A FUNCTIONAL ANALYSIS OF ARCHAIC FORESHAFTS AND OTHER WOODEN DART COMPONENTS FROM THE NORTHERN CHIHUAHUAN DESERT

THESIS

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TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

CHAPTER I

INTRODUCTION

Prior to the introduction of the bow and arrow, the spear and atlatl (or spear-thrower) were essential parts of prehistoric weapon systems in North America. Most prehistoric spears, often and herein called darts, appear to have been comprised of three primary components: the point, the mainshaft, and an intermediary foreshaft to which the point was hafted. Projectile points and other lithic tools, and the debitage resulting from their manufacture, constitute the bulk of the artifacts recovered from Archaic archaeological sites and have been the subject of countless scholarly inquiries. The other normally-perishable components are rarely preserved, however, and relatively few comprehensive studies of wooden dart components have been conducted. The dry caves and rockshelters of the northern Chihuahuan Desert offer opportunities to study the organic elements of Archaic weapon systems usually absent in open-air sites. This thesis presents the results of a functional analysis of foreshafts and other wooden dart components recovered from the Lower Pecos and western Trans-Pecos regions of Texas. The parameters of several morphological attributes are examined, and the ways in which these attributes may have influenced the function and use-life of certain lithic tools are discussed.

CHAPTER II

THE STUDY AREA: ENVIRONMENTAL AND CULTURAL BACKGROUNDS

Present Environment

The Chihuahuan Desert is the largest and easternmost desert in North America. Occupying approximately 350,000 km^2, it covers north-central Mexico and southwest Texas, and extends northward into southern New Mexico and southeastern Arizona (Schmidt 1979). The exact boundary of the Chihuahuan Desert, as defined by various researchers, depends largely upon whether climatic or vegetative criteria are used to delineate this environmental zone (Monger et al. 2006:15; Schmidt 1979). Using climate, vegetation, physiography, and other biotic and abiotic phenomena, Griffith et al. (2004) recently redefined the Chihuahuan Desert ecoregion in Texas following a four-tiered hierarchical framework developed by the United States Environmental Protection Agency (USEPA), the United States Geographic Survey, and other federal and state agencies. As seen in Figure 1, the Chihuahuan Desert occupies the entirety of Texas west of the Pecos River - a region often referred to as the Trans-Pecos. This ecoregion also includes strips of land between the Pecos River and High Plains/Llano Estacado to the northeast, as well as between the Pecos River and the Edwards Plateau to the east and the Southern Texas Plains to the southeast - an area often referred to as the Lower Pecos. Designated the 24th

Level III ecoregion in North America, the Chihuahuan Desert is further refined by five Level IV ecoregions (designated 24a through 24e). Explanations of the USEPA's ecoregion levels and the criteria used to delineate them are provided by Gallent et al. (1989) and Omernik (1995).

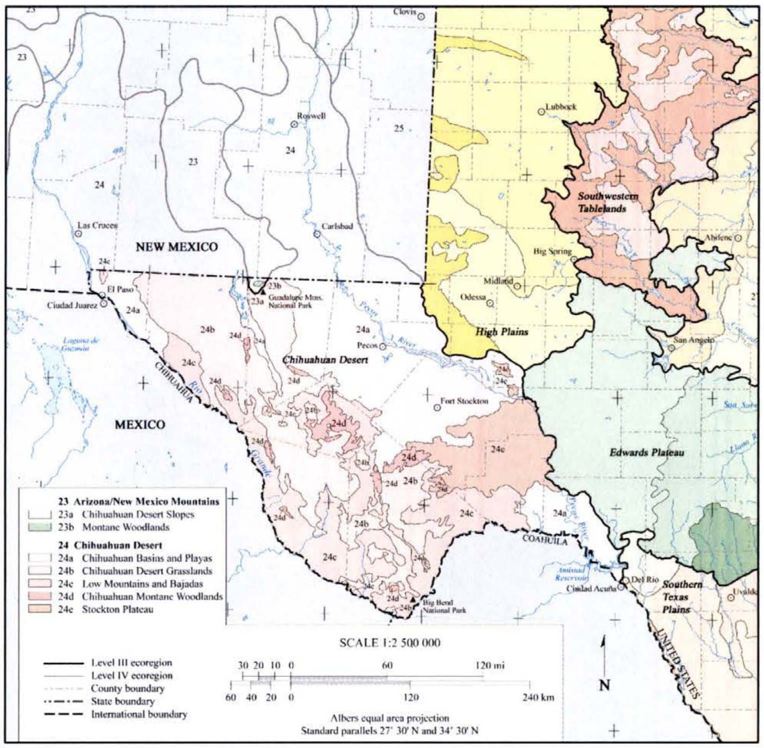

Figure 1. The extent of the Chihuahuan Desert in Texas. After Griffith et al. (2004).

The majority of the Trans-Pecos is physiographically characterized by northwest-to-southeast trending mountain ranges separated by wide drainage basins sometimes called bolsons (Miller and Kenmotsu 2004:207) (Figure 2). The primary internal drainage features include the Hueco Bolson and the Salt Flat, Delaware, and Toyah Basins. The most prominent ranges include, from north to south, the Guadalupe, Delaware, Davis, Glass, and Chisos Mountains. The Lower Pecos is characterized by the relatively flat Stockton Plateau, and the southern edge of the Edwards Plateau, which are dissected by the deeply-incised canyons of the Pecos, Devils, and Rio Grande Rivers. The canyon walls of these rivers and their tributaries are occasionally marked by eroded limestone rockshelters (Figure 3).

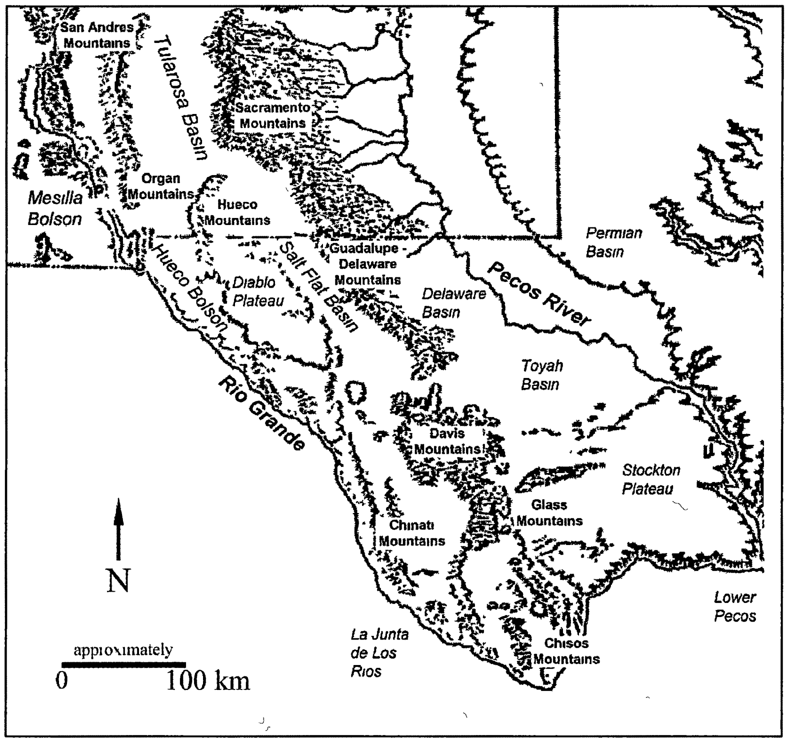

Figure 2. Major physiographic features of southwest Texas and southeastern New Mexico. After Miller and Kenmotsu (2004:Figure 7.2).

Although the climate of the northern Chihuahuan Desert is categorized as semi-arid or arid, with relatively low average rainfalls ranging from approximately 20-31 cm annually (Miller and Kenmotsu 2004:208; Saunders 1992:337; Schmidt 1979:245; Wainwright 2004:46), this desert environment supports a surprisingly wide variety of flora and fauna. Xeric plants, such as sotol (*Dasylirion* spp.), lechuguilla (*Agave lechuguilla*), yucca (*Yucca* spp.), honey mesquite (*Prosopis glandulosa*), and prickly pear cactus (*Opuntia* spp.) dominate most of the landscape (Blair 1950:106; Saunders

1992:337). River bottoms support communities of mesic plants including a variety of grasses and shrubs, and a number of deciduous trees such as willow (*Salix* sp.), walnut (*Juglans microcarpus*), pecan (*Carya illinioensis*), acacia (*Acacia rigudula*), oak (*Quercus* spp.), and Mexican ash (*Fraxinus greggii*) (Bousman and Quigg 2006:124; Lehmer 1958:109). Increased precipitation in the higher mountains supports montane forests of coniferous trees like ponderosa pine (*Pinus ponderosa*) and Mexican piñon (*Pinus cembroides*) intermixed with oak (Lehmer 1958:109). The northern Chihuahuan Desert is inhabited by a variety of medium-to-large mammals such as deer (*Odocoileus hemionus*), pronghorn antelope (*Antilocapra americana),* ringtails (*Bassariscus astutus*), rabbits (*Sylvilages auduboni* and *Lepus californicus*), and the occasional bear (*Ursus americanus*), as well as various rodents, reptiles, birds, and fish (Blair 1950:107-108; Lehmer 1958:110; Miller and Kenmotsu 2004:208; Saunders 1992:337).

Figure 3. View of Fate Bell Rockshelter in Seminole Canyon, about 5 km north of Rio Grande; looking southwest.

Cultural and Environmental History

The Chihuahuan Desert extends across multiple archaeological regions in Texas (Figure 4). How these cultural areas have been defined and delineated has varied considerably over time and between researchers. Most researchers now recognize at least three archaeological regions or districts in southwest Texas based on the distributions of specific cultural traits and adaptive strategies. The westernmost archaeological region in the study area is referred to as the El Paso/Hueco Bolson district (Lehmer 1958:127; Perttula 2004:7), or sometimes the Western Trans-Pecos/Jornada Mogollon culture region (Miller and Kenmotsu 2004), to emphasize connections to the Puebloan cultures of New Mexico and the greater Southwest. The smallest and easternmost archaeological region in the study area is the Lower Pecos. This region is largely defined by the distribution of distinctive styles of rock art centered on the confluences of the Pecos, Devils, and Rio Grande Rivers. The largest archaeological region, the Trans-Pecos, is characterized for the most part by somewhat homogeneous hunter-gatherer adaptations that persisted until European contact. Some researchers (e.g., Lehmer 1958; Miller and Kenmotsu 2004) also recognize the La Junta district along the Rio Grande in the vicinity of Presidio, Texas. This archaeological region is distinguished by the distribution of small pithouse villages dating between approximately A.D. 1200 and A.D. 1450 (Miller and Kenmotsu 2004:256-258). Although architecturally distinct, La Junta settlements may have been significantly influenced by the Mogollon of the El Paso area (Miller and Kenmotsu 2004:257-258). Because the artifacts in this study with known proveniences were recovered from sites located in the Lower Pecos and Hueco Bolson areas (Figure 5), these archaeological regions will be discussed in greater detail below.

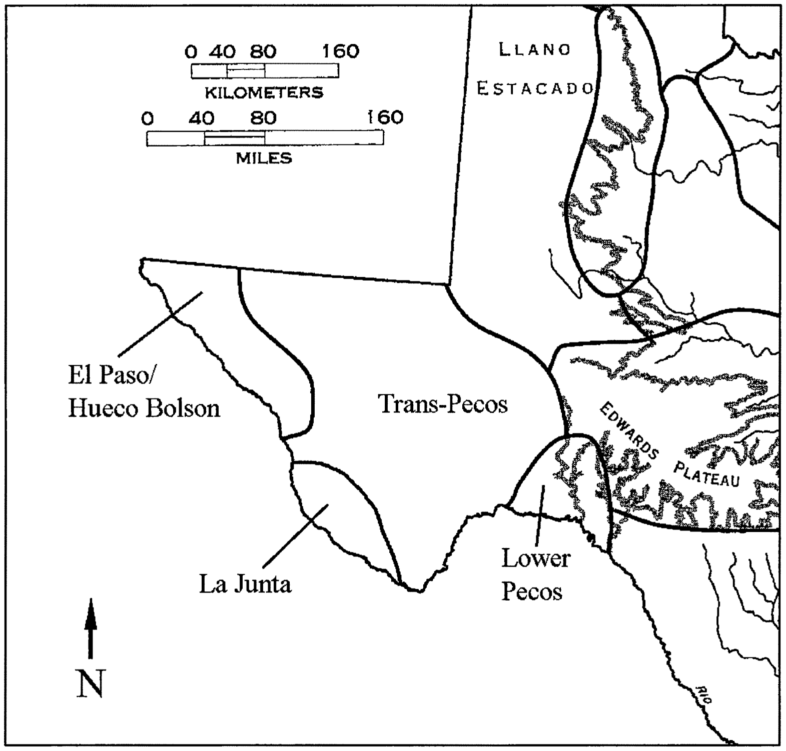

Figure 4. Archaeological regions/culture areas of southwest Texas. After Lehmer (1960:Figure 1) and Perttula (2004:Figure 1.1).

As with the delineation of culture areas in southwest Texas, the regional chronologies constructed for the portions of Texas currently occupied by the northern Chihuahuan Desert have varied over time and between researchers. Early attempts to classify the cultural sequences of the Lower Pecos and western Trans-Pecos regions relied on terminology and a general framework borrowed from prehistorians working in the Southwest. For example, M. L. Crimmins (1929) and George Martin (1933) used the term "Basket Maker" to describe pre-ceramic cultural horizons identified in the El Paso and Lower Pecos areas. Several different cultural chronologies have since been proposed for portions of southwest Texas. More detailed discussions of the various cultural chronologies constructed for the Lower Pecos and Trans-Pecos regions are presented by Lehmer (1958) and Turpin (1991). Thomas Hester (1989) divided the culture history of the Lower Pecos into four broad periods: Paleoindian, Archaic, Late Prehistoric, and Historic. This quadripartite construct is still in common usage and has been perpetuated, at least in the most general terms, in recent regional syntheses for the Lower Pecos (Turpin 2004) and the rest of southwest Texas (Miller and Kenmotsu 2004). A brief culture history overview of the study area prior to European contact is provided below. From this point forward, dates prior to A.D. 1535 are given in radiocarbon years before present (B.P.), or more precisely, A.D. 1950.

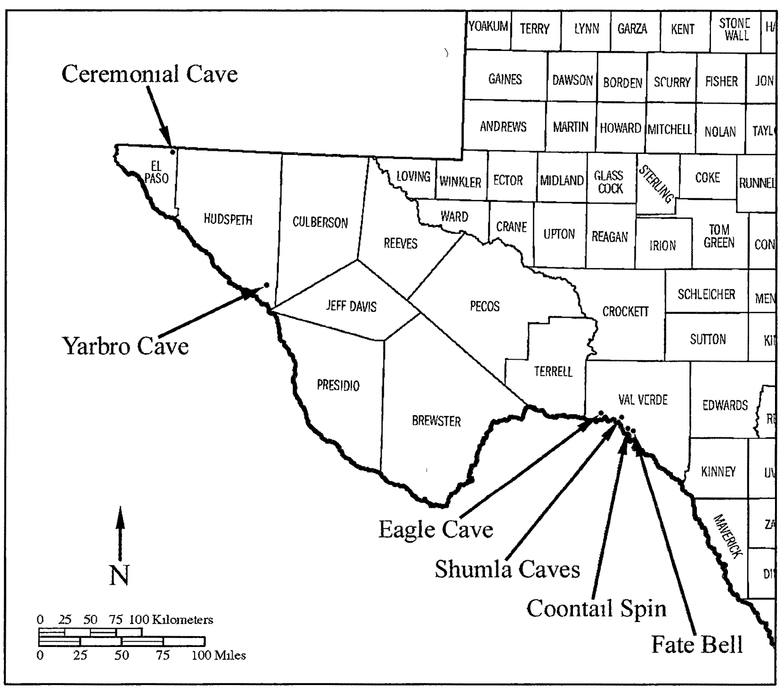

Figure 5. Approximate locations of the archaeological sites from which the majority of the study sample was recovered.

Paleoindian Period (12,000 to 8000 B.P.)

The earliest unequivocal evidence of human occupation in the northern Chihuahuan Desert dates to the Paleoindian period, approximately 12,000 to 8000 B.P. (Hester 1989:56-58; Miller and Kenmotsu 2004:213). Many scholars further divide this period into Early and Late subperiods - a division largely predicated on projectile point typologies, and to a lesser degree, the tool kits and subsistence patterns associated with them. In southwest Texas, the Early Paleoindian period is represented by two lanceolate projectile point types: Clovis and Folsom. Both point types exhibit distinctive flutes (or long, basally-originated channel flake scars) on one or both sides, although Folsom points tend to have thinner cross sections and longer flutes. The generally accepted date range for Clovis occupations throughout North America is approximately 11,500 to 10,500 B.P. (Fagan 2005:89; Haynes 2002:13). Reliable radiocarbon assays for Clovis occupations in Texas fall within this range (Bousman et al. 2004:47-48). Temporal estimations for Folsom occupations vary; some scholars suggest a date range of 11,000 to 10,000 B.P. (Amick 1996:411; Fiedel 1992:49; Justice 1995:27), while others propose a more restricted range of 10,900 to 10,200 B.P. (Dixon 1999:223; Hofman 1992:193).

Even though the precise dates for Early Paleoindian occupations remain problematic in Texas and elsewhere in North America (Bousman et al. 2004:49; Waters and Stafford 2007), Clovis and Folsom occupations are clearly associated with the latter part of the Pleistocene epoch, which is characterized by cool and moist climatic conditions that supported vast areas of mesic vegetation and now-extinct megafauna throughout much of North America. Early Paleoindians have traditionally been viewed as small bands of highly mobile hunters and gatherers who specialized in the killing of big game. Discoveries of Clovis and Folsom points in association with Pleistocene megafauna like mammoth (*Mammuthus primigenius*) and extinct bison (*Bison antiquus*) have captured considerable attention in both the popular and scientific press since the 1920s. While there is evidence for the exploitation of extinct big game in southwest Texas during the terminal Pleistocene (Dibble and Lorrain 1968), we now know that there was significant variability in Early Paleoindian diets and lifeways throughout North America (Amick 1996:412; Bousman et al. 2004:81; Fagan 2005:89-90; Fiedel 1992:67; Haynes 2002:272). Although long-distance exchange systems cannot be ruled out, an apparent Paleoindian predilection for exotic, high-quality lithic material - sometimes transported hundreds of kilometers from its source - supports the belief that Paleoindians, especially during the Early subperiod, were indeed highly mobile (Bousman et al. 2004:93; Haynes 2002:113-114; Miller and Kenmotsu 2004:216-217).

The Late Paleoindian subperiod in southwest Texas is represented by a number of projectile points that retain the lanceolate shape, parallel flaking patterns, and basal grinding that characterize most Paleoindian projectile points, but lack the distinctive flutes of Clovis and Folsom specimens. Projectile point types indicative of the Late Paleoindian period in southwest Texas include Golondrina and Angostura. The latter exhibits a slightly constricted or contracting stem - a morphological feature not uncommon among Late Paleoindian points throughout North America. Another point type often associated with the this period in southwest Texas is Plainview (Hester 1989:56; Miller and Kenmotsu 2004:217). Originally established in the 1940s, the Plainview projectile point type has undergone considerable revisions (Kerr and Dial 1998:452). By the 1970s, "it had become a label for any unfluted lanceolate projectile point with parallel sides and a concave base" (Bousman et al. 2004:18). As a result, the Plainview type enjoys a wide distribution, both temporally and geographically. The results of statistical analyses by Kerr and Dial (1998) suggests that some projectile points typed as Plainview might be roughly contemporaneous with Clovis.

