discussed in the following paragraphs in order to provide an ethnobotanic background for discussing the remains.

Native Plants

Agavaceae (Agave Family)

Agavaceae are perennial plants, that are typically found in the foothills and lower mountain areas of the Southwest }(Castetter, et al. 1938:79). Members of the agave family were utilized in a variety of food and fiber applications by native peoples of the Southwest. The crowns of *Agave* (agave, century plant, mescal) species were commonly collected and roasted in pits. Roasted agave could be consumed immediately, or further prepared by boiling or pounding into a paste. Fermented agave beverages were a later introduction to the Southwest, by way of Mexico and Mesoamerica. Fibers from members of the Agavaceae family, particularly those of *Yucca* species, were used to make cloth, sandals, baskets, rope, and a variety of other utilitarian items. Roots of *Yucca* species have a high saponin content, and were processed by groups throughout the Southwest to produce a soap for washing. *Yucca* species were also a source for edible seeds and fleshy fruits. (Bell and Castetter 1941; Castetter, et al. 1938:78; Ebeling 1986:468-474; Luomala 1978).

Xanthium (Cocklebur)

Xanthium (cocklebur) is a common weedy annual found throughout the United States, especially in dry areas, old fields, along roadsides, around alluvial washes and creek banks, and on beaches. The fruit is a pod about one inch long that is covered with stiff, hooked barbs and often called a bur. The inner seeds can be parched and ground into a flour. Shields (1984:59) notes that cocklebur was "employed by early desert people in remedies." Crushed, boiled pods have analgesic, diuretic, and antispasmodic effects, and have been used for diarrhea, excess sweating, and painful urination; however, large quantities or constant use can have toxic effects. Mature leaves can be used to treat shingles, skin and bladder infections, and to stop the bleeding of cuts and abrasions. A leaf tea was used as a diuretic and to treat cystitis (Krochmal and Krochmal 1973:236-237)(Moerman 1998:602; Moore 1990:23; Shields 1984:59).

Cultigens

Cucurbita (Squash/Pumpkin/Gourd)

Cucurbita (squash/pumpkin/gourd) is noted as one of the most important New World crops, and, along with corn and beans, belongs to what Ford (1981) has called the *Upper Sonoran Agricultural Complex* (Cordell 1984:171). These crops were the first to be cultivated everywhere in the Southwest. Fresh squash were cut into pieces, boiled, baked, or roasted whole in ashes. Squash and pumpkins also were cut in coils or strips that were dried for future use. Blossoms were used to season soup or fried in grease and used as a delicacy in combination with other foods. Seeds also were roasted and eaten or used to oil piki stones. Gourds were dried and made into cups, ladles, dippers, ceremonial rattles, and used for other purposes (Cordell 1984:178; Cushing 1920:561; Elmore 1944:79; Robbins, et al. 1916:100-102; Vestal 1952:46-47; Whiting 1939:93).

DISCUSSION

Site LA 32229 is located along the face of a caprock on a small hill in Eddy County, New Mexico (Adriana Romero, personal communication, October 15, 2010). Local vegetation consists of *Prosopis* (mesquite), *Larrea tridentata* (creosote), and grasses (Poaceae). Dates associated with the site and/or cultural affiliation were not provided. Three ceramic sherds and three groundstone fragments recovered from the site were examined for organic residues using Fourier Transform Infrared Spectroscopy (FTIR) (Table 1). Organic residue analysis is used to gain information regarding diet and tool function. Results from this analysis will be discussed below by level.

Level 4

Organic residue analysis of the ceramic sherd recovered from Level 4 (sample 94) yielded peaks representing major categories (functional groups) of compounds (4000-1500 wave number), as well as specific compounds noted in the fingerprint region (1500-400 wave numbers) of the spectrum. The functional group peaks indicate the presence of absorbed water and fats/oils/lipids and/or plant waxes (Table 2). Peaks within the fingerprint region represent the presence of aromatic rings; aromatic esters; proteins including nucleic acids; the amino acid glutamate; calcium carbonate; calcium oxalates; pectin; cellulose and carbohydrates; and the polysaccharide galactoglucomannan.

The best match for this signature was with calcium carbonate for several peaks (1434-1380, 1413; 878-854, 873; 717-705, 712), which are characteristic peaks of calcium carbonate. This is consistent with alkaline sediments in the area (Table 3). Matches with three distinct peaks in the calcium carbonate reference, at approximately 1415, 873, and 712 wave numbers, suggests the signature from this sample is heavily dominated by an environmental signal.

Although peaks representing glutamate were present, no good matches were made with them. The presence of this amino acid might represent either natural decomposition of faunal remains or possibly animal processing. Without matches to these peaks an indication of the type of animal contributing to the signal cannot be identified. Due to the ubiquitous nature of these peaks in other samples for this project, a complete restatement of their significance will not be made for each sample.

A peak at 775 wave numbers representing calcium oxalates also was not matched for this sample. Calcium oxalates are present in many plants, often in the form of crystals, particularly in agave, yucca, members of the Cactaceae (cactus family), and members of the Chenopodiaceae (goosefoot family). Some edible plants that contain calcium oxalates include legumes (leaves and pods), goosefoot (and spinach) greens (leaves), the fruits of saltbush, and cactus fruits and epidermal tissue. Samples that exhibit one or more peaks associated with calcium oxalates, but no matches to specific plants, probably have suffered a higher degree of degradation of compounds, which have obscured enough of the signature to make matching with modern references difficult. Calcium oxalates are easily dissolved and rarely observed, as crystals, in sediment samples. Therefore, recovery of an FTIR signature for calcium oxalates is considered to be a very valuable means of tracking the presence of this compound.

Peaks representing galactoglucomannan at approximately 934/935 wave numbers are common for this project and their significance will not be discussed for each sample. The presence of these polysaccharides suggest the woody and fibrous tissue of coniferous plants (Gymnosperms) are contributing to the signal. These compounds probably are attributable to plants growing in the local environment or possibly wood that was burned as fuel.

Level 3

Sample 36, representing a groundstone fragment from Level 3, yielded peaks representing functional group compounds including absorbed water and amines. Other peaks identified in the fingerprint range indicate the presence of aromatic rings; aromatic esters; protein; the amino acids lysine and leucine; calcium carbonate; calcium oxalates; pectin; starch; cellulose and carbohydrates; and the polysaccharides glucomannan and galactoglucomannan.

Good matches with foods were not made for the entire signature obtained from this sample; however, matches with raw *Cucurbita* (gourd/pumpkin/squash) flesh at peaks 962-911 and 943, representing glucomannan, and raw *Agave* leaf skin at peaks 788-764 and 778, representing calcium oxalates, were made with portions of the spectrum. Gourd/pumpkin/squash was matched with a peak at 943 wave numbers representing glucomannan. This polysaccharide is found in the fibrous tissues of dicotyledons, of which *Cucurbita* is a member, and this match suggests the possibility that gourd, pumpkin, and/or squash might have been ground with this artifact. Since glucomannan is found in many dicots, this peak is not considered to be specific enough to interpret processing cucurbits with this groundstone.

Processing agave, or perhaps it's close relative yucca, with the groundstone also is suggested by matches with agave references for a calcium oxalate peak at 778 wave numbers. Although the calcium oxalate peaks matched with plants (agave/yucca) known to contain calcium oxalate, the presence of this compound in other plants raises the possibility that other calcium oxalate-rich plants might have been processed with this groundstone. The inability to distinguish between calcium oxalate crystals found in different species using FTIR, makes it impossible to identify the specific plants contributing to the peak, although the match with agave suggests this plant probably is present in the sample. Since calcium oxalates are found in other locally growing plants including members of the Chenopodiaceae and Cactaceae families, these plants also might be contributing to the calcium oxalate peak even through matches with these references were not made with this peak, or any other portion of the spectrum.

Lysine peaks also are common for this project and their significance will not be reiterated for each sample. This amino acid is found in gourds and squash, as well as legumes and meat. Although none of the peaks for these samples were matched directly with these references, the presence of lysine suggests members of the Cucurbitaceae, legumes, and/or meat probably are contributing to the samples. Matches with gourd/pumpkin/squash were made in other portions of the spectrum for all samples in which lysine peaks are present.

A peak at 1375 wave numbers representing another amino acid, leucine, also was identified in this sample. No good matches were made with this peak; however, the presence of this compound suggest nuts, seeds, and/or meat are contributing to the signal. In the absence of matches for this peak it is difficult to determine the specific species present.

The environmental signal was visible in this sample by matches with peaks characteristic of calcium carbonate (1455-1368, 1413; 884-863, 872; 726-705, 712) and deteriorated cellulose and carbohydrates (1245-893, 1015). Although cellulose in the sample probably represents the natural breakdown of plant matter in the sediments from which the groundstone was recovered, the presence of cellulose also might indicate processing other plants that have deteriorated to the point they are no longer visible by their general cellulose signature.

Peaks representing amines, which are produced naturally by the breakdown of amino acids through the decomposition of plant and animals materials (Guch and Wayman 2007:176), might be attributable to either the cultural and/or environmental components of the sample's signature, as these compounds are not unique to cultural activities or natural processes.

Level 2

Two groundstone fragments recovered from Level 2 (samples 47 and 73) were tested for organic residues. Sample 47, representing the first groundstone fragment, yielded functional group peaks indicating the presence of absorbed water, amines, and fats/oils/lipids and/or plant waxes. Peaks within the fingerprint range of the spectrum represent saturated esters; protein; the amino acids lysine and serine; pectin; humates; and the polysaccharide glucomannan.

Matches with raw *Cucurbita* (gourd/pumpkin/squash) flesh for protein/lipid peaks located at 1481-1422 and 1459, and charred *Xanthium* (cocklebur) seeds also for protein/lipid peaks located at 1484-1437 and 1459, suggest gourd/pumpkin/squash flesh and/or cocklebur seeds (or closely related marshelder seeds) were ground with this stone. The match with raw cucurbit flesh is considered to be very general and probably unlikely for use of this groundstone. The more general nature of the compounds indicated by these peaks also might suggest processing other plants rich in proteins and lipids that are not visible in matches with this signature.

Although no good matches were made with a peak at 1270 wave numbers representing serine, the presence of this amino acid supports seed processing, and also suggests nuts and meat might be contributing to the signal.

A glucomannan peak at 939 wave numbers also was not matched. The presence of this polysaccharide might be attributable to *Cucurbita* in the sample; however, without a match to this peak for gourd, pumpkin, or squash, glucomannan in the sample also could be attributable to the presence of fibrous tissues from other dicots and coniferous plants.

A combination of cultural activities and natural processes probably resulted in peaks representing amines.

The second groundstone fragment from Level 2 (sample 73) yielded peaks representing functional group compounds including absorbed water and fats/oils/lipids and/or plant waxes.

Other peaks in the fingerprint range indicate the presence of aromatic and saturated esters; proteins including nucleic acids; the amino acid glutamate; calcium carbonate; pectin; cellulose; and the polysaccharides glucomannan and galactoglucomannan.

A match with peaks characteristic of calcium carbonate (1452-1371, 1420; 884-860, 873; 720-708, 712) was the only match made with the signature from the second groundstone found in Level 2. This match suggests the presence of a strong environmental signal in the sample representing this artifact.

The presence of a peak at 938 wave numbers indicates woody and fibrous tissues from conifers and dicots also are contributing to the signal; however, in the absence of matches with this peak, the specific flora species present cannot be identified.

A ceramic sherd from Level 2 (sample 37) also was examined for organic residues. Sample 37 yielded functional group peaks indicating the presence of absorbed water and fats/oils/lipids and/or plant waxes. Peaks within the fingerprint region of the spectrum representing aromatic esters; protein; the amino acid glutamate; calcium carbonate; calcium oxalate; cellulose and carbohydrates; and the polysaccharide glucomannan also were identified.

A weak match with raw *Cucurbita* (gourd/pumpkin/squash) flesh for peaks 965-911, and 937, representing glucomannan, with a glucomannan peak at 937 wave numbers suggests possibility of processing gourd, pumpkin, or squash. Repetitive matches with raw gourd/squash suggest the possibility that wild gourds have grown in this area and contributed to the environmental signal. Alternatively, it is possible that the peaks representing glucomannan have a different origin and are matching only with this single reference.

No good matches were made with the calcium oxalate peak at 778 wave numbers for this sample. Calcium oxalates in the sample might indicate native plants rich in these crystals including *Agave*, *Yucca*, *Opuntia* (prickly pear cactus), *Cylindropuntia* (cholla cactus), and/or various members of the Chenopodiaceae such as *Atriplex* (saltbush) and *Chenopodium* (goosefoot) were contained in the vessel; however, it also is possible this compound reflects the deterioration of plant matter from local vegetation.

Other matches with peaks characteristic of calcium carbonate (1434-1377, 1413; 887-857, 873; 717-708, 712) and deteriorated cellulose and carbohydrates (1192-977, 1019) attest to the presence of the local environmental signal in the sample. As stated above, cellulose also might indicate non-specific plant processing using the ceramic vessel represented by this sherd.

Surface

Sample 156, representing a ceramic sherd recovered from the surface, yielded peaks representing functional group compounds including absorbed water and fats/oils/lipids and/or plant waxes. Peaks within the fingerprint range indicate the presence of aromatic and saturated esters; protein; the amino acids lysine and serine; pectin; cellulose; and the polysaccharides rhamnogalacturonan, arabinogalactan, glucomannan, and galactoglucomannan.

These peaks were matched with raw *Cucurbita* (gourd/pumpkin/squash) flesh (1765-1694; 1735, lipids, saturated esters; 1395-1308, 1363, protein) suggesting gourd, pumpkin, or squash might have been contained in the vessel represented by this ceramic sherd or, as stated above, that this signal is pervasive at this site.

A glucomannan peak at 938 wave numbers also might be attributable to gourd, pumpkin, and/or squash in the sample; however, without matches to *Cucurbita* references for this peak, the presence of this compound also might indicate contributions from woody and fibrous tissue from other dicots, as well as conifers.

A peak at 1260 wave numbers, representing the amino acid serine, suggests nuts, seeds, and meat also might be contributing to the signal; however, in the absence of matches with this peak, the specific floral and/or faunal species present cannot be identified. Serine in the sample probably is attributable to the local environmental signal.

The environmental signature also is visible in peaks at 1043 and 821, and 1043 wave numbers representing rhamnogalacturonan and arabinogalactan, respectively. The presence of these polysaccharides throughout the plant kingdom makes it difficult to associate the compounds with specific floral species. Without matches to these peaks, identification of plants contributing to the signal cannot be made. Rhamnogalacturonan and arabinogalactan in the sample might result from both natural processes and cultural utilization.

SUMMARY AND CONCLUSIONS

As a whole, the FTIR record for the ceramic and groundstone recovered from all levels at site LA 32229 in Eddy County, New Mexico suggests processing gourd/pumpkin/squash, agave, and perhaps other native plants rich in calcium oxalates such as yucca, saltbush, goosefoot, and prickly pear cactus. Processing seeds, perhaps cocklebur or the closely related marshelder, was suggested only for one groundstone sample (47) recovered from Level 2.

All but two samples (47 and 156) exhibited strong environmental signals evident by matches with calcium carbonate and deteriorated cellulose.

TABLE 1
PROVENIENCE DATA FOR SAMPLES FROM SITE LA 32229, EDDY COUNTY, NEW MEXICO

Sample Number	Unit	Level	Provenience/Description	Analysis
156		Surface	Ceramic sherd [redacted]	FTIR
37	1.13	2	Ceramic sherd [redacted]	FTIR
73	1.2	2	Groundstone fragment [redacted]	FTIR
47	2.1	2	Groundstone fragment [redacted]	FTIR
36	2.3	3	Groundstone fragment [redacted]	FTIR
94	1.4	4	Ceramic sherd [redacted]	FTIR

FTIR = Fourier Transform Infrared Spectrometry

TABLE 2
FTIR PEAK SUMMARY TABLE FOR SAMPLES FROM SITE LA 32229, EDDY COUNTY, NEW MEXICO

Peak Range	Represents	156 Ceramic	37 Ceramic	73 Groundstone	47 Groundstone	36 Groundstone	94 Ceramic
3600-3200	Absorbed Water (O-H Stretch)	3393	3329,3325	3359	3384	3363, 3267	3332
3500-3300 sharp	Amines				3384	3363	
3000-2800	Aldehydes: fats, oils, lipids, waxes	2921, 2851	2921,2919, 2850	2919,2918, 2849	2923, 2852		2920,2919, 2850
2959, 2938, 2936, 2934, 2931, 2930, 2926, 2924, 2922	CH_2 Asymmetric stretch	2921	2921		2923		2920
1750-1730	Saturated esters (C=O Stretch)	1735		1735	1735		
1737	Lipids (Phosphopilids, C=O Stretch)	1735		1735	1735		
1700-1500	Protein, incl. 1650 protein	1637,1628, 1541	1577,1560	1655,1654, 1560	1637	1676, 1637,1636, 1586	1654, 1577,1560
1653	Proteins (Amide bands, 80% C=O Stretch, 10% C-N Stretch, 10% N-H Bend)			1654			1654
1680-1600, 1260, 955	Pectin	1637, 1628		1655,1654	1637	1676, 1637,1636	1654
1660-1655	Proteins, Nucleic acids			1655,1654			1654

TABLE 2 (Continued)

Peak Range	Represents	156 Ceramic	37 Ceramic	73 Groundstone	47 Groundstone	36 Groundstone	94 Ceramic
1640-1610, 1550-1485	Lysine (amino acid) NH_3^+ bending	1637, 1628			1637	1637,1636	
1585	Aromatic ring mode					1586	
1560,	Glutamate (amino acid) CO_2^- asymmetric stretching		1560	1560			1560
1415	Glutamate (amino acid) CO_2^- symmetric stretching		1413,1412	1420			1413
1500-1400	Protein	1458,1437	1413,1412	1463, 1420	1459	1483,1421, 1413,1412	1420,1413
1465-1455	Protein/lipids	1458		1463	1459		
1490-1350	Protein	1458,1437, 1363	1413,1412	1463,1420	1459, 1377	1483,1421, 1413,1412, 1375	1420,1413
1384, 1364	Split CH3 umbrella mode, 1:1 intensity	1363					
1377	Fats, oils, lipids, humates (CH_3 symmetric bend)				1377		
1375	Leucine (amino acid) CH_3 symmetric bending					1375	
1375	CH_3 Umbrella mode					1375	

TABLE 2 (Continued)

Peak Range	Represents	156 Ceramic	37 Ceramic	73 Groundstone	47 Groundstone	36 Groundstone	94 Ceramic
1350-1250	Serine (amino acid) O-H bending	1260			1270		
1170-1150, 1050, 1030	Cellulose	1164		1164			
1130-1100	Aromatic esters	1113					
1100-1030	Saturated esters	1043					
1028-1000	Cellulose Carbohydrates		1019,1012			1025, 1015, 1012	1021
1043, 989	Rhamnogalacturonan	1043					
1043, 985	Arabinogalactan	1043					
1026	Starch					1025	
1022, 972	Pectin						1021
1019	Primary alcohol CH_2-O stretch		1019				
941	Glucomannan	938	937	938	939	943	
934	Galactoglucomannan	934		934		935	935
872	$CaCO_3$		873	873		872	873
823	Rhamnogalacturonan	821					
780	Calcium oxalate		778			778	775

TABLE 2 (Continued)

Peak Range	Represents	156 Ceramic	37 Ceramic	73 Groundstone	47 Groundstone	36 Groundstone	94 Ceramic
750-700	Aromatic esters	722	712	712		728,727, 713,712	712
722-719	CH_2 Rock (methylene)	722					
692	Aromatic ring bend (phenyl ether)					692	
660, 648	O-H Out-of-plane bend	659					

TABLE 3
MATCHES SUMMARY TABLE FOR FTIR RESULTS FROM SITE LA 32229, EDDY COUNTY, NEW MEXICO

Match (Scientific Name)	Match (Common Name)	Part	156 Ceramic (Range)	37 Ceramic (Range)	73 Grndstone (Range)	47 Grndstone (Range)	36 Grndstone (Range)	94 Ceramic (Range)
CULTURAL								
Agave	Agave	Leaf skin (raw)					788-764	
Cucurbita	Gourd/Pumpkin/ Squash	Flesh (raw)	1765-1694 1395-1308	965-911		1481-1422	962-911	
Xanthium	Cocklebur	Seed (charred)				1484-1437		
ENVIRONMENTAL								
Calcium Carbonate	Calcium carbonate			1434-1377 887-857 717-708	1452-1371 884-860 720-708		1455-1368 884-863 726-705	1434-1380 878-854 717-705
Deteriorated Cellulose	Deteriorated cellulose			1192-977			1245-893	

Grndstone = Groundstone

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Appendix G: XRF Obsidian Analysis

BERKELEY ARCHAEOLOGICAL XRF LAB

Department of Anthropology
232 Kroeber Hall
University of California
Berkeley, CA 94720-3710

LETTER REPORT

AN ENERGY-DISPERSIVE X-RAY FLUORESCENCE ANALYSIS OF OBSIDIAN ARTIFACTS FROM EDDY COUNTY, SOUTHEASTERN NEW MEXICO

1 November 2010

Adriana Romero
TRC
5400 Suncrest Drive, Suite D-1
El Paso, TX 79912

Dear Adrianna,

The artifacts were all produced from one of the three main sources in the Jemez Mountains, Cerro Toledo Rhyolite, and Valles Rhyolite, the former two readily available in the Rio Grande Quaternary alluvium (Shackley 2005; Table 1). Valles Rhyolite has been found as far south as Albuquerque, but in very small nodule sizes (< 16 mm), and in proportions well below 1% (LeTourneau and Shackley 2009; Shackley 2010).

The samples were analyzed with a Thermo Scientific *Quant'X* EDXRF spectrometer in the Archaeological XRF Laboratory, El Cerrito, California. Specific instrumental methods can be found at http://www.swxrflab.net/anlysis.htm, and Shackley (2005). Samples assigned to source by comparison to source standards at Berkeley (Shackley 2005). Analysis of the USGS RGM-1 standard indicates high machine precision for the elements of interest (Table 1 here).

Sincerely,

M. Steven Shackley, Ph.D.
Director

VOICE: (510) 642-2533
INTERNET: shackley@berkeley.edu
http://www.swxrflab.net/

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2010 The Secondary Distribution of Archaeological Obsidian in the Rio Grande Quaternary Sediments, Jemez Mountains to San Antonito, New Mexico: Inferences for Prehistoric Procurement and the Age of Sediments. Poster presentation, 38th International Symposium on Archaeometry, Tampa, Florida..

Table 1. Elemental concentrations for the archaeological samples. All measurements in parts per million (ppm).

Sample	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
1	501	11568	204	9	48	173	57	Valles Rhyolite
2	425	9459	181	5	45	165	54	Valles Rhyolite
3	614	10697	239	6	69	184	104	Cerro Toledo Rhy
PNUM 160	529	9744	222	4	64	184	101	Cerro Toledo Rhy
PNUM 158	495	8540	195	4	59	168	93	Cerro Toledo Rhy
RGM1-S4	300	12602	155	107	25	216	8	standard

Appendix H: General Land Office (GLO) Maps

Appendix H has been removed to protect confidential site location information.

Appendix I: Collections From Early Excavations at Boot Hill (Graham 2010)

REPORT ON COLLECTIONS FROM EARLY EXCAVATIONS AT BOOT HILL

Martha Graham

Introduction

As part of TRC's archaeological research on the Boot Hill site, we sought to learn more about previous work done at the site and to locate collections from earlier excavations. We placed special emphasis on trying to learn more about the human remains that were removed from the Boot Hill site during the Lea County Archaeological Society (LCAS) 1957–1958 excavations, and whether it might be possible to locate them. TRC did not identify any other authorized excavations at the site, and was unable to locate additional field notes or other documentation about the 1957–1958 activities by the Boy Scouts or the LCAS. The only member of the LCAS that TRC located and interviewed was Dr. Calvin Smith. TRC has concluded that all of the field notes and most of the collections (including the human remains and associated funerary objects) are lost. Following is a description of the results of TRC's efforts and our conclusions.

Background

According to the preliminary report that Corley and Leslie (1960:1), the LCAS was "a newly-formed society and in need of a site for our members to work together under supervised and controlled methods of excavation." The LCAS conducted excavations at Boot Hill during the summers of 1957 and 1958, with each individual keeping the items he or she found (Corley and Leslie 1960:1).

The Boot Hill site was selected for its proximity to Hobbs, the LCAS's home base, and the evident depth of archaeological deposits at the site. In reporting on the site, Corley and Leslie (1960: 1) noted that they "were able to preserve all of the potsherds from the site, but will be lacking information on a few of the other artifacts" because each LCAS member "kept the items he found, and some have since moved away and failed to report all the items found." Therefore, only a few chipped stone artifacts, sketches, and photographs survive from the LCAS excavations.

The excavations were west of the bladed road and totaled about 1350 ft^2 and included a 90-ft manually dug trench. Cultural deposits extended as much as 4 ft below the surface. The excavations uncovered three child burials, of which one (Burial 1) included funerary objects. A fourth burial, containing about 90 shell beads, had been uncovered on the point of the hill by a Boy Scout troop shortly before the LCAS excavations. The whereabouts of the human remains and associated shell beads is currently unknown. Artifacts recovered during the LCAS fieldwork included 961 pottery sherds, 127 projectile points, hammerstones, various chipped stone (knives, scrapers, drills, gravers) and ground stone (manos, metates, polishing stones) tools, and faunal remains (shell and bone). The projectile point assemblage included a Midland-like (Paleoindian) base fragment and Archaic and Formative point types. Most of the ceramic assemblage consisted of Jornada Brown (n=434, 45.2%) and Chupadero Black-on-white (n=330, 34.3%) but also contained Mimbres Black-on-white (n=8, 0.8%) (Corley and Leslie 1960). A small carbon sample collected by the BLM Carlsbad Field Office in the 1990s from midden deposits exposed in the road cut yielded a date of 1290 radiocarbon years before present (rcy B.P.). The original Boot Hill site and its materials were not formally analyzed and only a brief preliminary report (Corley and Leslie 1960) has been written.

Corley and Leslie (1960:5) also reference the Boy Scouts' removing a burial from the site a few months before LCAS began its excavations, and provide a brief description of the burial. They do not report any other information about additional digging activities at the site.

Methods

TRC attempted to identify individuals, or their descendants, that had participated in the LCAS or Boy Scout excavations at the Boot Hill Site (see Table 1). Robert (Buster or "Bus") Leslie, John Corley, Calvin Smith, Jr,. Mark Leslie, Jonnie Cress, and Tony Webb are individuals named in LCAS's preliminary report on the Boot Hill site (Corley and Leslie 1960). Calvin Smith, Jr. was the only person that TRC succeeding in contacting and interviewing about the LCAS excavations at Boot Hill. Although other individuals might be identified from additional interviews with Dr. Smith and LCAS publications, Dr. Smith said that, to his knowledge, he is the only surviving member of LCAS that excavated at Boot Hill (Calvin Smith, Jr., personal communication).

On June 24, 2010, the author (Ethnographic Project Manager, TRC-Albuquerque) met with Dr. Calvin Smith, Jr. to discuss the possible locations of collections and notes from the LCAS's excavations of the Boot Hill site (LA 32229, also known as LCAS B-5). The author met with Dr. Smith at his office in the Western Heritage Museum in Hobbs, New Mexico.

The interview was informal, with the author taking notes but not taping the interview and working from a few prepared questions. The author had communicated with Dr. Smith by telephone and e-mail, beginning in February 2010. A letter dated May 17, 2010, formulated the basis of the interview: "I would like to visit the SENM Archaeological Research/Resource Center to interview you about the Lea County Archaeological Society's work at the site and your own experience there, as well as look at any collections the museum might have".

Findings

The author interviewed Dr. Smith for the purpose of learning about the LCAS excavations of Boot Hill in 1957 and ascertaining what Dr. Smith knew of existing collections and notes from these activities, with specific reference to trying to learn more about the human remains removed from the site. On February 3, 2010, George MacDonell, Lead Archaeologist, BLM–Carlsbad Field Office had written to Graham that, "one of the issues that we are seeking to resolve through the project is to determine if there are any NAGPRA materials still out there that we need to be concerned about. … My guess … is that none of those materials is going to be relocated in any collections. However, I want to make sure".

Dr. Smith spoke about the Boot Hill site primarily within the context of the LCAS's activities over the years, as well as his interests as an avocational archaeologist and his plans for the Southeastern New Mexico Archaeological Society (SENMAS), Southeastern New Mexico (SENM) Archaeological Research/Resource Center, and Western Heritage Museum. The conversation was wide ranging with special emphasis on Paleoindian (and Archaic) occupations in southeastern New Mexico.

Dr. Smith said that the LCAS organized in about 1957 and ended in the early 1970s. Dr. Smith was the second member to join the LCAS. He established the SENMAS, which has goals similar to those of LCAS, when he returned to Hobbs to take up his current position at the Western Heritage Museum.

Findings specific to the BLM's goals are:

1. Dr. Smith retained 42 lithic artifacts, primarily projectile points and tools (whole or fragments), from LCAS's 1957 excavations of the Boot Hill site. This appears to be the extent of existing collections from the LCAS's work at the site.
2. Dr. Smith gave the pottery that he had collected from the site to Robert (Bus) Leslie, as did several other LCAS members.

3. Leslie had most of the Boot Hill collections and any notes in his possession at the time of his death in the 1980s. The collections were at his residence in Hobbs, New Mexico, although Leslie passed away in Oklahoma.
4. After Leslie's death, the Boot Hill materials, as well as other LCAS collections, were taken to the Hobbs landfill by mistake. Dr. Smith subsequently went to the landfill to retrieve the materials but he was unable to find them.
5. Dr. Smith said that he had no knowledge of what happened to the human remains removed from the site during the LCAS excavations, either at the time of removal or at present, or by the Boy Scouts prior to LCAS's work.
6. To his knowledge, Dr. Smith is the only surviving member of the LCAS that participated in the 1957–1958 excavations.
7. Dr. Smith said the artifacts exhibited spatial variation at the site, specifically, obsidian occurred in the northern. He also said the site had a greater diversity of pottery types than he has seen at any site in the area. He attributes the blackness of the soil to organics and development of a midden. In addition, the nearby seep or spring indicates a reliable water source and probably lengthy occupations at the site.
8. Professional archaeology in New Mexico at the time was focused nearly exclusively on Puebloan materials, and there was little being done in southeastern New Mexico either to investigate or protect cultural resources. LCAS tried to address these gaps through their work, first through surface recording and collecting and then excavations.

Conclusions

TRC attempted to locate members of the LCAS and Boy Scout troop that excavated at the Boot Hill site in the late 1950s. TRC concludes virtually all material and notes from early archaeological work at the Boot Hill site are irretrievable. The few stone tools in Dr. Smith's collections are the only confirmed materials from LCAS's 1957–1958 excavations, and no material from the Boy Scouts' excavations have been identified. TRC was unable to locate the human remains the Boy Scouts and LCAS removed from the site.

Table 1 Summary table of informants for the Boot Hill site (LA 32229)

Name	Affiliation	Relationship to Boot Hill site, Comments
Harris, Jim , Director, Lea County Museum, Lovington, NM		No collections from Boot Hill site; forwarded Graham's inquiry to Calvin Smith for response.
Speth, John	Museum of Anthropology, University of Michigan, Ann Arbor, Michigan	Has Leslie notes and photographs only from the Merchant Site, and not Boot Hill. Confirms that the rest of the material was taken inadvertently to the Hobbs city dump.
Smith, Calvin	Executive Director of the Western Heritage Museum Complex at New Mexico Junior College, Hobbs, New Mexico	Founding member of LCAS, participated in excavations at Boot Hill. Retained approximately 42 chipped stone artifacts from the 1957–1958 excavations.
Leslie, Robert (Buster, Bus)	LCAS member, participated in the 1957 and 1958 excavations at the Boot Hill site	Deceased. Had possession of most of the Boot Hill artifacts and notes, but these were discarded after his death.
Thibodeau, Anthony, Collections Manager, Archaeological Research Collections, and Julia Clifton, Curator of Archaeological Research Collections	Museum of Indian Arts and Culture/Laboratory of Anthropology, Santa Fe, New Mexico	Collections from LA 32229 consisting of one bag of lithics and sherds collected during a survey by the BLM in 1989.
Corley, John	LCAS member, participated in the 1957 and 1958 excavations at the Boot Hill site	Could not locate – deceased?
Leslie, Mark	LCAS member, participated in the 1957 and 1958 excavations at the Boot Hill site	Could not locate – deceased?
Cress, Jonnie	LCAS member, participated in the 1957 and 1958 excavations at the Boot Hill site	Could not locate – deceased?
Webb, Tony	LCAS member, participated in the 1957 and 1958 excavations at the Boot Hill site	Could not locate – deceased?

Appendix J: Lea County Archaeological Society (LCAS) Site Report for the Boot Hill Site

BULLETIN 2

THE BOOT HILL SITE
L.C.A.S. B-5

A PRELIMINARY REPORT

LEA COUNTY ARCHEOLOGICAL SOCIETY

HOBBS NEW MEXICO

BY:
JOHN A. CORLEY and
ROBERT H. LESLIE

April, 1960
Reprinted March, 1965

Harvey R. Hicks
1510 Grant
Carlsbad, New Mexico

BULLETIN II

THE BOOT HILL SITE

L.C.A.S. B-5

A PRELIMINARY REPORT

By
John A. Corley and
Robert H. Leslie

April, 1960
Reprinted March, 1965

ACKNOWLEDGMENTS

Grateful acknowledgments is made bt the authors to our fellow members of the LEA COUNTY ARCHEOLOGICAL SOCIETY who generously contributed to the writing of this report.

Special indebtedness is acknowledged to Mr. Stewart Peckham of Santa Fe, N.M. for his help in pottery identification. To Mrs. Kathryn Morris for typing and editorial assistance. To Mr. John Runyan for assembling and publishing.

Hobbs, New Mexico
April, 1960

John Corley
Robert Leslie

Special acknowledgments is made to Mrs. Joe Helen Sparger and Mrs. John W. Runyan for retyping this bulletin, and to the many people who helped in reprinting and assembling.

March, 1965

Editor
John W. Runyan

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THE BOOT HILL SITE

L.C.A.S. No. B-5

A Preliminary Report

by

John Corley and Robert (Buster) Leslie

During the summer of 1957 and that of 1958, members of the Lea County Archeological Society carried on excavations at a site located in northeastern Eddy County, New Mexico, some six miles northwest of Maljamar, and one mile west of the Caprock (at this point known as Mescalero Ridge.)

At that time we were a newly-formed society and in need of a site for our members to work together under supervised and controlled methods of excavation. All we had located in our local area at that time were open campsites, usually long blown out and below the original occupational level. We were fortunate to discover the Boot Hill Site, although it is quite a distance (some 66 miles from Hobbs) for a weekend amateur to travel.

Everyone was very enthusiastic the first few weeks, but as the artifacts were few, the weather hot, and the dirt black, soon the fever began to cool until, by the end of the second summer, digging was about at a standstill.