Typological problems aside, the Late Paleoindian subperiod corresponds to the Late Pleistocene/Early Holocene transition. The warming and drying trends at the beginning of the Holocene around 10,000 B.P. precipitated changes in Late Paleoindian subsistence practices - particularly in the intensified hunting of bison, deer, and antelope, as well as a variety of smaller game (Bousman et al. 2004:75-83; Collins 2004:117; Johnson and Holliday 2004:287). Proxy indicators of paleoenvironmental conditions suggest that the mesic savanna grasslands and woodlands occupying the study area during the Late Pleistocene were replaced with plant communities typical of the Northern Chihuahuan Desert around 9000 B.P. (Havstad and Schlesinger 2006:3; Miller and Kenmotsu 2004:208; Turpin 2004:266). Botanical remains recovered from archaeological sites in the Lower Pecos indicate that the inhabitants of the region were exploiting xeric plants like agave, sotol, yucca, and cactus by 8500 B.P. (Bryant and Shafer 1977:15).

Archaic Period (8000 to 1800 B.P.)

The next broad cultural period, the Archaic, is often divided into three subperiods: the Early, Middle, and Late Archaic. The Archaic period is marked by a number of human adaptations including, among others: the manufacture of stemmed and notched projectile points; increased utilization of plant foods and small game; increased population; and decreased mobility. The Archaic period is also marked by gradually increasing warmth and aridity punctuated with brief periods of cooler temperatures, increased moisture, and the return of mesic habitats.

The Early Archaic subperiod in southwest Texas is generally dated from about 8000 B.P to 5500 B.P. (Hester 1989:58; Miller and Kenmotsu 2004:220). Early Archaic sites are somewhat rare in southwest Texas, and occupations dating to this period are usually represented by thin rockshelter deposits, surface lithic scatters in uplands settings, and a small number of features identified in deeply-buried alluvial sediments. Only a few radiocarbon dates have been obtained from Early Archaic occupations in the Trans-Pecos, where the temporal estimates for this period are based largely on cross-dating regional projectile points with similar forms found elsewhere (Miller and Kenmotsu 2004:220). Although relatively little is known about this subperiod in the Northern Chihuahuan Desert of Texas, wide distributions of similar projectile point forms may reflect "a broad Early Archaic cultural pattern" (Hester 1989:58). It is during the Early Archaic that we begin to see the nascent beginnings of cultural patterns indicative of the Archaic period in general, such as the use of burned rock features and groundstone artifacts for processing plant foods, as well as other indications of increasingly diverse subsistence economies. Other important hallmarks of the Archaic that first make their appearance during the early subperiod are increases in the regionalization of projectile forms and the use of local, lower-quality lithic material, both of which probably reflect more restricted ranges and decreased mobility (Miller and Kenmotsu 2004:221-222).

The Middle Archaic subperiod in southwest Texas is dated from approximately 5500 B.P to 3000 B.P. (or somewhat later) (Hester 1989:58-61; Miller and Kenmotsu

2004:223). This period is relatively well-represented in the Northern Chihuahuan Desert, and Middle Archaic occupations have been observed in numerous rockshelters as well as in open sites occurring in a wide variety of topographic settings. In general, the Middle Archaic subperiod in southwest Texas is marked by a number of interconnected cultural trends including increases in: population density; the exploitation and reliance upon desert succulents; the utilization of landscapes; and the regionalization of cultural patterns (Mallouf 1985; Miller and Kenmotsu 2004; Turpin 2004). Another significant characteristic of this period is the appearance of house structures in far-west Texas and southern New Mexico. These so-called huts "are among the earliest evidence for semisedentary settlements in the Southwest" (Miller and Kenmotsu 2004:224). First identified by Thomas O'Laughlin (1980), these structures occur in clusters and are represented by shallow, circular pits measuring 2-3 m in diameter. In the Lower Pecos region, the Middle Archaic is characterized by increasingly regionalized projectile point types, and the emergence of the Pecos River Style rock art (Bement 1989; Hester 1989; Shafer 1986; Turpin 2004). These elaborate polychrome pictographs, some monumental in size, are thought to be iconographic expressions of shamanic rituals and ideologies (see Boyd 2003; Kirkland and Newcomb 1967). Middle Archaic occupations are present in most Lower Pecos rockshelters, and often include a wide range of lithic tools, an abundance of perishable materials, and mobile art in the form of painted pebbles and less-common clay figurines.

The Late Archaic subperiod, beginning about 3000 B.P., is characterized by a number of changes in settlement patterns, subsistence, and technology. Perhaps the most conspicuous change is the dramatic increase in sites, which probably reflects growing populations and/or changes in economic pursuits (Mallouf 1985:125). Late Archaic sites are found in nearly all environmental and topographical settings in the Trans-Pecos, and the bulk of most rockshelter deposits can be attributed to this period (Miller and Kenmotsu 2004:226). Some Late Archaic adaptations can be unambiguously correlated with climatic changes. Fossil pollen records from west Texas suggest that the gradual warming and drying climatic trend of the Holocene was briefly interrupted around 2500 B.P. by a period of cooler and wetter conditions (Bryant and Shafer 1977:17-18). This climatic shift supported the return of grasslands and large herbivores as evidenced by the remains of modern bison (*Bison bison*) in the uppermost bone bed at Bonfire Shelter (Dibble and Lorrain 1968), as well as other Lower Pecos rockshelter deposits roughly contemporaneous with this mesic interlude (Turpin 2004:272). The appearance of Red Linear Style rock art in the Lower Pecos, which often depicts hunters armed with atlatls, has been tentatively linked with the "Late Archaic intrusion of bison hunters" (Turpin 2004:272). With the subsequent retreat of the grasslands and the return of arid conditions, the inhabitants of the Lower Pecos resumed the economic strategies of earlier Archaic periods (Turpin 2004:273-274). The broad-bladed projectile points often associated with Late Archaic bison hunters were replaced with smaller corner-notched points, and the exploitation of desert succulents, while never abandoned, was again intensified. Ring-shaped middens of burned rock, used to cook sotol and lechuguilla bulbs, are associated with the Late Archaic and are common in the Trans-Pecos outside the Hueco Bolson (Miller and Kenmotsu 2004:229).

Late Archaic cultural adaptations in the Hueco Bolson took a different course. Even though paleoclimatic data from packrat middens in the Hueco Mountains supports a unidirectional, increasingly xeric vegetation sequence through the Holocene (Van Devender 1990:121), radiocarbon assays for the appearance of corn (*Zea mays*) near El Paso and in southeastern New Mexico date to 3175±240 B.P. (Upham et al. 1987:412) and 2945±55 B.P. (Tagg 1996:317) respectively, and closely coincide with the mesic interlude mentioned above. Exactly why cultigens were adopted, and to what degree they were utilized remains a question of debate, but "it is evident that agricultural production was only one facet of what was clearly a broad-spectrum subsistence economy" (Miller and Kenmotsu 2004:228).

Late Prehistoric/Formative Period (1750 B.P. to A.D. 1535)

The Late Prehistoric period is marked by two revolutionary technical innovations: the manufacture of ceramics, and the introduction of the bow and arrow. In many regions throughout North America this general cultural period is also characterized by the increased use of cultigens and/or a subsistence base relying heavily on agricultural products. While the bow and arrow was nearly universally adopted, albeit at different times across North America, other cultural developments associated with the Late Prehistoric were not embraced in all regions of the Northern Chihuahuan Desert. In the Lower Pecos, and throughout much of the Trans-Pecos, generalized hunter-gatherer subsistence patterns were maintained until the eighteenth century (Miller and Kenmotsu 2004:255-256; Shafer 1989:27). The beginning of the Late Prehistoric period in the Lower Pecos region is a subject of debate. Estimated dates for the introduction of the bow and arrow generally range from about 1350 B.P to 1000 B.P. (Bement 1989:73; Hester

1989:61; Turpin 2004:274). Other cultural developments indicative of the Late Prehistoric in the Lower Pecos include stone tipi rings, cresent-shaped middens of burned rock, limited use of ceramics, and changes in mortuary practices and rock art styles (Hester 1989:61; Turpin 2004:275-276).

In contrast to most of the Trans-Pecos of Texas, cultural changes associated with increased sedentism and agricultural dependence developed in far-west Texas and in the La Junta district along portions of the Rio Grande valley. In the Hueco Bolson and southern New Mexico, these transitions developed into a puebloan culture called the Jornada branch of the Mogollon. Because of the apparent connections to Southwestern culture centers, the period following the Archaic in the western Trans-Pecos is called the Formative period, which dates from approximately 1750 B.P. to 500 B.P. (Miller and Kenmotsu 2004:236). The Formative period is conventionally divided into three phases: Mesilla, Dona Aña, and El Paso (Lehmer 1948; 1958). Although this construct is a somewhat arbitrary parsing of a cultural continuum, it is still commonly used (Miller and Kenmotsu 2004:237-238).

The Mesilla phase dates from about 1750 B.P to 950 B.P. (Miller and Kenmotsu 2004:238). Distinguishing features of the Mesilla phase include the production of plain brown ceramics, and pithouse architecture occurring in small clusters scattered across the landscape. Although cultigens were utilized to some degree, domestic plants were probably a minor part of the Mesilla subsistence base (Miller and Kenmotsu 2004:237). The Dona Aña phase dates from 950 B.P to about 700 B.P. and is traditionally viewed as a period of "pithouse-to-pueblo transition" (Miller and Kenmotsu 2004:238). The last phase, the El Paso, represents the culmination of the preceding cultural developments.

Around 700 B.P., the villages of the Hueco Bolson began to exhibit the formalized architecture and settlement structure of Southwestern pueblos - clear reflections of social complexity and integration. Whereas Mesilla phase villages were dispersed across most of the environmental zones in the region, El Paso phase settlements tend to occur near more reliable and significant sources of water (Miller and Kenmotsu 2004:245). Other traits of the El Paso phase include increasingly complex polychrome ceramics, and agricultural specialization in and reliance on corn, beans (*Phaseolus* sp.), and squash (*Cucurbita* sp.). For reasons not fully understood, the pueblos of the Jornada Mogollon appear to have been abandoned by 500 B.P., before the first European *entradas* into the region (Miller and Kenmotsu 2004:258).

Historic Period (post A.D. 1535)

The historic period begins with the Spanish exploration of the region during the middle-to-late sixteenth century. First contact with Europeans may have occurred during Cabeza de Vaca's journey through the Trans-Pecos area in 1535 (Lehmer 1958:111). Spanish expeditions had certainly reached the Trans-Pecos by 1581 (Miller and Kenmotsu 2004:259) and the Lower Pecos by 1590 (Turpin 2004:277). The chroniclers of these early Spanish *entradas* recorded several, sometimes contradictory names for the indigenous groups occupying the Trans-Pecos and La Junta districts during this time (Lehmer 1958:111; Miller and Kenmotsu 2004:259). Taken together, Spanish ethnohistorical accounts suggest that the inhabitants of the Northern Chihuahuan Desert practiced two distinct subsistence pursuits. The occupants of villages along portions of the Rio Grande in the La Junta district reportedly relied on agricultural products like corn and beans, while other groups, such as the Manso and Suma groups of far-west Texas, subsisted primarily on foods hunted and gathered (Lehmer 1958:111,128; Miller and Kenmotsu 2004:259).

The Sites

This section provides general descriptions of the sites from which the majority of the study specimens were recovered (see Figure 5). In several cases, however, specimens could not be associated with a single known site. Specimens lacking site-specific proveniences are discussed individually in Chapter IV.

Ceremonial Cave (41EP19)

Ceremonial Cave is located along the rim of the Hueco Mountains near the northeast corner of El Paso County. Like most of the rockshelters and prehistorically-occupied caves in southwest Texas, Ceremonial Cave is situated at the top of a talus slope along the base of a limestone canyon wall. The mouth of the cave reportedly measures approximately 8 m (27 ft) wide and 4.6 m (15 ft) high (Cosgrove 1947:34), but the depths and widths of the internal chambers are unknown. In 1928, the cave's maximum dimensions measured 27.4 m (90 ft) deep and 12.6 m (41.5 ft) wide (Cosgrove 1947:34), but the subsequent excavation of a mine shaft (Woolsey 1936:12) and the presence of hitherto unexcavated drifts (Creel 1997:76) have almost certainly altered or obscured the original shape and size of the chambers.

Ceremonial Cave was heavily disturbed by rampant looting shortly after its discovery in 1926 (Alves 1930; Cosgrove 1947; Creel 1997). Fortunately, Eileen and Burrow Alves of El Paso were able to acquire most, if not all, of the looted material. Portions of the Alves' collection are now curated at the Texas Archeological Research Laboratory, The University of Texas at Austin (TARL). Throughout the late 1920s and 1930s, a number of researchers revisited the cave on behalf of various institutions, and the records and materials resulting from these early investigations are now curated at no less than seven museums and repositories (Creel 1997). Perhaps the most notable visitors were C. B. Cosgrove and E. B. Sayles. On behalf of Harvard University's Peabody Museum, Cosgrove conducted limited excavations at Ceremonial Cave in 1927 and 1928 (Cosgrove 1947). Under the auspices of Gila Pueblo, a private research organization in Globe, Arizona, Sayles tested portions of the site, which he documented as El Paso:3:7 (Sayles 1935). As was typical of the time, very little information regarding stratigraphy and artifact provenience was recorded during these excavations. In addition to providing a thorough review of the archaeological investigations at Ceremonial Cave, Creel (1997) presents a synthesis of the recorded observations and interpretations of this site.

Taken together, the limited data available for Ceremonial Cave suggests that the site served as a shrine for several centuries. A ceremonial use of the site, as implied by the name, is supported by a paucity of domestic refuse and hearth features, as well as a concentration of so-called offerings near the mouth of the cave (Alves 1930:64; Cosgrove 1947:36; Creel 1997:83). Although specific information about this deposit is lacking, "miniature grooved throwing sticks, darts wrapped and decorated to be converted into pahos, *tablitas*, and reed cigarettes" are listed by Cosgrove (1947:36) as examples of ceremonial objects. Other unusual deposits include an unprecedented number of sandals (Cosgrove 1947:35), and a large quantity of human excrement (Creel 1997:81). Based on the presence of darts and El Paso Polychrome ceramics, Creel (1997:83) estimated that Ceremonial Cave was used from approximately 1250 B.P (or shortly before the introduction of the bow and arrow) to about 500 B.P. However, there is evidence to suggest that the cave was occupied much earlier. Some of the dart points from Ceremonial Cave compare favorably to specimens dating to the Early and Late Archaic subperiods in the western Trans-Pecos (cf. Miller and Kenmotsu 2004:221-222). An even earlier occupation is suggested by Sayles, who purportedly found the bones of Pleistocene antelope (*Tetrameryx*) in association with an "undisturbed hearth level" (1935:67). Cosgrove also recovered the remains of extinct animals, but contended that bones were "not in position to prove that such animals and man were contemporaneous" (1947:46).

Fate Bell Rockshelter (41VV74)

This rockshelter is situated in the west wall of Seminole Canyon approximately 14.5 km southwest of the town of Comstock in Val Verde County, Texas. Seminole Canyon was carved by an intermittent stream, and like many other canyons in the area, is deeply incised into the limestone bedrock. The steep cliffs of the canyon are marked by at least eight rockshelters presumably resulting from undercutting alluvial erosion, weathering, and the opening of subterranean solution caverns (Parsons 1965:6). Fate Bell, the largest rockshelter in the canyon, is crescent-shaped and measures up to 157 m long and approximately 30 m deep (see Figure 3). The rockshelter is perhaps best known for the impressive array of polychrome pictographs that fill its walls (Boyd 2003; Kirkland and Newcomb 1967). Unfortunately, the shelter's conspicuousness drew considerable attention from relic hunters, and looting continued largely unabated until the surrounding property was acquired by Texas Parks and Wildlife in the 1970s.

The first controlled excavation of Fate Bell was conducted in 1932 by A. T. Jackson under the supervision of University of Texas Professor J. E. Pearce (see Pearce and Jackson 1933). Jackson excavated a 6 m (20 ft) wide trench from the outer edge of the shelter to the rear wall down to bedrock. A series of 1.5 m (5 ft) wide trenches of varying lengths were subsequently excavated near or along portions of the rear wall. As with many excavations of the time, little information regarding stratigraphy and artifact provenience was recorded. Despite these limitations, Jackson's excavations recovered an important collection of archaeological materials including an abundance of normally-perishable artifacts such as sandals, netting, cordage, woven mats, processed plant remains, and dart and arrow shafts. Jay Peck (1991) analyzed the projectile points recovered during the 1932 excavation and identified over 50 forms dating from the Early Archaic to Late Archaic periods. The majority of the collection represents two periods: the late Middle Archaic, and the latter part of the Late Archaic (Peck 1991:80-82).

Fate Bell was revisited by professional archaeologists in 1963 (see Parsons 1965). The Texas Archeological Salvage Project, an organization affiliated with The University of Texas at Austin, conducted limited test excavations at Fate Bell as part of an agreement made with the National Park Service to investigate sites threatened by the construction of the Amistad Reservoir. Three test units measuring a total of 7.25 m^2 (78 ft^2) were excavated "to determine the nature and extent of undisturbed deposits in order to evaluate the...[research] potential of the site" (Parsons 1965:72). Four stratigraphic zones, collectively measuring at least 1.8 m (6 ft) in depth, were identified in the test units (Parsons 1965:Figure 3). The 1963 excavation recovered a relatively small number of artifacts, none of which are included in the present study. In addition to the Archaic dart point sequence represented in the 1932 collection, the 1963 excavation recovered a single Late Prehistoric arrow point from the uppermost level (Parsons 1965:73).

Shumla Caves

As part of an effort to obtain objects for display at the Witte Museum in San Antonio, Texas, George Martin investigated nine rockshelters in Val Verde County collectively called Shumla Caves (Martin 1933; McGregor 1985). These sites are located at or near the junction of the Milo and Rio Grande Canyons near the town of Shumla, Texas. While Martin presumably collected artifacts from all nine sites during the Witte's 1933 expedition, only two were completely excavated: Cave No. 1 and Cave No. 5 (Martin 1933). Caves No. 1 and No. 2 have since been designated 41VV112; the trinomial for Cave No. 5 is 41VV113.

By modern standards, Martin's excavation methods lacked precision and thoroughness. Artifact proveniences were mostly unrecorded, and many of the objects collected from Shumla Caves can no longer be associated with a specific site. Information regarding each site's stratigraphy is likewise lacking any detail. Martin did provide a brief description of Cave No. 5 (41VV113), which he deemed to be "typical of those at Shumla, and these typical of most of the shelters of the vicinity" (1933:11). Cave No. 5 is a crescent-shaped shelter of eroded limestone measuring approximately 26.5 m wide and 12 m deep. Martin (1933:11-12) describes the stratigraphy as several successive but discontinuous layers of ash and fiber collectively measuring a maximum of 2 to 2.4 m (7 to 8 ft) in thickness. Several hearths and burials were also encountered, the latter described by Martin (1933) in some detail.

Martin's excavations recovered a large collection of lithic and perishable artifacts. The perishable artifacts include items such as sandals, basketry, netting, animal hides, and cordage, as well as atlatl fragments, and dart foreshafts (some with hafted lithic points intact). Selected artifacts from the Witte's Lower Pecos collection, which includes objects recovered from Shumla Caves and Eagle Cave (discussed below), have subsequently been analyzed by Mardith Schuetz (1956; 1961; 1963) and Francis Meskill (1985). Some of these items are also featured in Shafer (1986). While the Shumla excavations recovered projectile points dating from the Late Paleoindian subperiod to the Late Prehistoric period, the majority of the projectile points and concomitant perishable materials recovered from Shumla Caves date to the Middle and Late Archaic (McGregor 1985:130; Scheutz 1956:137-138,146).

Eagle Cave (41VV167)

Eagle Cave is located along the west wall of Mile Canyon less than a kilometer northeast of Langtry, Texas. This large, crescent-shaped rockshelter is 56 m wide and

26.5 m deep and is sheltered by an unusually tall limestone overhang rising 27 m above the talus slope (Ross 1965:9). Eagle Cave was initially excavated in 1936 by J. Walker Davenport, an artist and handyman employed by the Witte Museum (Davenport 1938; McGregor 1985). This early investigation consisted of two perpendicular trenches, each 2.4 m (8 ft) wide and over 12 m (40 ft) long; the first trench ran east-west and cut through the central portions of the site, the second trench, oriented north-south, was excavated along the rear wall. Davenport (1938) provides brief descriptions and a schematic drawing of five discrete layers cumulatively measuring up to 3.6 m in thickness. Although the stratigraphic positions of many of the artifacts recovered during this excavation have been lost or were never recorded, a number of artifacts can be assigned to one of the strata recognized by Davenport. Compared to Shumla Caves, Eagle Cave contained relatively few perishable artifacts. Projectile points and other lithic artifacts were numerous, however. Schuetz (1956) typed and tabulated the projectile points recovered from Eagle Cave in 1936, and found projectile points dating from the Early to Late Archaic subperiods. But as presented, the stratigraphic distribution of points with known proveniences suggests considerable mixing of deposits (see Schuetz 1956:154-158).

As part of the Texas Archeological Salvage Project at Amistad Reservoir, Richard Ross (1965) revisited Eagle Cave in 1963. The remnants of numerous potholes showed that the site had been rather extensively looted since Davenport's excavation (Ross 1965:9). Ross excavated a 3 m by 6 m (10 ft by 20 ft) block of seeming undisturbed soil adjacent to Davenport's central trench after it was cleaned out and profiled (see Ross 1965:Figure 4). Another deep test pit of unspecified size was excavated at the north end of the shelter. In keeping with the times, Ross employed strict horizontal and vertical controls and collected several charcoal samples for radiocarbon analysis. Ross identified five strata containing cultural debris, the upper three disturbed in varying degrees by pothole and rodent disturbances. The lowermost zone, designated Stratum V, contained two lanceolate projectile points characteristic of the Paleoindian period. Five of the six radiocarbon samples collected from Stratum V are consistent with this period and collectively range from 9060 B.P. to 8300 B.P. (Ross 1965:20). The eight remaining radiocarbon assays, collected from Strata IIa, IId, III, and V, date to the Early and Middle Archaic and range in age between 6880 B.P to 3250 B.P. (Ross 1965:15-20). Although Stratum I was not dated and contained projectile points from all three Archaic subperiods, point types characteristic of the Late Archaic, like Shumla, Ensor, and Frio, were common in the uppermost zone and altogether absent below.

Ross' excavations recovered only a small amount of perishable material, and none of the artifacts he collected are included in this study.

Coontail Spin (41VV82)

The Coontail Spin Site is a large rockshelter approximately 16 km west of Comstock. Formed of eroded limestone in the north wall of the Rio Grande Canyon, the overhang shelters an area about 91 m long and up to 12 m deep (Nunley et al. 1965:3). Coontail Spin was first recorded by John Graham and William Davis (1958) during a survey of the area prior to the construction of the Amistad Dam and Reservoir. As part of the salvage work at Amistad, portions of Coontail spin was excavated by John "Parker"

Nunley and his associates in 1962 (Nunley et al. 1965). Two excavation blocks, each measuring approximately 25.5 m^2 (275 ft^2), were opened at both ends of the site. Excavations in the western end of the shelter, designated Area A, revealed a complex series of strata up to several meters in thickness. Excavations in the eastern end, designated Area B, revealed equally complex stratigraphy which, unfortunately, could not be correlated with the sequence observed in Area A (Nunley et al. 1965:5). Although the report of the excavation seems to suggest that some strata contained "undisturbed cultural debris" (Nunley et al. 1965:6), the mixed distribution of temporally diagnostic dart points, which date from the Late Paleoindian period through the Late Archaic, suggests that the deposits were significantly disturbed. Prehistoric cultural features encountered during the 1962 excavations include 5 burials, a large pit, and a group of eight upright stakes or posts possibly representing a structure of some sort (Nunley et al. 1965:13). Radiocarbon assays of 3950 ± 120 B.P. and 4430 ± 140 B.P. were obtained from two of the posts (Nunley et al. 1965:13).

Yarbro Cave (41HZ79)

According to an accession card on file at the Museum of the Big Bend in Alpine, Texas, Yarbro Cave is located in Culberson County approximately 40 km (25 mi) southwest of Van Horn, Texas. No other information about this site was recovered during a brief examination of the museum's collections, except that the artifacts had been loaned by someone named Burch Carson. A search of the paper files at TARL revealed that Yarbro Cave, also called Eagle Mountain Rockshelter, is in Hudspeth County and is designated 41HZ79. Darrel Creel (1981) located and inspected the site in 1979 during a survey of the Eagle Mountains Natural Area. Site 41HZ79 is situated at the base of breccia cliffs near the top of Eagle Bluffs, about 4.5 km south by southeast of Eagle Peak. The cave, which measures approximately 7 m wide and 20 m deep, was reportedly dug during the 1930s by Burch Carson and R. K. Wylie, the latter an amateur archaeologist out of Van Horn (Creel 1981:177). Creel (1981) was unable to determine how much of the cave had been disturbed, and no artifacts were visible on the surface except for the remnants of screens and a shovel. Whether or not 41HZ79 and Yarbro Cave are in fact the same site remains uncertain. The probable connection is supported by the Site Survey Form on file at TARL in which Creel (1979) reports finding the name "Burch Carson" carved on the back wall.

CHAPTER III

THEORETICAL FOUNDATIONS

Archaeologists have long recognized that stone tools, as products of reductive or subtractive manufacturing processes, undergo morphological changes during their manufacture. Attempts to understand "the processes of stone tool production and use" date to as early as 1894 with the work of William Holmes (Andrefsky 2005:4). Although many researchers probably implicitly recognized that the morphologies of stone tools change not only during manufacture, but also during their uselife, George Frison was among the first to explicitly discuss this phenomenon (Andrefsky 2005:4). Frison's (1968) work at the Piney Creek site (48JO312), a buffalo kill and butchering site in northern Wyoming, has proved to be influential among lithic analysts. Through refitting and microscopic edge-wear analysis, Frison demonstrated that: (1) resharpening or refurbishing can significantly change the morphology of stone tools during their uselife; and (2) the cycles of use and resharpening (at Piney Creek) evidenced stylized, parsimonious processes that seem to have conformed to a "principle of least effort" (Frison 1968:154), and were designed to maximize tool use.

These realizations led Arthur Jelinek to coin the term the "Frison effect," which refers to "the phenomenon...in which the tool kit ultimately abandoned at [a] site is the result of the modification of an original set of tools and may be quite different in form from the original set" (1976:22). According to Harold Dibble, "the Frison Effect...suggests...that certain characteristics of tools are not always clear reflections of their original design, but may reflect also the degree of intensity to which they were used and recycled" (1995:315). It is important to note that the Frison effect not only recognizes that lithic tools can be morphologically dynamic, but that modifications are usually made in the interest of efficiency.

Since the 1970s, a number of scholars have proposed analytical schemes and models that recognize the stages of lithic tool manufacture (Muto 1971), as well as the effects of resharpening and recycling (Andrefsky 2005; Collins 1975; Schiffer 1972; Whittaker 1994). Two of the earlier models (i.e., Collins 1975; Schiffer 1972) were formulated using a systemic approach and "flow models" representing the life cycle of lithic artifacts. Although there are some significant differences in the models proposed by Schiffer (1972) and Collins (1975), both feature five steps or stages beginning with procurement and ending with discard; internal feedback loops account for maintenance and modification. Neither model, however, recognized the hafting process. Based on his ethnoarchaeological work in Australia, Richard Gould (1978:823) amended Schiffer's model by including hafting as an integrated process. But Gould "does not elaborate on the significance of this insertion" (Keeley 1982:798). It appears that Lawrence Keeley (1982) was the first researcher to give serious consideration to the effects of hafting on the archaeological record, and his contributions will be discussed below.

Hafting

In order to facilitate the following discussion, some important distinctions and considerations are required at the outset. Following Keeley's definitions:

> The term "haft" refers to the element or set of elements, including bindings, mastic, etc., to which a hafted tool is attached [usually a handle or shaft]. The term "retooling" is used here to refer to the act of replacing the hafted part of a tool in its haft, while "rehafting" implies the replacement of the haft rather than the tool [1982:799].

Three basic hafting arrangements, often appearing in combinations, have been recognized in archaeological and ethnographic contexts: (1) wedged hafts use only mechanical forces to join tool and shaft or handle; (2) mastic hafts use an adhesive, usually made of animal glue, plant resin, or tar to secure or reinforce the joint between the tool and shaft or handle; and (3) wrapped hafts use cordage made of plant fiber, sinew, or animal hide to lash tools to the shaft or handle (Keeley 1982:799; Turner and Hester 1999:33).

Ethnographic and experimental data suggest that, in general, hafts take more time and effort to manufacture than the tool to which they are attached (Keeley 1982:800; Spencer 1974:57; Whittaker 1994:248-251). Keeley suggested that "because the handle of shaft is usually more 'expensive' that the tool that arms it, it follows that the former would be regarded as especially valuable, and therefore highly curated and conserved"

(1982:800).

The Effects of Hafting on the Archaeological Record

Scholars have proposed a number reasons why some stone implements are hafted, specifically in terms of the advantages hafted tools have over unhafted tools. Among others, these reasons include: increased leverage, enhanced precision and efficiency, reduced breakage and waste, and protection against user injury (Andrefsky 2005:168; Keeley 1982:799; Tomka 2001:212). Given the apparent prevalence and importance of hafting in prehistoric tool technology, a general discussion of the possible effects of hafting on the archaeological record is warranted.

Depositional Context. Gould's (1978) ethnoarchaeological observations concerning the disposal of hand-held lithic tools lead Keeley (1982) to make a general, but important distinction between the depositional contexts of hand-held tools and their hafted equivalents. Paralleling Schiffer's (1972) distinction between primary and secondary depositional contexts respectively, Keeley proposed that "hand-held tools are quite likely to be abandoned immediately after the completion of work and therefore accumulate at the location of their last use" (1982:802). In contrast, "once-hafted tools tend to accumulate in archaeological contexts when and where they are replaced in their hafts, which is neither necessarily when nor where they were last used" (Keeley 1982:802). This phenomenon is likely to result in false associations and the misidentification of activity areas if the effects of retooling on once-hafted tool distributions are not recognized (Keeley 1982). Additionally, inter-site variability in the distribution of once-hafted and unhafted (or hand-held) tools might be conditioned by a number of factors. For example, occupation near lithic raw material sources may result in the conservation of hafted tools, and longer-term occupation sites in any given settlement system are likely to contain greater evidence of maintenance activities, such as the retooling of hafted tools, than their shorter-term counterparts (Keeley 1982:803-804).

Tool Morphology. Hafting can be expected to leave its mark on stone tools in a number of ways. Whether a flake, uniface, or biface, a stone tool may exhibit an intentionally dulled edge for manual prehension (Andrefsky 2005:167-169; Keeley 1982:807). In contrast, hafted tools frequently exhibit extensive grinding along edges, presumably to prevent damage to haft bindings, and polishing along edges and ridges resulting from contact with haft elements (Andrefsky 2005:168,183-184; Keeley 1982:807). Hafted tools are also "likely to have special features that are related to their haft arrangements - like tangs, bilateral notches, shoulders, etc." (Keeley 1982:801). Inasmuch as hafted tools are resharpened in the haft, we can expect that hafted versions of a tool are likely to be more extensively retouched than hand-held versions (Keeley 1982:801). As a result of the resharpening process, the blade of a hafted tool may undergo significant alterations during its uselife. The edges of a hafted tool blade may become progressively steeper with each sharpening (Kelley 1982:801). Moreover, the overall shape of the blade may also change during use and resharpening, while the protected hafted portions remain relatively unaltered (Andrefsky 2005:182-183).

This phenomenon of changing morphologies as a result of the hafting process is exemplified by an often-cited study by Albert Goodyear (1974), who is perhaps best known for his analysis of a Dalton (Late Paleoindian) lithic tool assemblage from the Brand site in Arkansas. He classified Dalton bifaces into distinct morphological categories: preform stage, initial stage (Dalton points), advanced stage (Dalton knives), and final stage (Dalton drills) (Figure 6), and demonstrated that while the characteristic basal configurations of Dalton points remained relatively unchanged, their overall morphologies (and commonly-inferred functions) changed through use and resharpening.

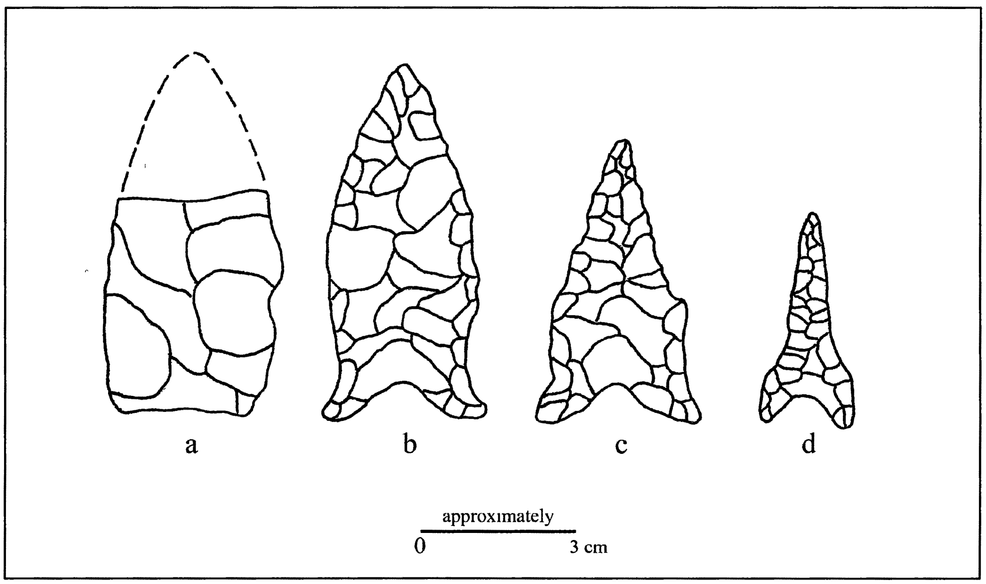

Figure 6. Dalton bifaces from the Brand site: (a) preform stage; (b) initial stage (Dalton point); (c) advanced stage (Dalton knife); and (d) final stage (Dalton drill). Redrawn from photographs in Goodyear (1974).

Projectile Point Hafting Technologies

Certainly one of the most common, and arguably most important applications of hafting technologies was the binding of projectile points to their shafts. Projectile points are, by definition and design, hafted implements. Indeed, most projectile points would be practically useless if left unhafted (Keeley 1982:799). Hafting a projectile point to a foreshaft, which in turn is joined to the distal end of a mainshaft, has advantages over spears with fixed points. Hypothetically, the use of multi-component spears allowed hunters to carry fewer cumbersome mainshafts. Darts with lost or damaged projectile points would have been more easily and quickly repaired with pre-hafted replacements (Frison 1991:293; Judge 1973:264-265). Furthermore, by carrying several foreshafts with pre-hafted projectile points, a hunter could conceivably modify their armaments to their intended quarry. Foreshafts could also function as handles when projectile points are removed from mainshafts and used as knives (Callahan 1994:38; Haynes 1980:116). Another advantage of foreshafts, originally posited by Dan F. Morse, lies in the greater ease in which points can be resharpened in the hand when not attached to mainshafts (Goodyear 1974:33).

It is generally agreed that Paleoindian projectile points were probably hafted to a foreshaft of wood or bone (Dixon 1999:153; Frison 1989:768). Unfortunately, no unequivocal examples of Paleoindian projectile point hafting designs have been recovered, and exactly how these points were hafted remains unknown (Fagan 2005:92; Frison 1991:293; Haynes 2002:117-122). A number of conjectural models of Paleoindian foreshaft design have been proposed, however. Kelley (1982) and Ahler and Geib (2000) propose seemingly intuitive models based on morphological attributes of certain Paleoindian projectile points. The most convincing hypothetical hafting designs are derived from studies of bone and ivory artifacts recovered from a handful of Clovis sites.

Larry Lahren and Robson Bonnichsen (1974) conducted a functional analysis of 11 bone rods (including two complete specimens) recovered from a burial at the Anzick site in southwestern Montana. Through experimental reconstruction and replication, they tested the feasibility that these bone rods, beveled on one or both ends, are examples of Clovis foreshafts. They postulated two hafting arrangements that, when combined with a conjectural wooden splint, would account for the puzzling morphology of the specimens (Figure 7). Lee Lyman and and Michael O'Brien (1998) examined the shapes and mechanical properties of a 43 bone and ivory rods recovered from Anzick and ten other sites throughout North America, and suggested that beveled rods were used as levers to tighten the sinew binding on hafted butchering tools. The recovery of another type of bone artifact from the Mill Iron Paleoindian site in southeast Montana led Bruce Bradley and George Frison to propose a hypothetical hafting design similar to "ethnographic collections from Eskimo groups" (1996:67). This mammoth rib fragment exhibits a "carefully drilled conical-shaped hole," which Bradley and Frison (1996:67) suggest was made to receive the tapered ends of foreshafts (Figure 8a). Dennis Stanford (1996) proposed another hafting arrangement similar to Eskimo techniques after identifying a possible foreshaft socket recovered from a peat bog in Indiana. This antler specimen exhibits a distal slot to which a projectile point was presumably hafted. The base is characterized by two flaring tangs and a slightly tapering hole that compares favorably to the tapered end of at least one bone rod from Anzick (Figure 8b). Although a radiocarbon assay of the object resulted in a date of 7990±120 B.P., Stanford (1996:46) suggested the socket may be part of a long-lived hafting technology in North America. A few years later, Anthony Boldurian and John Cotter (1999) proposed two hypothetical Clovis hafting arrangements drawn from the design of Inuit whale harpoons similar to Stanford's model. David Hunzicker (2005) recently tested the relative efficiency of the "Eskimo" design and four other experimental hafting systems, but the results were inconclusive.

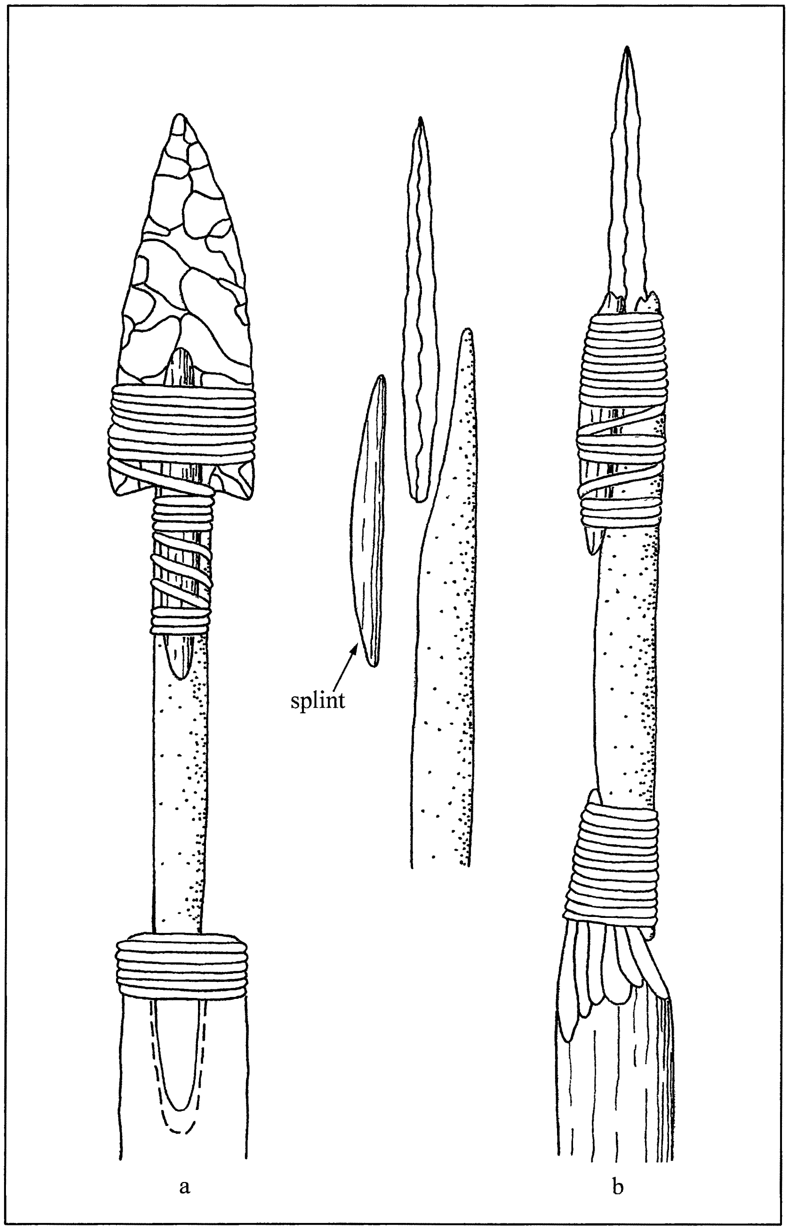

Figure 7. Postulated uses of beveled bone rods as Clovis foreshafts: (a) uni-beveled rod; (b) bi-beveled rod. Redrawn after Lahren and Bonnichsen (1974:Figure 3).