We have hesitated in preparing this report, hoping to secure more data from the site, but it is advisable that we report what we have collected before some of the information is lost or misplaced. We were able to preserve all of the potsherds from the site, but will be lacking information on a few of the other artifacts. Each individual kept the items he found, and some have since moved away and failed to report all the items found. From records that were kept during the excavations, however, we feel that very little will not be included in this report.

The site sits atop a small hill along the edge of a large (for this region) dry creek or "draw" which was possibly the inhabitants' water supply. At the time of occupation, there may have been springs up along the Caprock which have long since gone dry. (Fig. 3) Tradition has it that many such springs were still flowing shortly after the turn of the century, but the writers know of none now. We do believe, though, that this is not an indication of a difference in rainfall, although that is possible, but rather because of the pressure relieved by many water wells drilled and water removed from the ground up on the Caprock. The refuse covers practically the whole top of the hill. Measurement from east to west, approximately 250 feet; from north to south, 200 feet. As shown (Fig. 3) a pipeline and road cut through the east side of the hill. The site would have been difficult to reach had it not been for that road.

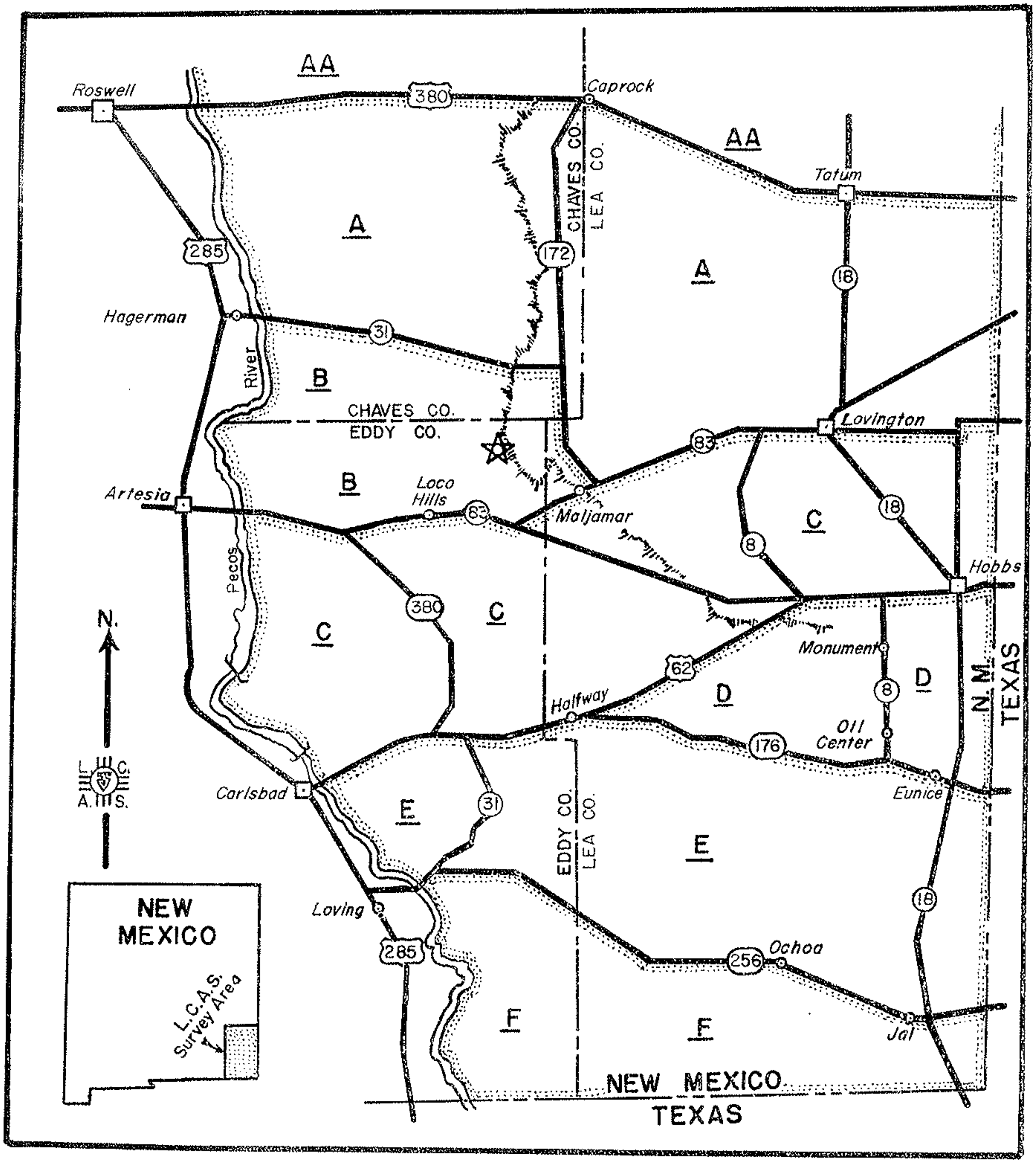

FIGURE 1. Site survey area. ☆ location of the Boot Hill Site, B-5.

BOOT HILL SITE MAP.

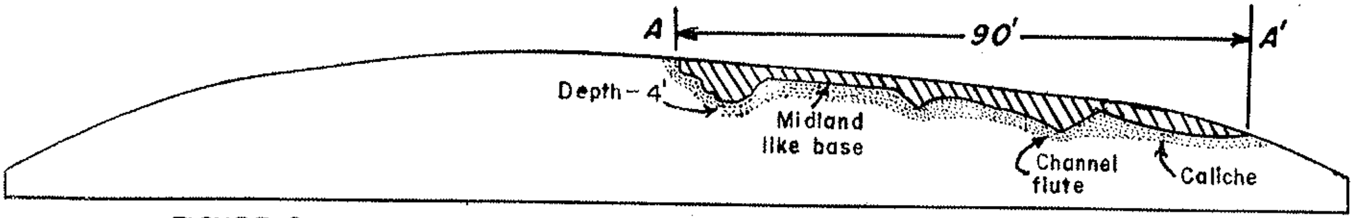

FIGURE: 2

Cross section A-A' (As determined by 90' x 5' trench).
Depth of excavation 6" to 4'.
Horizonal scale 1" = 30".
Vertical scale: none.
▨ section excavated.

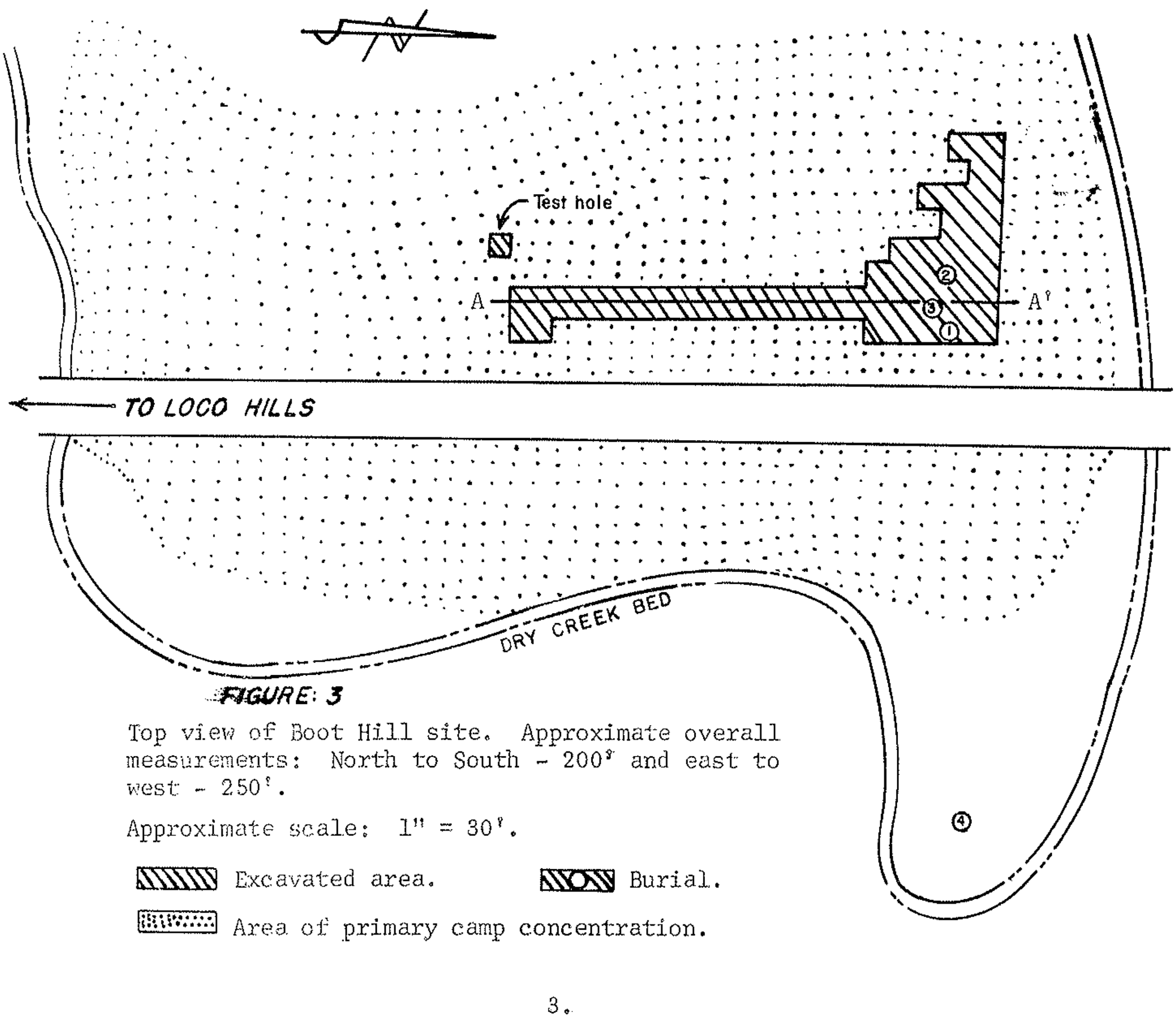

FIGURE: 3

Top view of Boot Hill site. Approximate overall measurements: North to South - 200' and east to west - 250'.

Approximate scale: 1" = 30'.

▨ Excavated area. ▨ Burial.

▦ Area of primary camp concentration.

The site is different from other sites in this area in that instead of blowing and weathering down, it built up. The refuse will vary in depth from a few inches to some four feet. (Fig. 2) The soil is unusually black, and a large amount of burned rock of various sizes is present at all levels.

Excavations were started on two 30-foot by 30-foot blocks, (1 and 2) which were divided into six strips 5 feet wide. Each strip was divided into six 5-foot squares. The strips were numbered 1, 2, etc., and the squares A, B, C, etc. Each square was taken off in 6-inch layers, screened through a quarter-inch screen, and all items recorded as to the locations in which they were found. No different occupational strata or levels were recognized. Due to weathering, the refuse seemed to be turned unside down. The concentrations probably were at one time confined more to the center of the hill, but have since weathered down the slope of the hill, and if there was a difference in strata, it has been obscured by the shifting action. This being the case, we are using only two levels in our report. Considering the first six inches as the top or surface level, and reasoning that the rough holes and ditches that covered the hill before any occupation occurred on the site (Fig. 2) would be filled first, and within a relatively short period, before any other buildup would take place, we are considering it as one and the same level, even though there is a variation in depth.

Block 1, was completely excavated, with Strip 2 of this block carried for 90 feet to the crest of the hill (See Fig. 2 for cross-section and Fig. 6 for sherd chart). Along near the end of Strip 2, the fill was only six inches deep and the absence of so much burned soil indicated that at one time this area had been uncovered to the hard caliche that covers the top of the hill. Within the area designated as "Q", the depth was greater, and was excavated to four feet. From the "bank" or wall of this hole, plus the presence of a large amount of large unburned rock in the fill (which was left in place), we thought it could possibly be a pitroom, although, we could not detect any difference in the color of the soil: It was all black. As our time was limited, it was some two or three weeks before we could return to the site. When we did we found a mountain of large stones thrown out of our excavation, and any evidence that may have existed completely destroyed. We tried to find traces within the strip just to the east, but saw nothing to indicate the presence of a pitroom. At present, Block 2 has been about one-half excavated.

The following pages will contain the data as it was found during our diggings. We have tried to be as accurate as possible, but are sure mistakes have been made.

BURIALS

Three burials have been uncovered from the excavations, and one is known to have been uncovered out on the point of the hill, east of the concentrated part of the site.

BURIAL NO. 1: Located in Block 1, Strip 1, Square C. The pit was some eight inches into the caliche, and 24 inches below the present surface. Was a small child, age six to 12 years, badly deteriorated, sex undetermined (no study has been made). Head to the south-southeast, tight flex, on right side. Clutched in right hand were three small polished bone discs. Two fresh water mussel shell teardrop-shaped pendants were found near the head, indicating they probably had hung around the neck. No burial cairn was present.

BURIAL NO. 2: Located in Block 2, Strip 2, Square B. Also of a small child, age and sex undetermined. Pit was dug down to the natural caliche, some 18 inches below the present surface. Head to the south, tight flex, and lying on left side. No burial cairn or mortuary offerings present.

BURIAL NO. 3: Located in Block 1, Strip 3, Square D. Also of small child, age and sex undetermined. Pit was dug into natural caliche six inches, 24 inches below the present surface. Head to the south-southeast, loose flex, on right side. A burial cairn which consisted of three large stones was present. There were no mortuary offerings.

BURIAL NO. 4: This burial was uncovered by a Scout Troop a few months before we began our excavations. No information known except that a small string of some 90 shell beads (type unknown) was found with it.

DESCRIPTION OF ARTIFACTS FOUND

The artifacts found would be considered few in number. The people seem to have had only the bare necessities. Some of the items recovered show skilled workmanship, but most of them are crude, with only enough work on them to make them useful.

GROUND-STONE

MANOS: With the exception of the one cylindrical pestle type, the manos were all one-hand oval Plains type, with one and two grinding faces. A total of 11 were found on the surface and from the excavation, along with several fragments.

METATES: Only fragments have been recovered. These indicate they were of the Plains milling stome, slab-and-basin type. None of the trough type has been noticed. Fourteen were found.

HAMMER STONES: Two were discarded "cores" or chunks of material, The remainder are round, or near-round, natural stones. Most of them were well worn from use. Fourteen were found.

POLISHING STONES: Many small pebbles were found that could have been used as such. Only three showed wear or polish from use. One of these was rather large with two polishing faces.

and had either been shaped or had been used as a hammer stone. The other two were small pebbles with the surfaces smoothed and polished from use.

MISC: Other ground items included a fragment of a small rectangular, thin stone with well-ground, beveled edges. Made from very fine-grained sandstone. The back side was unfinished, while the face was ground flat. Several small, shallow grooves or scratches in the face may indicate that it was used to grind small objects, possibly ornaments. Another object was a fragment of an incised plaque, or similar item. Made of a thin slate or shale-like material. The incisions included a number of geometric design elements.

ORNAMENTS

Nineteen beads and pendants of the following materials were recovered from the excavations. None was reported from the surface.

SHELL: Eleven items were found in several forms:
1. Small, snail-like shell with hole in center.
2. Three triangular-shaped pendants of fresh water mussel shell. Two have a hole in one corner, the other has two. All small.
3. Four tear-drop shaped pendants made of frest water mussel shell with holes in the smaller ends.
4. Three flat, disc-shaped items of fresh water mussel shell without holes.

BONE: Seven bone items were found.
2 cylindrical, 2 cm. in length, made from the leg bone of some type fowl.
Five disc-like beads.
Also may include the two small bone discs found with burial No. 1.

IVORY: One fragment of a cylinder-shaped ivory bead was found.

WORKED SHERDS: Two worked sherds were found. Both were Chupadero B/W. One is round with a diameter of 2.5 cm., the other is rectangular in shape with a length of 2.5 cm., and a width of 1.2 cm.

MISCELLANEOUS

OBSIDIAN: One small obsidian point was found. Type: Side notched concave base, fine chipping. Also a small number of chips or flakes.

OTHER chips and flakes were scarce, as was any kind of waste material which may indicate that very few of the chipped stone items were made on the site. Practically every piece of material had been converted into some useful object.

OCHRE: A few small pieces of red ochre were found. The larger number has ground faces.

FOODSTUFFS

Many animal and fowl bones were found scattered throughout the excavations. A few "pockets" or concentrations were noticed, otherwise they were rather thin and occurréd at all levels. Some we were able to identify as deer, bison, rabbit, plus various types and sizes of fowl.

A few fresh water mussel shells were found, indicating that mussels could have been used as food.

No evidence of agriculture has been foumd at this time, although the appearence of the site itself indicates farming could have been practiced.

CHIPPED STONE TOOLS

Only a small number of items of this class have been found. There are very few knives of any type found on local sites, but usually one will find many scrapers of various types.

KNIVES: Five wre found, of the following types:

1. Base-tang, (A,Fig. 4) shows the blade to have been re-sharpen ed until rather thick, also very dull from use.
1. Leaf-shaped, (B, Fig, 4). Poor workmanship and material.
1. Broken, leaf-shaped, (C, Fig. 4). This blade also shows some signs of being re-sharpened.
1. Uni-face oval flake. Could have been more of a scraper.

DRILLS: Only two were found.
One has point broken; small, with worked base (D, Fig. 4).
One has fine worked point, but base is unworked (E, Fig. 4).

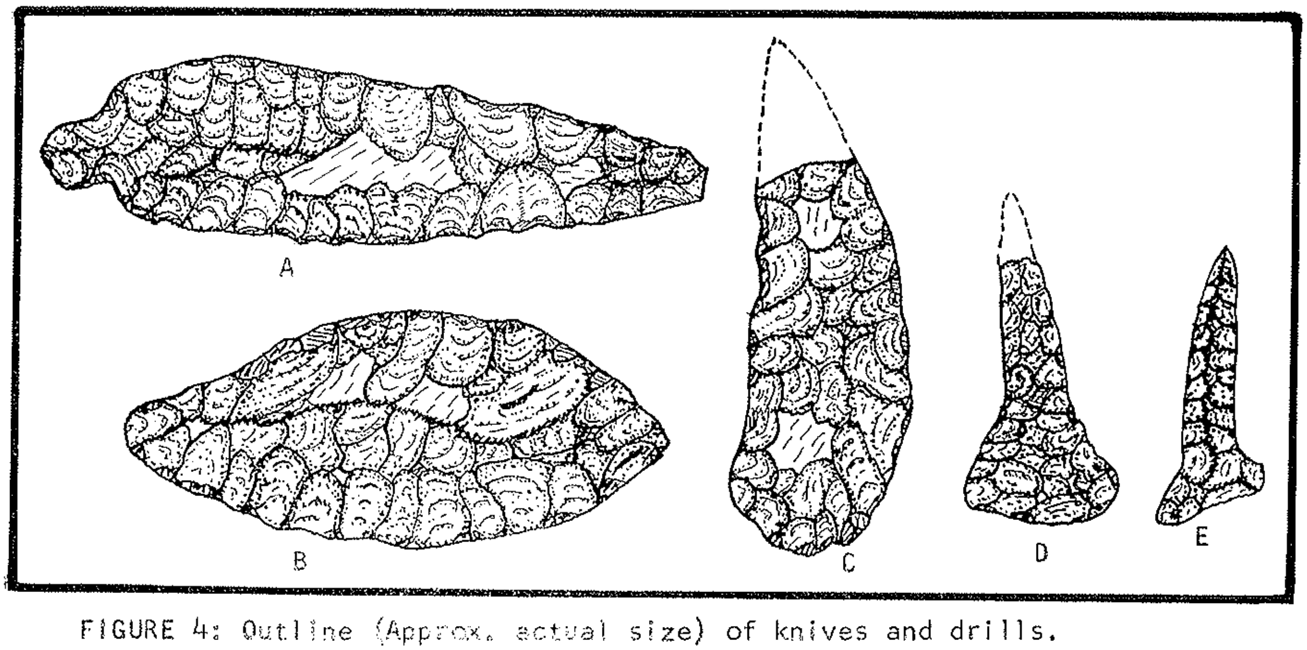

FIGURE 4: Outline (Approx. actual size) of knives and drills.

SCRAPERS: Only 20 scrapers of various sizes were found throughout the digging. We consider this number unusally small as compared with other sites in the area.

Two were small, thumbnail, fine chipped.

Four were medium-sized oval disc-shaped, two very well worked, the other two worked about half-way around.

Five were small and medium, snub-nosed or turtle-back, all crudely worked.

Five were medium sized, side-and-end, two worked slightly on two sides, one only on one side. Two are end scrapers, worked on only one end. All are poorly made.

Four were flakes, medium sized, only small amounts of flaking on side or end.

GRAVERS: Two gravers were found. Both made from thin flakes chipped to a fine point.

CHOPPERS, HAND AXES OF ANY TYPE: None.

FLAKING TOOLS: None.

BONE AWLS: One complete and one fragmentary bone awl. Both were of the split section of the leg bone of deer or antelope.

PROJECTILE POINTS

For lack of significance, no great amount of emphasis is usually placed on projectile points when associated with the Pueblo cultures, but within this region, we have a great deal of overlapping of Plains and Pueblo people, along with a lengthy time span usually indicated. Therefore, we believe that they may have some significance at the Boot Hill Site, if only suggest occupations prior to the pottery complex.

A total of 127 points has been recorded from the surface and diggings. (As there was no apparent difference in the locations they were found, we have not separated them in this report). We have loosely separated them into similar types that appear most often, and into several others that occur once or so. Lacking photographs, we are including an outline of some of the variations of these types (Fig 5 and 6), which, of course, will show only the shapes of the points. Many of these can easily be classified according to the classifications used by the Texas Archeological Society. Others have what we call "the Pueblo look", an expression we use among ourselves in noting a difference between a Central Texas type and a similar type from the Pueblo area, or similar comparisons. From our experience with the two versions, we may think we notice a difference when it is still doubtful if any such difference exists.

Following is a brief description of the more common variations of each type as we have grouped them. We have also included some of our own suggestions and comparisons, along with some speculations.

GROUP 1: Small arrow point, usually showing fine chipping. As shown in Fig. 5, several minor variations are present. They may be condensed to some three or four major differences, as the following: Side notches with concave base, side notches with convex base, side notches with straight base, and also some difference in the width and depth of the notches as in A and D. Length, from 1 to 3 cm., width from 1 to 1.5 cm., usually very thin. The common version very often to be found along with these points, with the third, or basal notch, is absent from those found at Boot Hill. These would probably be typed as Harrell Points, according to the Texas system, but we would say they have that "Pueble look." Similar points occur to the east north and south of this area, but more so to the west and northwest. We rather think these points are associated with the pottery on the site. In number, this type is the most common found. We have placed 37 in this group, including identifiable base fragments.

GROUP 2: Small arrow point, triangular in shape. Some show fine chipping, while others are rather crude. Usually very thin, although the cruder ones are sometimes thicker. Length 1.5 to 3 cm., width 1 to 1.5 cm. The more common variations in this type are: expanding or flaring, concave base, rounded or convex base, and some with straight bases. This type found along with Type 1 over a wide area. Would probably be typed as Fresno points according to the Texas system. We rather think these points also are associated with the pottery at this site. Number placed in this group, 19.

GROUP 3: Small arrow point. Length 2 to 3 cm., width, 1.5 to 2.5 cm. Some show fine chipping, others are rather thick and stubby. All have minor differences or variations, such as narrow and wide corner notches, long and weak barbs, some with only strong shoulders: stems straight and expanding, bases both straight and convex. Possibly a small number placed in this group could be typed as Scallorn Points by the Texas system, but they, too, have that "Pueblo look," and don't seem to have any standard form or shape. Similar points occur with pottery on many local compsites, but never in large numbers. We, therefore, suggest that these points are associated with the pottery. Number placed in this group, 11.

GROUP 4: Small arrow point. Length 2 to 3.5 cm., width, 1 to 2 cm. These points show good chipping in part, but with the deep serrations and projecting barbs, they appear crude. The barbs and serrations are somewhat uniform in some, but the larger number appear to have been chipped in a haphazard sort of way. With the exception of one point (E, Fig. 5) all placed in this group have expanding stems and straight or convex bases. Although some are possibly variations. or re-works of other types, as a whole they seem to represent a variety of the Livermore Point. Similar type points and pottery types found at Boot Hill are found with "classic" or "typical" Livermores on many local campsites, especially farther south. Although we are unable to place these as being associated with the pottery, we are also unable to separate them from it, as they occurred at all levels, with three found on the surface. That they were found in such large numbers would suggest a definite type and not "miss-makes", or the results of the makers' wild imaginations. We believe these points may be of important diagnostic value to the site although more work will have to be done to bear out that opinion. They occur second in number, 21.

The following types, with the exceptions of Type 8, aa and bb, could possibly represent one general type. Nevertheless, we have separated them, to some degree, into similar versions, as there appear to be somewhat different types present. It is questionable whether some of these are arrow or dart points, so we will refer to them as projectile points. Their relationship to the pottery is unknown, but the occurrence of some of these types possibly suggests an occupation or occupations earlier than the pottery users.

GROUP 5: Small projectile point, thick, usually rather crude. Length 2.5 to 3.2 cm., width 1.5 to 2 cm. Wide corner notches, weak barbs or strong shoulders, expanding stems, convex bases. All placed in this group are similar in size, shape, and workmanship, but differ in materials. Similar to small Pallimias Points. The relationship of these points with the pottery on the site is unknown. The estimated age of the Pallimias Point is somewhat older than the dates given to the pottery, which may suggest these points are older. Number placed in this group, 8.

GROUP 6: Small to medium-sized projectile point. Length 2.5 to 3.5 cm., width, 2 to 3 cm. Short to long downward barbs, wide expanding stems, convex bases. A very common type on local sites. Has created quite a lot of curiosity and speculation among some of our local amateurs because of the circumstances under which tyis type occurs. Now and then various types are found that show re-working on the point. An unusually large number of this type appears to have been reworked. Two small sites known to the writers have yielded only similar points. On one site, six of this type with five re-worked, on the other, four with two showing reworking. No pottery or other artifacts were found, only small amounts of burned rocks and broken fragments of sandstone. They are found on both small and large concentrated sites, with pottery and without. It is impossible to determine any sites to place them, but (purely speculation) if a type point can be attributed to the late Plains people (such as the Apache, Commanche, etc.) this would be our first choice. Number placed in this group, 9.

GROUP 7: Medium-sized projectile point. Length, 3 to 4 cm., width, 2 to 2.3 cm. Usually outward projecting barbs, caused by wide, deep corner notches. Short expanding stems, convex bases. Three of this number are of identical material. Points similar to these, of similar materials, have been observed from rock shelter sites near Fort Davis and Sanderson, Texas. Number in this group, 5.

GROUP 8: Those placed in this group are very similar to Early Man types in shape, chipping, etc., but lack the usual ground edges. Leaf-shaped blades, bases concave and straight. Length, 3.5 to 4 cm., width, 1.3 to 2 cm. Very fine pressure flaking. B is of a grainy type material and chipping is poor. A has side broken, and possibly was never finished. Very similar in shape and material (without flute) to a fluted point of the Clovis type, found by one of members about 300 yards east of the site while we were excavating. Until more evidence of Early Man is found, we will have to place this type as Archaic, possibly very early in that stage. Number placed in this group, 6.

GROUP 9: We have placed three points in this group that possibly are of the same type as those in Type 5; just a larger variety. Only one was complete. It had a length of 5 cm., a width of 3 cm. The other two were broken on the point and possibly could have been longer. Corner notched, expanding stem, convex base. These would be Pallimias Points according to the Texas classification, and likely are intrusive from the nearby area to the east or southeast.

GROUP AA: This is the only one recovered that can be identified as an Early Man Point. It is very fragmentary, but as near as can be determined, it is of the Midland type. Has pronounced grinding on the basal edges, also basal thinning. Was found up near the crest of the hill in the 90-foot trench on top of the original caliche. It is unknown at this time whether it was left from an Early Man occupation, or a later intrusion by a later individual.

MISC. Seven other points of various types not fitting any of the above types were found.

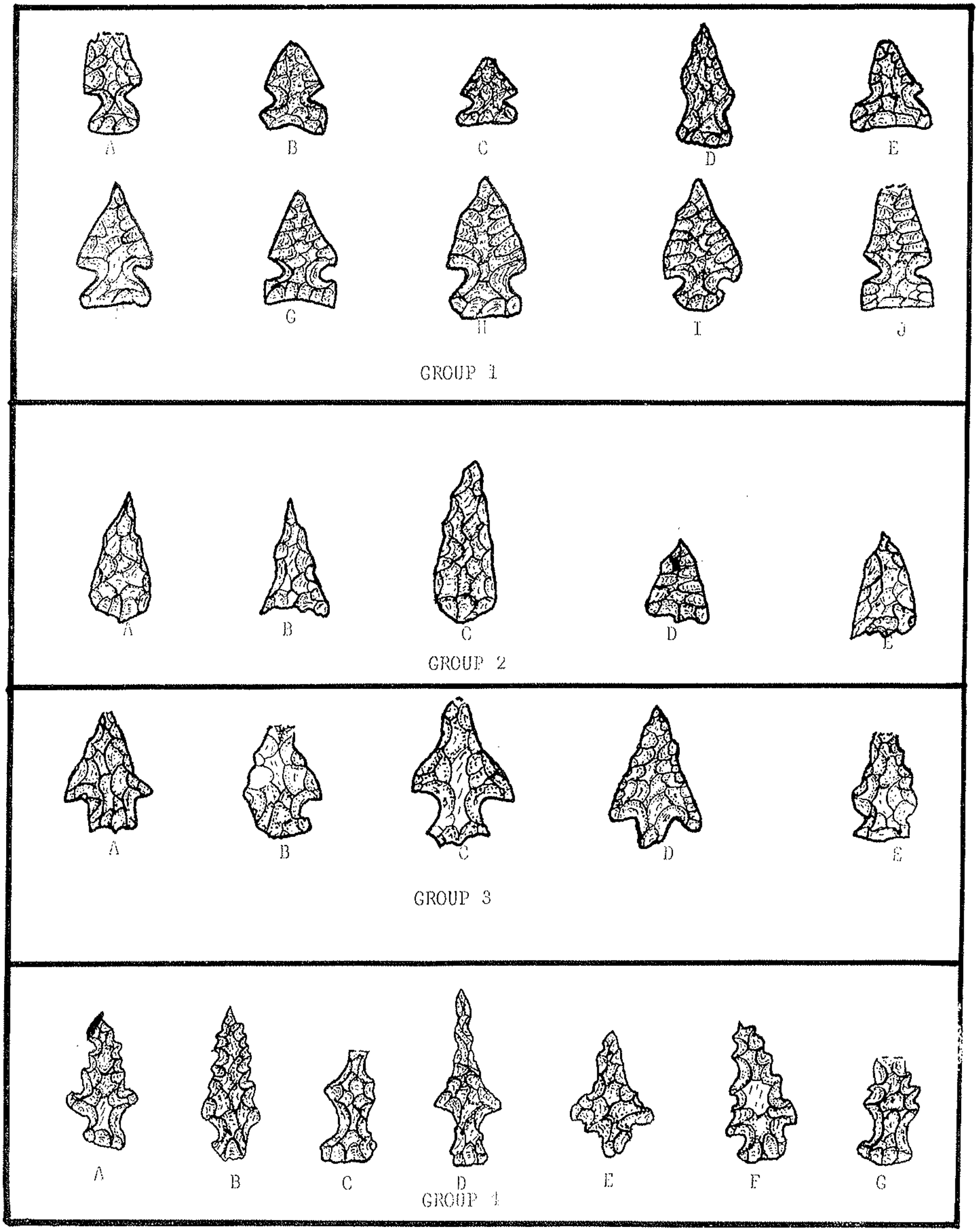

FIGURE [illegible]: Boot Hill projectile Point Types. Approximately actual size.

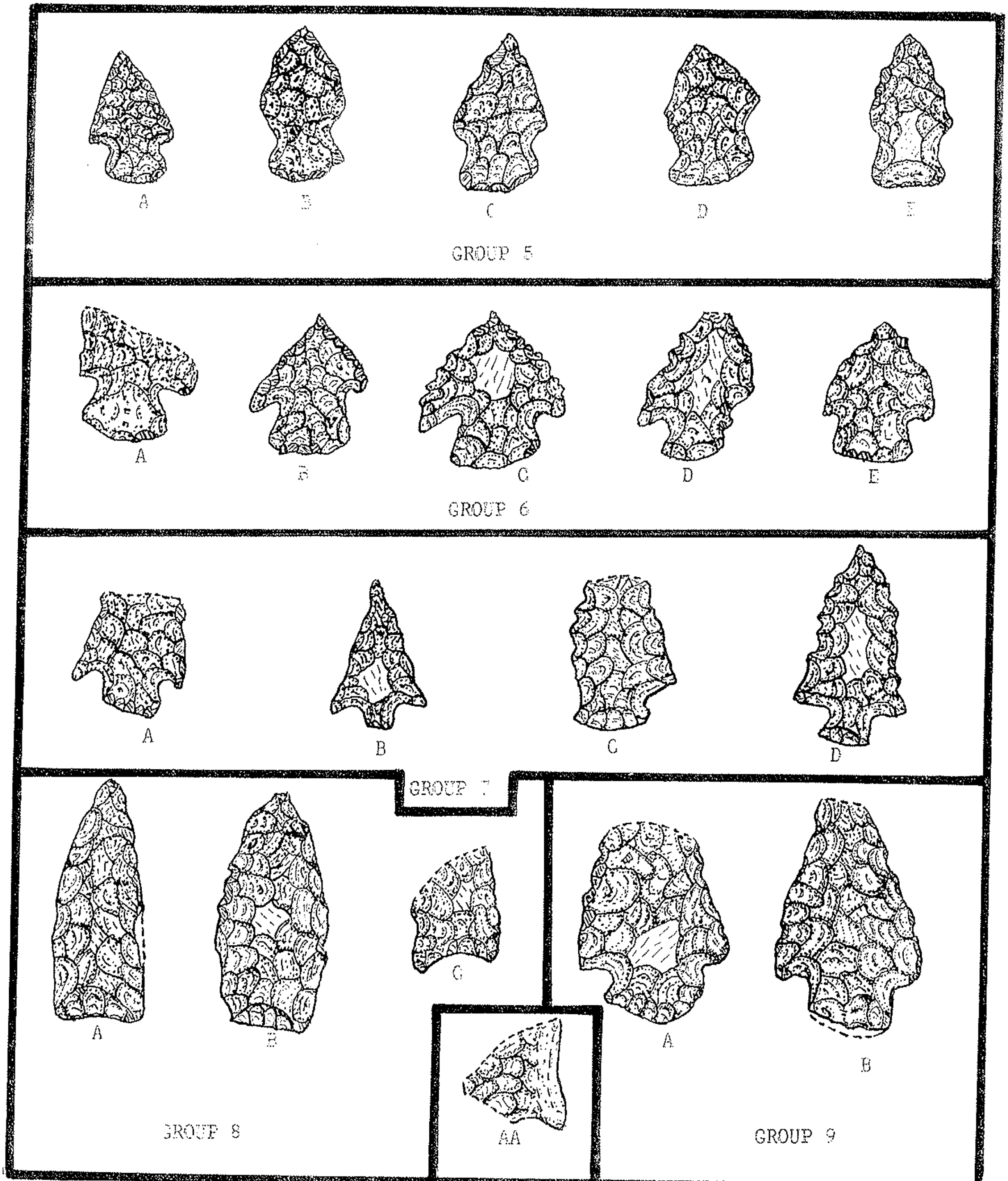

FIGURE 6: Boot Hill projectile point types (continued). Approx. actual size.