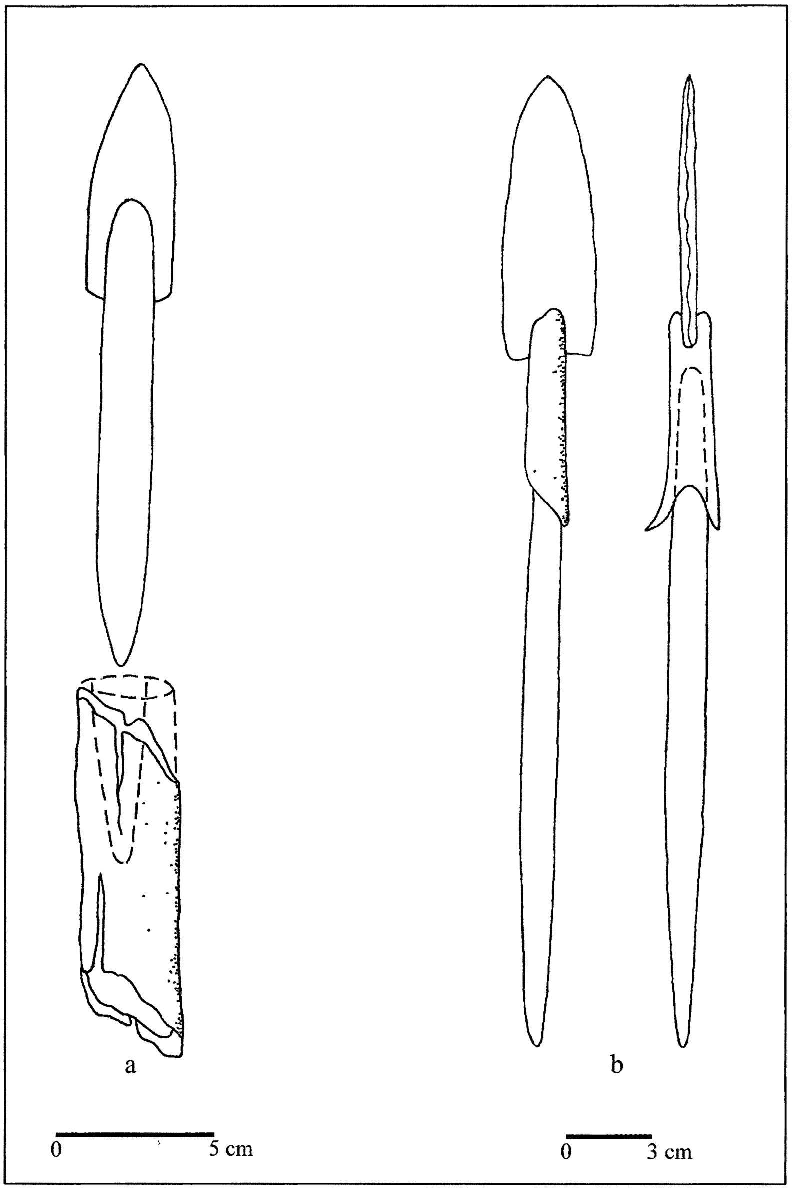

Figure 8. Hypothesized Clovis hafting arrangements. (a) Mammoth bone tool; (b) antler foreshaft socket. Redrawn after Bradley and Frison (1996:Figure 4.18) and Stanford (1996:Figure 1).

While Paleoindian hafting arrangements remain equivocal, a number of Archaic foreshafts (some with hafted points intact) and other dart components have been recovered from dry caves and rockshelters in southwest Texas and the greater Southwest (see e.g., Dick 1965; Holden 1937; Setzler 1933; Word 1970), the Great Basin (e.g., Frison 1965; Heizer 1937; Tuohy 1981), and the tar pits of California (Salls 1986; Woodward 1937). Regardless of location, Archaic foreshafts appear to exhibit some remarkable similarities in material and design. Unlike the Paleoindian candidates discussed above, Archaic foreshafts appear to have been made of wood and not bone or ivory. The distal ends of Archaic foreshafts are characterized by a slot (or nock) into which the projectile point is hafted. Transverse scoring is often observed at and immediately below the slot, presumably to provide 'bite' to the sinew binding and/or mastics used to anchor the lithic point. The proximal ends, when intact, are generally tapered and often exhibit transverse scoring, almost certainly to aid in tightening or securing the press-fit joint between foreshaft and mainshaft (Frison 1965:89). Unlike foreshafts, mainshafts show considerable variation in materials and design. Common features include conical sockets at the distal end, the outer surfaces of which are often reinforced with sinew wrappings. The proximal ends of mainshafts usually exhibit cuplike depressions where the hooks or spurs that characterize the distal ends of most atlatls were engaged. Although uncommon, specimens with remnants of feather fletching have been reported (Cosgrove 1947:54; Heizer 1937:70). Other perishable dart components sometimes found in association with atlatls and Archaic projectiles are wooden points and bunts (or blunted projectile of wood, bone, or antler), both ethnographically associated with hunting small mammals and birds (Ellis 1997:46).

While many factors potentially conditioned the technological organization of prehistoric weapon systems (Nelson 1991), functional requirements and standardized hafting strategies (Tomka 2001), and the costs and benefits of reliable and maintainable designs (Bleed 1986) were probably significant influences on the morphology of formalized bifacial stone tools such as projectile points. Although Brian Fagan (2005:111) suggests that the side- and corner-notching of Archaic stone projectile points might signal the introduction of the atlatl in North America, I prefer the view that the appearance of notching on projectile points, long considered to be a hallmark of the Archaic period, probably reflects a change in hafting strategies and/or foreshaft design. Robert Musil (1988) posited a compelling model that uses increasingly efficient hafting techniques to explain changes in projectile point morphology. Musil recognized what he calls three "major hafting traditions" (1988:373). He hypothesized that fluted and lanceolate projectile points were hafted in a split-stem shaft (Musil 1988:375) (Figure 9a). Although probably quite secure, the bindings of this arrangement would cause considerable drag reducing penetration. Moreover, this hafting method would often result in fractures across the medial portions of points just above the haft, disallowing refurbishment and reuse (Musil 1988:376) (Figure 10). Stemmed projectile points, typical of some Late Paleoindian and Early Archaic assemblages, were also possibly secured by a spit-stem hafting arrangement (Musil 1988:379) (Figure 9b). Although not explicitly stated, Musil (1988) seems to suggest that stemmed points were hafted directly to mainshafts without the use of foreshafts. This method reduced penetration drag by placing the bindings below the blade edges, and often resulted in either tip or basal fractures allowing more frequent refurbishing (Musil 1988:379-382). This type of breakage pattern has been observed at the Levi Rockshelter in Central Texas, where most of the Angostura points where broken just above the base (Bousman 1993:81).

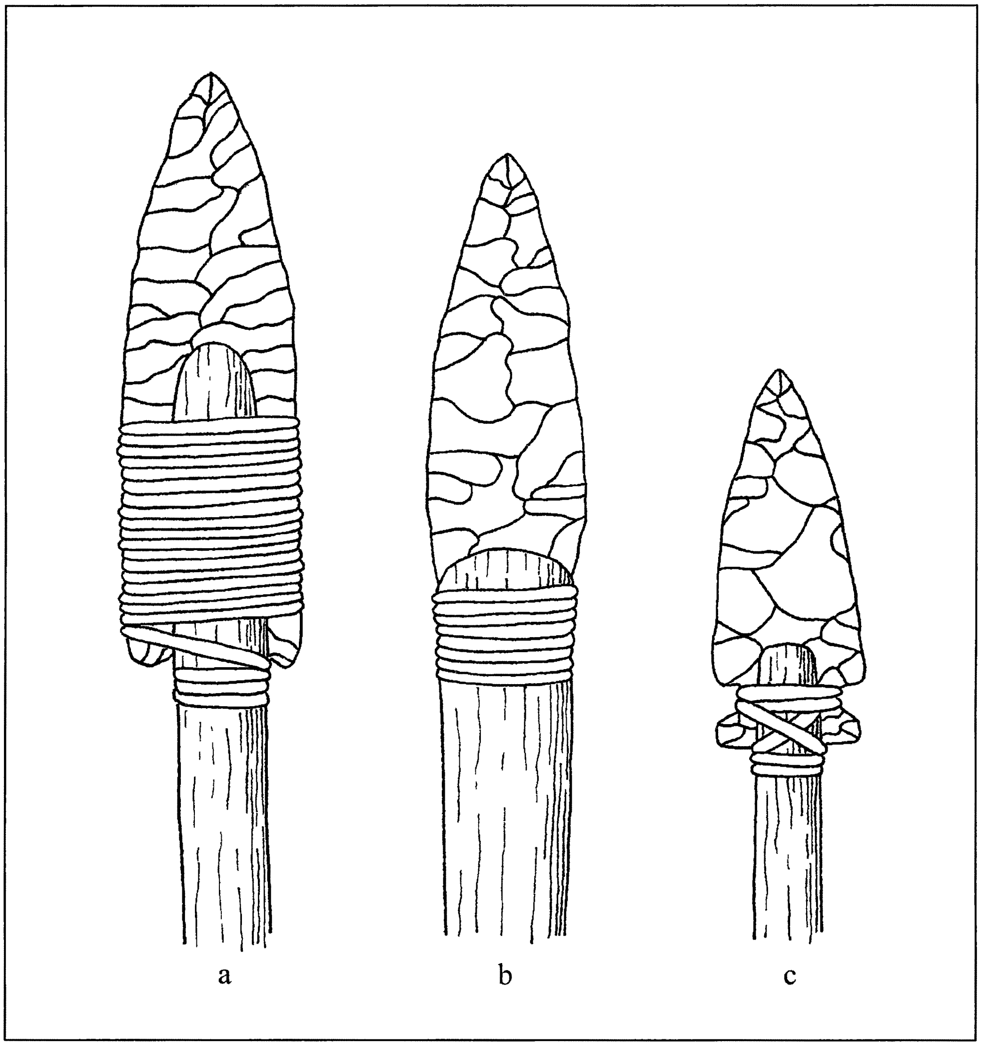

Figure 9. Proposed hafting arrangements for the three primary hafting traditions: (a, b) split-stem; (c) slotted. Redrawn after Musil (1988:Figure 1).

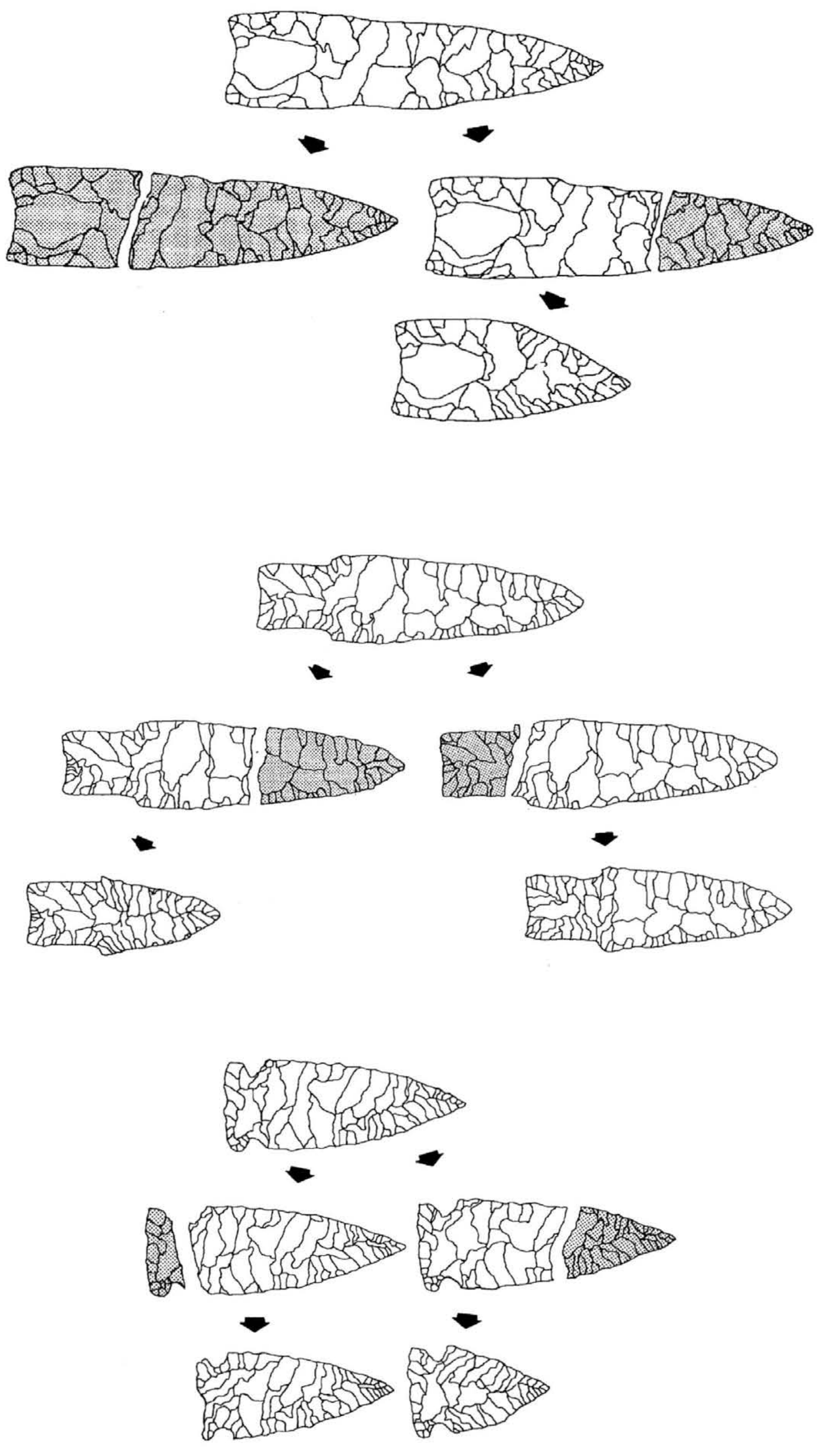

Figure 10. Hypothesized patterns of breakage and refurbishment for fluted/lanceolate (top), stemmed (middle), and notched (bottom) projectile points. Shaded portions depict discard (modified after Musil 1988:Figures 3, 5, and 8).

Musil (1988) suggests that the most efficient hafting method is seen in the design of corner- and side-notched projectile points, which archaeological evidence demonstrates were hafted into slotted foreshafts. As with the stemmed tradition, the bindings are removed from the blade (Figure 9c). According to Musil, "the major advantage of notching is that damage to the haft element [of the point] usually occurs across the notches on impact, which means there is much less waste of lithic material when the basal fragment is discarded" (1988:382). Musil's criteria for efficiency only concern hunting effectiveness (i.e. penetration), the conservation of lithic material, and to a lesser degree, "preservation of damage to the shaft" (1988:379). He suggests that "changes in point form are not related to economic factors" (Musil 1988:385) because bison were hunted with all three point traditions (i.e., fluted/lanceolate, stemmed, and notched). While this may be true, Musil does not take into account the broad trends in prehistoric subsistence patterns throughout much of North America or other factors plausibly conditioning the design of projectile points and their respective hafting arrangements. Given the apparent willingness of Paleoindians to invest high amounts of time and energy in (1) the procurement and transport of exotic lithic materials, (2) the selective use of the risky knapping technology of fluting (Amick 1995; Flenniken 1978), (3) the hunting of large, highly mobile game, and (4) the manufacture of sophisticated tools of bone and ivory, it is not unreasonable to suspect that Early Paleoindian hafting techniques were expensive and elaborate. Costly and over-designed tools are characteristic of reliable weapon systems (Bleed 1986), which according to risk management models proposed by Torrence (1989) and Bousman (1993), should be associated with high-risk subsistence economies typical of the Early Paleoindian period.

On the other hand, the slotted, easily-replaceable wooden foreshaft, presumably used throughout most of the Archaic, might be viewed as a tradeoff between only moderately high manufacturing costs and the advantages of a reasonably reliable and flexibly interchangeable design. This system is easily repaired, and thus more maintainable (Bleed 1986). From the viewpoint of risk management, less expensive technologies are expected to be associated with broader-based, and thus often less risky, subsistence economies (Bousman 1993:77; Torrence 1989:61) typical of most North American Archaic populations.

Musil's (1988) model, which I have both simplified and elaborated here, suggests a unidirectional evolution in design. Calvin Howard has pointed out, however, that "the chronological order of the major hafting traditions cannot be considered in a truly linear perspective relative to improvement," and that "technological change of weapon systems had neither temporal of spatial uniformity" (1995:299). Instead, "the archaeological record is far too complex and non-linear to be envisioned simply as a continuum of functional and maintainability improvement, but is best explained as the result of experimentation and design variation in response to continuous change in hunting conditions, methods, and emphasis" (Howard 1995:291). This sort of experimentation and non-linear development in lithic design and patterns of subsistence during the Paleoindian-Archaic transition is well documented at the Wilson-Leonard site in central Texas, where early stemmed points were recovered stratigraphically situated between lanceolate points dating to the Early Paleoindian subperiod below, and the Late Paleoindian subperiod above (Bousman et al. 2002).

Conical Sockets, Press-Fit Friction Joints, and Lithic Drills

While the development of hafting arrangement designs, as extrapolated from projectile point morphologies, appears to have been non-linear, complex, and discontinuous, at least one feature is found in most Archaic darts mainshafts and two of the bone artifacts mentioned above: conical sockets. Clearly, these sockets were designed to accept the proximal tapers of foreshafts and organic projectiles, but to my knowledge, no traces of any type of adhesive have been identified in any mainshaft socket or on any proximal foreshaft taper recovered from the study area. This stands to reason if one wishes to replace the foreshaft with relative ease. However, without adhesives, this type of juncture between inwardly and outwardly tapered conical surfaces, described here as a press-fit friction joint, almost certainly requires relatively close tolerances and low angle tapers to create a secure bond. While doing background research for the project described in this thesis, I began to question how conical sockets were made. Some authors have explicitly described these tapered sockets as having been "drilled" as opposed to “carved” (e.g., Bradley and Frison 1996:67; Cosgrove 1947:36; Stanford 1996:45). Indeed, the conical sockets that characterize the distal ends of mainshafts described in this study (see below) and elsewhere, closely resemble the shapes of certain lithic drills.

Lithic drills are relatively common prehistoric tools and are found in a variety of shapes and sizes. Stone tools with somewhat long, narrow, and tapered protuberances or projections are also called perforators or awls (Andrefsky 2005:208; Gramly 1996:25; Turner and Hester 1999:270), the distinction being one based primarily on presumed function. Even though ethnographic observations concerning stone tool use in Australia

(Gould 1978:119) and New Guinea (Heider 1967:56) suggest that stone tool form does not necessarily correlate with function, the term "drill" will be used here with the understanding that many stone tools probably served multiple functions and the extent to which any tool was specialized or generalized probably varied individually (Andrefsky 2004:210). Ideally, determinations of prehistoric stone tool functions should draw from multiple lines of evidence, such as morphology, context, adhering residues, patterns of breakage and refurbishment, ethnographic and experimental analogy, and macroscopic and microscopic traces of wear (Collins 1993). Although microscopy was not used in this study, microwear analyses reportedly provide a "reliable and accurate means to determine tool function independent of tool form" (Kay 1996:340).

Microscopic use-wear analyses of drill-like stone tools have produced varying results. For example, Goodyear's (1974) analysis of Dalton (final stage) drills from the Brand site (mentioned above) was inconclusive. He was unable to identify any striations or definite wear patterns with a 30X microscope, but found that several specimens exhibited even amounts of dullness along their entire lengths (Goodyear 1974:31-32). Richard Yerkes and Linda Gaertner (1997) examined a single Dalton (final stage) drill from the Sloan Cemetery in Arkansas at magnifications up to 500X and found traces of use-wear only at the tip. Small striations and a weakly developed polish suggested the tool was used briefly as an awl on dry hide (Yerkes and Gaertner 1997:69). On the other hand, one "advanced stage" Dalton point from the Brand site exhibited wear patterns that suggest it had been used to drill an unidentified material (Yerkes and Gaertner 1997:66). Boyce Driskell (1998) examined a sample of 25 lithic specimens from the Wilson-Leonard site including three bifacial tools categorized as perforators/drills. None of these three tools exhibited clear indications of use at magnifications up to 500X, although one specimen did display a pattern of perpendicular striations "consistent with potential use as a drill" (Driskell 1998:739). Using a magnification range of 100-400X, Marvin Kay (1998) examined an additional 121 lithic specimens from the Wilson-Leonard site including six bifacial perforators/drills. Use-wear traces indicated that all six specimens had been hafted. Two Late Paleoindian specimens were not used as drills; the first was used as a knife, the second as an awl (Kay 1998:764). The remaining four, recovered from Early, Middle, and Late Archaic contexts, exhibited traces of microwear that suggest the tools were used in a drill's rotary motion on relatively hard materials (Kay 1998:764). At least two of these four Archaic drills were "recycled" projectile points (Kay 1998:764). Another example of the changing morphologies and functions of dart points comes from Douglas County, Kansas, where two lithic tools were recently found in association with a Middle Archaic burial (Hoard et al. 2004). Microscopic examinations at 100-400X revealed use-wear patterns indicating that the side-notched biface (Figure 11a) initially functioned as a hafted projectile point, but was later used as a knife on soft materials (Hoard et al. 2004:730). The drill (Figure 11b), remarkably similar to the other biface in its basal characteristics, "was hafted in a wooden handle and used to drill dry hardwood" (Hoard et al. 2004:730).

Taken together, use-wear analyses suggest that lithic tools commonly categorized as drills, perforators, or awls served multiple functions. But I believe that it is safe to assume that at least some, if not most, of these tools were actually used as drills, and I suspect that drills were important elements in the prehistoric tool kits used to manufacture dart mainshafts.

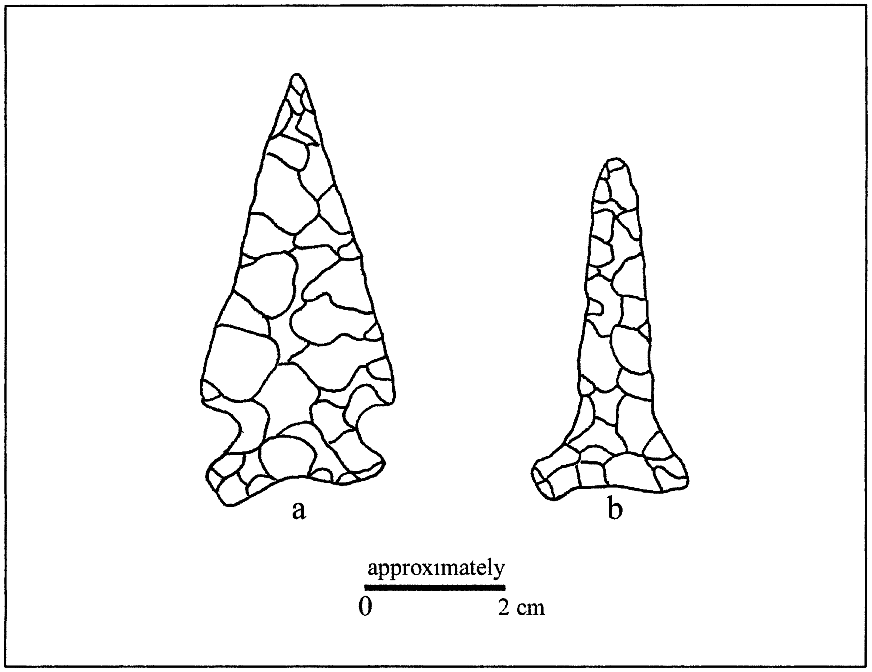

Figure 11. Projectile point and drill from Middle Archaic burial in Kansas. Redrawn from photographs in Hoard et al. (2004).

Research Objectives and Questions

While a number Archaic dart foreshafts have been described by scholars, detailed and systematic analyses of metric and non-metric attributes have not been produced to my knowledge. Except for length and diameter, the parameters of the morphological attributes of Archaic dart components remain largely unexplored, especially attributes associated with the juncture between foreshaft and mainshaft. This juncture has proved to be prone to failure during some experimentations with replicas of prehistoric darts and arrows (Cheshier and Kelly 2006:356; Frison 1989:770) and is one of the foci of this study.

In an attempt to increase our understanding of Archaic multi-component dart technology, this study addresses three primary research questions:

1) What are the parameters and patterns of the morphological attributes of wooden dart components?

2) Can patterns of damage and wear tell us something about the use-life and functions of these components?

3) Can certain lithic drills be morphologically associated with the manufacture of dart mainshafts, and if so, what does this association tell us about use-life of projectile points?

CHAPTER IV

MATERIALS AND METHODS

Overview of the Study Sample

A total of 36 wooden artifacts were analyzed as part of this study. The specimen number, type, site or area of origin, lot number, and repository of each specimen is listed in Table 1. The condition of each specimen is also included as one of four categories: complete (or nearly complete), distal fragment, proximal fragment, and unfinished. The sample consists of components of prehistoric wooden darts in storage at TARL; the Museum of the Big Bend (MBB); and the Witte Museum (Witte) in San Antonio, Texas. The sample included foreshafts and foreshaft fragments (n = 20), mainshafts and mainshaft fragments (n = 9), wood points (n = 4), and bunts (n = 3). Six foreshafts, 2 with hafted projectile points intact, were on display at the Witte during this investigation and were not available for study. Normally held by TARL, two additional foreshafts with hafted points (Figure 12) were loaned to the Bob Bulloch Museum in Austin, Texas shortly before this investigation and were similarly unavailable.

Table 1. Inventory of Wooden Specimens in Study Sample.

Specimen No.	Class/Type	Condition	Site or Region	Lot No.	Repository
01	Foreshaft	Complete	Ceremonial Cave	46808	TARL
02	Foreshaft	Proximal Frag.	Ceremonial Cave	46808	TARL
03	Foreshaft	Distal Frag.	Ceremonial Cave	46808	TARL
04	Bunt	Complete	Ceremonial Cave	46808	TARL
05	Bunt	Complete	Ceremonial Cave	46806	TARL
06	Wood Point	Complete	Ceremonial Cave	46807	TARL
07	Mainshaft	Distal Frag.	Ceremonial Cave	17509	TARL
08	Mainshaft	Distal Frag.	Ceremonial Cave	46817	TARL
09	Mainshaft	Distal Frag.	Ceremonial Cave	46817	TARL
11	Wood Point	Unfinished?	Ceremonial Cave	46807	TARL
12	Wood Point	Complete	Ceremonial Cave	46807	TARL
13	Wood Point	Distal Frag.	Ceremonial Cave	46807	TARL
14	Mainshaft	Distal Frag.	Ceremonial Cave	46817	TARL
15	Mainshaft	Distal Frag.	Ceremonial Cave	17509	TARL
16	Foreshaft	Complete	Lower Pecos?	1732-260	TARL
17	Foreshaft	Proximal Frag.	Fate Bell	202	TARL
18	Foreshaft	Proximal Frag.	Fate Bell	200	TARL
19	Bunt	Distal Frag.	Ceremonial Cave	15853	TARL
20	Foreshaft	Distal Frag.	Fate Bell	196	TARL
21	Mainshaft	Proximal Frag.	Fate Bell	248	TARL
25	Foreshaft	Unfinished?	Fate Bell	199	TARL
26	Mainshaft	Distal Frag.	Ceremonial Cave	46817	TARL
27	Foreshaft	Distal Frag.	Shumla Caves	128	Witte
28	Foreshaft	Distal Frag.	Lower Pecos	85	Witte
29	Foreshaft	Proximal Frag.	Eagle Cave	387	Witte
30	Foreshaft	Proximal Frag.	Shumla No. 5	201	Witte
31	Foreshaft	Proximal Frag.	Eagle Cave	401	Witte
39	Foreshaft	Complete	Yarbro Cave	2508-14	MBB
40	Foreshaft	Complete	Yarbro Cave	69-516	MBB
41	Foreshaft	Complete	Yarbro Cave	69-516	MBB
42	Foreshaft	Complete	Yarbro Cave	69-516	MBB
43	Foreshaft	Complete	Coontail Spin	159	TARL
47	Foreshaft	Proximal Frag.	Lower Pecos	1986-10	TARL
48	Foreshaft	Distal Frag.	Lower Pecos?	1732-28	TARL
51	Mainshaft	Complete	Ceremonial Cave	46816	TARL
52	Mainshaft	Complete	Ceremonial Cave	46816	TARL

Figure 12. Dart foreshafts with hafted projectile points from Ceremonial Cave.
Photograph courtesy of the Texas Archeological Research Laboratory,
The University of Texas at Austin.

The sampling design was simple: all available specimens consistent with items identified and described as components of prehistoric atlatl darts (or spears) by reputable scholars were selected for inclusion in this study. Six specimens (22, 23, 24, 32, 49, and 50) were removed from the study when, after further consideration, they did not meet this criterion. Unfortunately, high selectivity reduced the study sample both during and after the initial analysis and reduced the veracity of statistical tests. Furthermore, this selective methodology fails to recognize possible candidates for inclusion in the study and potentially under-represents the variability in this weapon system. An analysis of all possible study candidates (i.e., every cylindrical and/or pointed wooden object) was not feasible, however, and an overly-inclusive approach would probably confound the true parameters of several attributes.

Because drills are tools hypothesized to be used in shaft construction, a sample (n = 10) of lithic drills possibly used in the manufacture of dart mainshafts was also included in this study. My original intension was to locate drills that (1) were recovered in stratigraphic association with foreshafts and other dart components; and (2) exhibited two specific morphological characteristics: an intact distal terminus; and intensive bifacial trimming along a finely crafted bit. Basal morphology was not considered to be a relevant variable for inclusion or exclusion. Unfortunately, in the collections to which I had access, I was unable to establish any clear (temporal) associations between dart components and drills meeting the criteria for inclusion. Instead, drills or drill fragments meeting the criteria were drawn from site-specific or regional collections that contained foreshafts or foreshaft fragments. The admittedly selective and somewhat subjective criteria eliminated several drills and drill-like tools. An example of specimens *not* included in this study are shown in Figure 13, which depicts drill-like tools from Coontail Spin exhibiting crude manufacture, missing distal portions, or unifacial trimming. The specimen number, site or area of origin, lot number, and repository of each lithic specimen included in this study is listed in Table 2.

Figure 13. Examples of drills (from Coontail Spin) excluded from study sample.

Table 2. Inventory of Lithic Drills in Study Sample.

Specimen No.	Condition	Site or Region	Lot No.	Repository
10	Distal Frag.	Ceremonial Cave	46804	TARL
33	Complete	Shumla No. 5	unknown	Witte
34	Complete	Shumla No. 5	unknown	Witte
35	Complete	Eagle Cave	35-6302-120-P	Witte
36	Complete	Eagle Cave	35-6450-165-P	Witte
37	Complete	Shumla No. 5	unknown	Witte
38	Complete	Lower Pecos	unknown	Witte
44	Complete	Coontail Spin	253	TARL
45	Complete	Coontail Spin	122	TARL
46	Complete	Coontail Spin	239	TARL

Attributes, Methods, and Limitations

A suite of attributes was recorded for each of the 46 specimens in this study, but the number and types of variables recorded for each object depended upon artifact material, class, and relative completeness. A total of eleven metric attributes were recorded for wooden specimens (Table 3). Eight measurements applied to foreshafts. In addition to weight, the metric attributes include: length, diameter (at or near the distal end), taper length, maximum taper diameter, taper angle, slot thickness, and slot depth (Figure 14). Only the first six of these attributes applied to wood points and bunts, since these artifact types lacked distal slots. The mainshafts similarly lacked distal slots, but the recording of the conical sockets found at their distal ends, discussed in detail below, required three additional variables: maximum socket diameter, socket diameter 15 mm from opening, and socket depth.

In addition to artifact class or type (i.e., foreshaft, mainshaft, etc.), condition (fragmentary, complete, or unfinished), and site of origin, up to five additional nominal variables were recorded for wooden artifacts (Table 4). The first nominal variable is damage, which included seven categories: snapped, splintered, battered, burned, eroded, gnawed (by rodent or insect), and none. In the few cases in which specimens exhibited multiple types of damage, injurious modifications believed to be cultural in origin were given priority in the summary table. The second categorical variable is slot shape. When present, slots were found to be either V-shaped or rectangular. The third is taper termination shape, which was categorized as rounded, pointed, or flat. The final two nominal variables concern the surfaces of the conical tapers. Taper surfaces were

Table 3. Eleven Metric Attributes of the Wooden Specimens Sorted by Class.

Class/ Specimen No.	Length (mm)	Diameter (mm)	Taper Length (mm)	Maximum Taper Dia. (mm)	Taper Angle°	Slot Depth (mm)	Slot Thickness (mm)	Socket Depth (mm)	Max. Socket Dia. (mm)	Socket Dia. at 15 mm (mm)	Weight (gm)
Foreshafts											
01	135.6	12.4	18.7	11.4	13.0	15.6	5.6				10.7
02	114.1	10.7	18.0	10.9	12.0						8.5
03	146.2	10.2									8.5
16	153.0	10.7	26.9	10.1	11.0	9.4	5.3				9.0
17	148.7	10.0	22.7	9.0	10.5						6.8
18	79.7	10.9	22.4	10.7	9.0						4.8
20	103.4	11.1				18.4	5.1				5.3
25	195.0*	13.3				11 4	6.4				22.2
27	58.7	9.9				10 9	3.1				2.3
28	102.1	10.7				13.3					7.4
29	75.1	11.7	33.4	10.9	11.5						4.2
30	165.0	12.9	29.2	10.4	15.0						13.0
31	99.5	12 8	30.5	11.8	13.5						8.1
39	154.0	12.1	15.0	10.2	5.0	12.0	4.7				11.0
40	124.0	10.6	25.9	10.3	6.5	12.2	3.1				6.8
41	120.6	11 5	21.1	11.1	12.0	13.9					6 8
42	68.9	10 2	27.7	10.0	12.0	17.4					4 3
43	139.2	8 2	18.8	8.1	13.5	11.1					4.6
47	89.5	8 8	26.4	8.2	10.0						3.5
48	84.8	10.7				10.7	4.0				5.8
Wood Points											
06	145.3	10.6	18.0	10.5	12.5						7 9
11	183 0	10.9									13.1
12	170.0	9.5									8 4
13	123.9	11 5									9.3
Bunts											
04	100.9	32.1	27 3	11.7	12.0						28.5
05	100.1	25.2	29.6	15 2	13.5						26 9
19	51.2	34.9									19

* Estimated.

Table 3. Continued.

Class/ Specimen No.	Length (mm)	Diameter (mm)	Taper Length (mm)	Maximum Taper Dia (mm)	Taper Angle°	Slot Depth (mm)	Slot Thickness (mm)	Socket Depth (mm)	Max. Socket Dia. (mm)	Socket Dia. at 15 mm (mm)	Weight (gm)
Mainshafts											
07	225.1	17 3			9.0			27 2	11.1	8.8	16.9
08	196.0	16.2			7.5			32.4	8.8	6.8	15.6
09	171.7	15.7			8.0			24.7	9 2	7 1	14.1
14	198.0	15.3			11.5			27.5	10.0	7.0	13 3
15	180.0	15 9						27.0	9 7*		10.6
21	69 5	10.3									1 9
26	499.0	15 2			10 0			26.1	9.0	6 4	39 0
51	1708.0	16.7			10.5			18.5	8.9	6 2	132.8
52	1536 0	15 2			8 5			29 8	10.2	8.0	91.5

* Estimated.

Figure 14. Illustration of linear measurements recorded on foreshafts (as seen on Specimen 43): (1) length; (2) diameter; (3) slot depth; (4) slot thickness; (5) taper length; and (6) taper angle. Not shown: maximum taper diameter.

categorized as ground, chiseled, scored, or polished (smooth). The attribute "polished" does not appear in the summary table, however. A number of specimens exhibited traces of multiple, superimposed taper surface treatments probably reflecting sequential episodes of manufacture and use. Scoring, which included modifications ranging from light striations to heavy incisions, was given priority over polishing in the summary table. Scoring was further characterized as lateral (side-to-side) or oblique. The direction of oblique scoring was also recorded when applicable. Tapers that would hypothetically tighten in a socket if turned to the right, like most modern hardware fasteners, were categorized as having a clockwise twist; tapers tightening to the left were categorized as counterclockwise. Examples of clockwise (CW) and counterclockwise (CCW) transverse

Table 4. Six Non-metric Attributes of the Wooden Specimens.

Class/ Specimen No.	Damage	Slot Shape	Taper Shape	Taper Surface	Scoring Direction
Foreshafts					
01	gnawed	rectangular	pointed?	scored/oblique	CCW
02	snapped	rectangular	rounded	scored/oblique	CW
03	splintered			chiseled	
16	gnawed	rectangular	pointed	scored/oblique	CCW
17	splintered		pointed	scored/oblique	CCW
18	none		rounded	scored/oblique	CCW
20	burned	V-shaped			
25	none	rectangular			
27	none	rectangular			
28	snapped	V-shaped			
29	splintered		pointed	scored/oblique	CW
30	splintered	V-shaped	pointed	scored/oblique	CCW
31	burned		pointed	chiseled	
39	none	rectangular	flat	ground	
40	gnawed	rectangular	pointed	ground?	
41	splintered	rectangular	pointed?	chiseled	
42	splintered	rectangular	rounded	scored/oblique	CCW
43	snapped	V-shaped	pointed	scored/oblique	CCW
47	snapped		pointed	scored/oblique	CW
48	battered	rectangular			
Wood Points					
06	splintered		rounded	scored/oblique	CCW
11	none				
12	none				
13	snapped				
Bunts					
04	battered		rounded	scored/lateral	
05	battered		flat?	scored/oblique	CW
19	eroded				
Mainshafts					
07	splintered				
08	snapped				
09	snapped				
14	snapped				
15	snapped				
21	snapped				
26	splintered				
51	splintered				
52	snapped				

scoring are shown in Figures 15a and 15b, respectively. For the purpose of review, the presence (+) or absence (−) of six additional non-metric attributes were also listed for each specimen in Table 5 when applicable and possible. These attributes include: hafted lithic, adhesive, (vegetal) cordage, sinew, pigment, and distal scoring at or near the slot of foreshafts.