POTTERY

Pottery appeared only in sherd form. A total of 961 sherds was recovered from the site. Enough sherds of one vessel were not found to determine size or shape, except that both large and small bowls and jars were indicated. We will briefly describe some of the types listed in Fig. 8. The types not discussed are typical sherds to their respective types and we will omit a description of such pieces.

CHUPADERO B/W WITH EXTERIOR CORRUGATIONS: Eleven sherds of this type were found. This was the first time for this variety of Chupadero to come to the attention of the writers. Since then, it has been noticed in a number of other sites.

JORNADA BROWN: The sherds in this type (45% of total sherds) are all the brown sherds not identified as El Paso Brown or El Paso Ploychrome. They could be divided into separate types as to smoothness, polish, range of color, etc. These seem to be minor differences, as they all seem to remain within one type, so we have considered them all as Jornada Brown.

JORNADA RED/BROWN: These 12 sherds are identical to Jornada Brown with the addition of wide red lines (as if drawn with finger) with no apparent form or pattern. Three are jar sherds with large blotches of red near the rim on exterior.

EL PASO BROWN: Forty-eight sherds have been placed in this type. Possibly they are unpainted sherds from Polychrome vessels, although many of them are thicker than the usual El Paso Polychrome sherds.

TERRACOTTA BODY-PLAIN RED BODY: As no Lincoln Black/Red (with decorations) was found, these may be all undecorated body sherds of Three Rivers Red/Terracotta.

RED WASH: Similar sherds of this type are mentioned by many writers as occurring on most sites reported belonging to the Jornada Branch. They have been mentioned as a variety of the Three Rivers and Jornada types. Very little can we add, as they appear in both bowl and jar forms. Some have interiors decorated with a thin, blood red fugitive paint in the appearance of a wash. Others are decorated on the exteriors, while two of the sherds have the wash on both the interior and exterior. In paste, texture, and color, some are similar to Jornada Brown, others have a strong resemblance to Three Rivers Red/Terracotta.

MIMBERS CLASSIC BLACK/WHITE: We have used the term "Classic" as six of these eight sherds can be so typed. It is possible the other two could be Bold Face.

The only type that could be termed intrusive, or foreign, possibly is the Mimbres Classic Black/White. The Three Rivers and El Paso types probably are intrusive to the site, but not to the

D	E		F		G		H		I		J		K		L		M		N		O		P		Q		R		TOTAL
2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
-	-	-	-	-	-	-	-	-	11	2	1	21	15	1	19	-	5	-	3	-	1	-	1	-	10	2	10	16	140
																											1		1
													3		1														4
	2	4	3	3		2		5	10	2		3	11	4	3		6		2		1		3		7	6	3	17	124
													4				3											2	9
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	1		1										1	1											4	2	3	4	21
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		1								2							2				2		1		1		2	1	15
-	3	4	5	3	-	2	-	6	24	6	1	24	35	7	23	-	17	-	5	-	5	-	4	-	22	10	21	44	333

SHERD CHART II

POTTERY TYPES	90' TRENCH	ALL OTHER EXCAVATIONS	ALL EXCAVATIONS	SURFACE	TOTAL SHERDS FROM SITE	PERCENTAGE OF TOTAL
Chupadera B/W	140	182	322	8	330	34.3
With Corrugated Exterior	1	10	11	-	11	1.1
Casa Colorado B/W	4	14	18	-	18	1.9
Jornada brown	124	256	380	54	434	45.0
Jornada Red/Brown	9	3	12	-	12	1.1
Jornada Polychrome	-	-	-	-	-	-
El Paso Brown	21	18	39	9	48	5.0
El Paso Black/brown	-	-	-	-	-	-
El Paso Polychrome	4	12	16	3	19	1.9
Three Rivers R/TC N.L.	3	6	9	5	14	1.4
Three Rivers R/TC B.L.	2	3	5	2	7	0.7
Terra Cotta Body	3	7	10	7	17	1.8
Plain Red Body	1	3	4	2	6	0.6
Lincoln B/R	-	-	-	-	-	-
Plain Corrugated Brown	3	2	5	-	5	0.5
Indented Corrugated Brown	1	1	2	-	2	0.2
Mimbres Classic B/W	2	6	8	-	8	0.8
Red Wash	15	7	22	8	30	3.1
TOTALS	333	530	863	98	961	99.9

FIGURE 8: Sherd chart of total sherd collection from site, showing count and percentage of each type.

SHERD CHART III B-5

TYPE	TOTAL No. of SHERDS	PERCENT of TOTALS
UTILITY WARES	489	50.9
PAINTED WARES	472	49.1
UTILITY WARES		
Jornada Brown	434	88.7
El Paso Brown	48	9.8
Plain Corrugated Brown	5	1.0
Indented Corrugated Brown	2	0.5
TOTALS	489	100.0
PAINTED WARES *		
Chupadero B/W	330	69.7
With Corrugated Exterior	11	2.2
Casa Colorado B/W	18	3.8
Jornada R/Br.	12	2.3
El Paso Polychrome	19	4.0
Three Rivers R/TC N.I.	14	2.4
Three Rivers R/TC B.I.	7	1.2
Terra Cotta Body	17	3.9
Plain Red Body	6	1.1
Mimbres Classic B/W	8	1.3
Red Wash	30	6.3
TOTALS	472	98.2

FIGURE 9 * Includes unpainted body sherds.

culture. With the occurrence of such small numbers of El Paso Polychrome sherds, and the absence of Lincoln Black/Red and Glaze I possibly suggests a terminal date of around 1300. The beginning of the occupation of the pottery users is undetermined at this time.

SUMMARY AND SPECULATIONS

Our excavations so far have revealed the following information much of which is of a speculative nature:

That the site was a favorite campsite within the area for many groups of several cultures over a period of possibly several thousands of years. Whether it was a lengthy occupation by any one group or culture is not known, but we rather think it to have been of seasonal nature, with the possible exception of the pottery phase which could have been, and most likely was, a continuous occupation for some length of time.

That the beginning of man's living upon the site probably started with Early Man, and continued from time to time into Historic times, although no evidence of the latter is present at this time. The presence of Early Man is but faintly indicated, represented only by a Midland-like projectile point base (which could have been brought in by a later individual), a possible channel flute (which, with the present evidence is really stretching ones imagination), and by the occurrence of other points similar to Early Man types (which at present will have to be considered Archaic types). With this little evidence, we are hoping future excavations will produce definite information of an Early Man occupation. If we are correct in assuming that the projectile points in Type 4 are of the Livermore type, future work is needed to establish whether from a pre-pottery occupation, or directly associated with it.

That during the Archaic and Neo-American stages, the site was occupied by Eastern groups, probably at short intervals by small nomadic bands.

That the bulk of the refuse or camp debris was contributed by a pottery using and making people belonging to the northern area of the Jornada Branch of the Mogollon Culture, possibly in the Capitan and Three Rivers Phase. The earlier phase probably would run parallel with L. A. Site No. 2000 (Penasco Bend), which is some 80 to 90 miles west. The appearance of such great amounts of Chupadero B/W suggests either a continued late occupation or a separate occupation by a separate people. We must admit that we have not been able to determine very much from our present work in regards to this pottery phase with thich we are the most concerned. The beginning of this occupation is undetermined, but the presence of a small amount of El Paso Poly chrome, and the absence of any Lincoln B/R or Glaze I Red possibly suggests a terminal date of around 1300 A.D. The fact that we strongly suspect the occurrence of some form of pitrooms on the site has prevented us from forming any conclusions until further work is done to prove or disprove our suspicions. Purely as speculation on our part, we should like to present the following discussions:

If the site were located 50 or 75 miles to the west, there probably would be no question but that pitrooms are present. The general appearance of the site, the refuse, the sherd collection are of no apparent difference from known pitroom sites. We believe the pottery itself suggests a confined group or groups closely related, and not many different groups from many different areas, as is evident on so many of our local campsites. It is not unusual for all the types that occur on the Boot Hill site to be found on Jornada Branch sites to the west. As it is apparent that the people were from the area where permanent dwellings were used in the form of either pit or surface rooms, why, then should they change their type dwelling and begin living in skin tents or similar type shelters? The fact that we have found no evidence of agriculture could be because we used a screen with too large mesh (one-quarter inch), because we are inexperienced in observing, or because within the refuse no evidence survived the time elements. It may be that no such evidence is present.

In the near future, we plan to continue working on the site as we are just now prepared to obtain information of a more valuable nature. As amateurs, our time is limited, and we are unable to put in as much time as we would like. The past year we have confined most of our time to a pitroom site located some 45 miles south of Boot Hill. It is a very interesting site, as it seems to be more Plains than Pueblo. Present evidence indicates one local pottery type, some 5000 sherds recovered so far: A brown-black finger indented, very crude and poorly made for the date suggested by the rather few intrusive sherds present (identified as Chupadero B/W, Three Rivers R/TC Narrow Line, El Paso, and St. John's Polychrome, Lincoln B/R, and Glaze I Red and Yellow). Other artifacts have led us to suspect it to be of the Bravo Valley Aspect, La Junta Focus, centered around Presidio, Texas. Much work and investigation will have to be done to bear this out.

Lea County Archeological
Society

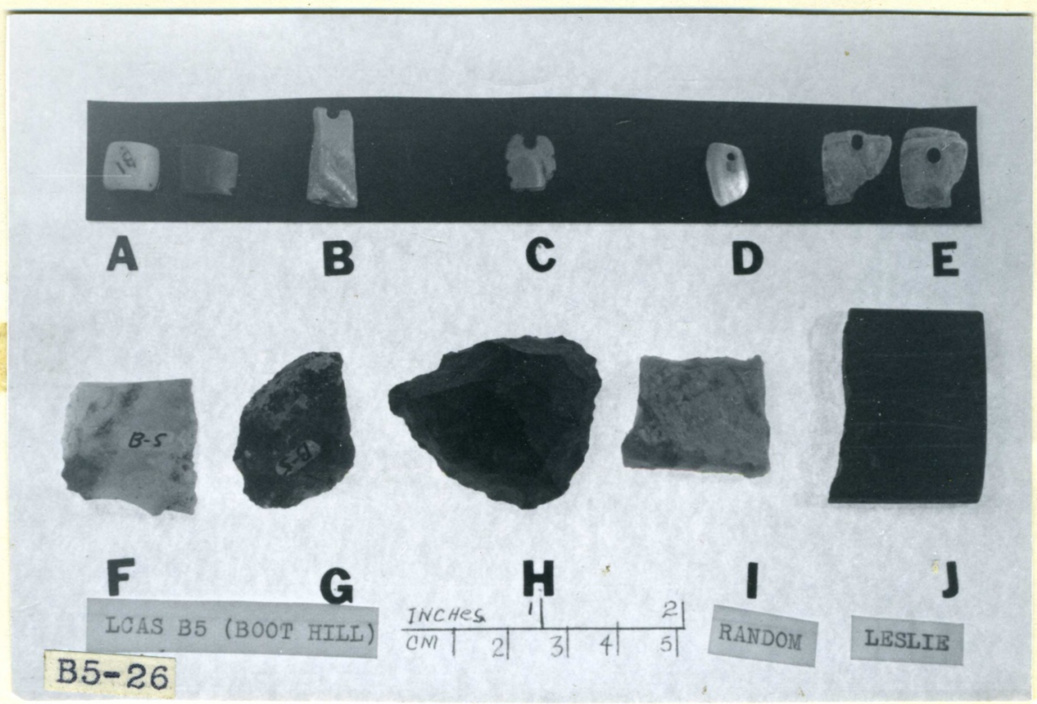
Hobbs, New Mexico

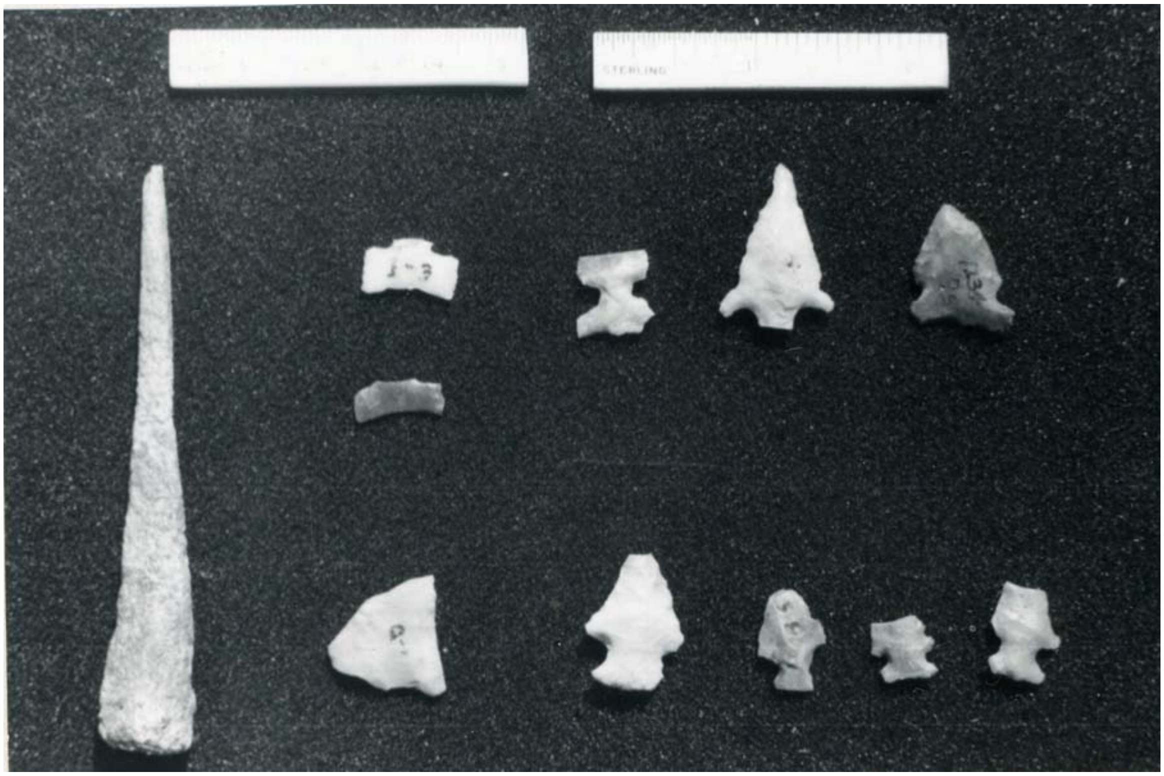
Appendix K: Photographs From the LCAS 1957–1958 Excavations at Boot Hill


INCH 1 2 3 4
RANDOM
BOOT HILL SITE-B5
LESLIE


INCH 1 2 3 4
RANDOM
BOOT HILL SITE-B5
LESLIE

Artifacts from Lcas B5, The Boot Hill Site




STERLING


INCH 1 2 3 4
RANDOM
BOOT HILL SITE-B5
LESLIE


INCH 1 2 3 4
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INCH 1 2 3 4
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LESLIE


B5-6
INCH 1 2 3 4
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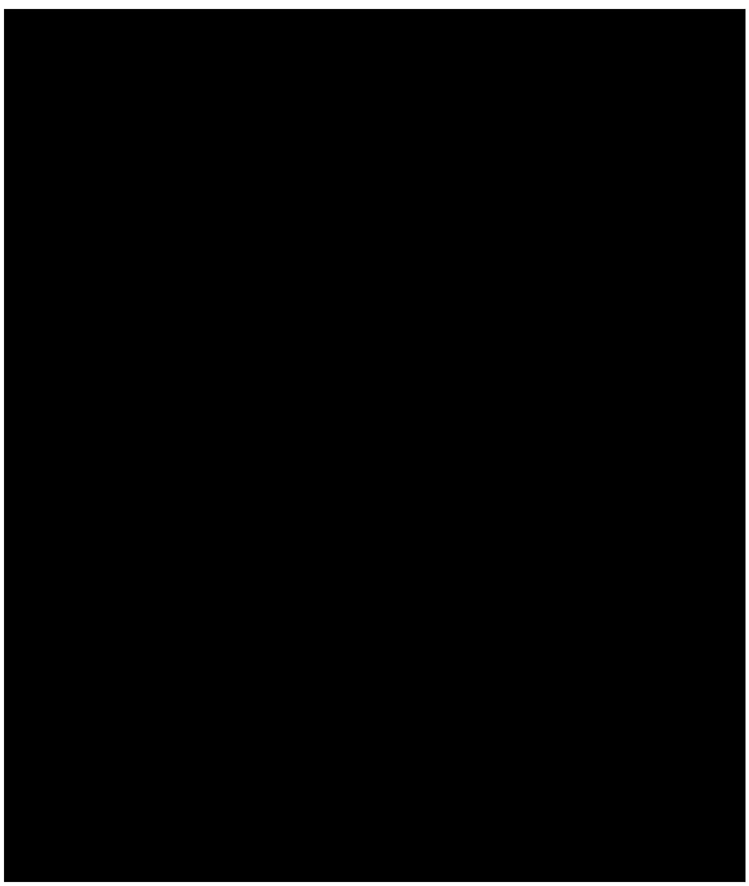
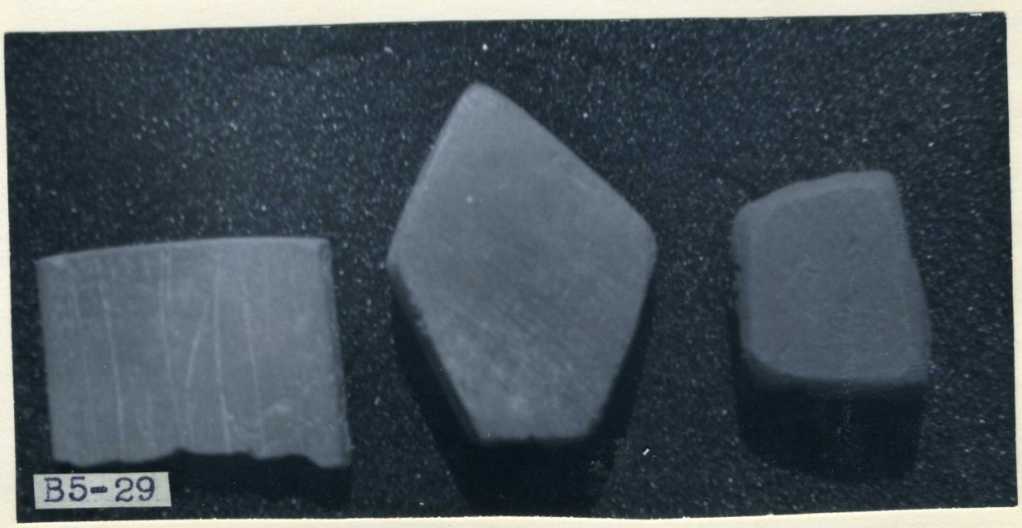
BOOT HILL SITE-B5
LESLIE



[redacted]

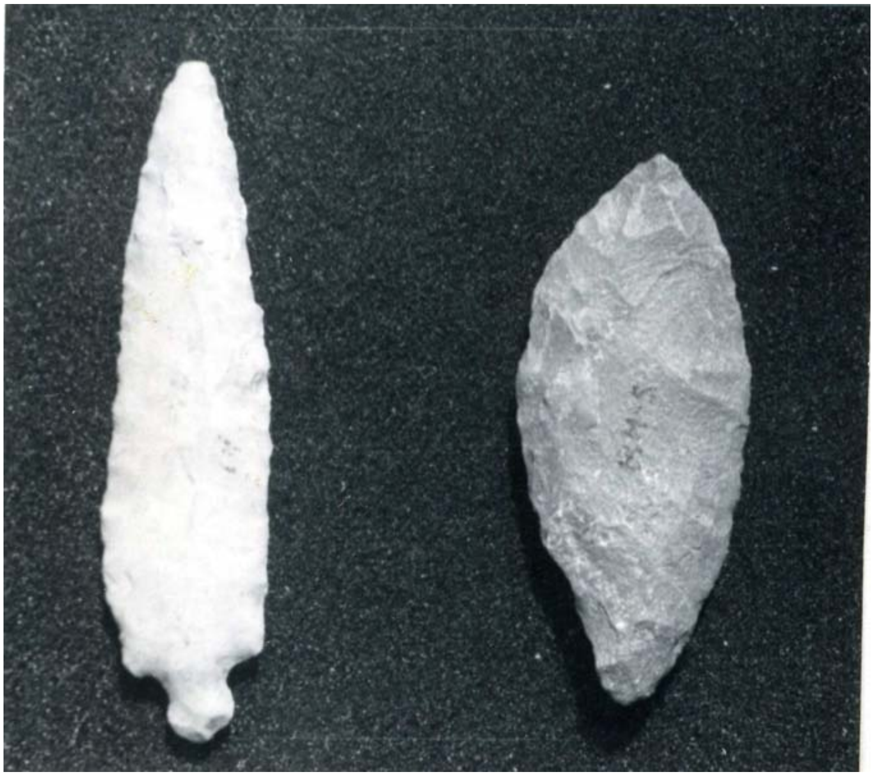
Ground stone artifacts
From LCAS B5 "BOOT HILL"



Ground stone artifacts
From LCAS B5 (BOOT HILL)

MARK Leslie Screening
At "Boot Hill" (Age 7)
(Faceing North)

The Boys swimming in "Bogle" TANK July 4, 1957 Tempeture 107%

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B5-10


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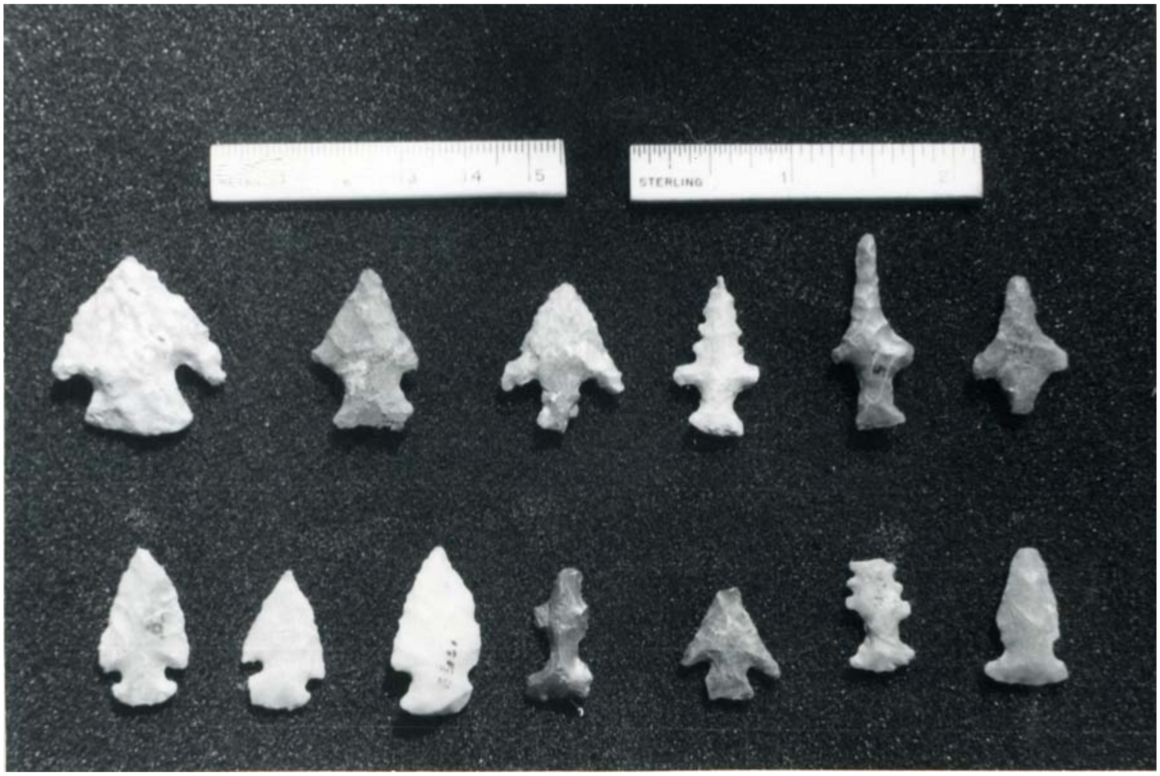
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LESLIE
BOOT HILL SITE—B5

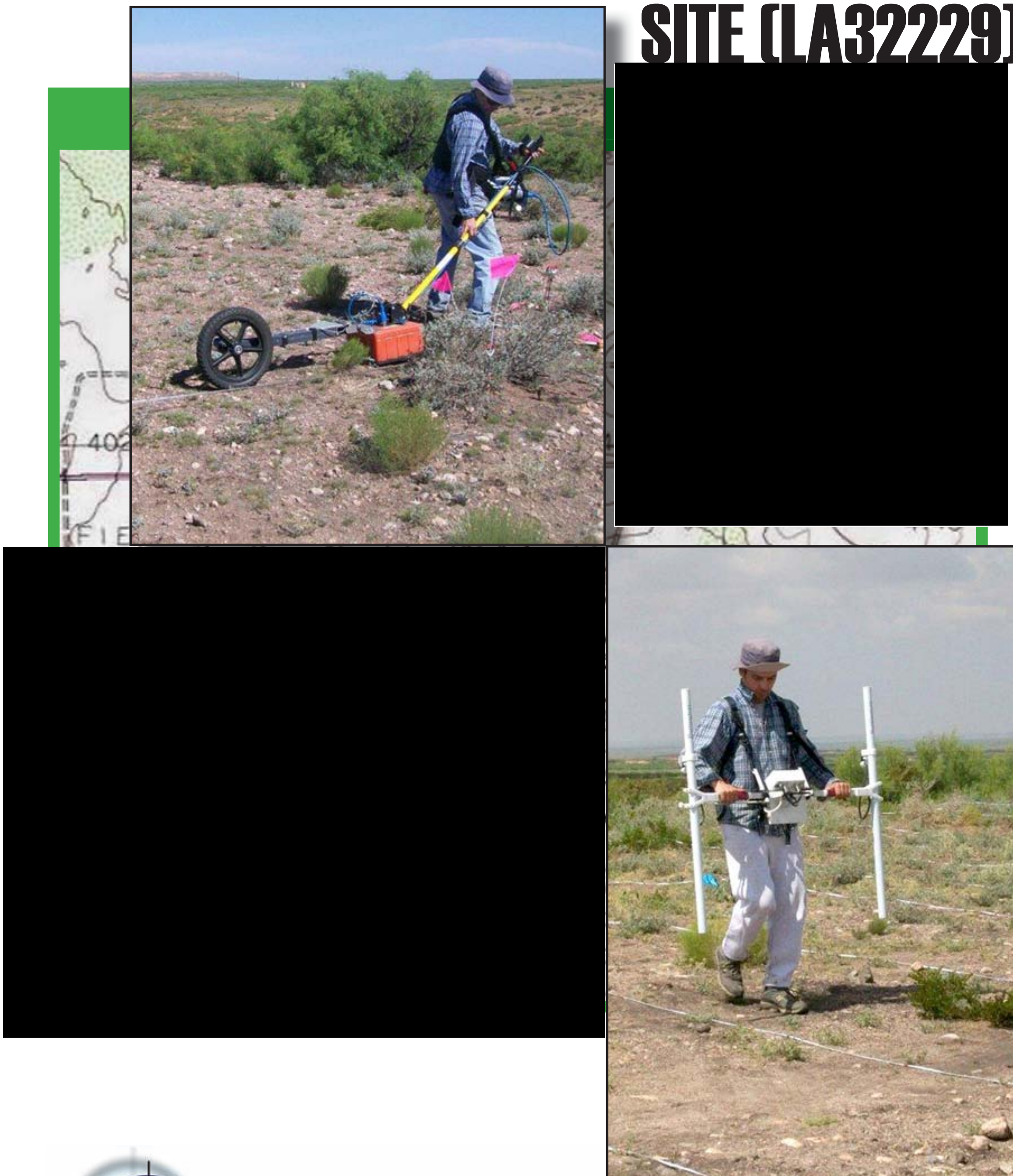
Jonnie Cress & Tom Webb
Screening at "Boot Hill" 1957


NOTICE

This is how "Boot Hill"
got it's Name
(Note) Road that crossed
site
(Faceing South West)

Appendix L: Complete Geophysical Report

GEOPHYSICAL SURVEY OF THE BOOT HILL SITE (LA32229)



NEW SOUTH ASSOCIATES
PROVIDING PERSPECTIVES ON THE PAST

Geophysical Survey of the Boot Hill Site (LA32229)

Eddy County, New Mexico

Task Order No. 01

Report submitted to:

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Shawn M. Patch – Principal Investigator

July 27, 2010 • Draft Report

New South Associates Technical Report 1896

ABSTRACT

New South Associates conducted a geophysical survey of a portion of the Boot Hill site (LA32229) in Eddy County, New Mexico. The work was accomplished through a subcontract with TRC Environmental's Albuquerque office for the Bureau of Land Management (BLM), Roswell Field Office.

Specific instruments included a ground penetrating radar (GPR) and magnetometer (fluxgate gradiometer). Survey blocks were established over a broad area of the site, encompassing a total of approximately 4,714 square meters (1.16 ac.). Selection of survey block locations was based on a combination of factors, including management and research needs, surface vegetation, overall size, and expected data return.

Surface vegetation proved to be the most challenging aspect of the survey for two reasons. First, it prohibited the establishment of large blocks for more efficient surveying, thus requiring more time. Second, clearing of surface vegetation was both time-intensive and detrimental to long-term preservation because of its stabilization effect. In other words, clearing broad areas, while effective for geophysical survey, would also introduce the potential for additional erosion and/or vandalism by exposing more surface area to the elements.

Results indicate both instruments performed well and generated complementary datasets. Multiple prehistoric features were identified along with natural elements such as caliche bedrock. Preliminary ground-truthing confirms the presence of several geophysical anomalies.

Intensive activities appear to have occurred near the central portion of the site immediately west of County Road 220. This area also corresponds to a natural high point in the general vicinity. Possible feature types include hearths, large pits, and other processing areas. These data provide a broad perspective on cultural activities at the site that would not be possible with other archaeological techniques.

This project has demonstrated the effectiveness and utility of geophysical methods for archaeological investigations in southeastern New Mexico. Future studies should be undertaken at additional sites to further explore the use of geophysics for both research and management needs.

ACKNOWLEDGMENTS

I would like to take this opportunity to express my sincere gratitude to Peter Condon, TRC's Principal Investigator for this project. Peter's interest in geophysical investigations as a complement to other methods deserves acknowledgement. In addition, Peter provided invaluable assistance in the field with grid selection, vegetation clearing, and sampling density. I am grateful for his help, enthusiasm, and support for this project.

Special thanks are also extended to Ben Bury for mapping the survey grid corners with the total station, and to Spencer Larson for providing those points in a GIS format.

I also extend my gratitude to George MacDonell, archaeologist in BLM's Carlsbad Field Office, for his understanding of the challenging field conditions. George's site visit while the survey was underway also provided a chance to meet and discuss the geophysical techniques and preliminary results.

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I. INTRODUCTION

New South Associates conducted a geophysical survey of a portion of the Boot Hill site (LA32229) in Eddy County, New Mexico (Figures 1-2). The work was accomplished through a subcontract with TRC Environmental's Albuquerque office for the Bureau of Land Management (BLM), Roswell Field Office. Fieldwork occurred from June 12-19, 2010. During that time, weather conditions were typical for early summer, with hot days, moderate humidity, and afternoon thunderstorms.

PROJECT OVERVIEW

Boot Hill is one of the premier prehistoric sites in the greater Carlsbad area. It is located on Federal land managed by the BLM. Unfortunately, very little research has been published on it to date. Corley and Leslie (1960) provided a brief report on the results of investigations conducted by the Lea County Archaeological Society (LCAS) in the late 1950s. At that time, the site yielded multiple burials, high artifact frequencies, and evidence of additional features. Artifact analysis suggested the site had multiple components, from Folsom to the late Formative. However, the bulk of the remains are likely associated with the Jornada Mogollon (A.D. 1200-1450).

The site is located in the Chihuahuan desert, with dense stands of creosote bush, mesquite, and other plants. It is approximately 3.5 kilometers (2.5 miles) west of the caprock on a prominent landform. There is a large draw/arroyo running northeast-southwest along the site's southern boundary. At the time of the survey, a large area on top of the hillcrest had been cleared of vegetation, making it clearly visible from long distances. Numerous rocks of varying size (including cobbles and small boulders) are present across the surface.

The geophysical survey at Boot Hill was designed to address three specific research goals. The first goal was to identify and locate LCAS excavations from the 1950s. The second goal was to identify additional archaeological features and offer interpretations about patterning and other cultural activities. Finally, we were to assess the overall potential of geophysical techniques as a management tool for archaeological sites on BLM property.

The original scope-of-work called for a geophysical survey of an area equivalent to 100x100 meters (10,000 square meters or 2.4 acres). The scope was subsequently modified after a field visit by BLM officials and a discussion of the challenges inherent in an area of that size. Because of the need for large open areas with no surface obstructions, it would have required a tremendous amount of labor to clear vegetation. In addition, once vegetation is cleared, it opens the site to additional erosion and threats from increased vandalism.

The resulting survey sampled a broad area of the site. While survey block placement was generally chosen in relation to low density surface vegetation, it was also balanced with a need to sample different depositional and topographic zones. Presumably, cultural activity would have varied over the site, with different activity areas.

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Specific instruments included a ground penetrating radar (GPR) and magnetometer (fluxgate gradiometer). Survey blocks (n=18) were established over a broad area of the site, encompassing a total of approximately 4,714 square meters (1.16 acres). Selection of survey block locations was based on a combination of factors, including management and research needs, surface vegetation, overall size, and expected data return.

Surface vegetation proved to be the most challenging aspect of the survey for two reasons. First, it prohibited the establishment of large blocks for more efficient surveying, thus requiring more time. Second, clearing of surface vegetation was both time-intensive and detrimental to long-term preservation because of its stabilization effect. In other words, clearing broad areas, while effective for geophysical survey, would also introduce the potential for additional erosion and/or vandalism by exposing more surface area to the elements.

Results indicate both instruments performed well and generated complementary datasets. Multiple features were identified along with natural elements such as caliche bedrock (Kruse et al. 2000). Preliminary ground-truthing has confirmed the presence of several geophysical anomalies, although final interpretations are not yet available.

Intensive activities appear to have occurred near the central portion of the site immediately west of County Road 220. This area also corresponds to a natural high point in the general vicinity. Possible feature types include hearths, large pits, and other processing areas. These data provide a broad perspective on cultural activities at the site that would not be possible with other archaeological techniques.