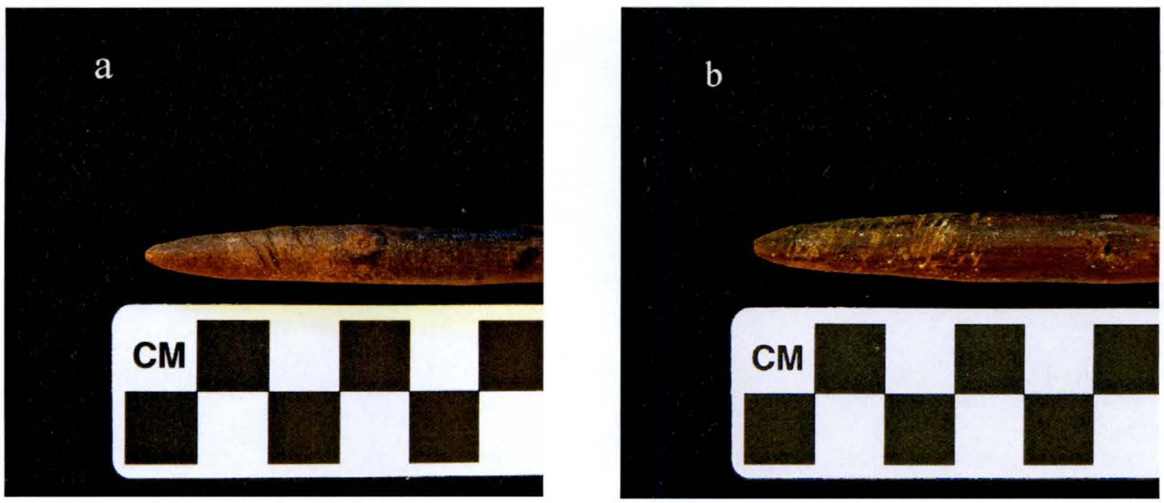

Figure 15. Examples of directional scoring: (a) clockwise scoring on Specimen 47; (b) counterclockwise scoring on Specimen 16.

Up to eight metric attributes were recorded for each lithic drill in the study sample (Table 6). In addition to weight, the metric attributes include: maximum length, maximum width, maximum thickness, bit length, maximum bit width, maximum bit thickness, and taper angle (Figure 16). The presence or absence of five non-metric attributes was also recorded when applicable (Table 7). These include: tip wear, edge wear, basal smoothing, beveled blade, and beveled stem.

Table 5. Presence or Absence of Six Additional Non-metric Attributes.

Class/ Specimen No.	Hafted Lithic	Adhesive	Cordage	Sinew	Pigment	Distal Scoring
Foreshafts						
01	–	+	–	–	–	+
02	–	–	–	+	–	*
03	+	+	–	+	+	*
16	–	–	–	–	+	+
17		–	–	–	+	
18		–	–	–	–	
20	–	+	–	–	–	+
25	–	–	–	–	–	+
27	–	–	–	–	–	–
28	–	–	–	–	–	+
29		–	–	–	–	
30		+	–	–	–	+
31		–	–	–	–	
39	–	–	–	–	+	+
40	–	–	–	–	–	–
41	–	–	–	–	–	–
42	–	–	–	–	–	+
43	–	–	–	–	–	–
47		–	–	–	–	+
48	–	–	–	–	+	+
Wood Points						
06		–	–	–	–	
11		–	–	–	–	
12		–	–	–	–	
13		–	–	–	–	
Bunts						
04		–	–	–	–	
05		–	–	–	–	
19		–	–	–	–	
Mainshafts						
07		–	–	+	–	
08		–	–	–	+	
09		–	–	–	+	
14		+	–	–	+	
15		–	+	–	+	
21		–	–	–	+	
26		–	–	+	+	
51		–	–	–	+	
52		–	+	+	+	

* Indeterminate.

Table 6. Eight Metric Attributes of the Lithic Drills.

Specimen No.	Max. Length (mm)	Max. Width (mm)	Max. Thickness (mm)	Bit Length (mm)	Max Bit Width (mm)	Max Bit Thickness (mm)	Taper Angle°	Weight (gm)
10				18 9*	8.1*	6 1*	11 5	1.2
33	60.9	39 5	8.7	36.5	13.0	7.5	14 0	11.5
34	49.5	22.7	8.6	28.0	10.5	7.7	13 0	5.8
35	55.0	22 7	7.8	29 8	12.2	7.8	13.0	5.7
36	93 8	27 6	18.0	43 3	12 5	4.2	9 0	14 6
37	74 6	22.8	8 1	57 7	13.4	7.6	8 0	9 2
38	59.1	26 9	7 5	33 1	13.0	6 9	12 5	9.6
44	72.6	36.4	9.9	50 2	16.3	9.1	12.0	14 9
45	69.5	31.0	7 5	42.0	12 1	7.5	12.0	8 6
46	75.8	26 3	7 4	53 2	16 9	6 0	14 0	10.0

* Incomplete

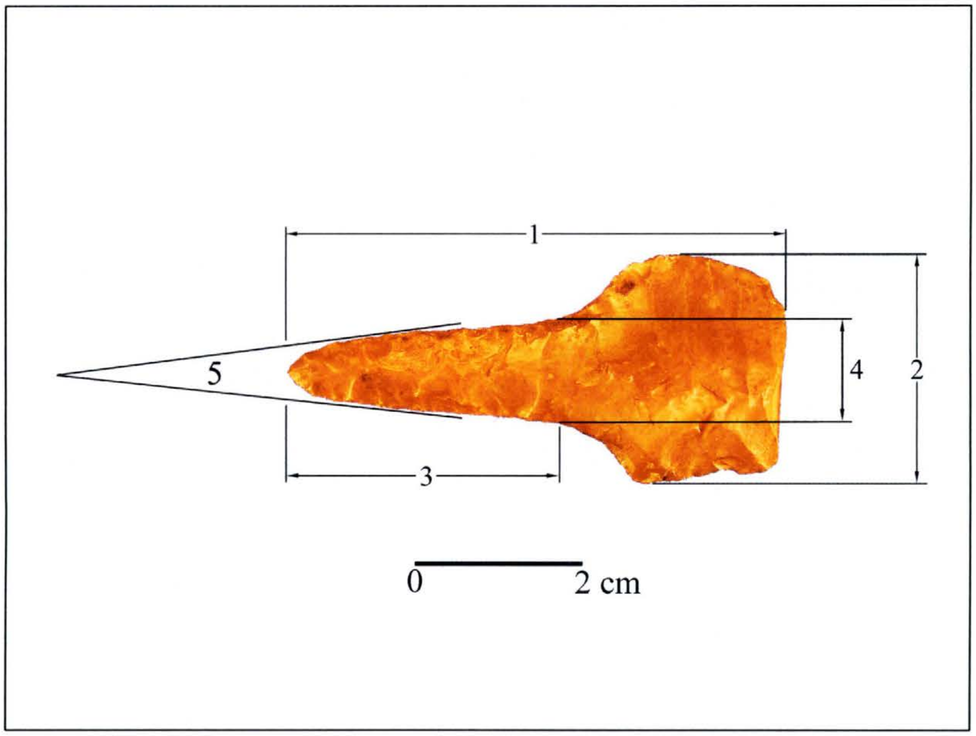

Figure 16. Illustration of linear measurements recorded on drills (as seen on Specimen 38): (1) max. length; (2) max. width; (3) bit length; (4) max. bit width; and (5) taper angle. Not shown: max. thickness and max. bit thickness.

Table 7. Presence or Absence of Six Non-metric Attributes of the Lithic Drills.

Specimen No.	Tip Wear	Edge Wear	Basal Smoothing	Beveled Blade	Beveled Stem
10	+	+			
33	+	+	+	–	–
34	–	–	–	–	–
35	–	–	–	–	–
36	–	–	–	–	–
37	–	–	–	–	–
38	+	+	+	–	–
44	+	+	+	–	+
45	+	+	+	–	–
46	–	–	+	+	–

A variety of equipment was used to identify, record, and analyze the attributes discussed in this study. Linear measurements of 150 mm or less were taken to the nearest .1 mm with SPI 2000 sliding calipers manufactured by KWB Switzerland. Linear measurements greater than 150 mm were taken to the nearest 1 mm with a standard tape measure manufactured by Stanley Tools. Weights were recorded to the nearest .1 gm with an Ohaus JE 250 digital scale. Macroscopic use-wear and surface modifications were identified with the aid of a Hastings Triplet 10X magnifier by Bausch & Lomb. External angles were approximated to the nearest .5° with a True Angle® protractor/bevel tool manufactured by Quint Measuring Systems. Photographs were taken with a Kodak P880 digital camera. And lastly, unless otherwise noted, SPSS (version 16 for Windows) was used to compute test statistics.

Objective and accurate recording of several attributes proved to be difficult. The measurements of taper angles are perhaps the most problematic. In many cases, the proximal tapers, present on 17 wooden specimens, form a compound cone (or bullet shape) with angles increasing in steepness as they approach their points. Similarly, the outer edges of some of the drill bits in the study sample are slightly curved and increase in steepness as they approach their distal termini. In these cases, the angle thought to be most representative of the given specimen was recorded. While this determination was somewhat subjective, the wear patterns on several wooden tapers gave a clear indication as to what portions of the cone functioned as a working surface (i.e., the surface that formed the joint between the foreshaft, point, or bunt, and mainshaft). It should be noted that these conical tapers generally exhibit rotational symmetry and can be classified as right circular cones. The taper of a right circular cone is usually described by the angle of only one generatrix - or one of the lines along the lateral surface that join the apex to the perimeter of the base - denoted by θ in Figure 17. I found, however, that measuring a single generatrix against the estimated center line of any conical artifact element was more difficult, and presumably more susceptible to error, than determining the angle between two opposing lateral surfaces (generatrices). Strictly speaking, the taper angles presented here for wooden specimens exhibiting conical shapes are measurements of aperture, or twice the measurement of θ. The same can perhaps be said for the recorded tapers of the lithic drills described in this study, although without exception, the drills in the study sample are roughly diamond-shaped or lenticular in cross section, and are thus more accurately described by multiple generatrices.

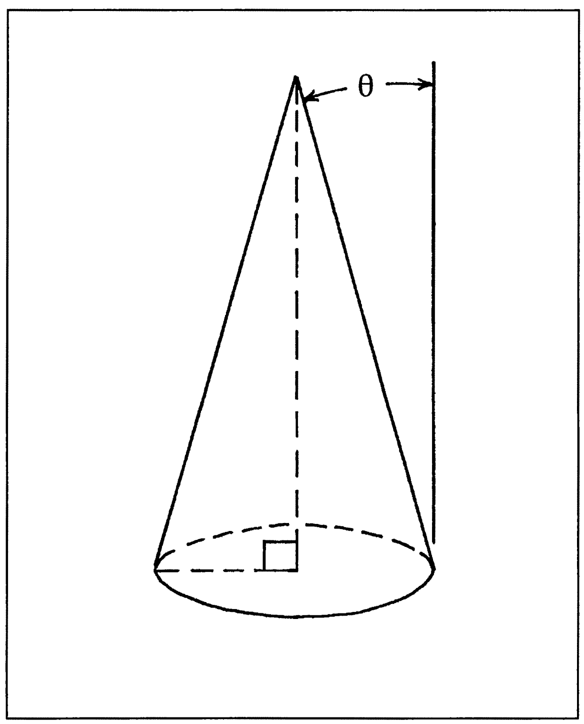

Figure 17. Measurement of taper for a right circular cone.

Measuring the angle of the tapered, conical sockets of seven mainshafts and mainshaft distal fragments in the study sample presented additional challenges. Because these internal angles could not be measured with a protractor, mainshaft socket tapers were estimated trigonometrically using socket radii derived from two measurements: maximum socket diameter (i.e., the diameter of the socket at its opening), and socket diameter at 15 mm from the socket opening (Figure 18). Assuming symmetry, socket taper angles were estimated with the following formula where θ equals the taper of the conical sockets:

$$\theta = \tan^{-1} [(\tfrac{1}{2}\text{diameter} - \tfrac{1}{2}\text{diameter at 15 mm})/15]$$

The results of this computation were multiplied by two, and then rounded to the nearest .5° to make them comparable to external taper measurements recorded for the 17 foreshafts, points, and bunts exhibiting intact proximal tapers. The measurements of taper lengths on several foreshafts are also subject to problems relating to repeatability. Exceptionally smooth or irregular transitions from proximal taper to foreshaft body prohibited precise measurements in several instances. Determining the exact bit lengths of the lithic drills was similarly difficult. The drills included in this study exhibited relatively smooth, gradational transitions from bit to body or base, making bit length a matter of judgment to some degree.

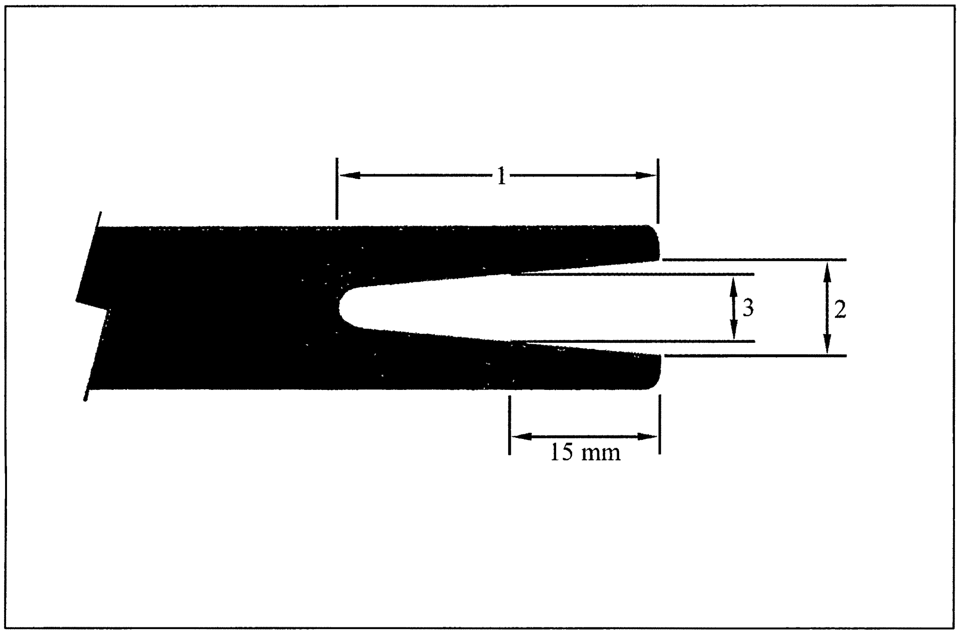

Figure 18. Schematic lengthwise cross section of mainshaft showing measurements taken from distal sockets: (1) socket depth; (2) max. socket diameter; and (3) socket diameter at 15 mm.

Individual Specimens

This section provides descriptions of the individual specimens in the study sample. Special attention is paid to information and attributes not included in the summary tables. Basic metric attributes are not repeated except in cases where clarifications of previously-presented data are warranted.

Foreshafts

Specimen 01. Collected from Ceremonial Cave, this finely-crafted specimen exhibits many of the characteristics typical of Archaic foreshafts (Figure 19). The artifact appears to have been manufactured from a peeled hardwood twig with intensive modifications at the distal slot and proximal taper. The slot is roughly rectangular, and the grooves that were cut to form the slot are clearly visible at its base. The distal ends of the slot prongs have been ground into rounded shapes, presumably to reduce penetration drag. The inner surfaces of the slot prongs have been concavely carved to form opposing surfaces similar in shape to the typical lenticular cross sections of dart point bases. A band of lighter-colored wood, 13.7 mm wide, can been seen 14.4 mm from the foreshaft's distal tip. Under magnification, light transverse scoring and thin lines of amber-colored mastic, probably pine resin, are visible. These observations suggest that binding materials, probably sinew coated with pine resin, were present at the time of deposition and protected this band from patination. It would appear that these materials were later removed by a rodent, as indicated by superimposed gnawing. The polished surfaces of the proximal conical taper are also lighter in color. Under magnification, light counterclockwise scoring is also visible on the taper surfaces, as well as irregular chiseling at the taper terminus, the point of which is missing. While the taper appears to have been chiseled into shape, it is not clear whether the taper was intentionally scored prior to being polished through use, or if the scoring was the result of twisting during insertion into a mainshaft socket.

Specimen 02. This foreshaft, also collected from Ceremonial Cave, exhibits moderate damage at its distal end (see Figure 19). One prong is slightly damaged, the other has snapped off near the base of the slot. This type of foreshaft damage is reportedly common (Spencer 1974:52), and is seen in other specimens described below.

The remnants of sinew wrapping, 7.6 mm wide, is present at the base of the slot. Light clockwise scoring, presumably the result of twisting during insertion, overlays the surfaces of the conical taper which, under magnification, appear slightly rough as if ground into shape.

Figure 19. Specimens 01, 02, and 03. Arranged from top to bottom.

Specimen 03. This distal foreshaft fragment from Ceremonial Cave exhibits extensive splintering along the proximal and medial portions of the shaft (see Figure 19). The base of a dart point is hafted into the distal slot with sinew binding 12.0 mm wide and coated in the same amber-colored resin observed on Specimen 01. The point is made of dark gray chert and, although obscured by the sinew, appears to exhibit the weaklyexpanding stem typical of many Late Archaic dart points. Under magnification, the remnants of the proximal taper appear chiseled and possibly ground. The intact outer surfaces of this specimen are coated with a reddish-brown pigment.

Specimen 16. This complete foreshaft (Figure 20) is part of a collection originally donated to the Texas Memorial Museum, now a part of the Texas Natural Science Center, The University of Texas at Austin. According to the undated accession record on file at TARL, the present repository, all of the materials associated with this specimen "had been labeled 'Smugglers' - probably the name of the site" thought to be a rockshelter in Val Verde County (Suhm n.d.). Although its provenience cannot be verified, this meticulously-crafted specimen serves as another excellent example of an Archaic dart foreshaft and is remarkably similar to Specimen 01. The slot is rectangular in shape. The distal ends of the slot prongs are slightly rounded and the inner slot surfaces are concavely carved. Evidence of binding is in the form of a lighter-colored band extending 17.3 mm from the distal tips of the slot prongs, where light transverse scoring and superimposed rodent damage is visible. The proximal taper exhibits a chiseled point and moderately-deep, nearly-continuous counterclockwise scoring perhaps best described as spiral incisions. This specimen also appears to have been painted with a reddish-brown pigment.

Figure 20. Specimens 16 and 48. Arranged from top to bottom.

Specimen 17. This proximal foreshaft fragment (Figure 21) was recovered from the disturbed upper level of Fate Bell, and is pictured and briefly described by Pearce and Jackson (1933:Figure 28, 121). The taper exhibits deep, widely-spaced lateral and oblique scoring, the latter twists in a counterclockwise direction. Minor damage can be observed at the point of the proximal taper. A long transverse crack, not visible in the photograph, resulted in the loss of the distal slot and portions of the medial shaft. The outer surfaces of this specimen show traces of dark reddish-brown pigment.

Figure 21. Specimens 17, 18, and 20. Arranged from top to bottom.

Specimen 18. This unusual specimen (see Figure 21), pictured and briefly described by Pearce and Jackson (1933:Figure 28, 121), was also recovered from the disturbed upper level of Fate Bell. Tentatively categorized as a proximal foreshaft fragment, the rounded tip of the proximal taper exhibits chisel marks, and the conical surface of the taper exhibits deep, nearly-continuous oblique scoring best described as counterclockwise spiral incisions. The distal end takes the shape of a tenon, and appears to be the byproduct of slot manufacture.

Specimen 20. This distal foreshaft fragment (see Figure 21), pictured and briefly described by Pearce and Jackson (1933:Figure 29, 121-122), was recovered from Fate

Bell at a depth of approximately 15 cm (6 in) and probably dates to the Late Archaic subperiod. The inner surfaces of the V-shaped slot are encrusted with asphaltum residue. Abundant, tightly-spaced, and shallow transverse scoring is present below the slot. Below the scoring, which extends to a distance of 34.8 mm from the distal end of the prongs, the diameter of the shaft has been slightly reduced (ca. .5 mm) and smoothed. The proximal end is burned and the entire specimen has a gray, ashy patina.