GEOPHYSICAL INVESTIGATIONS

Current trends in geophysical archaeology are moving toward expanding the interpretive value of geophysical data to explicitly address anthropological questions (Conyers, personal communication 2010; Ernenwein 2008; Gaffney and Gater 2003; Kvamme 2003; Kvamme et al. 2006a; Lukowski et al. 2006). There is a growing recognition among practitioners that geophysical data can provide unique and highly detailed perspectives on archaeological sites that goes beyond simply identifying subsurface features (Patch 2010; Patch and Gregory 2009, 2010). This may be particularly applicable to larger sites and/or cultural landscapes, where traditional methods might provide only a small window on broader patterns. Technological advances in recent years have demonstrated the effectiveness of various equipment and methods (Gaffney and Gater 2003). The challenge now is to apply these advances to specific research questions.

Geophysical investigations of archaeological sites has increased considerably in recent years (Gaffney and Gater 2003). For purposes of this project, the following discussion is limited to previous regional studies and those with theoretical and/or methodological considerations.

Kvamme et al. (2006a) recently completed a multiyear, comprehensive geophysical study of four sites on Department of Defense (DOD) installations around the country. The purpose of the study was to identify specific combinations of remote sensing methods and data integration for the detection, identification, and interpretation of cultural resources in various environments and archaeological circumstances. Because it was comprehensive, a full range of geophysical instruments was selected, as well as aerial photography and satellite imagery. Most importantly, initial interpretations of remote sensing data were subsequently tested through field verification (i.e., ground-truthing) of selected anomaly classes. The data were then reevaluated and revised interpretations were offered for each of the sites. The final outcome was an evaluation of the effectiveness of various sensor combinations and data integration methods against specific site conditions, and development of guidance documents for their use in various settings.

This study is invaluable for cultural resource managers and geophysical archaeologists alike. It has provided a systematic, intensive, and rigorous application of different methods in a range of environments around the country. Although oriented toward DOD installations, the results and implications are applicable on a much broader scale. It provides an important overview of not just the instruments and methods, but also the theory behind anomaly identification and detection, data integration, and interpretive potential of limited excavations.

One of the sites they investigated was Pueblo Escondido, located on Fort Bliss, in Otero County, New Mexico (Lukowski et al. 2006). The site was well known, but published information was limited. Archaeologically, it was an excellent choice because of its relatively open setting and the presence of probable architectural remains such as adobe walls and burned floors. Despite its large size, little was known about the site's internal structure.

Subsequent field efforts at Pueblo Escondido were based on a detailed sampling strategy and generated important information about the geophysical anomalies (Kvamme et al. 2006a; Lukowski et al. 2006). Specific methods included a combination of backhoe trenches, hand excavated units, and auger samples. Because of these efforts, the initial classes of 14 separate anomaly types were subsequently collapsed to five categories: floors, walls, interior features, lineations, and small features. The overall success of feature predictions from geophysical data was generally high, although some were more reliable than others (e.g., room floor v. small feature). One of the conclusions indicated a success rate of approximately 57 percent when a single sensor identified an anomaly, and approximately 82 percent when identified by two or more sensors.

Other geophysical studies have been conducted in southern New Mexico, although the results are not always easily accessible. Kemrer (1999, 2001) reported on magnetometer investigations at two prehistoric sites. At the Gap Hill site (LA125819) in Dona Ana County, results indicated at least one buried wall at a Classic Mimbres Pueblo (Kemrer 1999). Investigations at Montoya Ruin (LA88891) in Sierra County revealed several buried features and possible collapsed wall segments.

Doria Kutrubes (personal communication, 2010) conducted a GPR survey of several prehistoric sites with possible architectural remains at White Sands Missile Range. Ongoing data analysis indicates several probable buried structures in numerous survey areas. Unfortunately, the report is classified and not available to the public.

Most recently, Hyndman (2010) conducted a geophysical survey of the Laguna Plata site (LA 5148) in Lea County, New Mexico for the Carlsbad Field Office. This project used GPR, magnetometer, and conductivity to characterize a small area of the total site, with the primary goal of identifying previous excavation units. Results indicated areas that were suspected to be old excavation units, as well as probable additional features.

II. METHODS

Geophysical techniques are frequently used by archaeologists to investigate a wide range of research questions. In archaeological applications, the primary goal is to detect, identify, and interpret potential subsurface features. The techniques are non-invasive, non-destructive, relatively quick and efficient, and highly accurate when used in appropriate situations. They provide an alternative way of viewing and understanding archaeological sites.

Geophysical data collection, processing, and interpretation are ultimately designed to identify anomalies. In simple terms, anomalies possess chemical, electrical, or other physical properties that distinguish them from the surrounding matrix and are detectable by a range of instruments with sufficient precision and sampling density (Kvamme 2006a; Kvamme et al. 2006a). Anomalies are formed under a range of circumstances, including cultural, geological, pedological, and biological factors.

FIELD METHODS

Surface obstacles can be a major hindrance to any geophysical survey for a number of reasons. First, it is often difficult to physically navigate the instruments in a systematic manner. Second, root systems, large rocks, and other objects are also imaged and detected with the instruments, making it more difficult to distinguish them from anomalies of interest.

The most critical challenge of this project was dealing with the site's vegetation. Large portions of the site are covered with typical desert plants such as mesquite, creosote bush, and other grasses (Figure 3). Grid 1 was the only exception, as it had been cleared of most vegetation relatively recently. In the remaining areas, vegetation had to be cleared by hand, which turned out to be labor and time intensive. Creosote was easier to cut and clear than mesquite. Consequently, it was necessary to identify areas that were relatively open in order to minimize the amount of clearing and maximize ground coverage.

In order to effectively collect and process geophysical data, it is necessary to establish a formal grid. In this case, grid layout was accomplished with three metric tapes and surveyor's chaining pins. The actual size, orientation, and layout of each grid was determined by surface features and presumed orientation of the targets. All grid corners were mapped with a total station by TRC's field crew and tied to the new datum.

Geophysical data were collected in 18 separate grids (Table 1, Figure 4). When possible, contiguous grids were established to provide seamless views of adjoining areas. However, because of the surface vegetation, it was frequently necessary to adjust grid location, size, and orientation. With the exception of Grids 1 and 6, most others were generally longer on one axis. In very few cases, small portions of two or more grids overlapped.

Figure 3.
Photographs of Selected Geophysical Grids After Clearing

A. Grid 1(Looking South)

B. Grid 6 (Looking Northeast)

C. Grid 17 (Looking Norteast)

D. Grid 18 (Looking South)

Figure 4.
Location and Layout of Geophysical Survey Grids

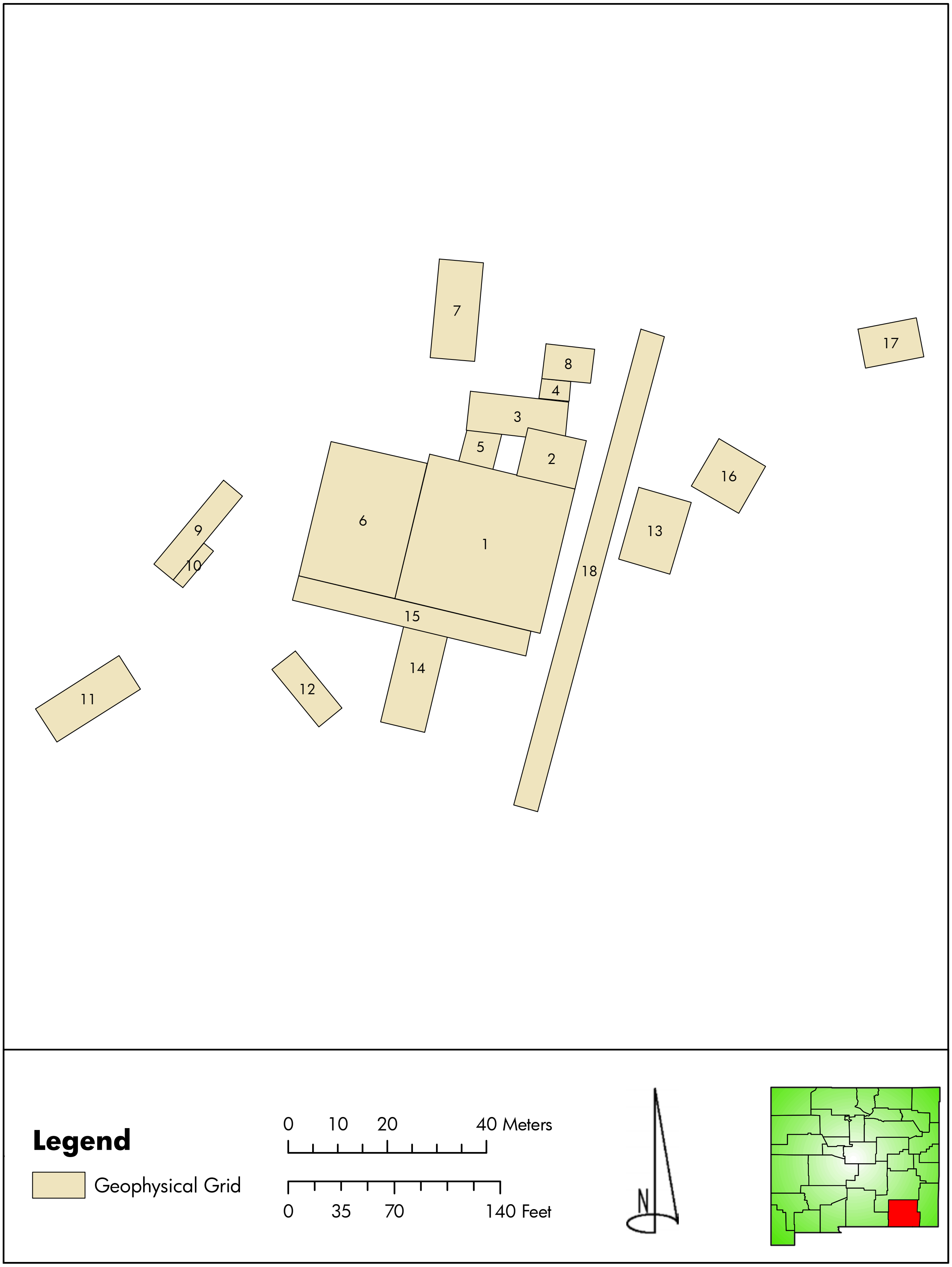

Table 1. Geophysical Survey Grids.

Grid	X Length	Y Length	Area (square meters)	GPR Transect (cm)	GPR Antenna (mhz)	Mag Sampling Density
1	30	30	900	25	400	16/m
1	30	30	900	25	900	16/m
2	12	10	120	25	400	16/m
3	20	8	160	25	400	16/m
4	6	4	24	25	400	16/m
5	7	8	56	25	400	16/m
6	20	28	560	50	400	16/m
7	9	20	180	50	400	16/m
8	10	7	70	50	400	16/m
9	5	22	110	50	400	16/m
10	2.5	15	37.5	50	400	16/m
11	8	20	160	50	400	16/m
12	15	6	90	50	400	16/m
13	11	15	165	50	400	16/m
14	9	25	225	50	400	16/m
15	48	5	240	50	400	16/m
16	11	11	121	50	400	16/m
17	12	8	96	50	400	16/m
18	5	100	500	NA	NA	16/m
Total			4714.5			

GROUND PENETRATING RADAR (GPR)

GPR data are acquired by transmitting pulses of radar energy into the ground from a surface antenna, reflecting the energy off buried objects, features, or bedding contacts and then detecting the reflected waves back at the ground surface with a receiving antenna (Conyers 2004:1). When collecting radar reflection data, surface radar antennas are moved along the ground in transects, typically within a surveyed grid, and a large number of subsurface reflections are collected along each line. As radar energy moves through various materials, the velocity of the waves will change depending on the physical and chemical properties of the material through which they are traveling (Conyers 2004). The greater the contrast in electrical and magnetic properties between two materials at an interface, the stronger the reflected signal; and therefore, the greater the amplitude of reflected waves (Conyers 2004). When travel times of energy pulses are measured, and their velocity through the ground is known, distance (or depth in the ground) can be accurately measured (Conyers and Lucius 1996). Each time a radar pulse traverses a material with a different composition or water saturation, the velocity will change and a portion of the radar energy will reflect back to the surface and be recorded. The remaining energy will continue to pass into the ground to be further reflected, until it finally dissipates with depth.

The depths to which radar energy can penetrate, and the amount of resolution that can be expected in the subsurface, are partially controlled by the frequency (and therefore the wavelength) of the radar energy transmitted (Conyers 2004). Standard GPR antennas propagate radar energy that varies in frequency from about 10 megahertz (MHz) to 1000 MHz. Low frequency antennas (10-120 MHz) generate long wavelength radar energy that can penetrate up to 50 meters in certain conditions but are capable of resolving only very large buried features. In contrast, the maximum depth of penetration of a 900 MHz antenna is about one meter or less in typical materials, but its generated reflections can resolve features with a maximum dimension of a few centimeters. A trade-off therefore exists between depth of penetration and subsurface resolution. In this survey, depth penetration was approximately 35 nanoseconds (ns), or 1.5 meters. However, energy and depth penetration below approximately 20 nanoseconds fell off rapidly because of geological conditions.

The success of GPR surveys in archaeology is largely dependent on soil and sediment mineralogy, clay content, ground moisture, depth of buried features, and surface topography and vegetation. Electrically conductive or highly magnetic materials will quickly attenuate radar energy and prevent its transmission to depth.

The basic configuration consists of an antenna (with both a transmitter and receiver), a harness, and a wheel for calibrating distance (Figure 5A). The operator then pulls the antenna across the ground surface systematically (a grid) collecting data along a transect. This data are then stored by the receiver and available for later processing and manipulation.

The GPR survey was conducted with a Geophysical Survey Systems, Inc. (GSSI) SIR 3000 control unit with an attached 400MHz antenna. The first step was to calibrate the antenna to local conditions by walking over various areas of the project area and adjusting the instrument's gain settings (Conyers 2004). This method allows the user to get an average set of readings based on subtle changes in the RDP (Conyers 2004). Field calibration was repeated as necessary to account for changes in soil and/or moisture conditions. Effective depth penetration was approximately 1.5 meters. Signal attenuation (degradation) was a significant factor below approximately 20-25 nanoseconds.

The "time window" within which data were gathered was 35 nanoseconds. This is the time during which the system is "listening" for returning reflections from within the ground. The greater the time window, the deeper the system can potentially record reflections. To convert time in nanoseconds to depth, it is necessary to determine the elapsed time it takes the radar energy to be transmitted, reflected, and recorded back at the surface by doing a velocity test. Hyperbolas were found on reflection profiles and measured to yield a relative dielectric permittivity (RDP), which is a way to calculate velocity. The shape of hyperbolas generated in programs is a function of the speed at which energy moves in the ground, and can therefore be used to calculate velocity (Conyers 2004).

Because of this project's goals, New South Associates used a combination of different transect spacing and GPR antenna frequency. As the use of geophysics is relatively new in the project area, this site provided a unique environment for assessing the utility of different configurations.

Figure 5. Geophysical Data Collection at Boot Hill

GPR data were collected at either 25- or 50-centimeter intervals. Briefly, transect spacing is chosen based on a balance between the types of expected features, required resolution, and time. In general, 50-centimeter transects are standard and have been shown to work very well for identifying medium to large features (Pomfret 2006). Closer transect spacing, such as 25 centimeters, does not necessarily reveal any new features (although it sometimes can), but rather provides increased resolution, and therefore a better image. However, because the sampling interval has been doubled, the field time required for data collection increases accordingly.

A similar consideration applies to antenna frequency. For most archaeological applications, a 400mhz antenna is appropriate because it provides an excellent balance between depth, resolution, and portability. Seventeen of the geophysical grids were surveyed with a 400mhz antenna, while Grid 1 was also surveyed with a 900mhz antenna.

MAGNETOMETRY

Magnetometry is particularly well suited to archaeological sites because of the magnetic variations found in many sub-surface features (Aspinall et al. 2009). Technically, magnetometry is a passive geophysical method that maps local variations in the earth's magnetic field. One of the primary benefits of magnetic surveys is the rate at which data can be acquired. Large areas can generally be covered in a small amount of time, particularly in open areas with few surface obstacles. In addition, magnetometry offers high-resolution data that can effectively characterize a range of feature types in a given area. Regular, patterned, geometric features can generally be detected and identified quite well. For these reasons, magnetometry has become the workhorse of archaeological geophysics (Kvamme 2006a:206). The primary limitation of magnetometry is its inability to resolve targets at depths greater than one to two meters. Magnetometry is well suited to discovering metal and thermally altered features (e.g., burned structures, floors) (Aspinall et al. 2009).

The magnetic survey was conducted with a Bartington Instruments Grad 601 fluxgate gradiometer (Figure 5B). This is a dual sensor instrument with one meter spacing between each of the sensors. It offers high-resolution data and rapid acquisition rates. Sampling density was 16 readings per square meter, which produced a high-resolution dataset. Resolution with the Grad 601 is approximately 0.1 nT. In many cases, prehistoric features are relatively low contrast, falling in the range of ±5nT.

Prior to data collection, the Grad601 was turned on and allowed to warm up for at least 20 minutes. Then, with the instrument in Scan mode, it was necessary to find a "quiet" (i.e., metal-free) area of the site or grid for proper calibration. Fortunately, the amount of background noise and metallic interference at Boot Hill was quite low, making field calibration relatively smooth. Over the course of each day, the instrument was periodically recalibrated as temperatures changed.

Non-metallic survey tapes with marks spaced every meter were used to guide data collection. These were spaced two meters apart. All data were collected using the zig-zag method, which is also quite fast. Prior to data collection, each grid was cleared of obvious surface metal such as tin cans and other debris. However, it is possible that some metal still was present just under the Aeolian sand.

DATA PROCESSING

GPR

All data were downloaded from the control unit to a laptop computer for post-processing. Radar returns are initially recorded by their strength and the elapsed time between their transmission and receipt by the antenna. Therefore, the first task in the data processing was to set "time zero", which tells the software where in the profile the true ground surface was. This is critical to getting accurate results when elapsed time is converted to target depth. A background filter was applied to the data, which removes the horizontal banding that can result from antenna energy "ringing" and outside frequencies such as cell phones and radio towers. Background noise can make it difficult to visually interpret reflections. The third and final step was to "migrate" the data, which allows the user to eliminate the tails of the hyperbolic reflections and generate a more realistic view of the size, depth, and orientation of point targets. Hyperbolic reflections are generated from the way the radar energy reflects off point targets. In cemeteries, graves are often visible as hyperbolic reflections. Migration reduces this distortion using a linear regression analysis to remove the tails of hyperbolas, to more accurately portray the actual dimensions of point targets.

The next data processing step involved the generation of amplitude slice-maps (Conyers 2004). Amplitude slice-maps are a three-dimensional tool for viewing differences in reflected amplitudes across a given surface at various depths. Reflected radar amplitudes are of interest because they measure the degree of physical and chemical differences in the buried materials. Strong, or high amplitude reflections often indicate denser (or different) buried materials, such as building materials. Such reflections can be generated at pockets of air, such as within collapsed architecture, or from slumping sediments. Amplitude slice-maps are generated through comparison of reflected amplitudes between the reflections recorded in vertical profiles. In this method, amplitude variations, recorded as digital values, are analyzed at each location in a grid of many profiles where there is a reflection recorded. The amplitudes of all reflection traces are compared to the amplitudes of all nearby traces along each profile. This database can then be "sliced" horizontally and displayed to show the variation in reflection amplitudes at a sequence of depths in the ground. The result is a map that shows amplitudes in plan view, but also with depth. Often when this is done changes in the soil related to disturbances can become visible, making many features visible to the human eye that may not be visible in individual profiles.

From the original .dzt files (raw reflection data), a series of image files was created for cross-referencing to the amplitude slice maps that were produced. Two-dimensional reflection profiles were also analyzed to determine the nature of the features identified on the amplitude slice maps. The reflection profiles show the geometry of the reflections, which can lend insight into whether the radar energy is reflecting from a flat layer (seen as a distinct band on profile) or a single object (seen as a hyperbola in profile). Using these profiles to confirm or refute ideas about the nature of buried materials seen in the three-dimensional slice maps, potential subsurface features were then delineated.

Magnetometer

Magnetic data were downloaded from the Grad601 to ArchaeoSurveyor for post-processing. In general, the processing time for magnetic data is significantly less than for GPR data (Kvamme 2006b).

Because of irregular sizes, each grid was processed individually. The first step was to clip the data by eliminating outlying values that might otherwise mask subtle anomalies. It was then necessary to destagger, which eliminates inevitable variations in pace and data acquisition. The final step was destriping, which calculates the mean, median, or mode of each grid or traverse within a grid. It is generally used to remove differences between grids and inherent limitations of the magnetometer.

GIS Integration

The final step in the data processing was to integrate the GPR and magnetic data with other spatial data. This was done using ArcGIS 9.3, which can display and manipulate all forms of spatial data created for this project including GPR results, GPS data, and base graphics such as aerial photography and topographic maps. All geophysical anomalies were converted into an ESRI shapefiles to generate an overall interpretive map of Boot Hill (see following section).

III. RESULTS AND RECOMMENDATIONS

Both the GPR and magnetometer provided good results, with high quality datasets. Amplitude slice maps of GPR data are provided in Appendix A; selected GPR profiles are provided in Appendix B; and magnetic data are provided in Appendix C. The amplitude slice maps have been color enhanced to better indicate reflective contrasts. Blues and greens represent low amplitude values, while reds and whites indicate high amplitude values. GPR profiles show particular areas of interest (e.g., point reflection or geologic feature). Each dataset is discussed in detail below, and then combined to produce a more complete interpretation of Boot Hill.

GPR

GPR data were acquired in 17 of the 18 survey grids. Results indicate at least 39 distinct anomalies representing both natural and cultural objects/features (Table 2, Figure 6). Figure 6 shows only GPR anomalies at Boot Hill. At first glance, it is obvious that not all survey grids yielded anomalies, particularly those on the northern and eastern fringes (5, 7, 8, 16, and 17). Conversely, many more anomalies are evident in the remaining areas, with a notable cluster in Grid 1. This area corresponds to the highest point on the site, and it seems reasonable to conclude that more intensive activity may have occurred as a result.

The range of possible interpretations is necessarily limited at this point. However, based on the size, shape, depth, and reflected amplitudes, several general observations are possible. First, large areas of strong reflection are present through the central portion of the survey area that are likely caliche bedrock (Kruse et al. 2000). There is also an outlying section in the southern end of Grid 14. Second, several small anomalies are probably metal. Obviously, these resulted from historic activities at the site and do not relate to the prehistoric occupation. Third, there are several moderate to large sized circular anomalies that appear to be pits. Finally, no reliable interpretation can be offered other than probable feature for numerous other anomalies.

Table 2. GPR Anomalies and Probable Interpretations

ID	Depth (cmbs)	Interpretation
1	50-70	bedrock
2	50-70	bedrock
3	50-70	bedrock
4	50-70	bedrock
5	50-70	pit feature
6	50-70	pit feature
7	50-70	pit feature
8	50-70	pit feature
9	50-70	pit feature

Table 2. GPR Anomalies and Probable Interpretations

ID	Depth (cmbs)	Interpretation
10	50-70	pit feature
11	50-70	metal
12	50-70	metal
13	50-70	metal
14	50-70	metal
15	50-70	metal
16	50-70	rocks
17	40-70	feature
18	50-70	metal
19	50-70	feature
20	50-70	feature
21	50-70	feature
22	50-70	feature
23	50-70	feature
24	50-70	feature
25	50-70	feature
26	50-70	bedrock
27	50-70	bedrock
28	50-70	metal
29	50-70	metal
30	50-70	metal
31	50-70	metal
32	50-60	feature
33	50-70	feature
34	50-70	feature
35	50-70	feature
36	40-60	feature
37	50-70	bedrock
38	50-70	feature
39	50-70	feature

On GPR anomaly (#7) was targeted for excavation by TRC. Because of its size and shape in plan and profile view, as well as its reflective strength, it had the appearance of a possible pit feature. At present, excavation is complete and analysis and interpretation are ongoing. Artifact density was relatively high, with evidence of burning. At depth, the anomaly appeared to have been a natural depression in the caliche, although it was likely exploited culturally. Perhaps it was modified in some way for specific activities after being deliberately exploited because of its physical characteristics or location.

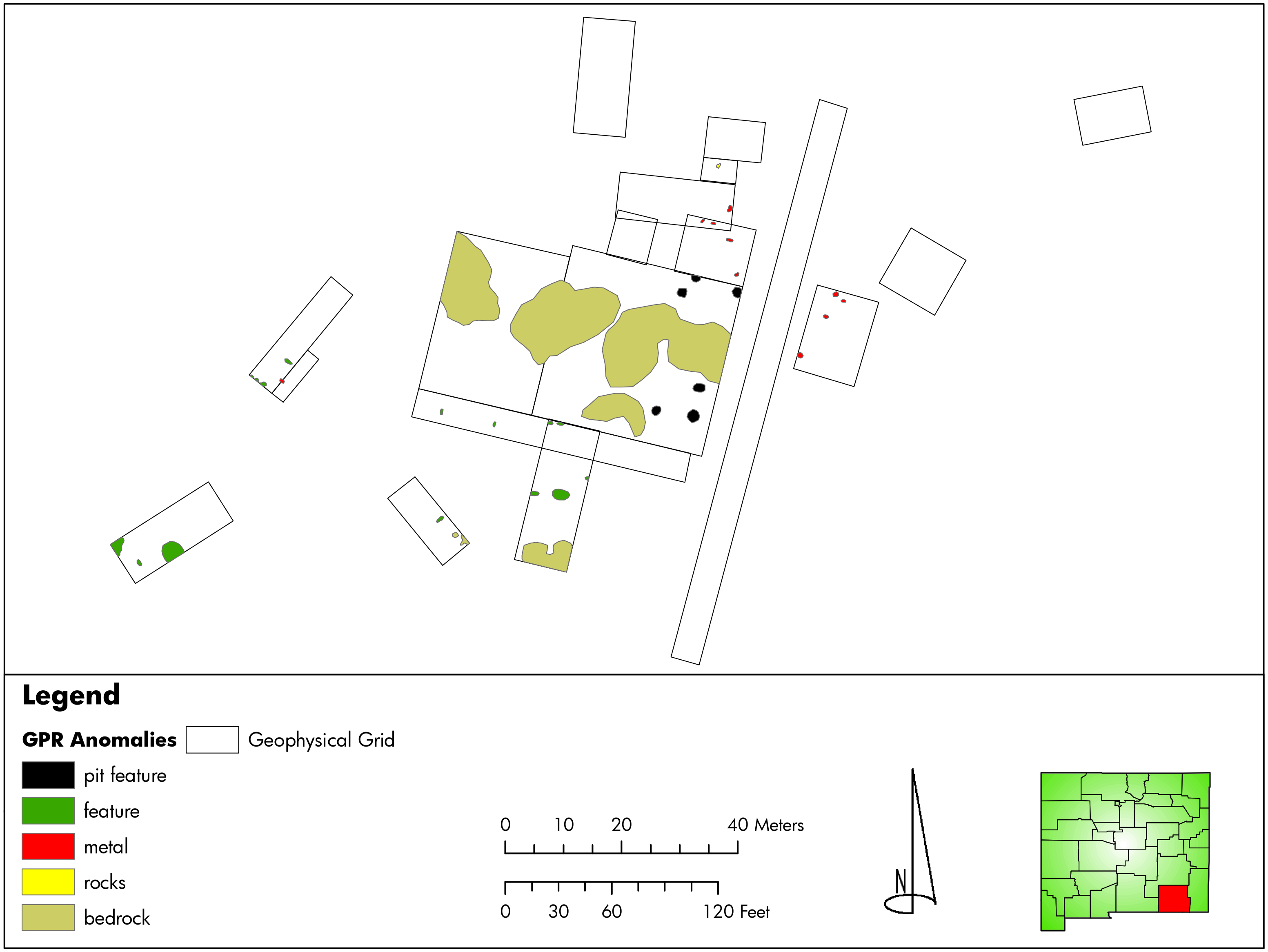

Figure 6.
Map Showing GPR Anomalies in the Survey Grids

MAGNETOMETER

Magnetic data were collected in all 18 survey grids (Table 3, Figure 7). Results indicate at least 61 distinct anomalies, representing a range of probable feature types. Figure 7 shows magnetic anomalies in the survey area. While they are more broadly distributed than GPR anomalies, several grids did not yield any (8, 10, 12, and 16). Not surprisingly, however, is the degree of clustering toward the central portion of the survey area, which is also present in the GPR data.

Interpretation of these anomalies is necessarily basic. However, it is clear from the magnetic data that there are differences in their overall strength. Some appear as dipoles, which suggest possible metallic objects, but not exclusively. At least one large dipole is present that could represent a metal object. Several anomalies are present that are relatively distinct, but slightly amorphous. Others have much better definition. Based on current knowledge of the site, and anomaly morphology, these have been divided into possible burned areas (which may or may not be well defined features), and general magnetic features.

Table 3. Magnetic Anomalies and Probable Interpretations

ID	Interpretation
40	feature
41	feature
42	feature
43	feature
44	feature
45	feature
46	feature
47	feature
48	feature
49	feature
50	feature
51	feature
52	feature
53	feature
54	feature
55	feature
56	feature
57	feature
58	feature
59	feature
60	feature
61	feature
62	feature
63	feature
64	feature

Table 3. Magnetic Anomalies and Probable Interpretations

ID	Interpretation
65	feature
66	feature
67	feature
68	feature
69	burned area
70	burned area
71	burned area
72	burned area
73	feature
74	burned area
75	feature
76	feature
77	feature
78	feature
79	burned area
80	burned area
81	burned area
82	burned area
83	burned area
84	feature
85	feature
86	feature
87	feature
88	feature
89	feature
90	feature
91	feature
92	feature
93	feature
94	feature
95	burned area
96	burned area
97	burned area
98	feature
99	feature
100	burned area

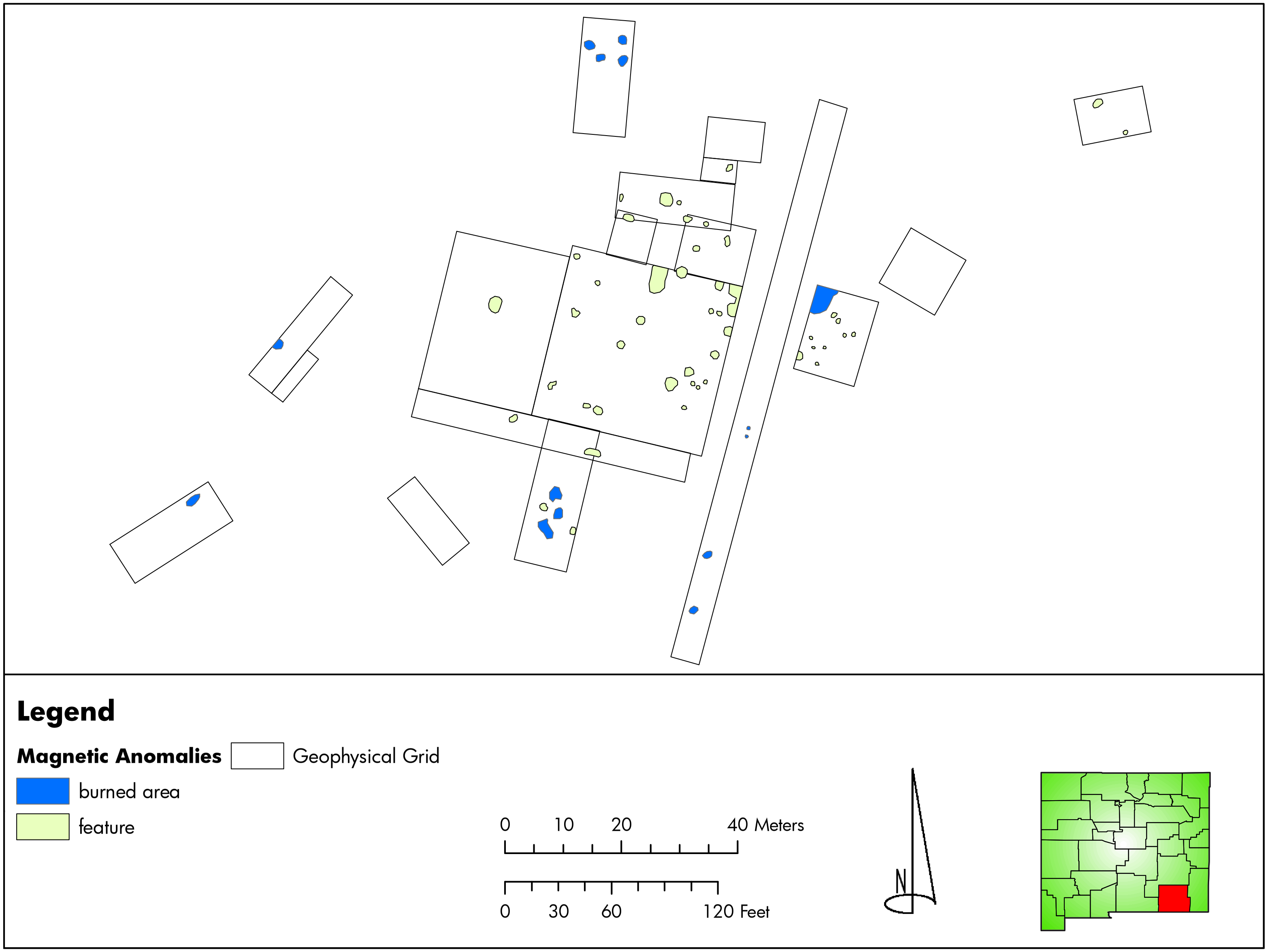

Figure 7.
Composite Map Showing Magnetic Anomalies in the Survey Grids

INTERPRETATIONS

Several preliminary interpretations can be offered from the geophysical data. While not exhaustive, the geophysical data provide a unique perspective on overall site conditions, particularly with respect to the presence of suspected features and stratigraphic differences.

CULTURAL FEATURES

Numerous anomalies were identified in both geophysical datasets (Figures 8-17). It is nearly impossible to determine what these are with 100 percent certainty without some type of verification through traditional archaeological methods. However, there is sufficient information available to generate general inferences regarding possible cultural activities.

Several large probable pit features have been identified, with a primary cluster in Grid 1. They have regular, circular shapes in plan view, and are basin shaped in profile. Their sizes are generally range from one to two meters in diameter. It is possible that these could have formed naturally and then been exploited culturally.

Numerous small, high amplitude features are present with signatures characteristic of metal. That is, their reflection amplitudes "ring" considerably throughout the profile, a phenomenon that is caused by the radar signal reverberating between the metal object and the surface. Given their depths, they do not appear to be surface objects. Possible explanations might include nails, cans, or other large ferrous objects. Obviously, these are cultural but not associated with the prehistoric occupation of the site. It is reasonable to conclude that these are likely objects from either earlier archaeological investigations or Aeolian burial of other modern trash.

The degree of anthropogenic modification at Boot Hill is staggering. Simply walking over the site it is clear that major burning activities have occurred (also visible on aerial photography). Several features are present in the magnetic data that are likely associated with burning events. Some could be discrete features such as processing pits, while others might be magnetically enhanced areas that resulted from wide-scale activities.

SUBSURFACE GEOLOGY, LITHOLOGY, AND STRATIGRAPHY

The GPR data indicate substantial differences in subsurface conditions across the sampled areas. Numerous broad areas of high amplitude reflection are present in Grids 1 and 6. Although irregular, they form a distinct band running approximately east-west across the highest landform, with depths ranging from 50-70 centimeters. In both plan and profile views, these are distinct areas of high contrast, which indicates objects and/or materials that are substantially different from the surrounding matrix. Given their size and reflective strength, these areas likely represent caliche outcrops that may be better formed or enhanced by water retention. They do not appear to be cultural.

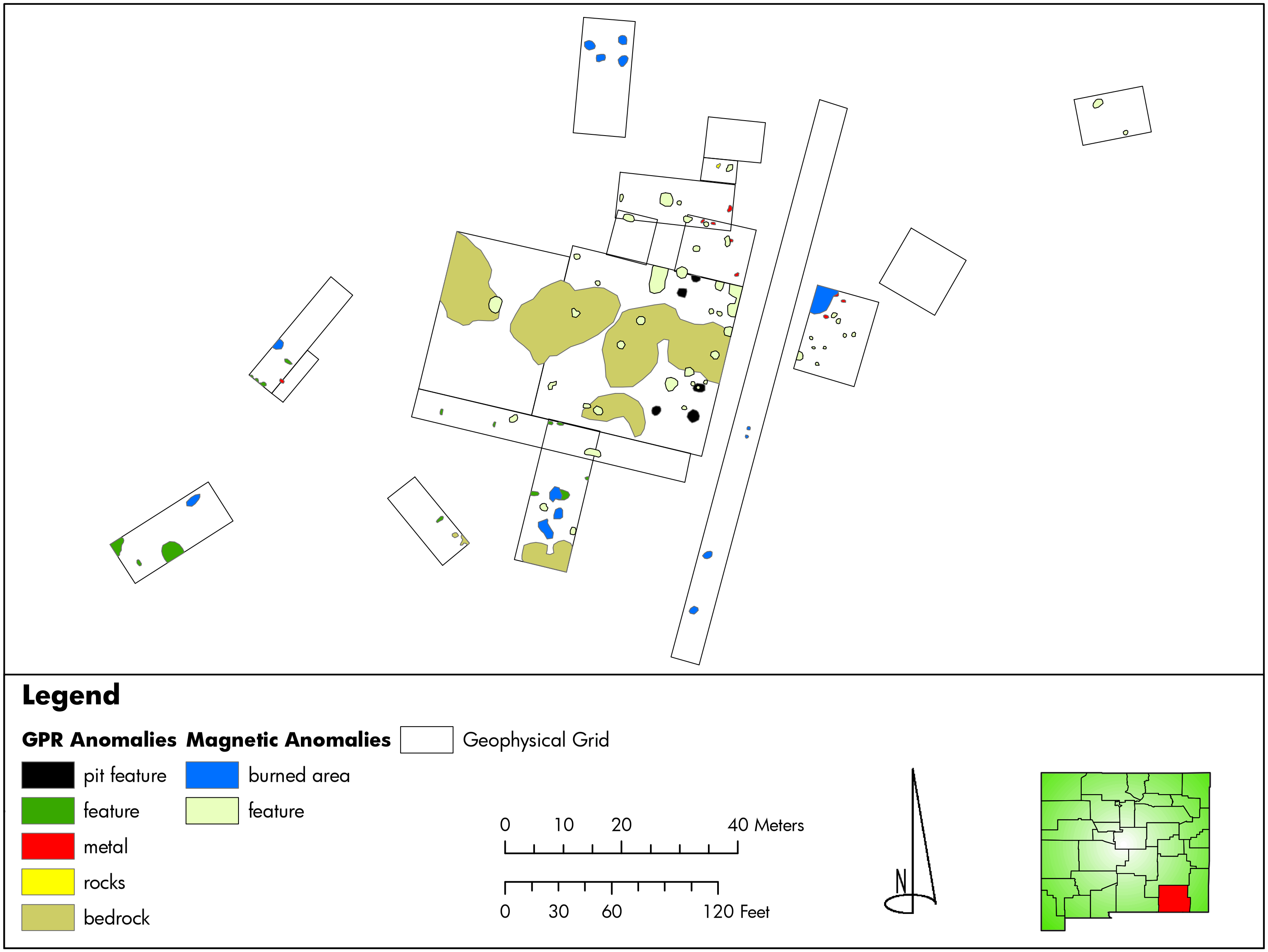

Figure 8.
Composite Map Showing All Geophysical Anomalies Identified at Boot Hill

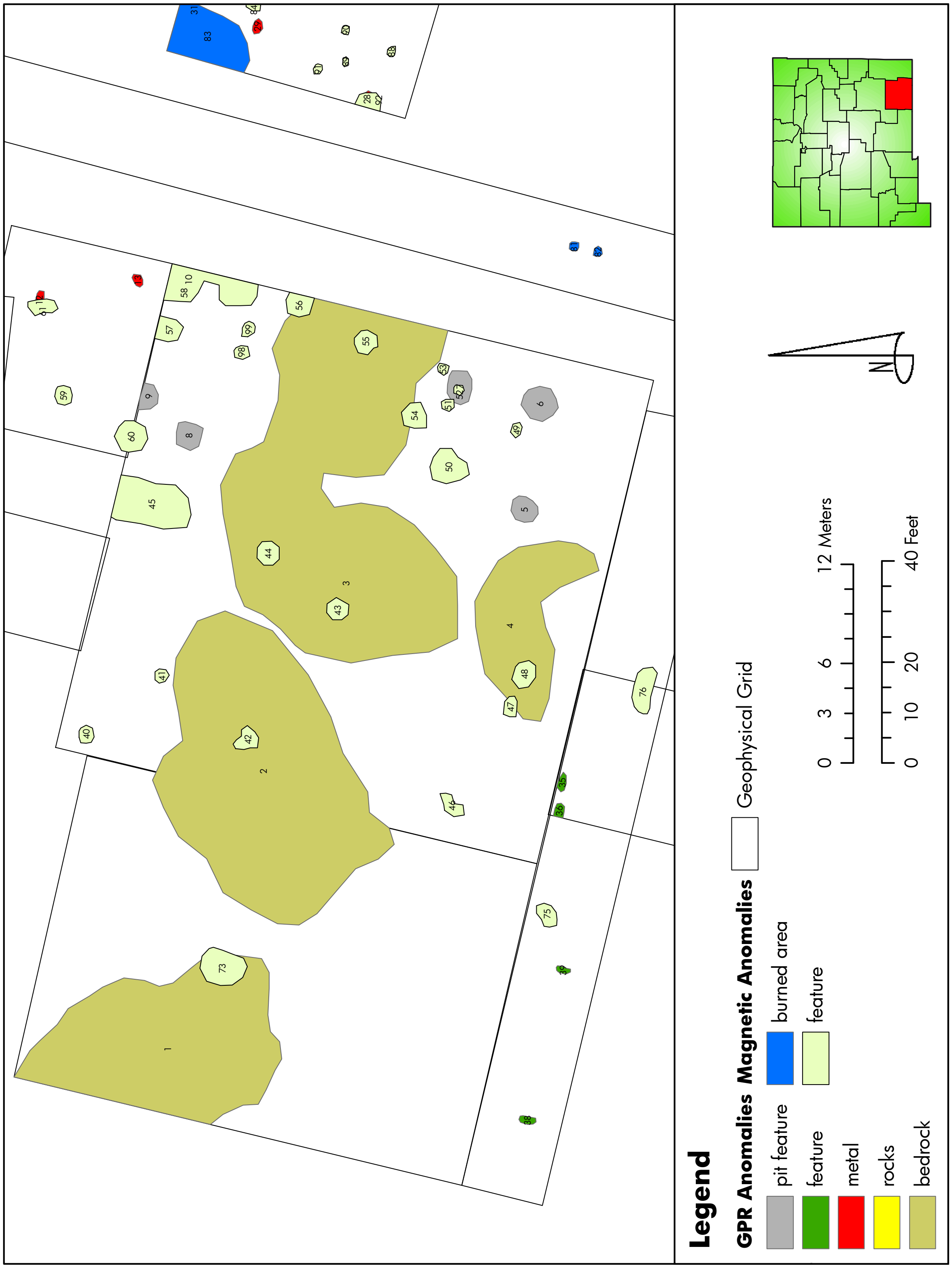

Figure 9.
Map Detail for Grids 1 and 6

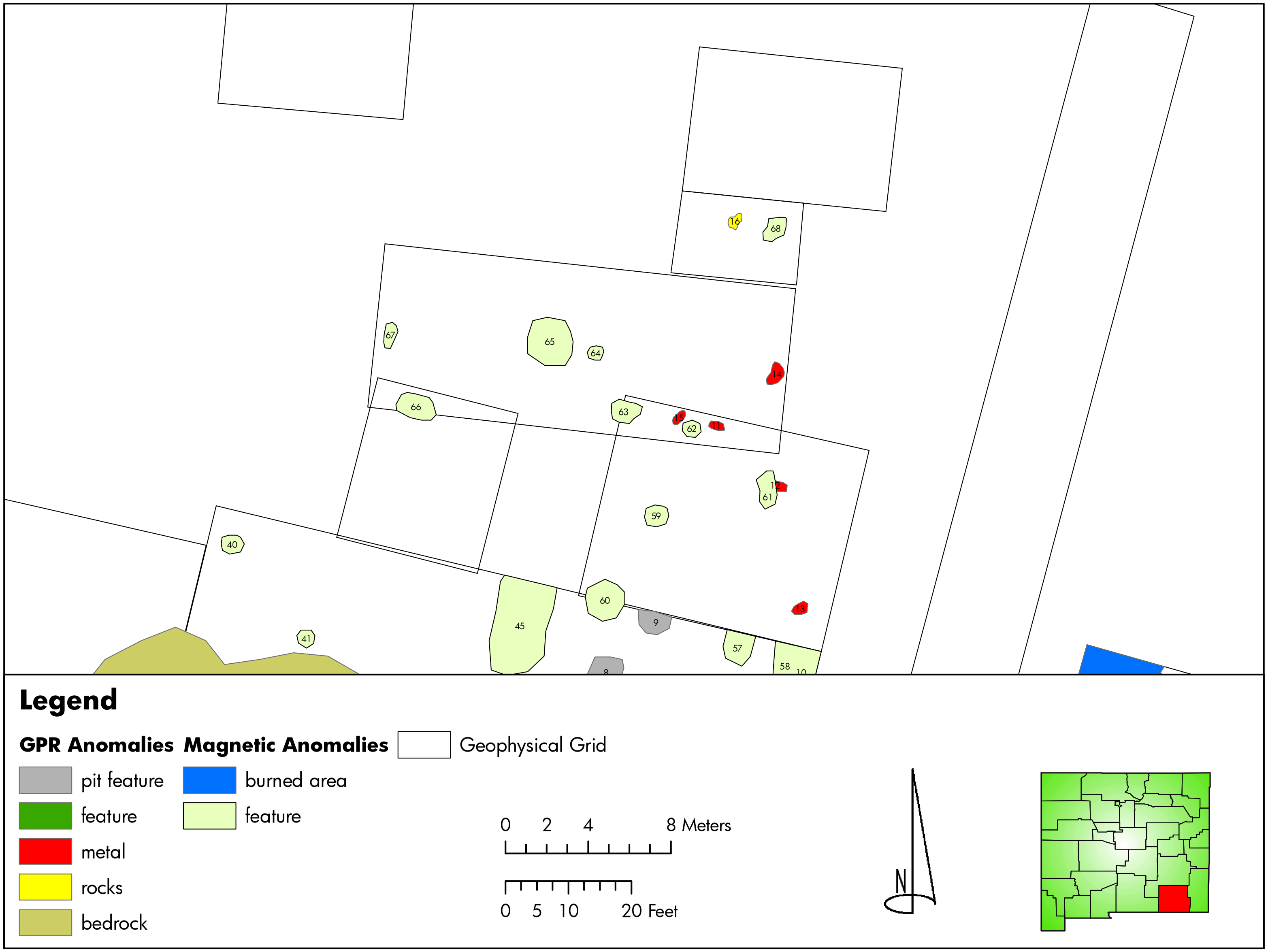

Figure 10.
Map Detail for Grids 2, 3, 4, 5, and 8

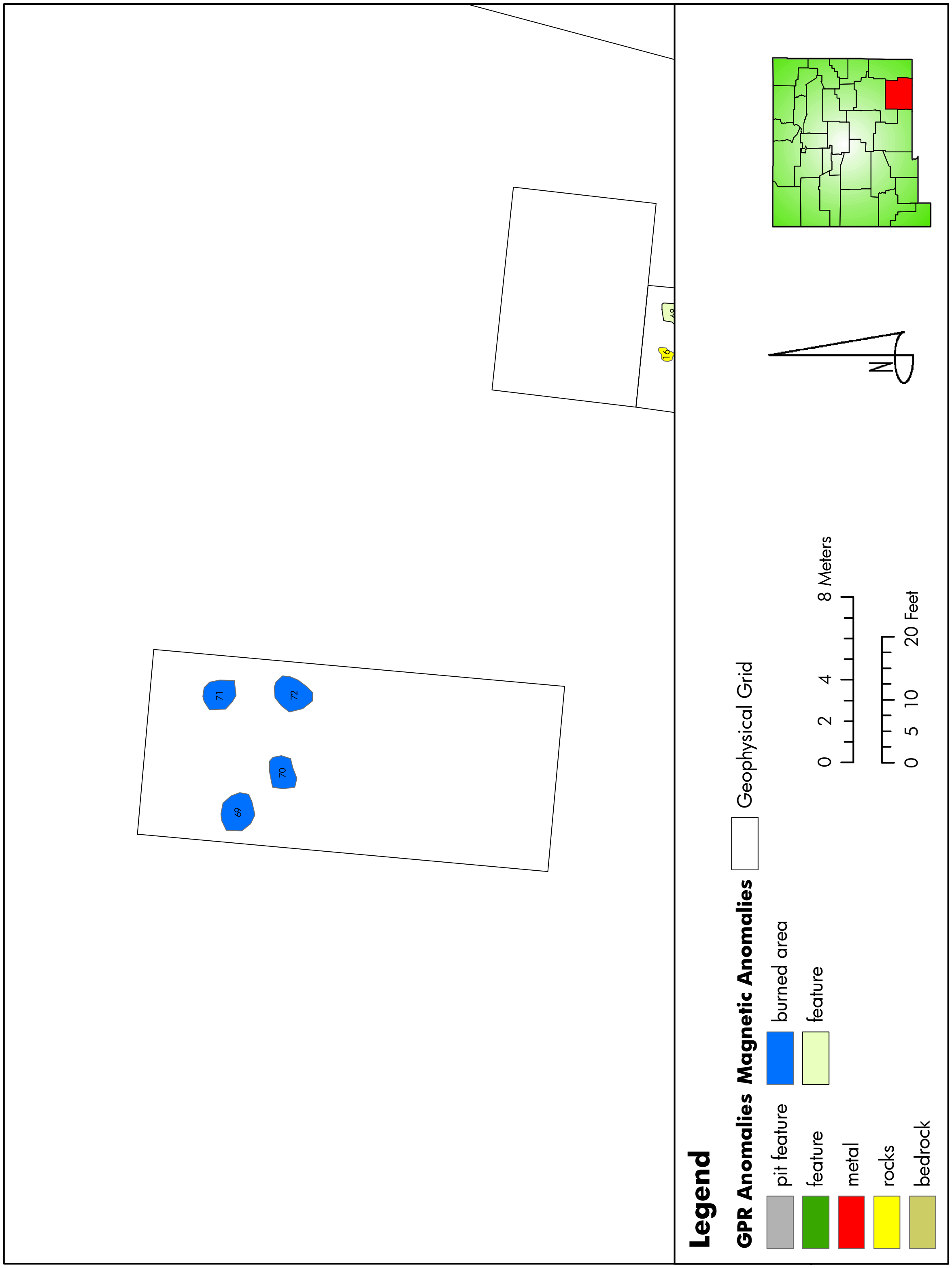

Figure 11.
Map Detail for Grids 7 and 8

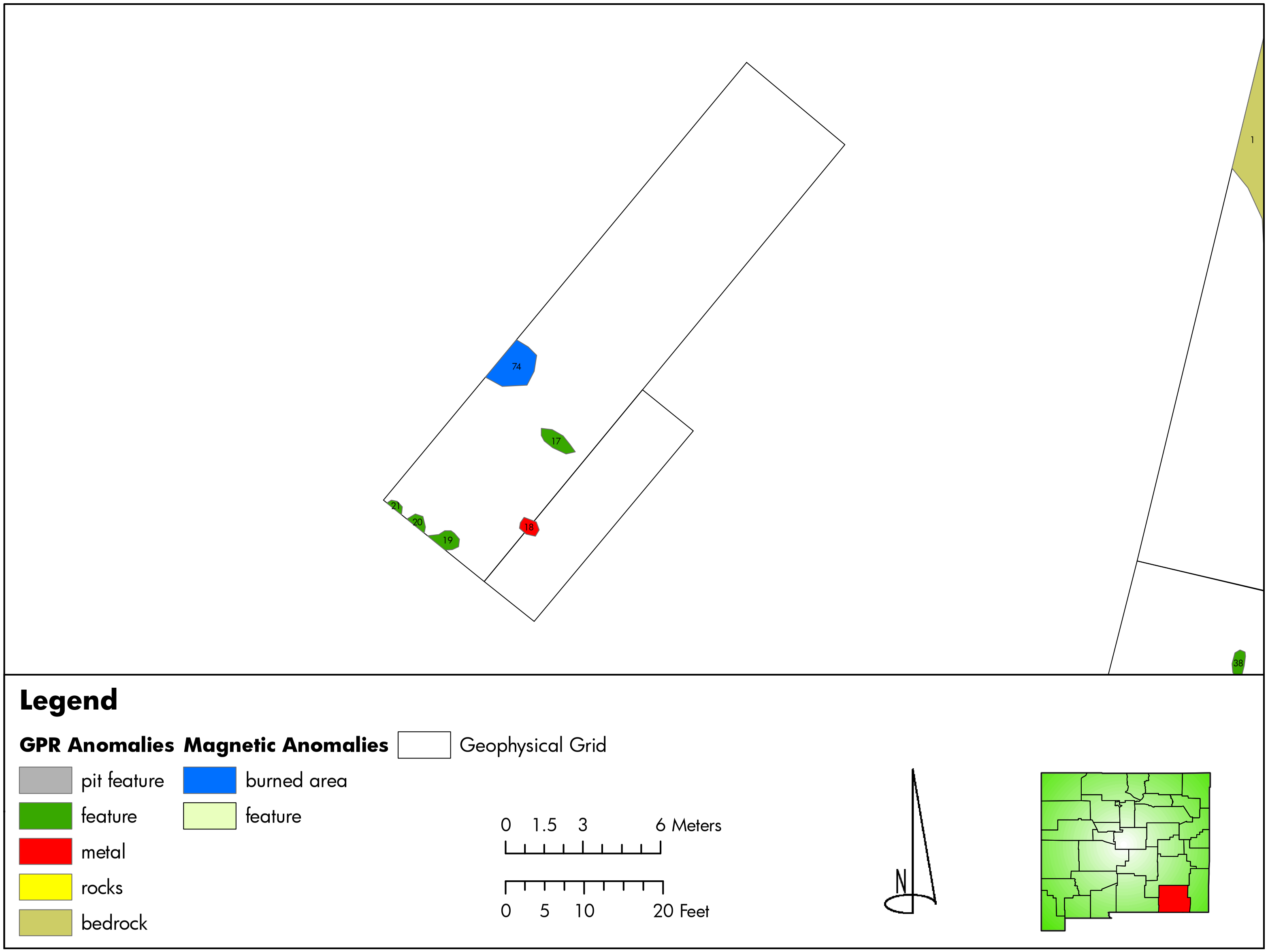

Figure 12.
Map Detail for Grids 9 and 10

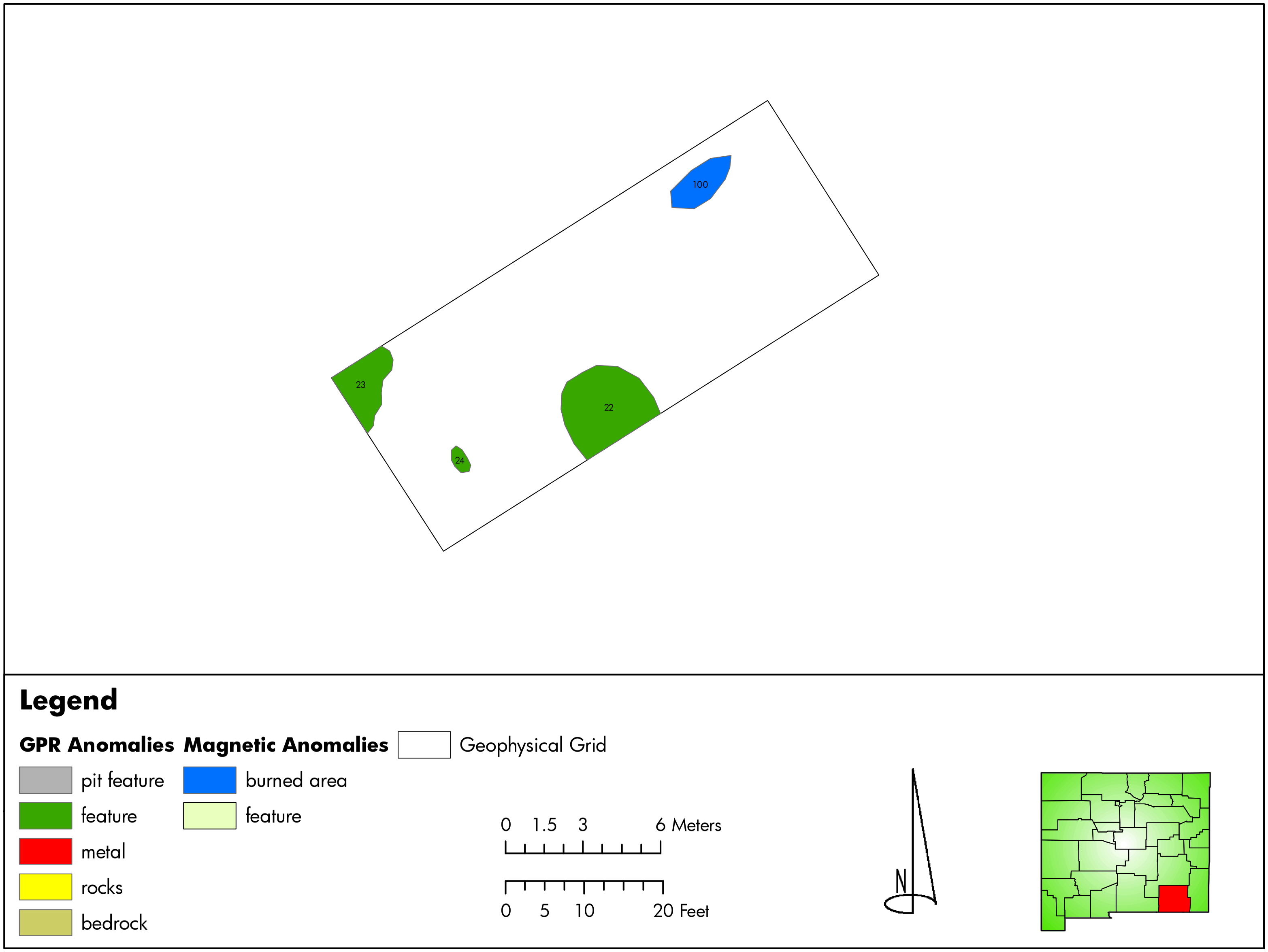

Figure 13.
Map Detail for Grid 11

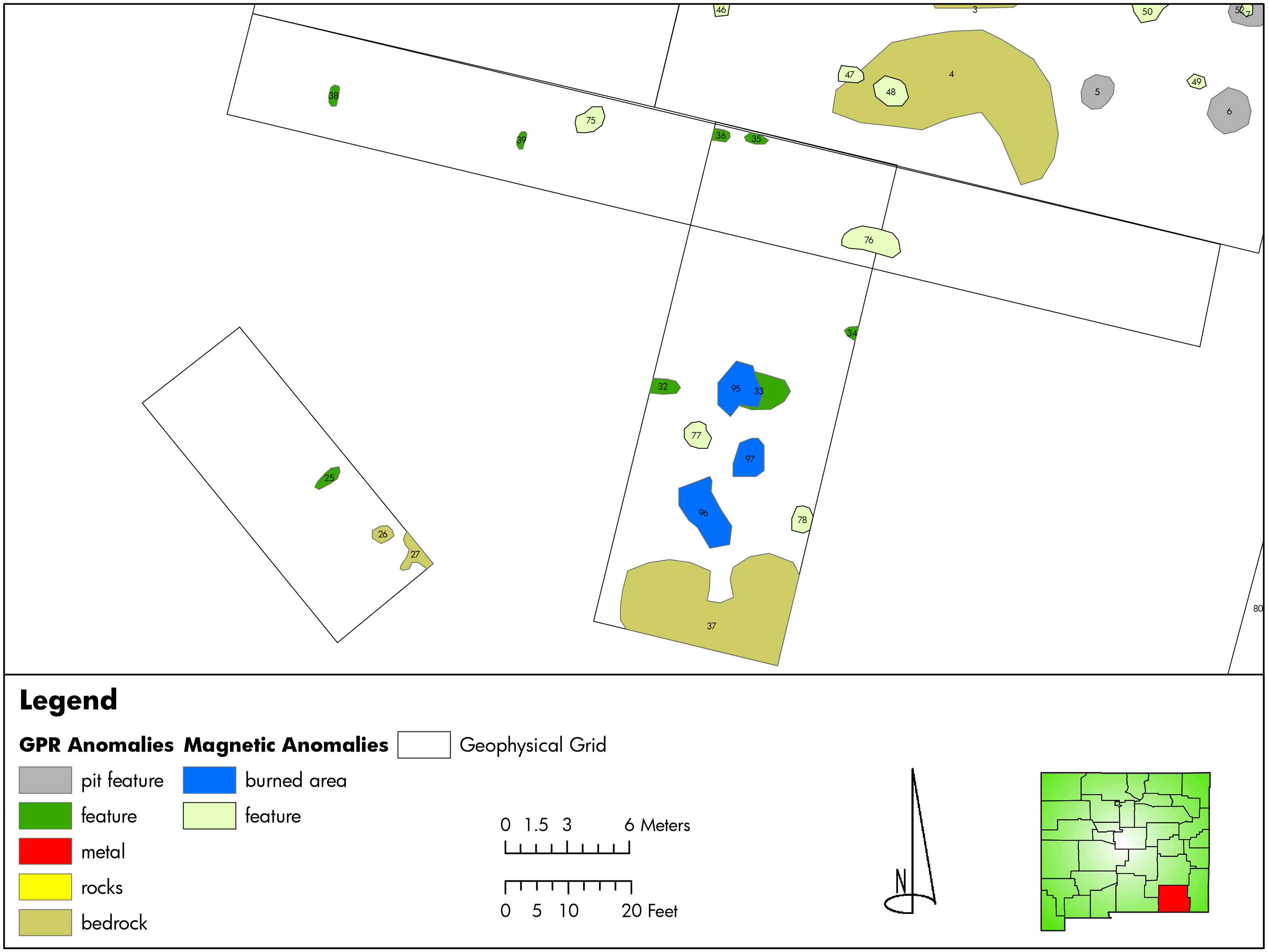

Figure 14.
Map Detail for Grids 12, 14, and 15

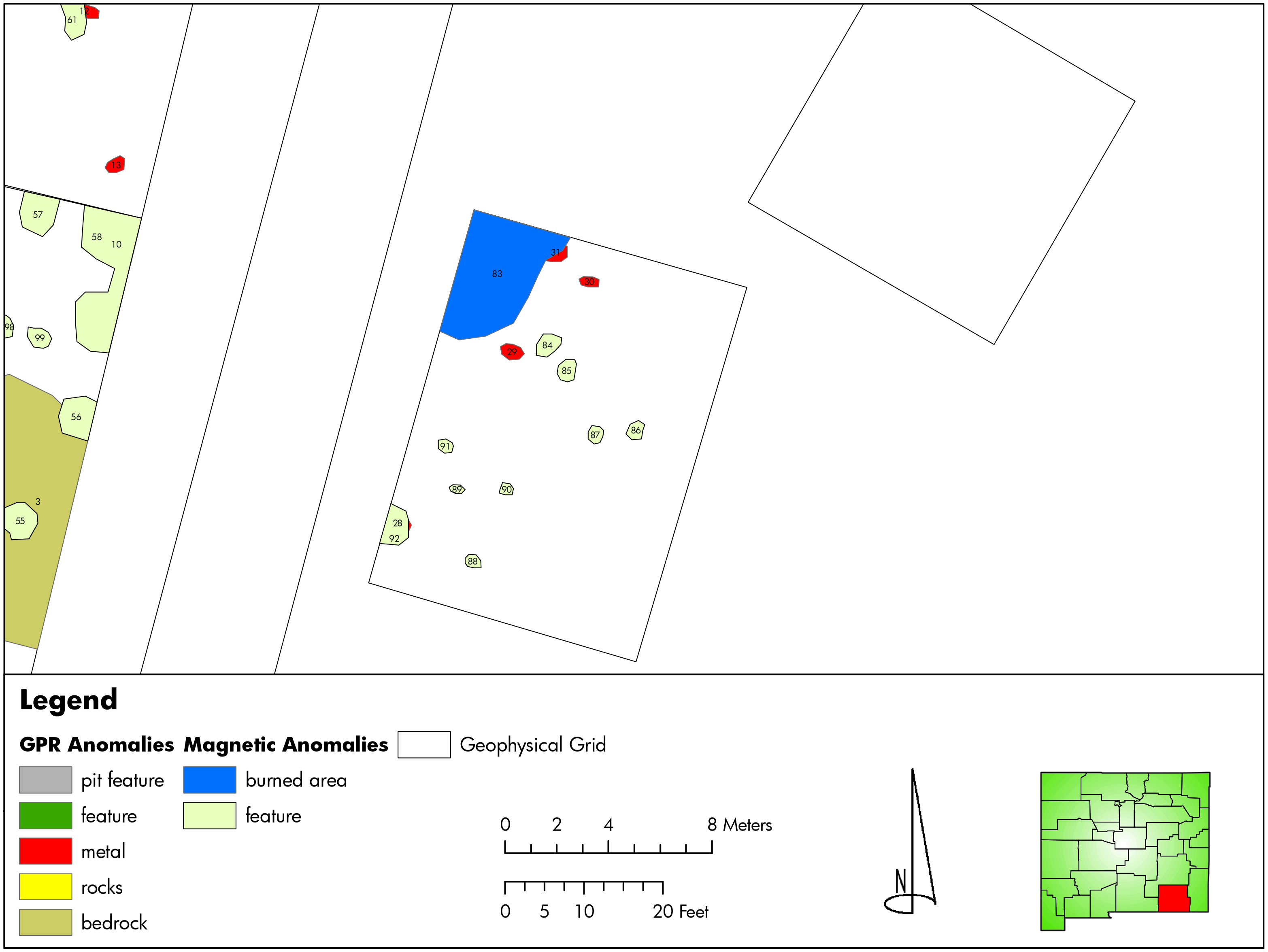

Figure 15.
Map Detail for Grid 13 and 16

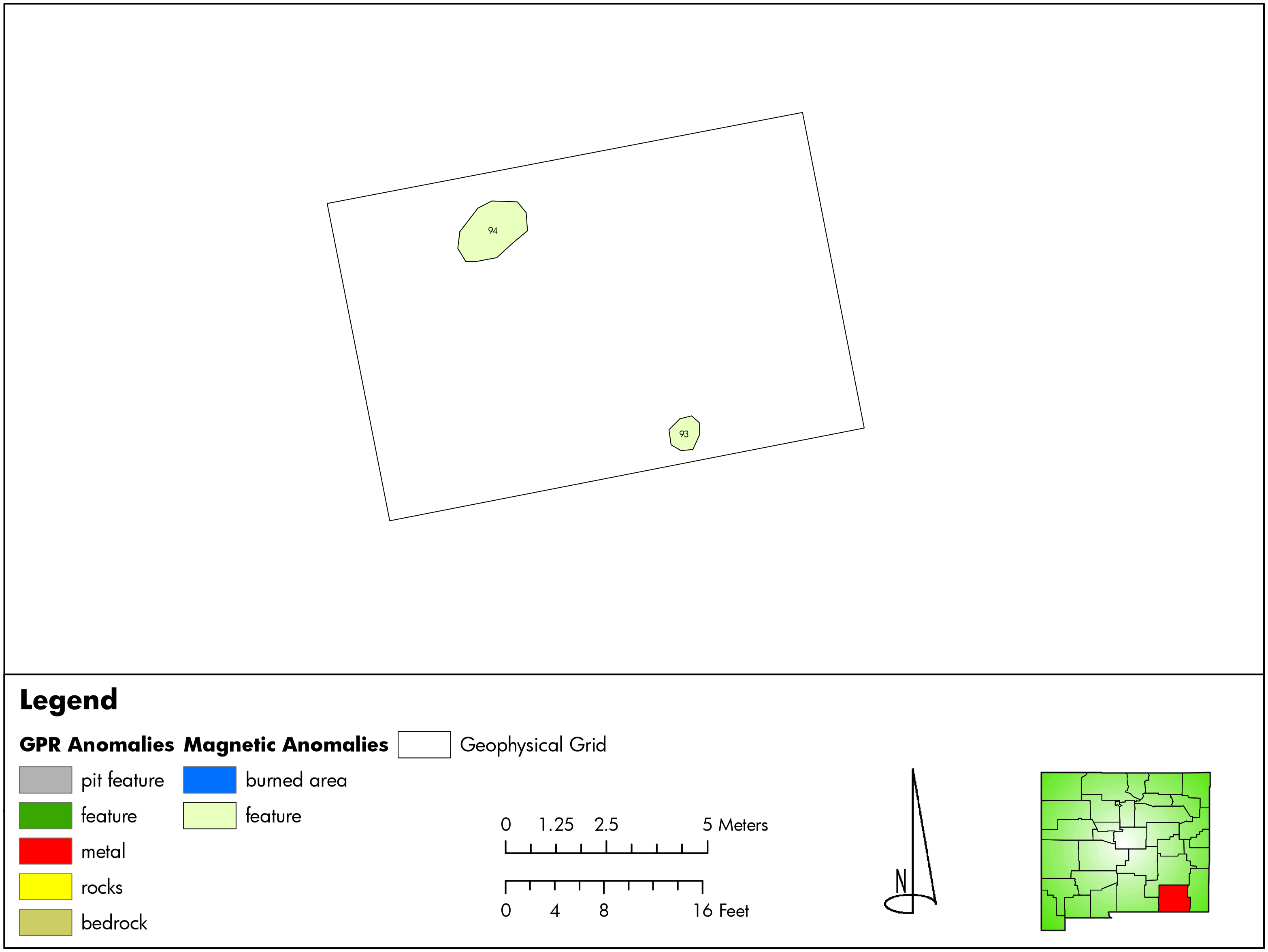

Figure 16.
Map Detail for Grid 17

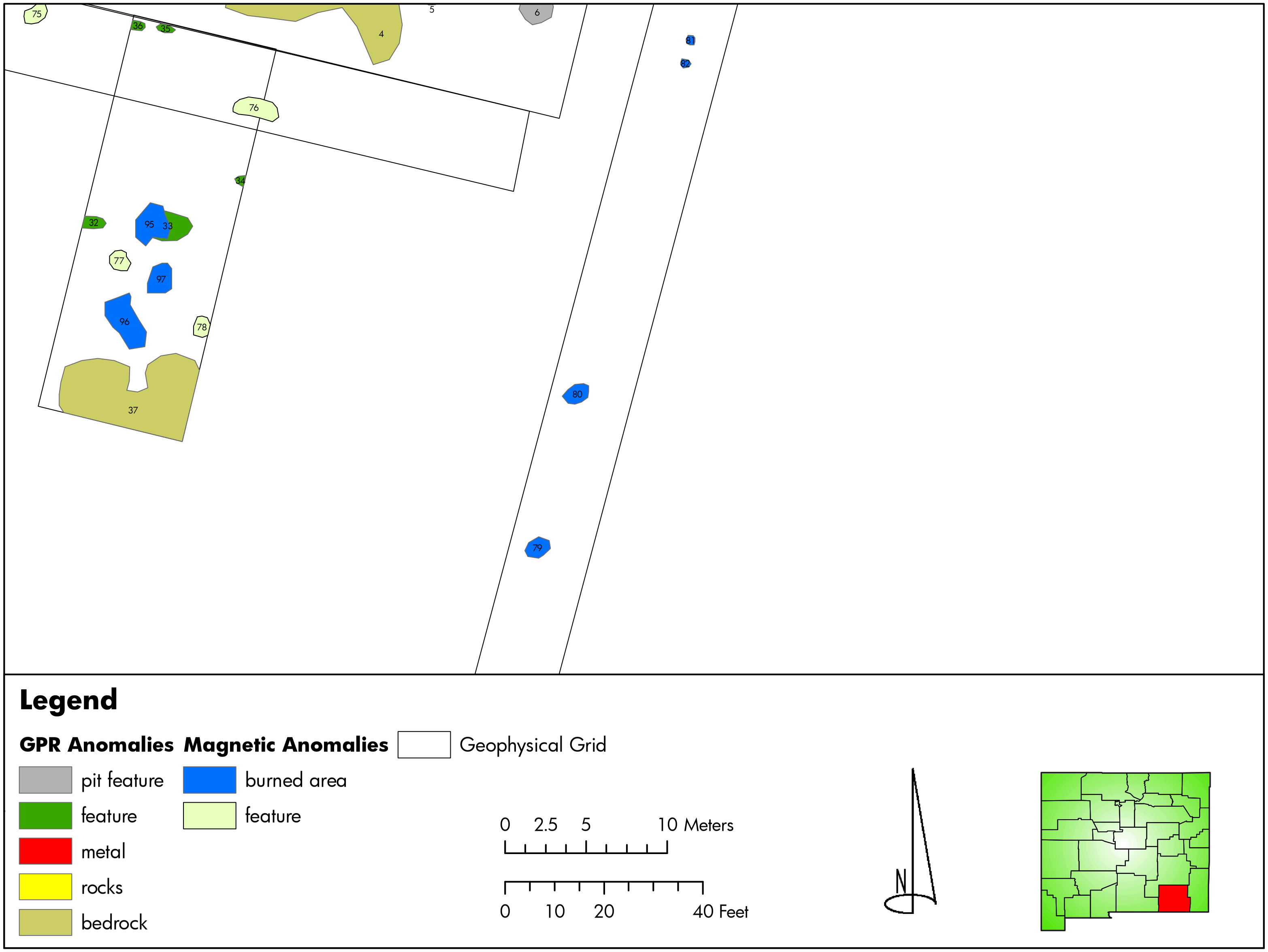

Figure 17.
Close-up Map Detail for Grid 18

In the central portion of the survey area, there appears to be more deposition. Individual GPR profiles clearly indicate major changes in RDP values between what has been interpreted as Aeolian sand and underlying bedrock. Deposition is somewhat shallower on the northern, western, and southern edges, and considerably shallower on the far eastern edge. Simple observation of surface conditions confirms this, with major color differences in sediments and clear areas of erosion/deflation on the eastern edge.