Specimen 25. This unusual specimen (Figure 22), pictured and briefly described by Pearce and Jackson (1933:Figure 29, 122-123), was recovered from Fate Bell at a depth of ca. 30 cm (12 in) and probably dates to the Late Archaic subperiod. The distal end of this specimen is not atypical of foreshafts - the slot is rectangular in shape, the distal edges of the slot prongs are rounded and the inner slot surfaces are concavely carved, and transverse scoring is easily visible on the outer surfaces of the slot prongs. But this specimen exhibits an unusually long and poorly-formed proximal taper, constituting 137 mm of the total length of 332 mm. At 195 mm from the distal end, the shaft is circumferentially inscribed and reduced in diameter. Interestingly, a very similar specimen, pictured and described by Meskill (1985:24), is on display at the Witte. I suspect that both are examples of unfinished foreshafts. The incision (at 195 mm) probably represents the intended length, and was recorded as such. Another possibility is that this foreshaft was never meant for insertion into a drilled foreshaft socket, but rather a hollow mainshaft of reed or cane, typical of darts from the Great Basin (Tuohy 1981:85). Modern modifications include the application of blue-green paint, varnish, and a synthetic adhesive.

Figure 22. Specimens 25 and 26. Arranged from top to bottom.

Specimen 27. This specimen, collected from one of the Shumla Caves, is tentatively categorized here as a distal foreshaft fragment (Figure 23). Schuetz described it as a "tenoned foreshaft" (1961:173). An illustration of this specimen is provided by Martin (1933:Plate X), who suggested that "such a devise might have been used to lengthen a too-short foreshaft" (1933:33). A more likely explanation is gleaned from the metric and non-metric attributes of the distal and proximal ends. The distal end is characterized by a well-made, but possibly unfinished rectangular slot, which measures 3.1 mm thick and 10.9 mm deep. The distal edges of the prongs are beveled, but only one inner prong surface is concavely carved. The proximal end is tenon-shaped, and appears to be the byproduct of slot manufacture. At 1.4 mm to 2.5 mm in thickness, the tenon is thinner than the seemingly unfinished distal slot. And at 12 mm in length, the tenon is also longer than the depth of the distal slot. It seems possible that the maker of this foreshaft found the original slot unsuitable for hafting the intended point, and the slot was remanufactured to be thinner and longer, thus making this specimen a waste product.

Figure 23. Specimens 27, 28, 29, 30, and 31. Arranged from top to bottom.

Specimen 28. As part of the Witte's Lower Pecos collection, this distal foreshaft (see Figure 23) was probably collected from one of the Shumla Caves or Eagle Cave. The remnants of a V-shaped nock are seen at the distal end. The distal half of one of the slot prongs is missing and appears eroded. The other prong, mostly intact, exhibits rounded distal edges and moderately-deep transverse scoring on its outer surfaces. The proximal end appears snapped and eroded.

Specimen 29. This proximal foreshaft fragment (see Figure 23) was collected from Eagle Cave. The distal end appears to have splintered and subsequently burned. The surfaces of the pointed proximal taper exhibit abundant, shallow to moderately-deep oblique scoring twisting in a clockwise direction.

Specimen 30. This thick, proximal foreshaft fragment (see Figure 23) was collected from Shumla Cave No. 5. The remnants of a V-shaped slot and deep transverse scoring is visible at the damaged distal end, as well as traces of what appears to be asphaltum. Minor damage is present at the point of the proximal taper. The taper surface is abundantly scored with moderately-deep, oblique incisions exhibiting a counterclockwise twist. Unlike most of the foreshafts in the study sample, which appear to have made of peeled hardwood twigs, the diameter of this specimen was reduced below the slot, and the medial portions of the shaft exhibits tool marks in the form of light transverse scoring. The lower portions of this specimen appear to have been coated in a synthetic varnish.

Specimen 31. This proximal foreshaft fragment (see Figure 23) was collected from Eagle Cave. This specimen appears to have been made of a knotty twig, the bark of which was peeled. The distal end is clearly burned. The proximal taper is roughly-hewn and exhibits lateral chisel marks and striations. Small amounts of synthetic varnish or adhesive are present as if the specimen was at some point mounted for display.

Specimen 39. This complete foreshaft (Figure 24) was collected from Yarbro Cave. The distal end displays characteristics typical of Archaic foreshafts: the inner surfaces of the rectangular slot are concave; the distal edges of the slot prongs are rounded; and the outer surfaces of the prongs are transversely scored. The ground proximal end is only slightly tapered, however. A dot of red paint, approximately 7-8 mm in diameter, is present near the proximal end.

Figure 24. Specimens 39, 40, 41, 42. Arranged from top to bottom.

Specimen 40. This complete foreshaft (see Figure 24) was collected from Yarbro Cave. The inner surfaces of the rectangular slot are slightly concave, and the distal edges of the slot prongs are rounded. No traces of transverse scoring at or below the slot were observed, however. Transverse scoring was similarly absent from the surfaces of the proximal taper, the tip of which exhibits a tenon-shape characteristic of slot manufacture waste. The lack of surface scoring may be due to erosion and post-depositional faunal damage, the later readily apparent in numerous, small insect burrows presumably the products of termite activity.

Specimen 41. This foreshaft, collected from Yarbro Cave, was categorized as complete even though the prongs of the rectangular slot are damaged (see Figure 24). Minor splintering at the distal end prohibits a measurement of slot thickness, but the depth of the slot is sufficiently intact to be measured. Additional damage includes a lengthwise crack originating from the base of the slot and moderate termite damage. The outer surfaces of the slot show no traces of transverse scoring. The point of proximal taper is damaged. The taper surfaces exhibit shallow, multi-directional scoring as if chiseled and possibly subsequently ground.

Specimen 42. This complete foreshaft (see Figure 24) was collected from Yarbro Cave. This specimen is unusually short in overall length, and may have been remanufactured from another, previously-damaged foreshaft. The outer surfaces of the slot prongs are transversely scored, and the distal edges are rounded. The distal end of this specimen was subjected to excessive compression as evidenced by the longitudinal crack that extends from the base of the rectangular slot. This deformation prohibits an accurate estimation of original slot thickness. Under magnification, extremely faint, oblique, counterclockwise scoring is visible along the surface of the proximal taper.

Specimen 43. This nearly-complete dart foreshaft (see Figure 14), pictured and briefly described by Nunley et al. (1965:Figure 39a, 113-114), was recovered from Coontail Spin. The stratum from which this specimen was recovered (Upper Zone A-4) contained projectile point types spanning the entire Archaic period, although the majority (27 out of 41, or approximately 66%) of the temporally-diagnostic points associated with this foreshaft date to the Late Archaic subperiod. Blackened outer surfaces suggest that this specimen may have been charred. Two mended snap fractures, one at the slot and another at the mid-section, provide less equivocal evidence of damage. Minor damage was also noted at the proximal taper point and the mostly-intact prong, the latter prohibited measurement of the original slot thickness. The entire specimen was apparently coated with a clear synthetic adhesive, presumably in an effort to repair and stabilize the damage. Tightly-spaced, oblique, counterclockwise scoring overlays the lengthwise chisel marks that form the proximal taper.

Specimen 47. This proximal foreshaft fragment (Figure 25) is part of a collection donated to the Texas Memorial Museum in January of 1965. According to the accession record on file at TARL, the present repository, this specimen was collected from a cave near Langtry, Texas (Nesmith 1965). Originally identified in the accession record as a pointed twig, this specimen exhibits attributes consistent with other foreshafts in this study. The possible remnant of a nock was observed at the distal end immediately below the break. Light transverse scoring was observed along the entire length of the specimen, as if its diameter was reduced . Scoring was especially pronounced at the distal end and along the proximal taper, which was also deeply incised in an oblique, clockwise direction. Portions of the specimen are coated in what appeared to be a synthetic adhesive.

Figure 25. Specimen 47.

Specimen 48. This distal foreshaft fragment (see Figure 20), along with Specimen 16, is part of the "Smugglers" collection originally donated to the Texas Memorial Museum but now held by TARL. The distal ends of the rounded slot prongs appear battered, as if subjected to forces of compression. The slot is rectangular in shape, and the outer surfaces of the slot prongs are transversely scored. The proximal end exhibits an irregularly chiseled termination. The medial shaft is stained brown from the proximal end to a line ca. 6.5 mm below the base of the slot. This line probably represents the lower limit of sinew binding no longer present. Taken together, these observations suggest that this foreshaft was in the process of being remanufactured prior to deposition. The original proximal taper was presumably damaged during use, and the replacement taper was partially but not fully reformed.

Wood Points

Specimen 06. This wood point (Figure 26), collected from Ceremonial Cave, is very similar to other specimens recovered from the Hueco area (Cosgrove 1947:Figure 69, 51), the Upper Gila area of western New Mexico (Cosgrove 1947:Figure 70, 54), and northern Wyoming (Frison 1991:Figure 2.62c), the latter deposited with materials radiocarbon dated to the Late Archaic (Frison 1991:107). The distal point is slightly damaged and portions of the medial section has splintered away from the body of the shaft. Where intact, the medial section exhibits tool marks in the form of lengthwise and transverse scoring. Under magnification, the surfaces of the rounded proximal taper exhibit complex modifications including indications of grinding; moderately-deep counterclockwise scoring; and superimposed, fine lateral scoring presumably resulting from twisting motions.

Specimen 11. This specimen, interpreted as an unfinished wood point (see Figure 26), was collected from Ceremonial Cave. The distal point is sharp and undamaged. Tool marks are visible as lengthwise striations along the surfaces of the distal point taper and transverse scoring along the medial portions of the shaft. No indications of shaping or smoothing are present along the proximal outer surfaces, where the remnants of bark are visible. The proximal termination has a chiseled, roughly-hewn appearance.

Figure 26. Specimens 11, 12, 06, and 13. Arranged from top to bottom.

Specimen 12. This specimen, tentatively categorized as a complete wood point (see Figure 26), was collected from Ceremonial Cave. The distal point is finely shaped and undamaged, and tool marks in the form of lengthwise striations are visible on the outer surfaces of the distal point taper and medial shaft. The proximal end, however, is not tapered and exhibits no indications of wear associated with mainshaft insertion. It is not clear whether the lack of a proximal conical taper reflects a variation in design or an unfinished stage of manufacture.

Specimen 13. This distal wood point fragment (see Figure 26) was collected from Ceremonial Cave. The point of the polished distal taper exhibits minor damage. Moderate oblique chiseling is visible along the medial shaft. The majority of the proximal taper is missing and the terminus exhibits the characteristics of a snap fracture.

Bunts

Specimen 04. This wooden bunt (Figure 27) was collected from Ceremonial Cave. Cosgrove (1947:52) describes similarly-shaped wooden bunts recovered during his investigations at Ceremonial Cave, and Setzler (1933:56) describes an example from the Chisos Mountains area. The broad, convex distal surface is chiseled and battered. The outermost cylindrical surfaces appear mostly unmodified, except for the lack of bark, which was presumably peeled without the use of tools. An abrupt, chiseled taper joins the bulbous distal end to the shaft and proximal taper, both of which are chiseled and partially smoothed. Under magnification, faint lateral scoring is visible on the surfaces of the proximal taper.

Specimen 05. This crudely-made bunt (see Figure 27) was recovered from Ceremonial Cave. The convex distal surface is roughly-hewn and possibly battered. The outermost cylindrical surfaces appear mostly unmodified and the remnants of bark, comparing favorably to that of pine, is present. The interior grain is also consistent with soft, coniferous wood. An abrupt taper joins the distal end to the proximal taper, which exhibits deep, clockwise scoring best described as oblique chiseling. The terminus of the proximal taper is flat, possibly broken.

Figure 27. Specimens 04, 19, and 05. Arranged from top to bottom.

Specimen 19. This bunt fragment (see Figure 27) was collected from Ceremonial Cave. Unfortunately, this specimen is badly deteriorated, and only the eroded remnants of the proximal taper survive. Due to its poor condition, no meaningful data were obtained from this specimen except a measurement of diameter.

Mainshafts

Specimen 07. This distal mainshaft fragment (Figure 28) was collected from Ceremonial Cave. The conical socket at the distal end is mostly intact, although portions of its outer edges are missing (Figure 29). While the base of the socket is somewhat rough, the inner socket surfaces, where intact, are quite smooth as if polished. Reinforcing sinew binding, 19.3 mm wide and treated with what appears to be modern varnish, is wrapped around the distal end below the socket damage. The proximal end displays an irregular, splintered fracture possibly resulting from compression.

Figure 28. Specimens 08, 07, 09, 14, and 15. Arranged from top to bottom.

Figure 29. Distal ends of Specimens 26, 15, 09, 07, and 08. Arranged from left to right.

Specimen 08. This distal mainshaft fragment (see Figure 28) was collected from Ceremonial Cave. The conical socket at the distal end is intact (see Figure 29), although its inner surfaces are obscured by ashy, seemingly organic residues. Over a distance of 16.5 mm, the distal end is slightly tapered from a diameter of 16.2 mm to 13.0 mm. This taper was almost certainly wrapped in sinew and lacks the patina and pigment that characterizes the remainder of the specimen. The length of the remaining shaft is incised with a widely-spaced and discontinuous spiral. Within these incised lines a bright red pigment is visible, while the remaining outer surfaces are mottled with brown stains. The proximal end appears to have snapped along the spiral scoring.

Specimen 09. This distal mainshaft fragment (see Figure 28) was collected from Ceremonial Cave. The conical socket at the distal end is intact (see Figure 29). The base of the socket is rounded, and the inner surfaces of the socket are relatively smooth. Over a distance of 20.5 mm, the distal end is slightly tapered from a diameter of 15.7 mm to 13.2 mm. The distal taper is lighter in color and lacks the mottled brown stains that characterize the remainder of the shaft. The proximal end exhibits a slightly irregular snap fracture.

Specimen 14. This distal mainshaft fragment (see Figure 28) was recovered from Ceremonial Cave. The conical socket at the distal end is slightly deformed but intact. The inner surfaces of the socket, where visible, appear relatively smooth. Traces of resin, from yellow to reddish-brown in color, are visible in a band of 29.1 mm-wide unstained wood at the distal end. Under magnification, light transverse striations, presumably the impressions of tightly wrapped sinew, are visible where the resin is absent. The remainder of the shaft appears to be slightly stained with brown pigment or patina. The proximal ends exhibits a relatively clean break categorized as a snap fracture.

Specimen 15. This distal mainshaft fragment (see Figure 28) was collected from Ceremonial Cave. The distal end exhibits several lengthwise expansion cracks which have altered the shape and dimensions of the socket (see Figure 29). Multiple layers of vegetal cordage, presumably dislodged from the distal end, now loosely wrap the midsection of the remaining shaft. Portions of the shaft are mottled with brown stains, possibly pigment. The proximal end exhibits a snap fracture.

Specimen 21. This proximal mainshaft fragment (Figure 30) was recovered from Fate Bell. The distal end exhibits a relatively clean break categorized as a snap fracture. The outer surfaces are painted with a red pigment. The proximal end is characterized by a cup-like depression 2.2 mm deep (Figure 31).

Figure 30. Specimen 21.

Figure 31. Proximal end of Specimen 21.

Specimen 26. This distal mainshaft fragment (see Figure 22) was collected from Ceremonial Cave. The conical socket at the distal end is intact (see Figure 29). The inner surfaces of the socket are relatively smooth but partially obscured by sediment. The distal end is reinforced with sinew wrapping 26.2 mm wide. Beneath the sinew, the distal end is slightly tapered from a diameter of 15.2 mm to 11.8 mm. Like most of the mainshafts from Ceremonial Cave, the outer surface of this specimen exhibits brown, mottled stains. Unlike the other mainshafts, this specimen appears to have been manufactured from a peeled hardwood sapling. The proximal end exhibits a long, splintered fracture.

Specimen 51. This complete mainshaft (Figure 32) was collected from Ceremonial Cave. The conical socket at the distal end is mostly intact, but exhibits slight damage along the outer edge (Figure 33). The inner socket surfaces are encrusted with a whitish substance, possibly guano. The shaft is slightly tapered from the distal end, which measures 16.7 mm in diameter, to the proximal end, which measures 8.4 mm. The proximal end is characterized by a cup-like depression 2.4 mm deep.

Specimen 52. This mainshaft (see Figure 32) was collected from Ceremonial Cave. Although complete, this specimen is broken into three pieces of unequal length. The total length (1536 mm) was estimated after refitting the two snap fractures that fragment the shaft. The inner surfaces of the intact distal socket are relatively smooth (Figure 34). The distal end is reinforced with tightly wound sinew wrapping 27.5 mm wide. The shaft is slightly tapered from the distal end, 15.2 mm in diameter, to the proximal end, which measures 7.7 mm. Portions of the proximal cup are missing.

Approximately 255 mm from the proximal end, the shaft is wound with sinew in a band 11.1 mm wide and a few turns of thick vegetal cordage 8.2 mm wide. The outer surfaces of the shaft are stained with a reddish-brown pigment.

Figure 32. Specimens 51 (left) and 52 (center). Pointed stick on far right removed from study.

Figure 33. Distal end of Specimen 51.

Figure 34. Distal end of Specimen 52.

Lithic Drills

Specimen 10. This distal drill fragment (Figure 35) was the only lithic tool from Ceremonial Cave to meet the criteria for inclusion in this study. It was manufactured from fine-grained dark gray to grayish-brown chert. The tip and edges of this bit fragment exhibit heavy use-wear and are quite dull.

Figure 35. Specimen 10.

Specimen 33. This drill (Figure 36) was collected from Shumla Cave No. 5. The specimen is made of fine-grained brown and tan chert. The bit is lenticular in cross section. All edges show considerable dulling except along a thermal spall removed from the ovate base.

Figure 36. Specimen 33.

Specimen 34. This drill (Figure 37) was collected from Shumla Cave No. 5. The specimen is made of fine-grained gray chert. The bit, roughly diamond-shaped in cross section, joins the round base in a smooth transition. All of the edges are relatively sharp and exhibit no obvious signs of use.

Specimen 35. This drill (Figure 38) was collected from Eagle Cave. The specimen is made of fine-grained dark gray chert. The bit is steeply beveled and slightly thicker than the expanded base, which resembles the basal shape of many Late Archaic dart points. All of the edges are sharp.

Figure 37. Specimen 34.

Figure 38. Specimens 36 and 35. Arranged from top to bottom.

Specimen 36. This unusually long drill (see Figure 38) was collected from Eagle Cave. The specimen is made of fine-grained light brown chert. The bit, lenticular in cross section, gradually joins the thick, spatulate base. All of the edges are relatively sharp and exhibit no obvious signs of use.

Specimen 37. This drill (Figure 39) was collected from Shumla Cave No. 5. The specimen is made of fine-grained gray chert. The long, slender bit is steeply beveled. The base is somewhat small and irregularly-shaped - possibly the remnants of a refurbished, side-notched projectile point. None of the edges display obvious signs of use although portions of the base are dulled by small, steep-angled fractures.

Figure 39. Specimen 37.

Specimen 38. As part of the Witte's Lower Pecos collection, this drill (see Figure 16) was probably collected from Eagle Cave or one of the Shumla Caves. The specimen is made of fine-grained light brown chert. The bit, lenticular in cross section, exhibits moderate wear at the tip and slight wear along the edges. The base is irregularly-shaped and exhibits a partially retouched snap fracture.

Specimen 44. This drill (Figure 41), pictured and briefly described by Nunley et al. (1965:Figure 27c, 77), was recovered from an unspecified provenience at Coontail Spin. This specimen is made from fine-grained light grayish-brown chert. The slender bit is steeply beveled, and the ovate base is alternately beveled. The bit tip and edges exhibit slight to moderate wear. The basal edges are ground.

Figure 40. Specimens 44, 45, and 46. Arranged from left to right.