EVALUATION OF RESEARCH QUESTIONS

This project was designed to address three very specific research questions: the identification of earlier archaeological excavations, the identification of new and additional archaeological features, and an assessment of the use of geophysics for to achieve broader management goals. Each of these questions is discussed below, followed by an evaluation of the utility of geophysics.

LCAS EXCAVATION BLOCKS

At the time of the geophysical survey, TRC had an approximate location for the LCAS excavation blocks. The LCAS investigations included a large trench was oriented parallel to CR 220 on a slightly north-sloping area away from the highest point. Because of its orientation, data collection over this area occurred in the X (east-west) direction. This was done to provide a maximum number of transects perpendicular to the long axis of the blocks.

Despite expectations to the contrary, the geophysical data did not clearly indicate the edges of the excavated areas. GPR, in particular, has been used in other cases to successfully identify previously excavated areas. However, several small, discrete anomalies in both the radar and magnetic data appear to be metal, and they are concentrated in the areas where the excavation units are presumed to have been located. While the edges of the blocks themselves are not clearly demarcated, metal objects may be an indication of either nails or trash associated with the excavations. So, there is indirect and circumstantial evidence that TRC's estimate of the earlier block locations is accurate.

Why were the earlier excavations not detected directly with the geophysical instruments? This is a complicated question, but one that deserves an answer. Multiple variables are likely responsible, although they have more to do with site specific conditions than the instruments. Detection of any anomaly is based on the assumption of contrast. In order for an object to be detected, it must be substantially different from the surrounding matrix. This is the principle underlying all geophysical investigations.

At Boot Hill, the sediments are essentially homogeneous, with Aeolian sand on top of caliche bedrock. The thickness and depth of deposits varies considerably across the site (as seen in the geophysical data). Excavation of these sediments, screening for artifacts, then filling the holes again with the same material likely did not produce enough contrast for the survey instruments. Over time, as the deposits were weathered, whatever differences might have been visible would likely be erased. Unless the excavations extended into the bedrock itself, leaving a clear boundary, the probability is low for identifying those areas with geophysics alone.

FEATURE IDENTIFICATION

The second goal of this project was to use geophysical techniques to identify additional prehistoric features. A large number of anomalies were identified that have been interpreted as cultural. However, it is virtually impossible to determine with complete certainty what type of feature may be represented by a particular anomaly (Kvamme et al. 2006b). In general, it is sometimes possible to offer possible interpretations based on size, shape, depth, signal strength, and contrast, and compare these to what might be expected archaeologically based on previous work or experience.

In broad terms, interpretation of geophysical anomalies is divided into natural and cultural classes, based on their presumed origin and use. Natural anomalies are primarily limited to caliche bedrock, although other types may also be present. Cultural features include both prehistoric and modern activities. In the latter case, metal objects are the primary cause of disturbances, and may include tin cans, shell casings and bullets, barbed wire, pin flags, nails, and other debris. Many of these originated from different activities over several decades.

Potential prehistoric features are differentiated based on size, shape, depth, orientation, and reflective strengths. In general, they are more subtle and not as easily identified as metal objects. The range of possible feature types includes pits, hearths, posts, floors, pithouses, burned rock middens, and burials (Conyers and Cameron 1998; Kruse et al. 2000). For obvious reasons, some of these might be more easily identified than others (e.g., burned pithouse, or burned rock midden v. post or burial).

Magnetic data suggest several areas that have been thermally altered from burning. These are not necessarily high-fired burned features, but they appear to have been heated. In other cases, smaller point anomalies might represent posts or individual burned rocks.

GEOPHYSICAL TECHNIQUES FOR MANAGEMENT NEEDS

Geophysical techniques have tremendous potential for aiding management of archaeological sites (Kvamme et al. 2006a). Several variables must be considered in order to maximize that potential. Geophysical methods have the advantage of being non-invasive, relatively inexpensive, fast, efficient, and remarkably accurate. However, each of these depends on additional variables such as site type, environmental setting (e.g., soils, geology), surface obstacles (e.g., vegetation, excessive metallic debris), and operator experience.

Geophysical survey for the current project has yielded significant information about the site that would not have been possible with any other method. Specifically, we now have a better understanding of the spatial distribution of potential features (both horizontal and vertical), which in turn can be used for further interpretations about past cultural activity when compared to data from similar archaeological sites.

Approximately 100 anomalies were identified, including both GPR (n=39) and magnetometer (n=61). Somewhat surprisingly, there is little overlap in the data between the two methods. Excluding probable bedrock, there are six instances where GPR and magnetic anomalies intersect, including the one selected for ground-truthing by TRC. Based on the results at Pueblo Escondido, these anomalies should have the highest probability of being verified, and are likely cultural. Of the remaining anomalies, it is difficult to say what percentage might be cultural or natural. However, the fact that each method yielded different anomalies is entirely expected and illustrates one of the primary advantages of multiple instruments (Kvamme 2006b).

RECOMMENDATIONS

New South Associates recommends that the BLM carefully consider competing issues for future geophysical surveys. For example, vegetation can be expected to be a chronic concern. As it necessarily limits the effectiveness of geophysical data collection, vegetation is the prime obstacle to large-scale surveys over wide areas. Conversely, vegetation also acts as a stabilizer, which limits the effects of erosion and offers protection for a site. Removing and clearing large areas may not be desirable from a preservation standpoint because it exposes a site to both increased erosion and higher visibility, making it an easy target for vandalism and looting.

The current project relied on two methods: GPR and magnetometry. Both worked extremely well at Boot Hill and provided useful data on internal site structure and depositional setting. For the GPR, 25-centimeter transect spacing generated high-resolution data but took twice as long to collect. Given the constraints of surface vegetation and the necessity of smaller grids, this may be a good compromise for future surveys (i.e., increased resolution over smaller areas).

The 900mhz antenna also provided high-resolution data but was generally much "noisier", which is one of the problems with such a high frequency (Ernenwein and Kvamme 2008). The resulting data tended to show many more small objects, making it difficult to discern larger patterns. Several of the probable pit features identified in Grid 1 with the 400mhz antenna were not easily visible with the 900mhz antenna. In short, the 900mhz antenna provided too much data and it was more difficult to identify anomalies. For the amount of labor involved and degree of surface obstructions, the 900mhz antenna may not be particularly useful on a wide scale for future surveys. Consequently, a 400mhz or comparable antenna should be selected.

The magnetometer provided useful data over the entire site, with a few slight advantages over GPR. First, because it is carried above the ground surface objects such as large rocks and small clumps of vegetation are not a problem. Once a grid was cleared, it was relatively easy to survey with the magnetometer. Second, the magnetometer is less affected by the depth of bedrock, which means it could still provide good data in areas such as CR 220 and Grid 17 (on the eastern fringe in a different depositional setting).

New South Associates offers the following recommendations. Broadly, geophysical investigations can be applied in the areas of research, National Register for Historic Places (NRHP) eligibility evaluations, and resource management. They offer several distinct advantages, as outlined earlier, but should not be viewed as a substitute for traditional methods. Rather, they are complementary and can enhance the overall results and interpretations of a particular site.

Serious consideration should be given to the use of geophysical investigations on additional sites currently managed by the BLM. The application of these methods could be tailored to fit specific sites, or more broadly applied to classes of sites based on environmental setting (e.g., dunes, playa margin, caprock), type (e.g., burned rock midden, bison processing area, POW internment camp), or other research goal.

Integration of multiple geophysical datasets is critical to a more complete understanding of any archaeological site (Kvamme et al. 2006a). Geophysical surveys with multiple instruments generally produce the best results (Kvamme et al. 2006b). Not all instruments will be equally applicable in all situations, nor is it always possible or desirable to apply each one at the same scale. However, two or more instruments generally provide complementary data.

In addition, geophysical studies may help with evaluations of significance for the NRHP. First, they provide a more comprehensive perspective on individual sites than relatively limited traditional methods, usually at a fraction of the cost. Archaeological site evaluations tend to be rather expensive, time/labor intensive, and destructive. Geophysical studies may help increase the effectiveness and lower the costs of future evaluations.

Future geophysical studies would benefit greatly by being conducted well in advance of any planned traditional investigations. In fact, geophysical survey should be given a high priority in planning to maximize the data return. For example, with geophysical data, initial interpretations, and anomaly maps, subsequent fieldwork could focus specifically on excavating, validating, and evaluating potential features. It would at least provide a targeted approach that would entail better use of limited time and funds.

In order to effectively use geophysics for better management, some type of ground-truthing is necessary. The scale and complexity could be designed in relation to research goals and management needs on a case-by-case basis. Results of ground-truthing at Pueblo Escondido were critical for evaluating both the geophysical anomalies and overall interpretations (Ernenwein 2008; Kvamme et al. 2006a; Lukowski et al. 2006).

Identification of anomalies is relatively straightforward for an experienced practitioner. The most difficult part is interpreting those anomalies and providing useful information about cultural activities and past human behavior. Oftentimes, it is not possible to provide firm interpretations of specific anomalies. In those cases, it is invaluable to actually see them exposed in the ground. At that point, the data can be revisited and interpretations refined in light of new evidence.

As a parting word of caution, it is necessary to point out that not all geophysical anomalies will turn out to be cultural. There is no way to determine with complete certainty the origin of a given anomaly. In some cases, it may be difficult to physically verify the presence of an anomaly. In those instances, something certainly caused the anomaly in the first place, but it could have been a subtle change in chemical or electrical properties that might not be easily visible. Rodent burrows, tree roots, soil/textural differences, and natural depressions will all be imaged with geophysical instruments.

The best interpretations of geophysical data flow from extensive experience with the instrument(s), familiarity with the local setting and regional archaeology, and ground validation of at least some anomalies.

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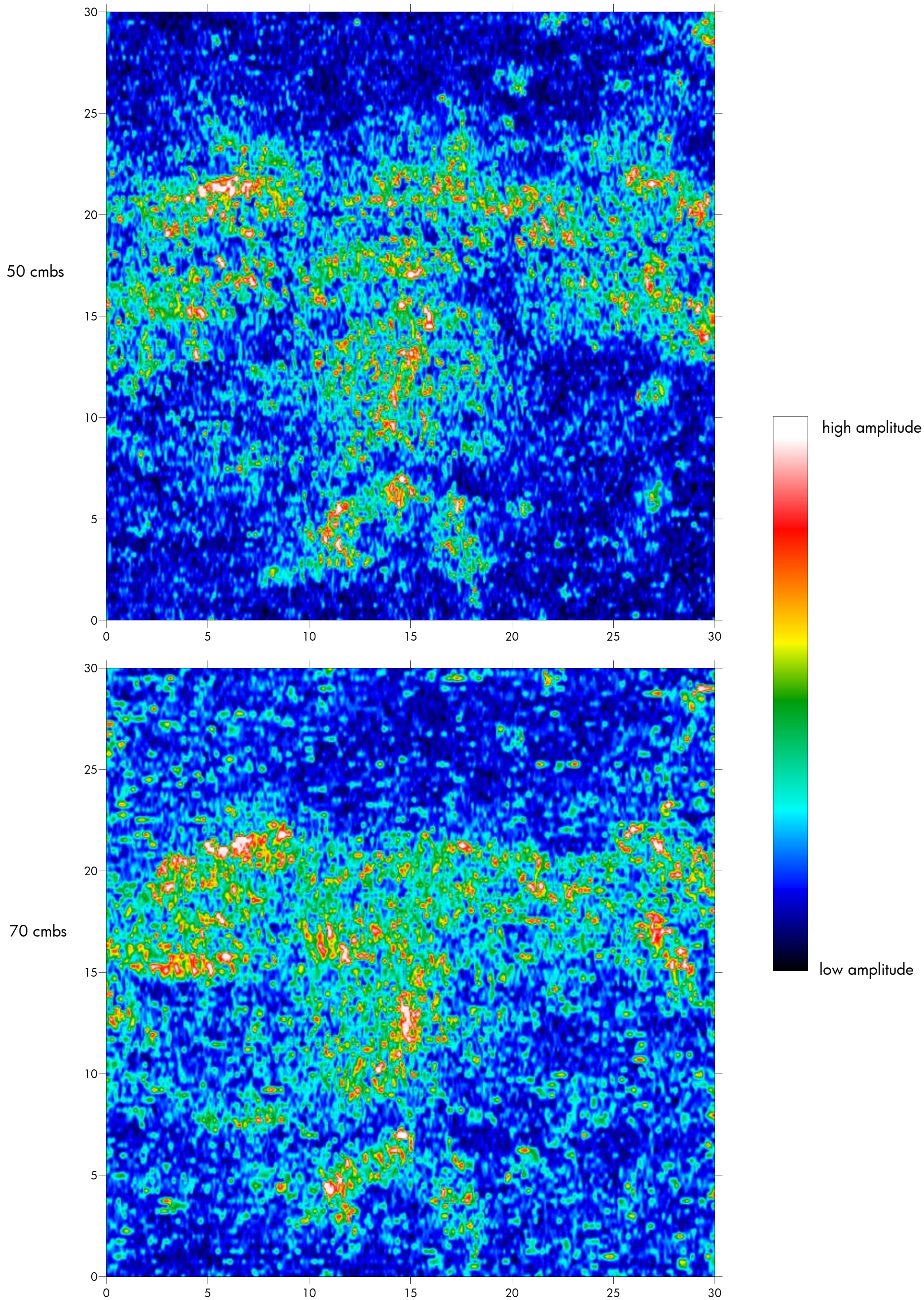
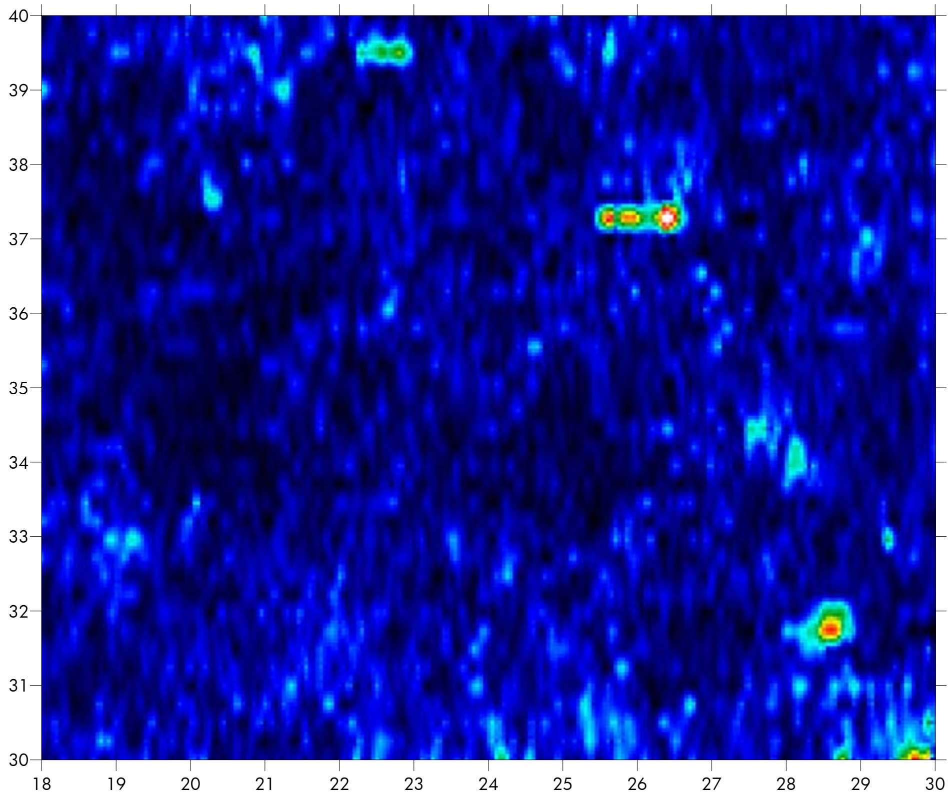
APPENDIX A. GPR AMPLITUDE SLICE MAPS

Boot Hill (LA32229)
Eddy County, NM
Grid 1
Amplitude Slice Maps

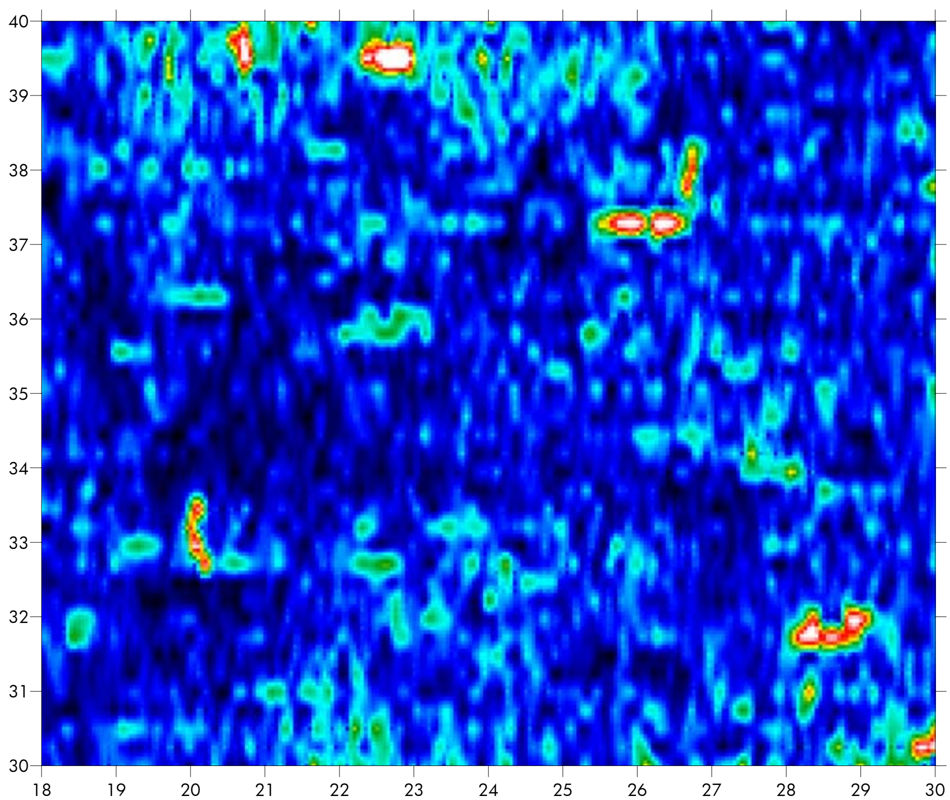


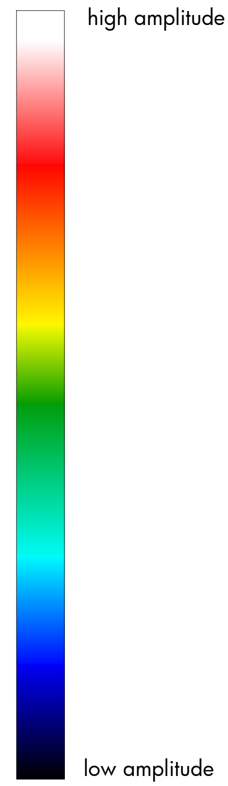
Boot Hill (LA32229)
Eddy County, NM
Grid 2
Amplitude Slice Maps

50 cmbs

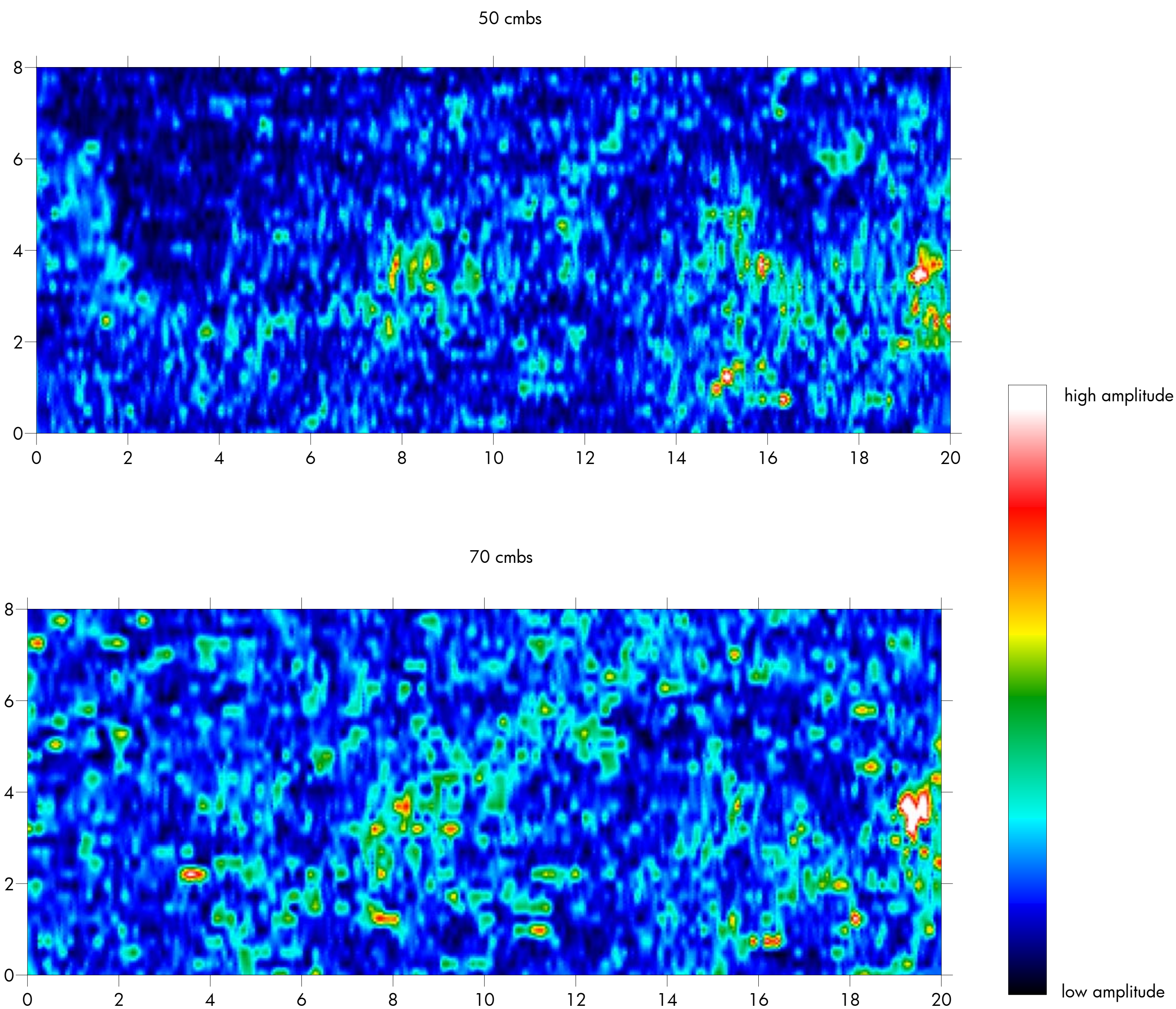


70 cmbs

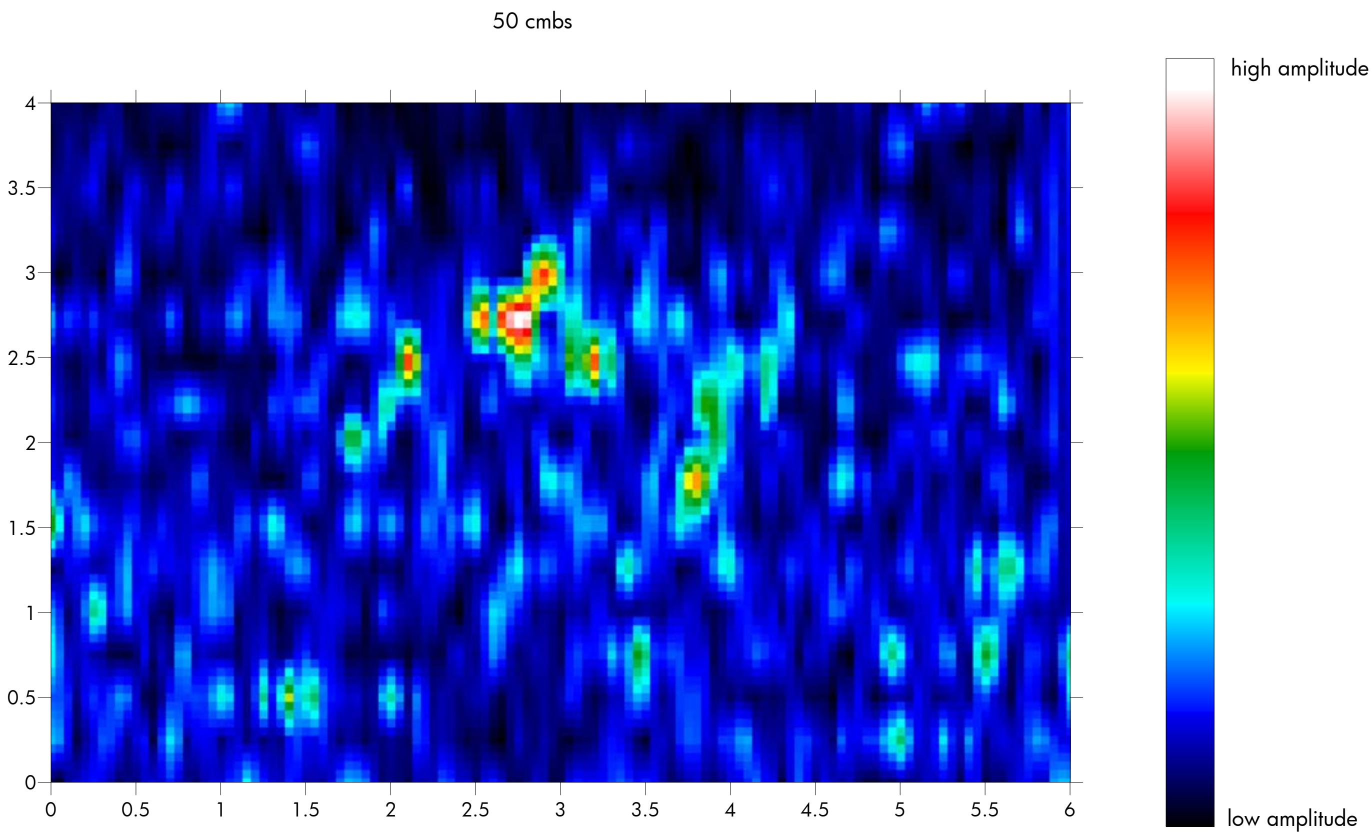




Boot Hill (LA32229)
Eddy County, NM
Grid 3
Amplitude Slice Maps

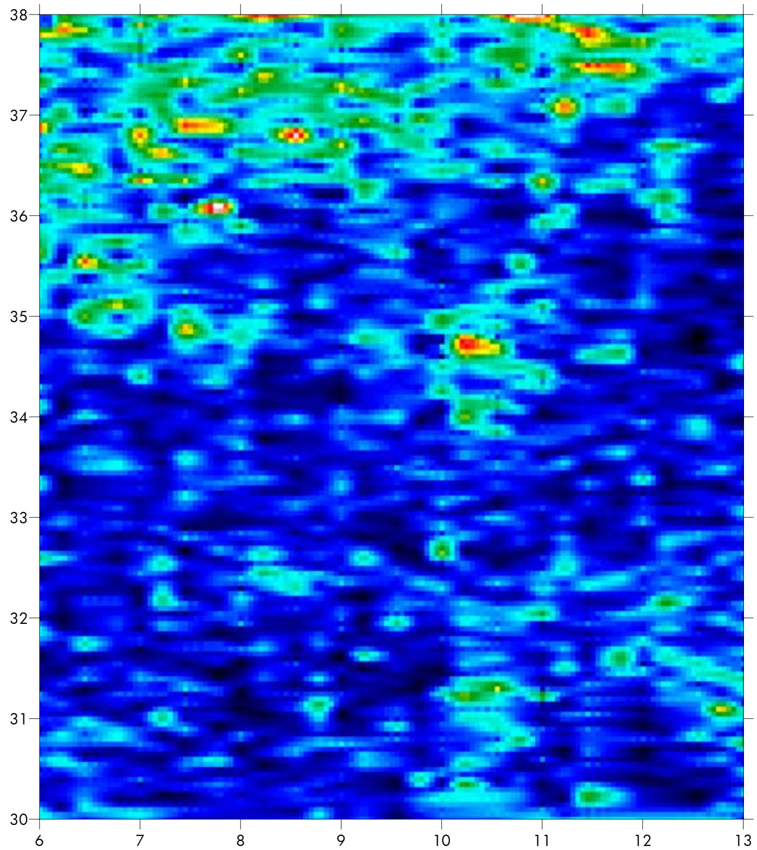


Boot Hill (LA32229)
Eddy County, NM
Grid 4
Amplitude Slice Map

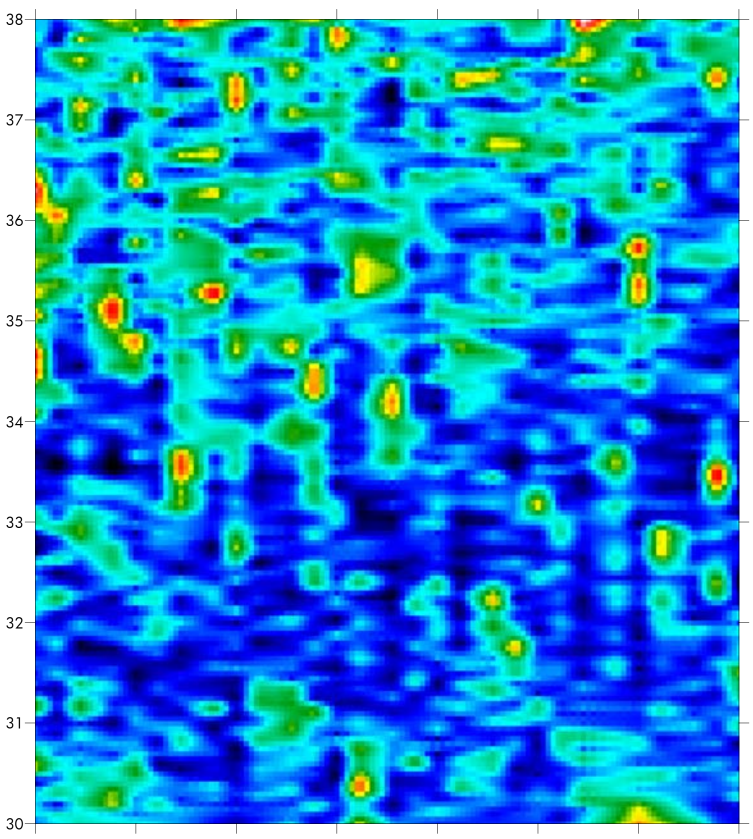


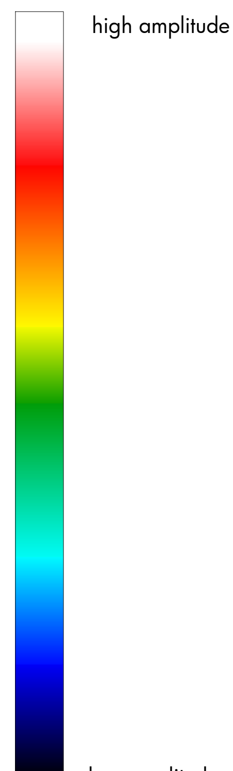
Boot Hill (LA32229)
Eddy County, NM
Grid 5
Amplitude Slice Maps

50 cmbs

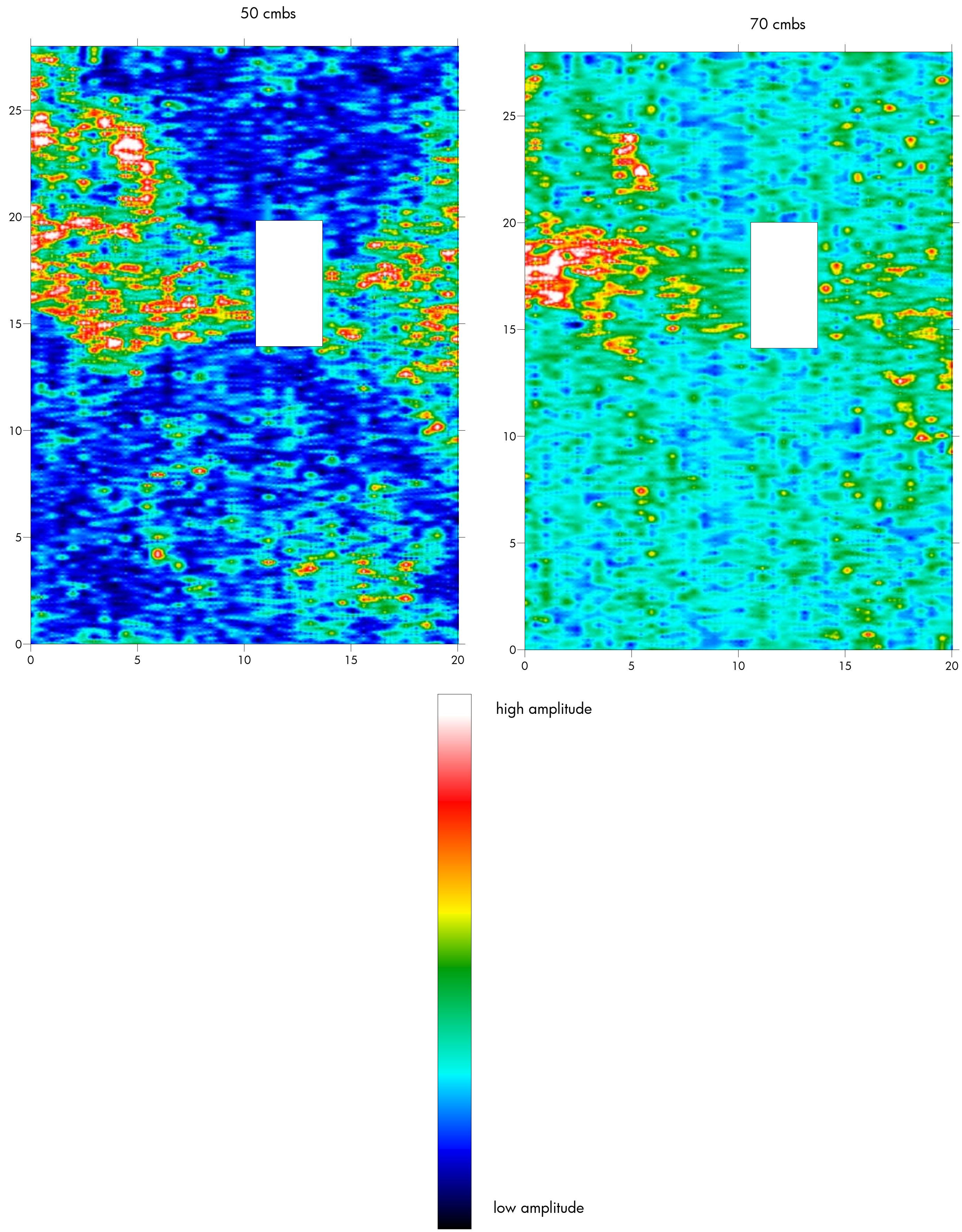


70 cmbs

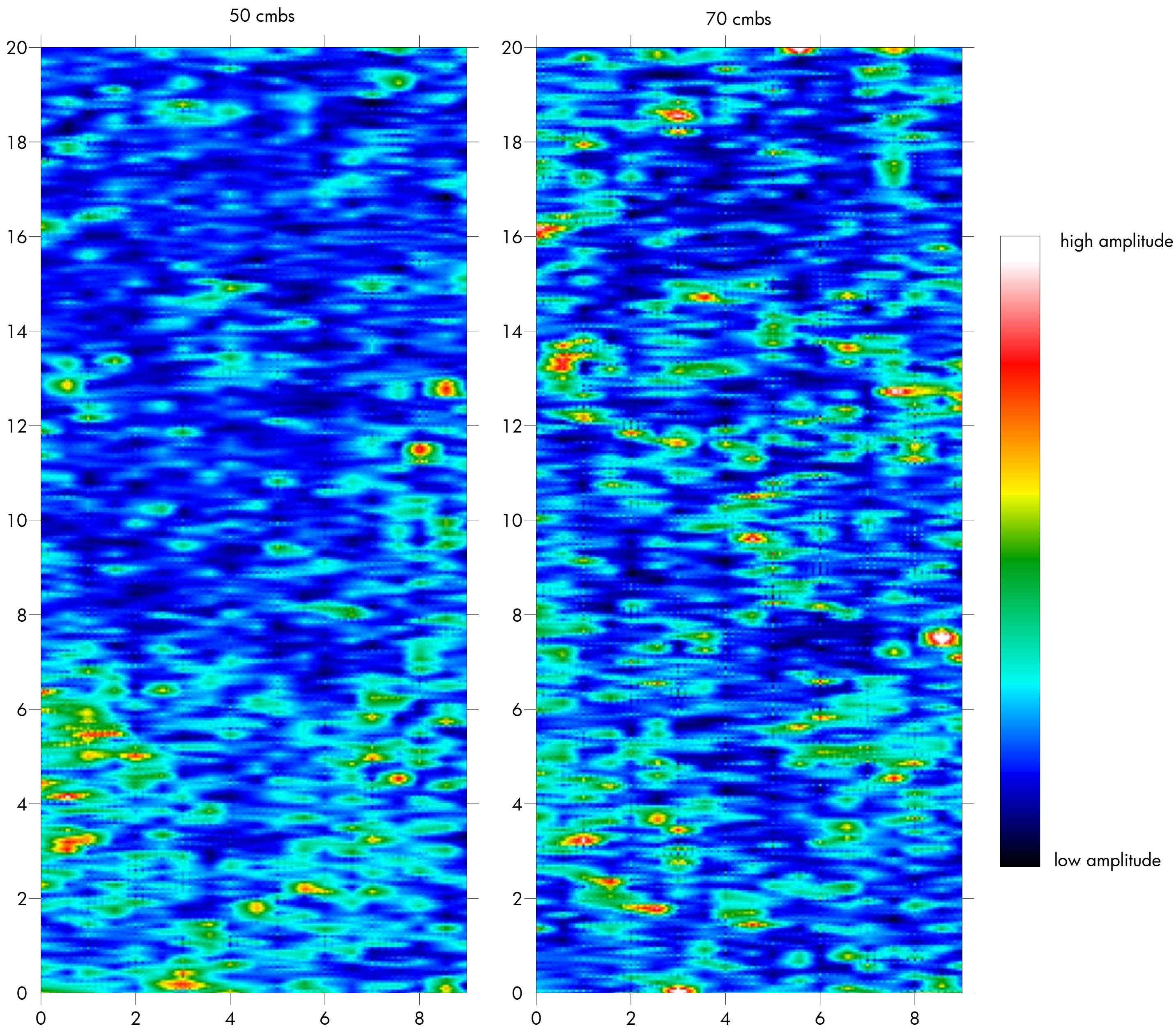




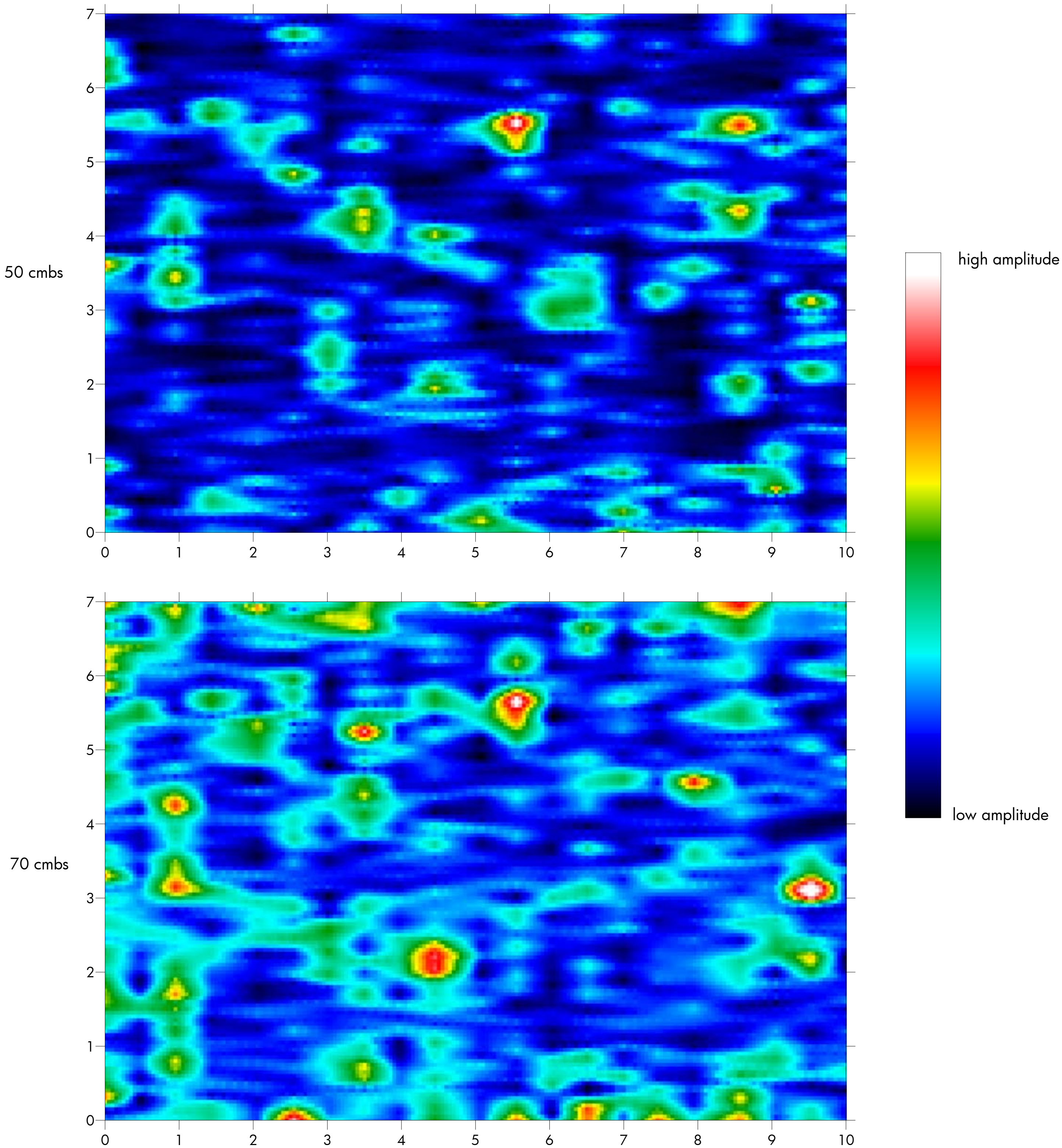
Boot Hill (LA32229)
Eddy County, NM
Grid 6
Amplitude Slice Maps



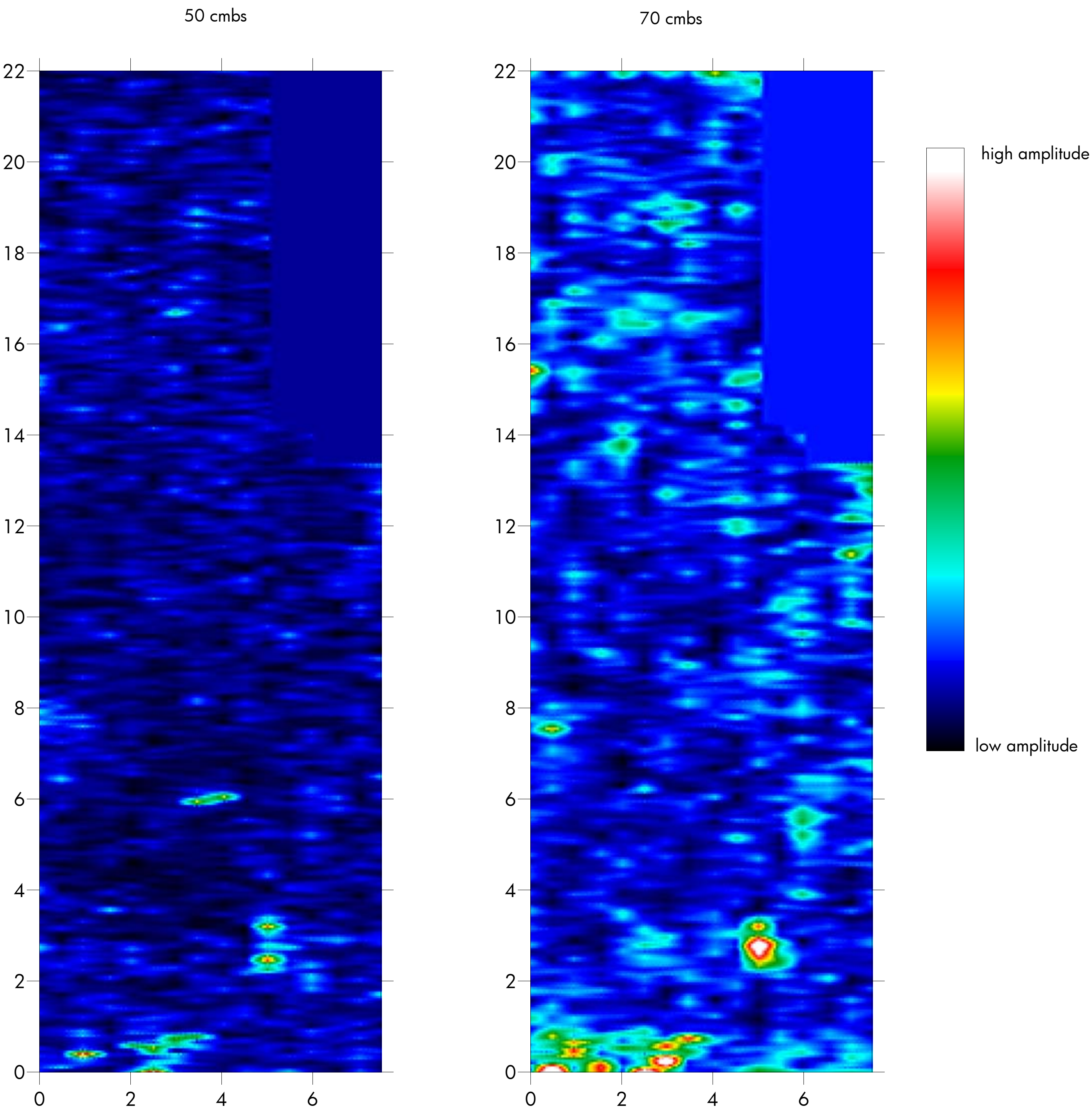
Boot Hill (LA32229)
Eddy County, NM
Grid 7
Amplitude Slice Maps



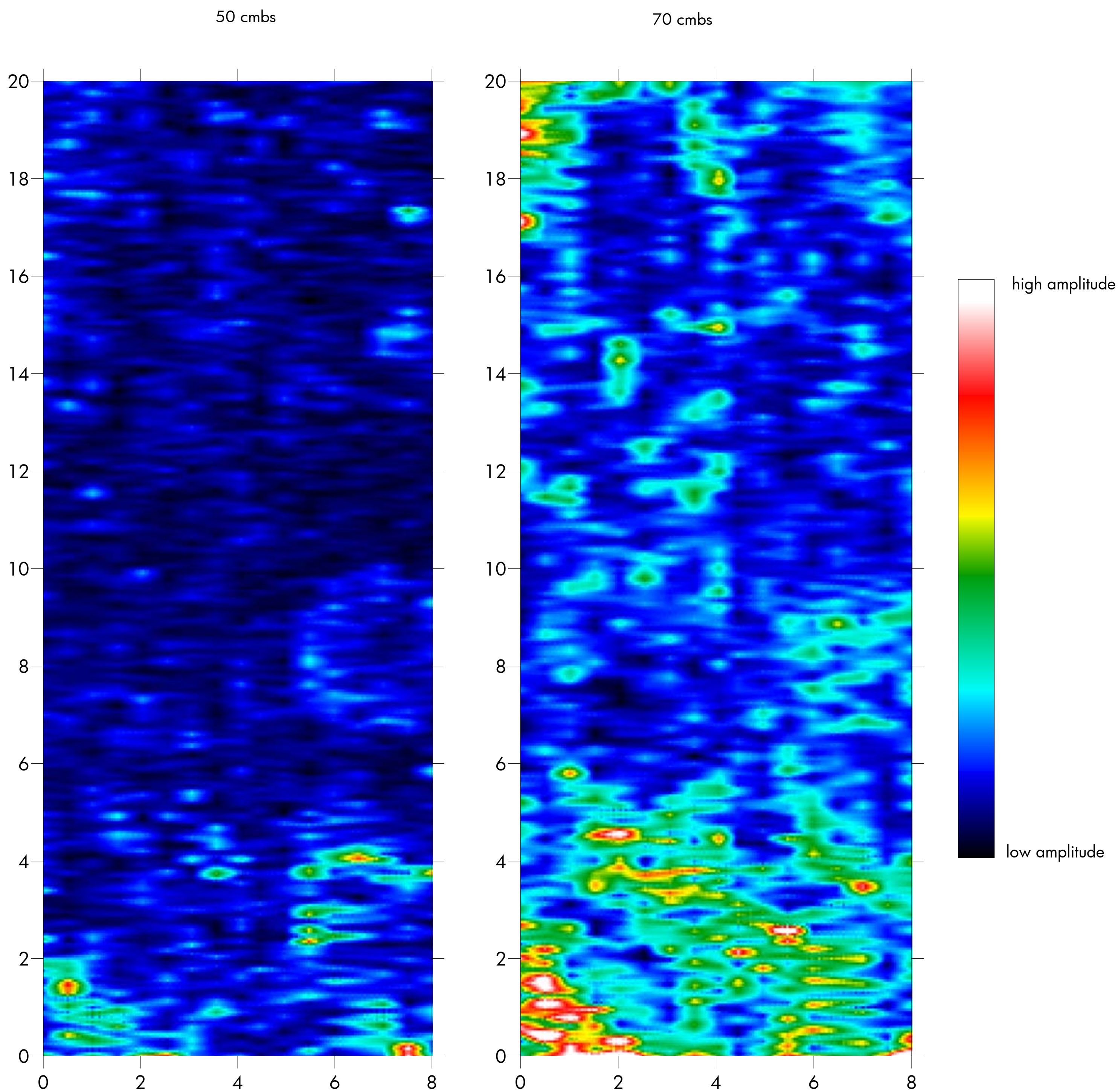
Boot Hill (LA32229)
Eddy County, NM
Grid 8
Amplitude Slice Maps



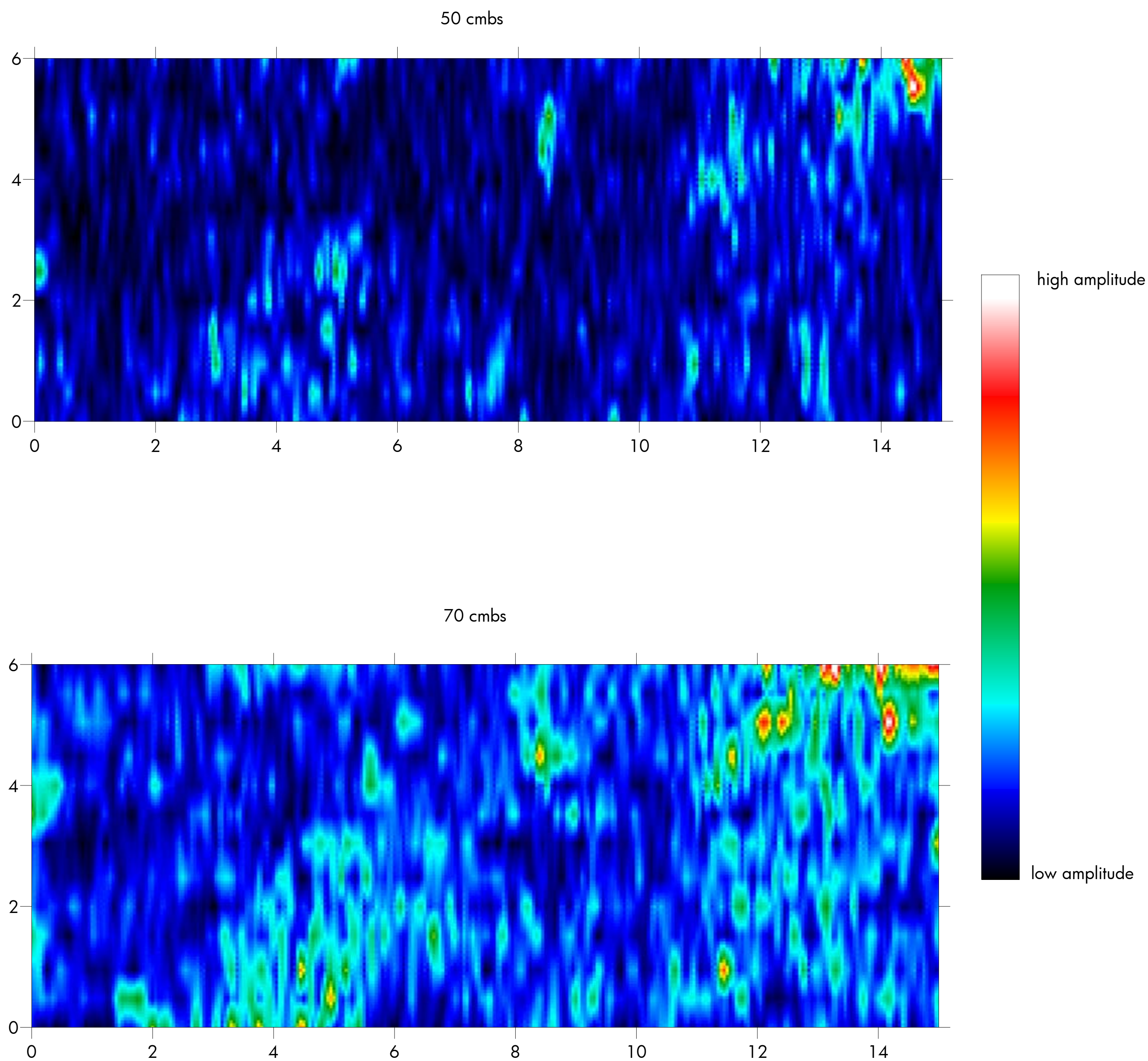
Boot Hill (LA32229)
Eddy County, NM
Grids 9 and 10
Amplitude Slice Maps



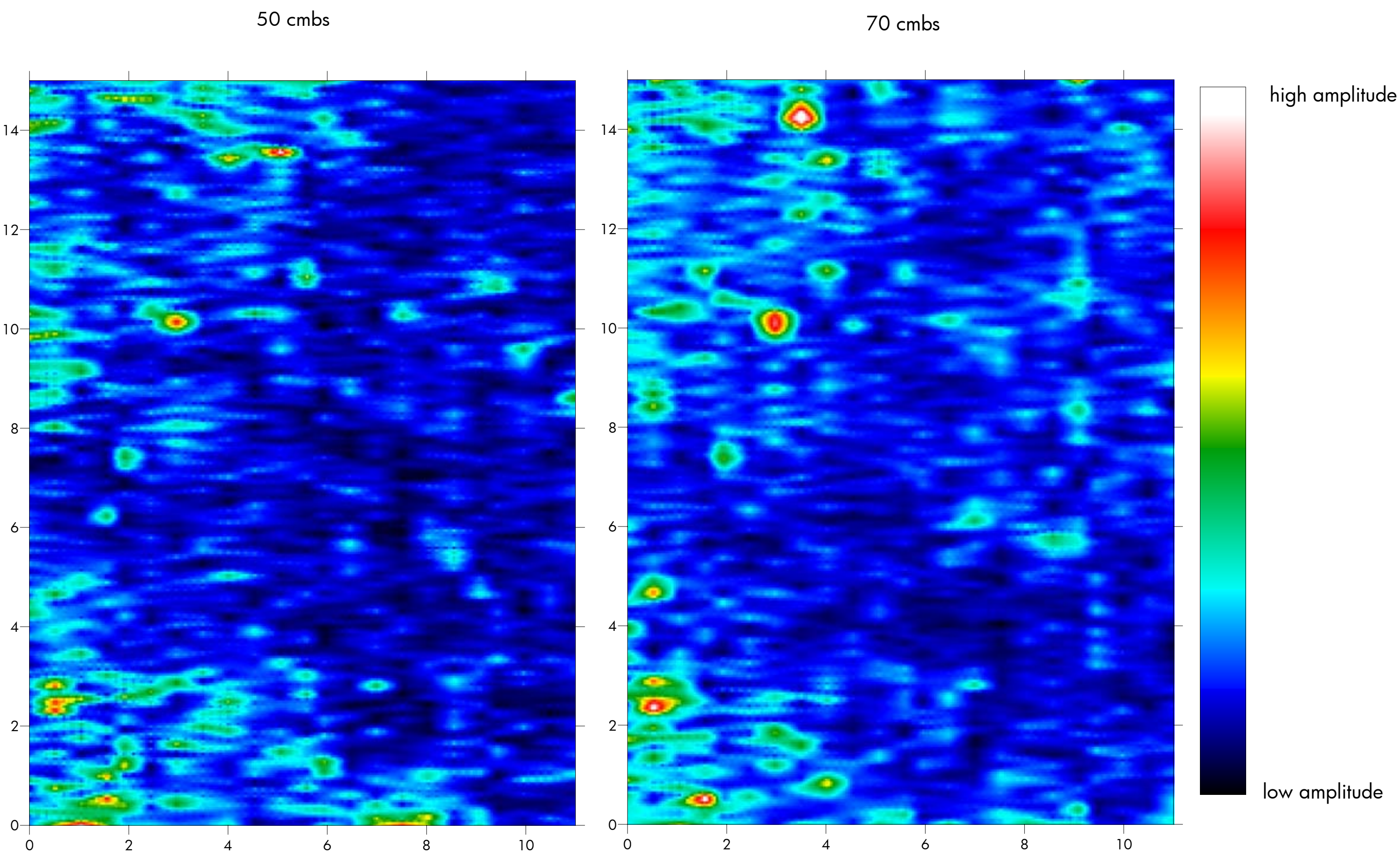
Boot Hill (LA32229)
Eddy County, NM
Grid 11
Amplitude Slice Maps



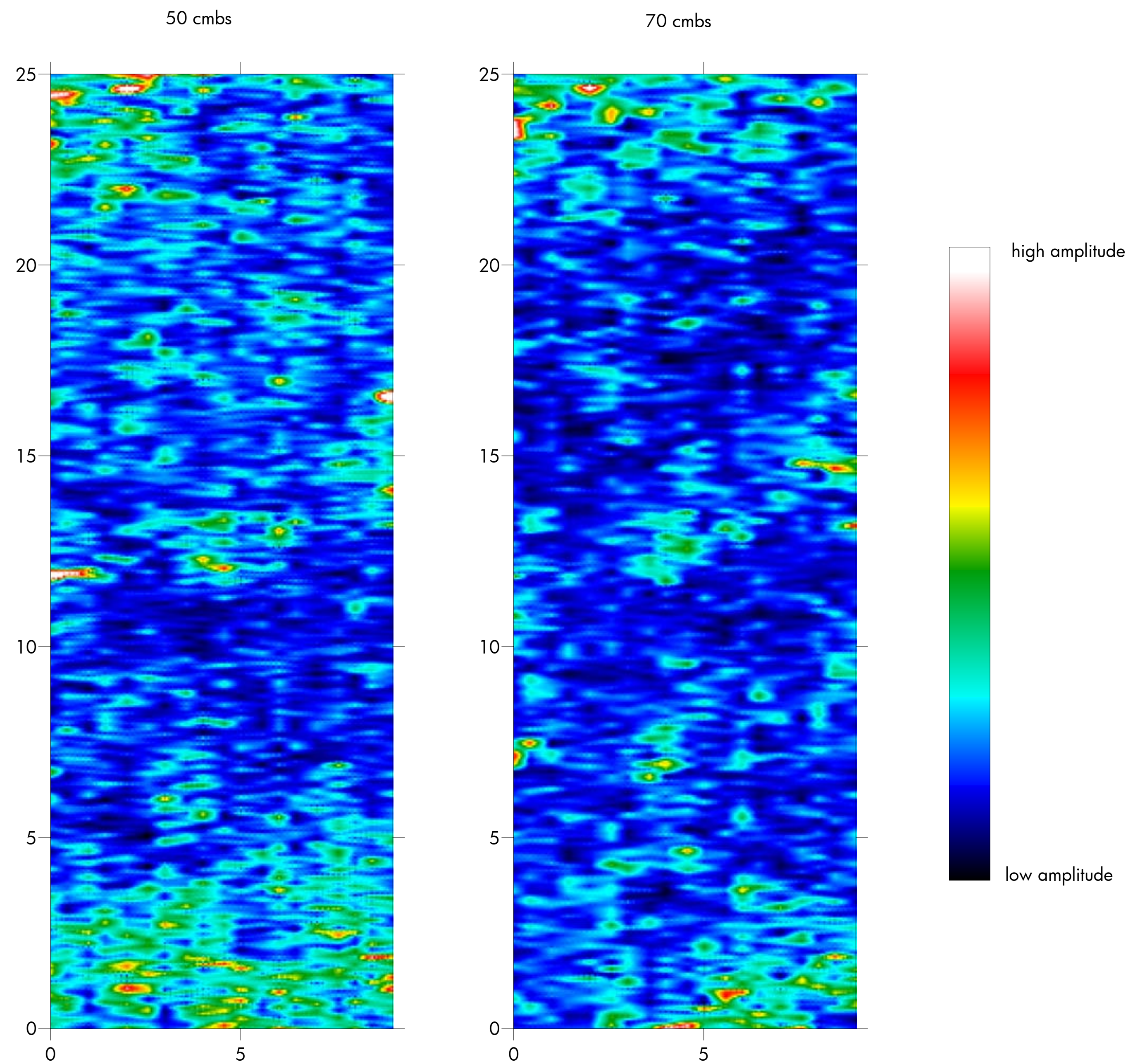
Boot Hill (LA32229)
Eddy County, NM
Grid 12
Amplitude Slice Maps



Boot Hill (LA32229)
Eddy County, NM
Grid 13
Amplitude Slice Maps

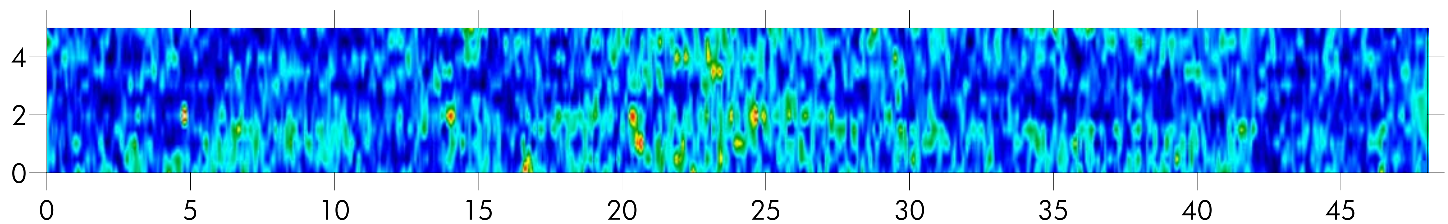


Boot Hill (LA32229)
Eddy County, NM
Grid 14
Amplitude Slice Maps

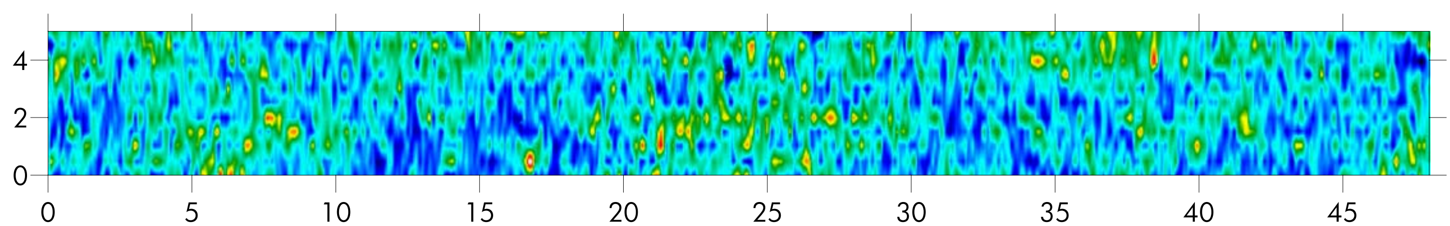


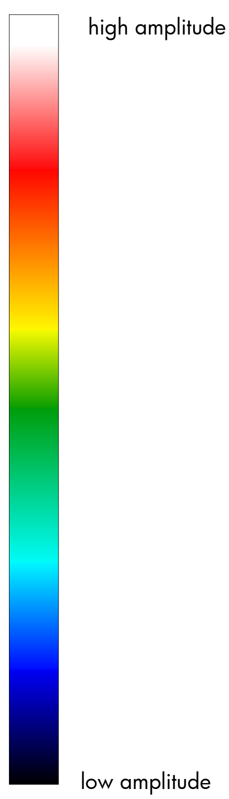
Boot Hill (LA32229)
Eddy County, NM
Grid 15
Amplitude Slice Maps

50 cmbs



70 cmbs

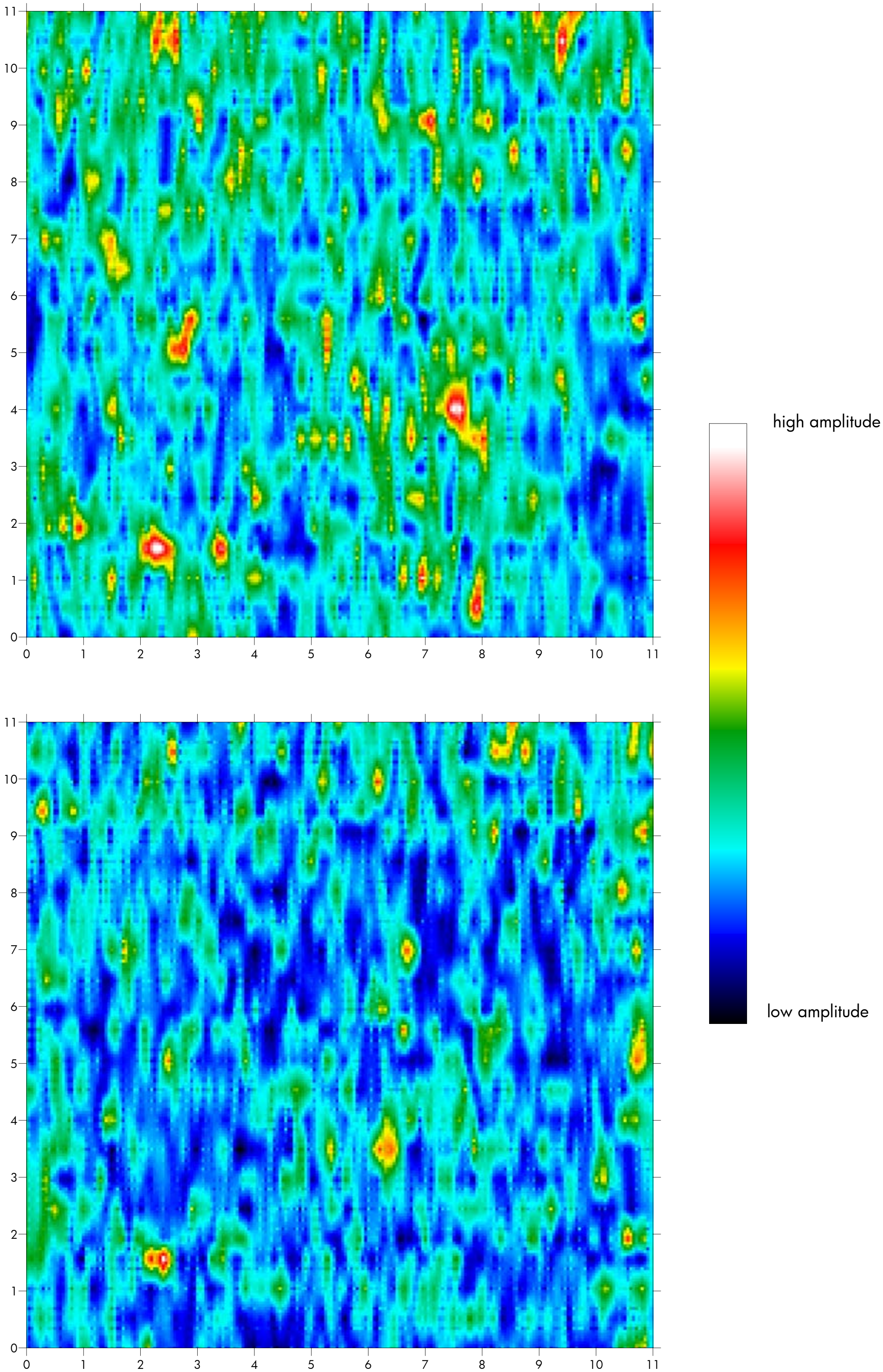




Boot Hill (LA32229)
Eddy County, NM
Grid 16
Amplitude Slice Maps

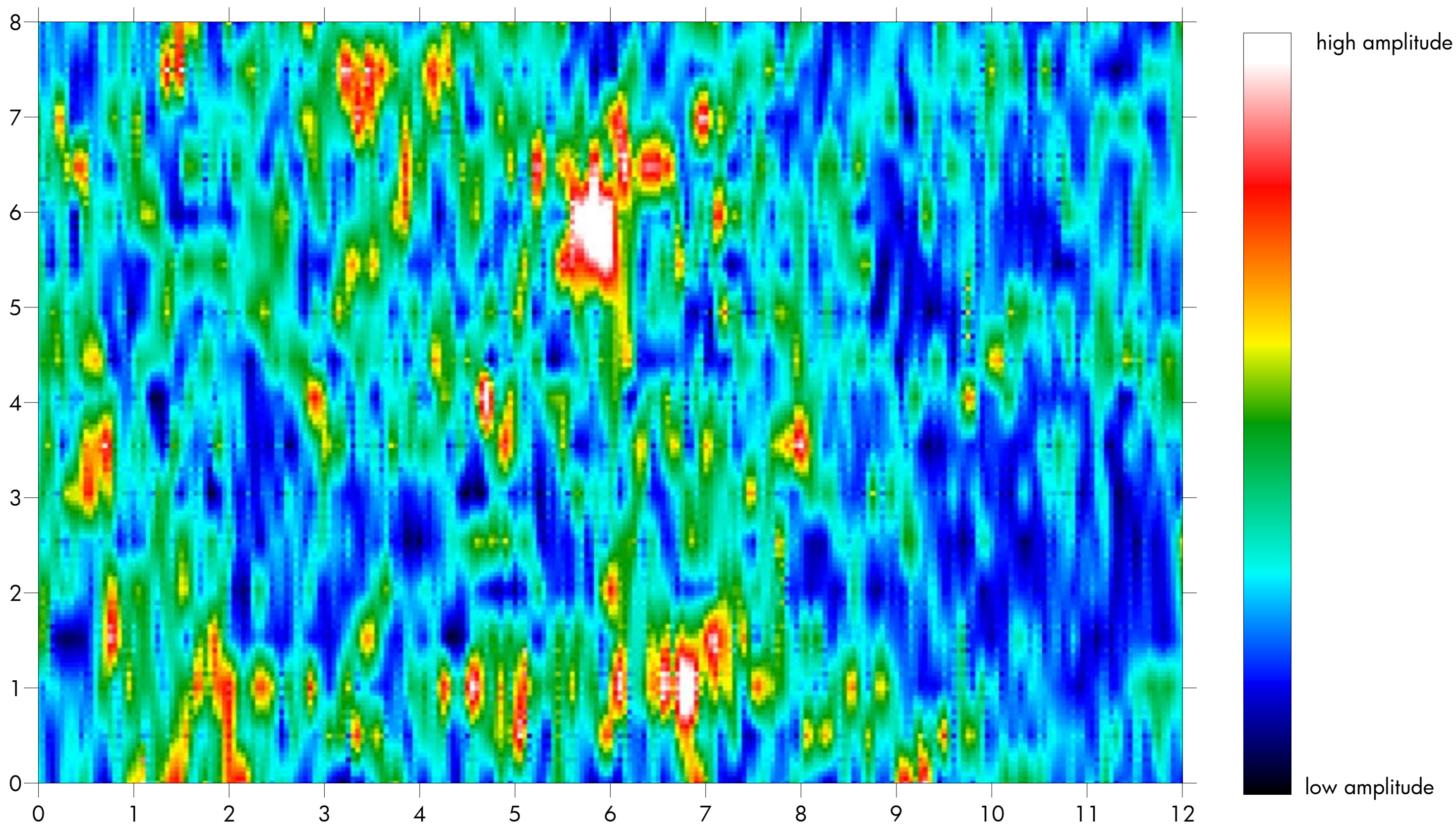
50 cmbs

70 cmbs

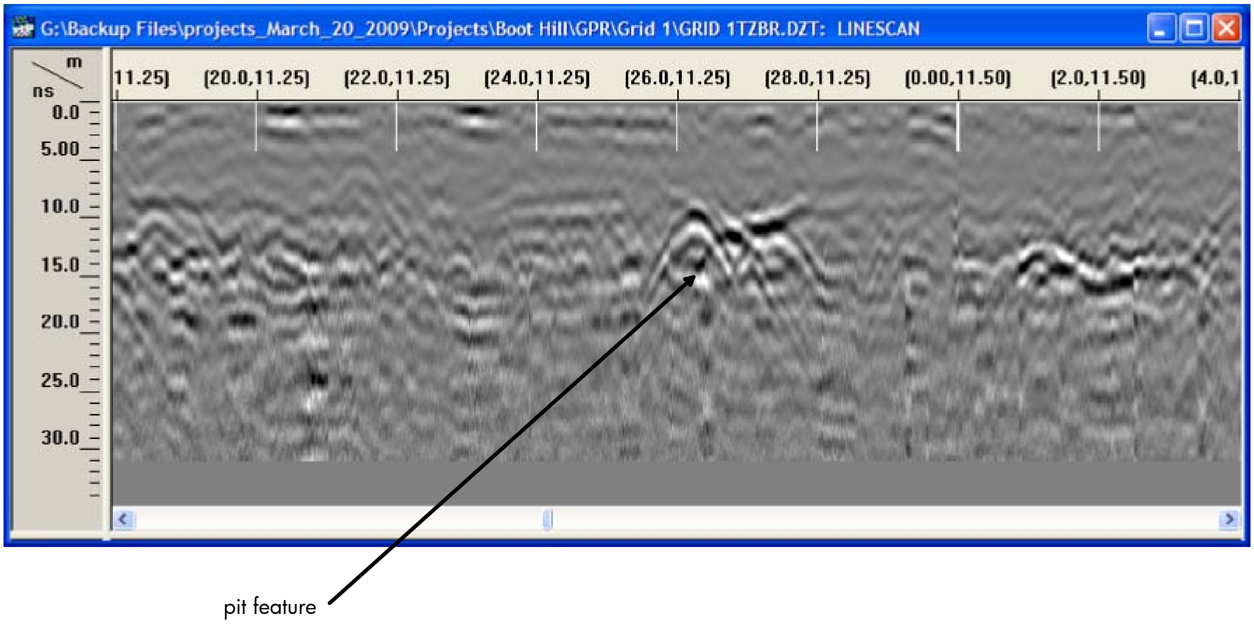


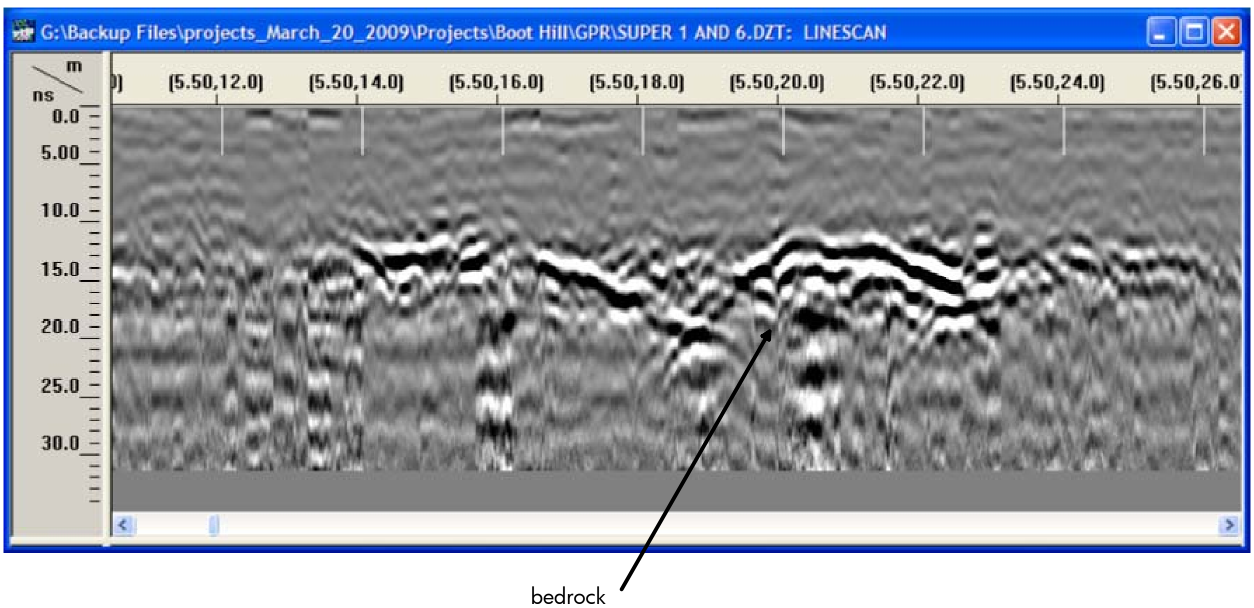
Boot Hill (LA32229)
Eddy County, NM
Grid 17
Amplitude Slice Maps

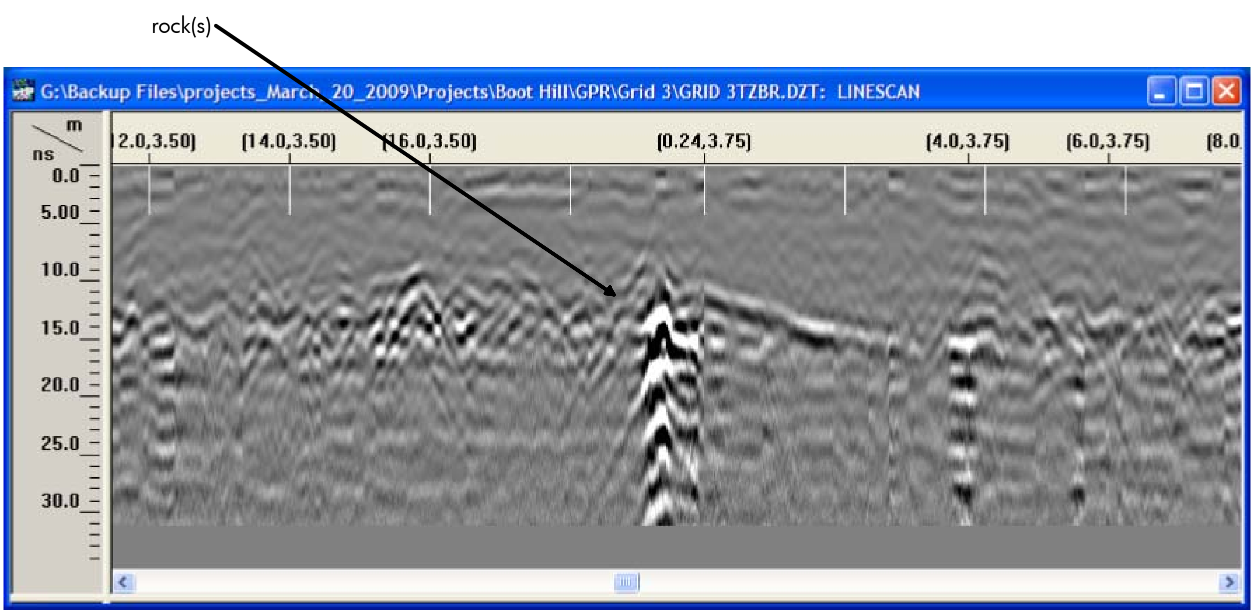
25 cmbs



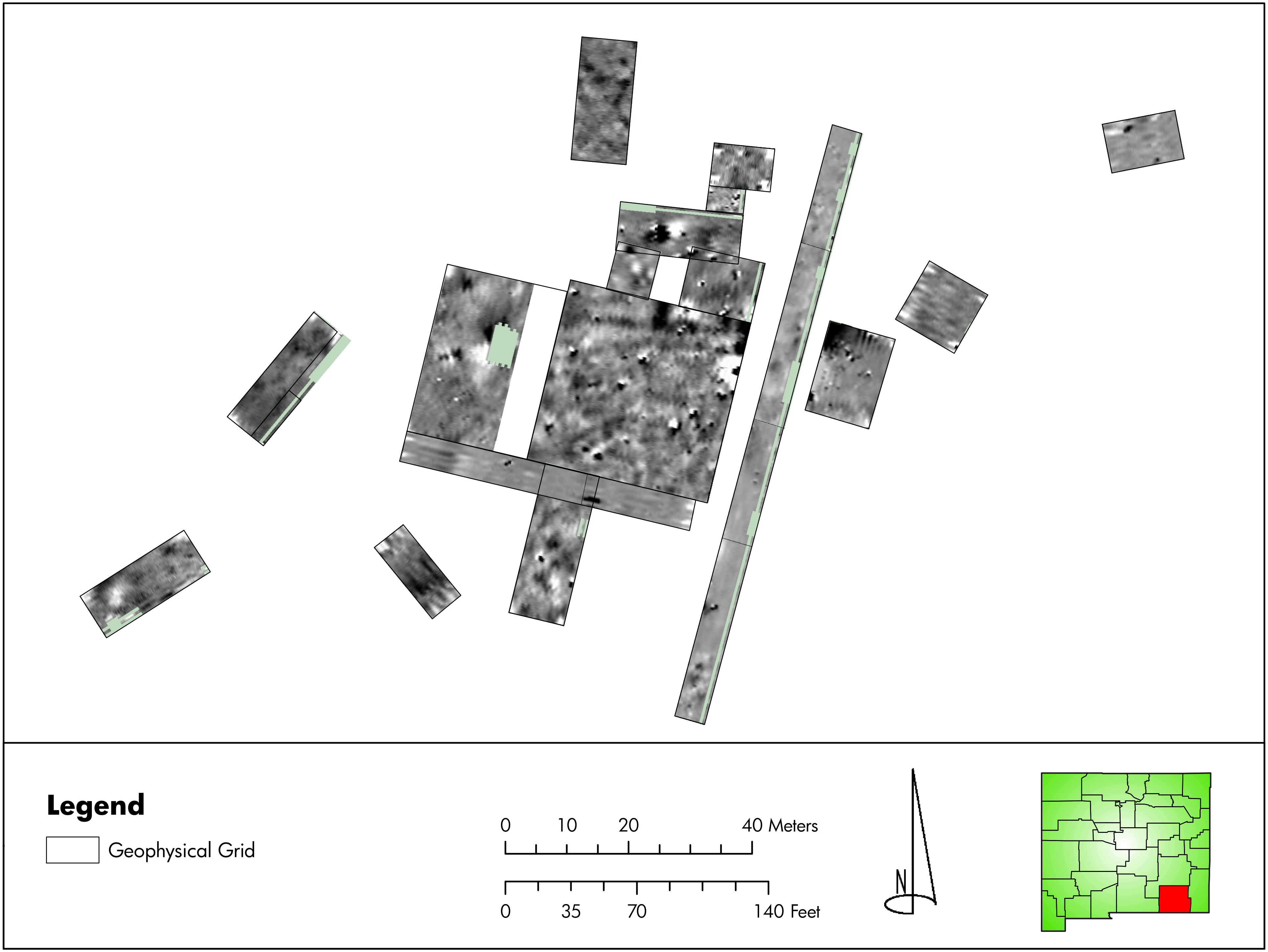
APPENDIX B. SELECTED GPR PROFILES

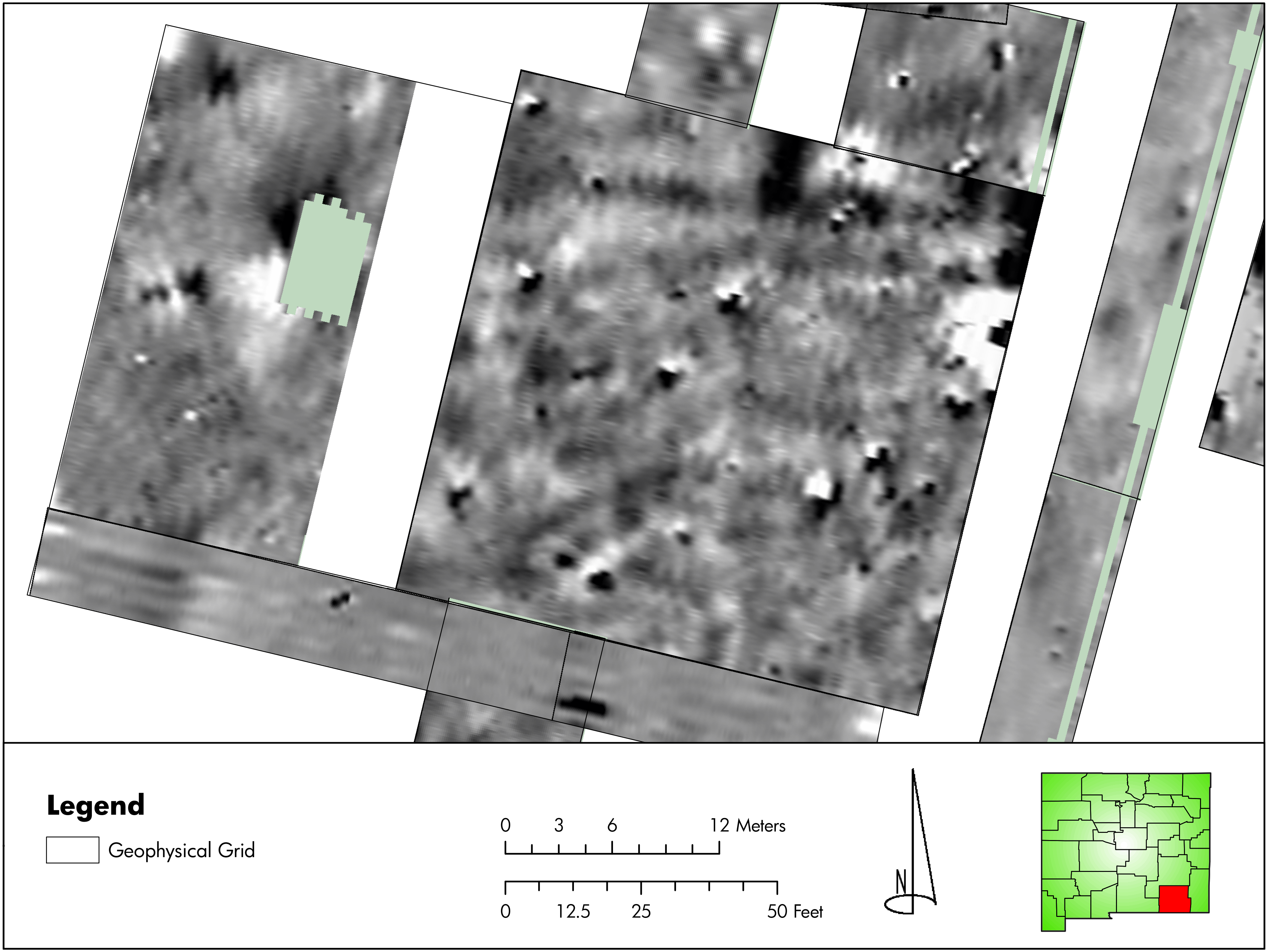

G:\Backup Files\projects_March_20_2009\Projects\Boot Hill\GPR\Grid 1\GRID 1TZBR.DZT: LINESCAN
m
ns
11.25) (20.0,11.25) (22.0,11.25) (24.0,11.25) (26.0,11.25) (28.0,11.25) (0.00,11.50) (2.0,11.50) (4.0,1
0.0
5.00
10.0
15.0
20.0
25.0
30.0
pit feature

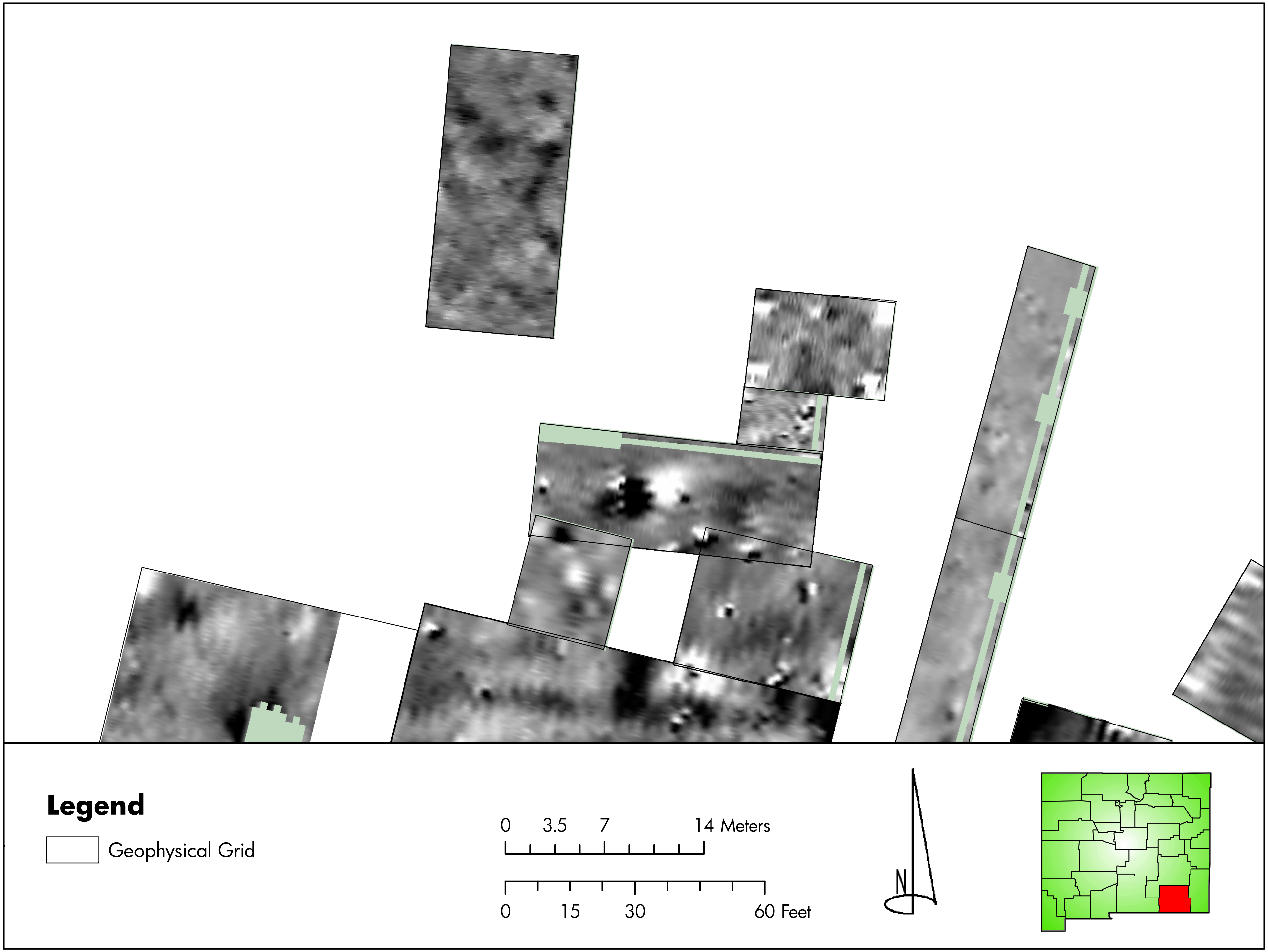

G:\Backup Files\projects_March_20_2009\Projects\Boot Hill\GPR\SUPER 1 AND 6.DZT: LINESCAN
m
ns
(5.50,12.0) (5.50,14.0) (5.50,16.0) (5.50,18.0) (5.50,20.0) (5.50,22.0) (5.50,24.0) (5.50,26.0
0.0
5.00
10.0
15.0
20.0
25.0
30.0
bedrock


rock(s)
G:\Backup Files\projects_March_20_2009\Projects\Boot Hill\GPR\Grid 3\GRID 3TZBR.DZT: LINESCAN
m
ns
2.0,3.50) (14.0,3.50) (16.0,3.50) (0.24,3.75) (4.0,3.75) (6.0,3.75) (8.0
0.0
5.00
10.0
15.0
20.0
25.0
30.0

APPENDIX C. MAGNETIC DATA


Legend
Geophysical Grid
0 10 20 40 Meters
0 35 70 140 Feet
N


Legend
Geophysical Grid
0 3 6 12 Meters
0 12.5 25 50 Feet
N



Legend
Geophysical Grid
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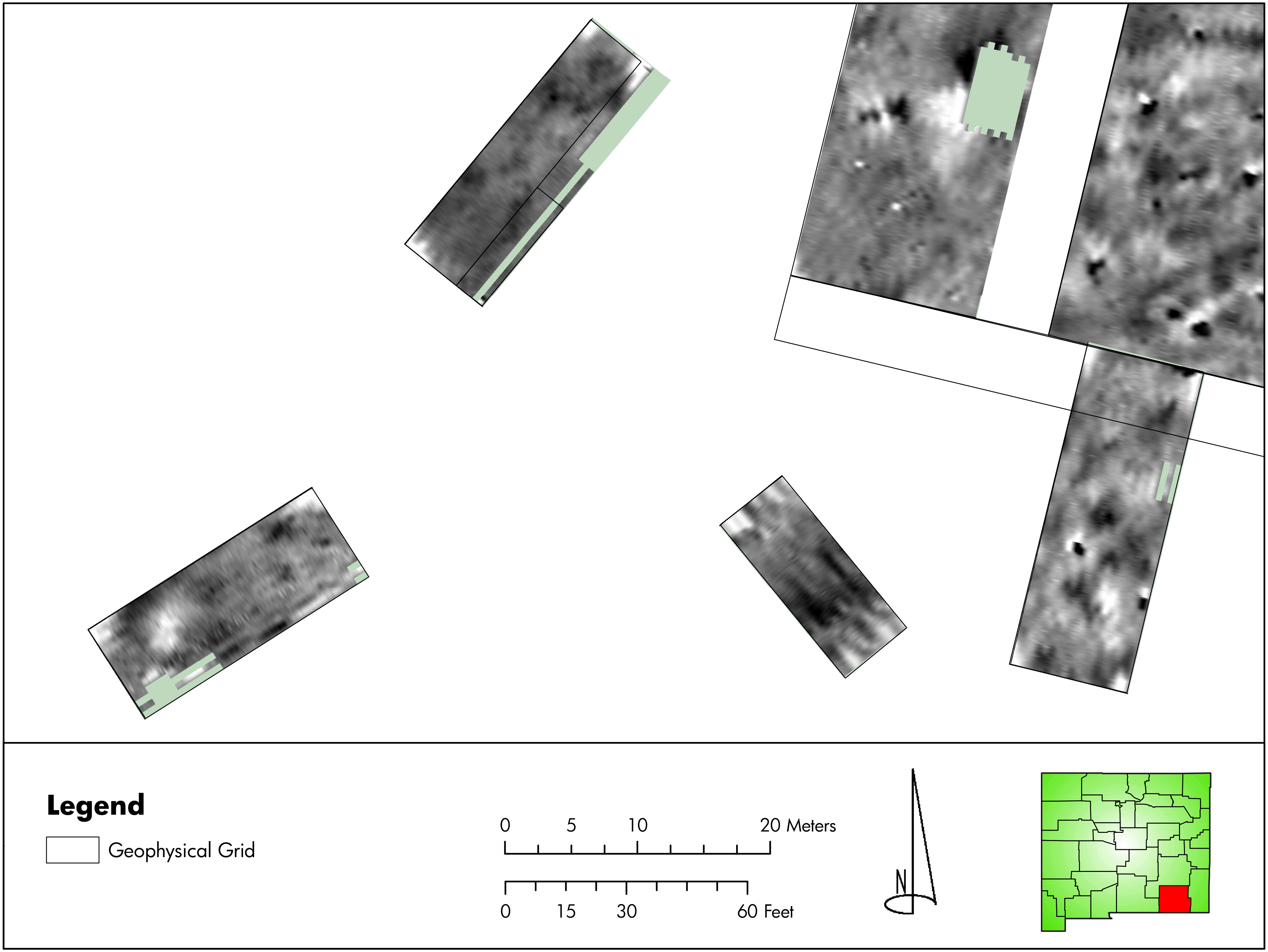
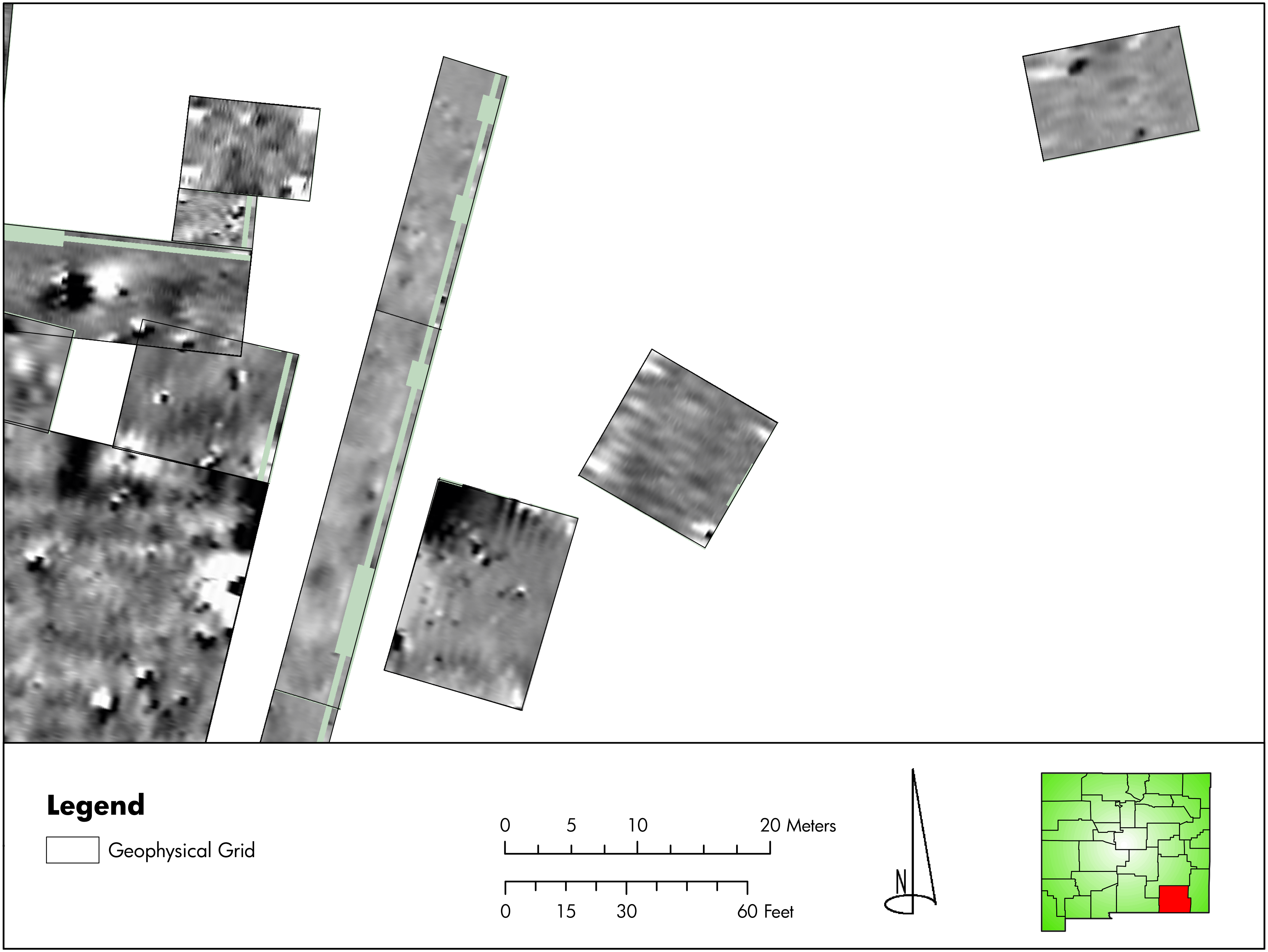
0 15 30 60 Feet
N



Legend
Geophysical Grid
0
5
10
20 Meters
0
15
30
60 Feet
N


Legend
Geophysical Grid
0
5
10
20 Meters
0
15
30
60 Feet
N

Appendix M: Additional Features Outside Project Boundary

Appendix M has been removed to protect confidential site location information.