Specimen 45. This drill (see Figure 41), pictured and briefly described by Nunley et al. (1965:Figure 27d, 77), was recovered from an unspecified provenience at Coontail Spin. This specimen is made from gray, coarse chert. The bit is diamond-shaped in cross section and the base is ovate in shape. The tip and edges of the bit exhibit moderate wear. The basal edges are slightly dulled.

Specimen 46. This drill (see Figure 41), pictured and briefly described by Nunley et al. (1965:Figure 27f, 78), was recovered from an unspecified depth in Area B of Coontail Spin. The base of the drill compares favorably to those of Pedernales dart points, which date to the latter half of the Middle Archaic subperiod (Turner and Hester 1999:171). This specimen is made from moderately-coarse grayish-brown chert. The bit is alternately beveled. Except for the concavity of the base, which is slightly dulled, all of the edges are relatively sharp and exhibit no obvious signs of use.

CHAPTER V

RESULTS AND DISCUSSION

Foreshafts

Metric Attributes

Table 8 presents summary statistics for the eight metric variables of foreshafts in the study sample. The number of specimens from which these data were derived vary and summary statistics for length and weight were calculated with only the seven complete specimens. The coefficients of variation (*CV*s) show that some measurements vary considerably, while others show relatively little variation. Weight is understandably the most varying measure (35.8%) since it is affected not only by length and diameter, but also density. In contrast, the variables diameter and maximum taper diameter, nearly identical measurements in all 14 foreshafts with intact proximal tapers, show much lower variation (11.9% and 10.9% respectively), which suggests relatively high levels of standardization (Eerkens and Bettinger 2001).

Inherently conditioned by the size of the projectile points for which they were designed, the slots found at the distal ends of the foreshafts show more variation. It is interesting to note that the *CV*s for slot depth and slot thickness (21.6% and 25.3%

Table 8. Summary Metric Data for Foreshafts in Study Sample.

Variable	n	Mean	*s*	Minimum	Maximum	Kurtosis	*CV* (%)
Length (mm)	7	127.90	29.00	68 9	154.0	3.172	22 7
Diameter (mm)	20	10 97	1.31	8.2	13.3	-.019	11.9
Taper Length (mm)	14	24 05	5.36	15.0	33.4	- 871	22 3
Max Taper Dia. (mm)	14	10.22	1.11	8.1	11.8	.077	10.9
Taper Angle°	14	11.04	2.73	5.0	15.0	.768	24.7
Slot Depth (mm)	12	13.02	2.81	9.4	18.4	-.249	21.6
Slot Thickness (mm)	8	4.66	1.18	3.1	6.4	-1.03	25.3
Weight (gm)	7	7.60	2.72	4.3	11.0	-1.72	35.8

respectively) are very near those for Great Basin projectile points at 22% (Eerkens and Bettinger 2001:499) and the basal elements of Texas Clovis points, which are thought to be effected by hafting constraints, and range from 19.14% to 23.75% (Bever and Meltzer 2007:87). There is little co-variation between slot thickness and slot depth in the study sample, however, and the Pearson's correlation coefficient between these two variables is not significantly different from zero ($r = .234$; $df = 6$; $p = .577$). This suggests that slot thickness, presumably conditioned by the basal thickness of the projectile point(s) for which each foreshaft was manufactured, took design precedence over slot depth, which understandably may have been less critical. Computations of correlation coefficients between all metric attributes of the sample foreshafts revealed that slot thickness co-varied significantly with three variables at the $\alpha = .05$ level: length; diameter; and weight ($r = .761, p = .028$; $r = .822, p = .012$; $r = .780, p = .022$, respectively). Although these correlations may be red herrings, the apparent associations between these variables might be sensibly explained if one considers a specific sequence of cause and effect: if thick slots were manufactured to haft projectile points with thick bases, then relatively thicker, longer, and consequently heavier foreshafts might have been preferred or required. While this seems reasonable, David Thomas (1978:469) did not find a significant correlation between the diameters of 10 prehistoric dart foreshafts and the thicknesses of the points with which they were hafted.

Other significant correlations between the metric attributes of the sample foreshafts include those between weight and length ($r = .817$, $df = 18$; $p = .000$), and weight and diameter ($r = .701$; $df = 18$; $p = .001$), both of which positively co-vary for obvious reasons. The only other significant correlation of foreshaft attributes lies between diameter and maximum taper diameter ($r = .856$; $df = 12$; $p = .000$), but as mentioned previously, these measurements are very similar in all 14 foreshafts with intact proximal tapers.

That lack of certain correlations in the study sample is noteworthy. Neither taper angle nor taper length co-varied significantly with any other metric attribute, which may be due to specific functional requirements. The lack of significant correlation between foreshaft diameter and length ($r = .362$; $df = 18$; $p = .117$) is also worth mentioning. This correlation coefficient, however, was calculated with complete and fragmentary foreshafts, the latter unrepresentative of functional length. Unfortunately, of the 20 foreshafts in the study sample, only seven are sufficiently intact to record total (functional) length. In order to increase the sample size of complete foreshafts, data published by Thomas (1978) were included in a reanalysis of co-variation between foreshaft diameter and length (Table 9). A scatter plot of these two variables, as seen in

Figure 42, does not suggest a strong relationship. The computed correlation coefficient ($r = -.132$; $df = 15$; $p = .612$) confirms this observation; there is no significant co-variation between these two variables. This result supports inferences drawn from other data collected during this study pertaining to the use-life of foreshafts. In short, it seems as if some foreshafts were sometimes refurbished. Or in other words, just as some projectile points are known to have been resharpened after dulling or breaking in the interest of minimizing materials and labor, some foreshafts appear to have been remanufactured after being damaged. This process would of course reduce the overall length of repaired specimens, and explains the relatively wide range in foreshaft length (171.5 - 56.9 = 114.6 mm).

Table 9. Diameters and Lengths of 17 Dart Foreshafts.

Specimen No.	Diameter (mm)	Length (mm)
1	12.4	135.6
16	10.7	153.0
39	12.1	154.0
40	10.6	124.0
41	11.5	125.6
42	10.2	68.9
43	8.2	139.2
A3048*	9.6	105.0
A3117*	11.8	126.0
A2814*	9.6	84.5
A3048*	10.6	118.4
96746*	12.3	56.9
96745*	9.1	105.9
A5582*	10.0	97.9
A5528*	10.1	99.4
97179*	8.8	129.7
None*	8.5	171.5

* Measurements from Thomas (1978:466).

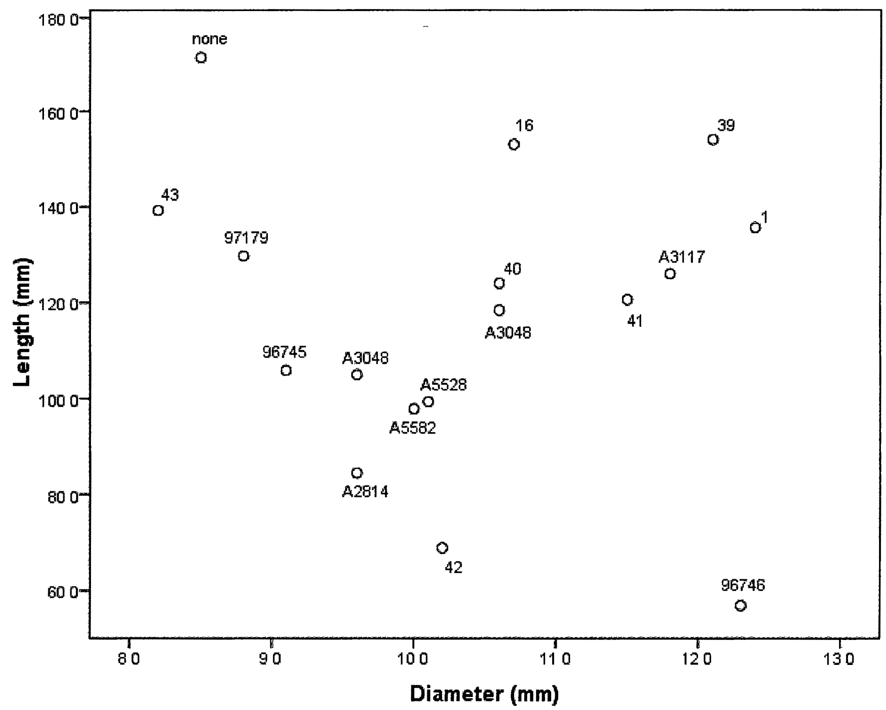

Figure 41. Scatter plot of the diameters and lengths of 17 complete dart foreshafts labeled by specimen number.

Non-metric Attributes

The distribution of categories of foreshaft damage provides information pertaining to use, discard, and post-depositional deterioration (Figure 43). Six of the twenty foreshafts (30%) exhibited splintering. Interpreted as the result of compression, splintering is not unexpectedly the most prevalent type of damage in the sample foreshafts and should be common in projectile components. Snap fractures, believed to be the result of lateral stress, and the absence of discernable damage (none), each constitute 20% of the sample. Post-depositional damage is reflected in five specimens exhibiting fire and faunal damage, which together constitute 25% of the sample. Distal battering was observed on one foreshaft (Specimen 48), but it was not clear whether this damage was post-depositional or the result of compression associated with penetration drag.

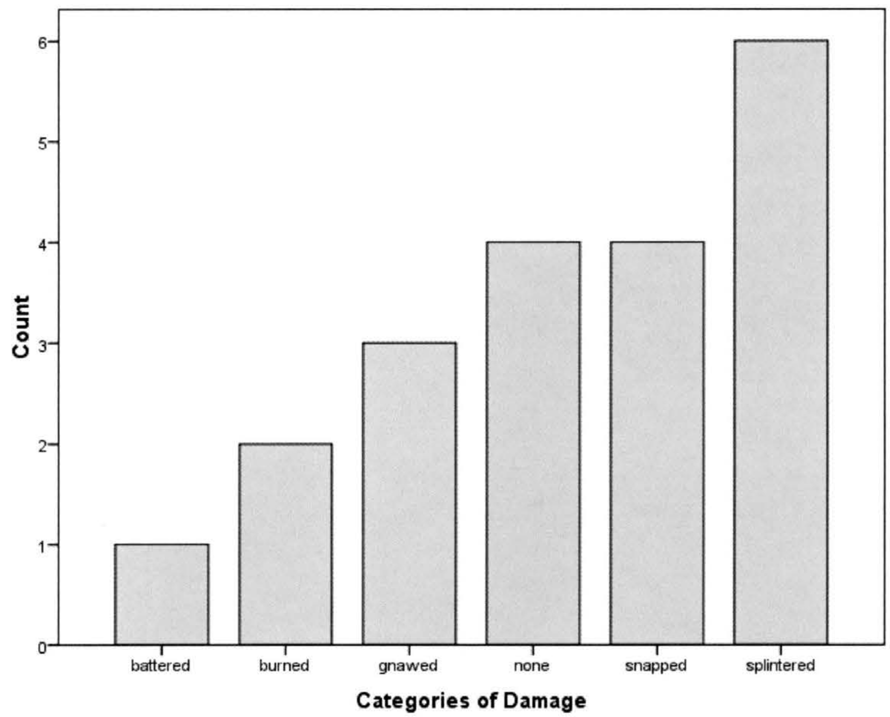

Figure 42. Frequency distribution of categories of damage in the sample of 20 foreshafts.

The distal slots in the foreshaft sample took two basic forms (see Table 4). Of the 14 intact slots, 10 (71%) were rectangular in shape. Most of these specimens exhibited perpendicular incisions indicative of the groove-and-snap manufacturing technique described by Cosgrove (1947:52-54) and Whittaker (1994:254). With this technique, the dimensions of the slot are deeply incised in the body of the foreshaft, and the tenon-shaped waste is simply broken out of the slot with a side-to-side bending motion. The remaining four specimens (29%) are characterized by V-shaped slots. This distribution seems counterintuitive since V-shaped slots would presumably provide a more secure fit with the usual lenticular shape of point edge cross sections. Perhaps for the majority of Archaic hunters, the advantages of a more solid haft was outweighed by the added difficulty in manufacturing V-shaped foreshaft slots. However, the presumably labor-intensive concave inner surfaces seen in the slot prongs of five foreshafts with rectangular-shaped slots (Specimens 01, 16, 25, 39, and 40) were almost certainly carved in the interest of a secure foreshaft-point bond.

Because the proximal tapers of the foreshafts, wood points, and bunts evidently served the same function, the following discussion of taper attributes will draw from all three artifact classes. The categorization of taper shape was somewhat arbitrary, and varying degrees of damage made definitive determination of original shape difficult in at least three cases (see Table 4). As seen in Figure 44, pointed taper termini occur most frequently in the sample (10 out of 17 specimens exhibiting intact proximal tapers, or approximately 59%). Whether the popularity of this shape reflects convention or functional advantage is not clear. The distribution may simply reflect individual variations in functionally equivalent shapes.

The function of the proximal tapers of foreshafts, wood points, and bunts is more clearly reflected in the modifications made to their conical surfaces. As described in the previous chapter, several tapers exhibited traces of a complex histories of manufacture and use. The tapers appear to have been chiseled and/or ground into their respective shapes. Scoring of varying depth and direction was sometimes intentionally applied to the taper surfaces prior to use. And finally, use-wear in the form of polish and/or fine striations is present on the tapers of several of the better preserved specimens. Although the use-histories of only a few specimens could be reconstructed with a reasonable level of confidence, the direction of oblique transverse scoring could be clearly identified on 12 specimens (see Table 4). Interestingly, eight of the 12 obliquely scored proximal tapers exhibit a counterclockwise (or left) twist; the remaining four exhibit a clockwise (or right) twist. This distribution seems counterintuitive if one assumes foreshafts, wood points, and bunts were inserted and twisted into mainshafts with the user's dominant hand. If, however, the mainshaft remained in the user's dominant hand and was twisted onto the foreshaft (held in the less-favored hand), one would expect to find higher frequencies of counterclockwise scoring.

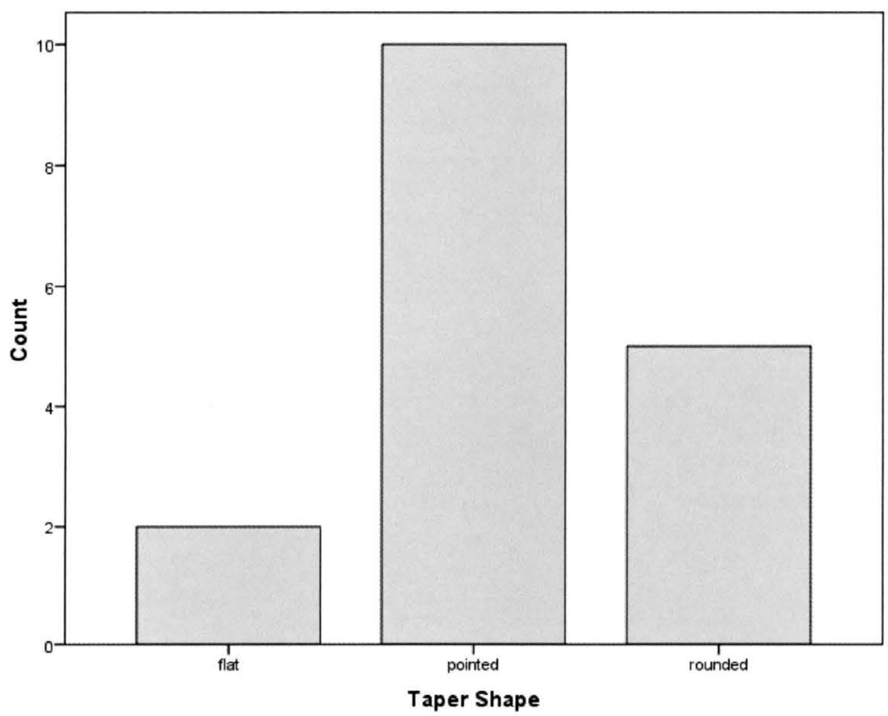

Figure 43. Frequency distribution of taper shapes in a sample of 14 foreshafts, one wood point, and two bunts.

Bearing in mind that approximately 10-13% of humans are left-handed (Raymond et al. 1996), and that there is evidence to suggest that this percentage has not changed appreciably in the last 5,000 years (Coren and Porac 1977), I constructed a table with the observed and expected frequencies of directional twist supposing that counterclockwise scoring reflected right-handedness (Table 10). The 1.56 expected occurrences of left-handed twist (13% of n = 12) was rounded up to two. A one-way chi-square test, computed by hand using Yates' correction for continuity (cf. Madrigal 1998:200-201), resulted in an insignificant value at $\alpha = .05$ ($\chi_c^2 = 1.35$; $df = 1$). This indicates that the distribution of directional scoring is not significantly different than expected if the underlying suppositions are true. It should be noted, however, that a standard one-way chi-square test reveals no significant difference between the observed frequencies and that of an even distribution ($\chi^2 = 1.33$; $df = 1$). Clearly, additional samples are needed to test the hypothesis that directional scoring reflects handedness.

Table 10. Observed and Expected Frequencies of Directional Twist.

	Counterclockwise	Clockwise
Observed Frequency	8	4
Expected Frequency	10	2

Although the presence or absence of the six additional non-metric attributes were listed in Table 5 for the purposes of review, it is evident that transverse scoring at and just below foreshaft slots is a common feature in the sample. The application of pigment, identified on five foreshafts (Specimens 03, 16, 17, 39, and 48), is also not uncommon in the study sample.

Wood Points and Bunts

Given that only one complete wood point and two complete bunts were included in the study sample, no summary statistics of metric attribute parameters are provided for these two artifact classes. The sample does allow for inferences drawn from qualitative observations, however. As shown in Figure 26, the four wooden points seem to represent stages of manufacture and use. Specimen 11 appears unfinished as if abandoned or discarded during manufacture - its point is finely-shaped and undamaged, but bark is visible at the proximal end which is roughly-hewn. Specimen 12 was categorized as complete and no indications of use were identified. The proximal end does not exhibit the characteristic conical taper of a complete specimen, however, and this specimen may in fact be unfinished in form. The blunted point and medial splintering of Specimen 06 are clear indications of use, as are the traces of oblique and lateral scoring on its taper surface. The polished point of Specimen 13 is only slightly damaged, but the use-life of this component appears to have ended when its proximal taper snapped off - presumably in a mainshaft socket.

Although the two intact bunts in the study sample are somewhat similar in form (see Figure 27), they are made of dissimilar materials and exhibit disparate levels of manufacturing quality. Made of hardwood, possibly some type of oak, Specimen 04 exhibits a high level of craftsmanship in shape and surface quality. Specimen 05, on the other hand, is roughly-hewn and appears hastily-made. As mentioned previously, the interior grain and remnants of bark compare favorably with a soft, coniferous wood, probably ponderosa pine or Mexican piñon. While both specimens exhibit battering at their distal ends, Specimen 05 might be, for lack of a better term, a "practice" piece. Experimenters have noted that accurately throwing a dart with an atlatl requires practice (Butler 1977:162; see also Dickson 1985:10-11). It seems reasonable to assume that students of the atlatl may want to practice throwing darts without fragile, hafted, and potentially expensive projectile points. Gould (1970:4) observed that young aborigine boys in the Western Desert of Australia often practice throwing darts in their play with crudely-fashioned and unfinished tools. He also noted that the fathers of older boys usually take an interest in their sons' atlatl skills, and each father "generally makes a small spear-thrower and a set of small spears for his son to use in practice" (Gould 1970:6). These "toy spears" typically lack the barbs that characterize fully-functional darts (Gould 1970:7).

Mainshafts

Metric Attributes

Table 11 presents summary statistics for five of the seven metric variables of mainshafts in the study sample. The number of specimens from which these data were derived vary and summary statistics for length and weight were not calculated since only two mainshafts (Specimens 51 and 52) are complete or nearly so. The *CV*s show little variation in attributes. The especially low *CV* for the variable maximum socket diameter (8.3%) suggests a high level of standardization. As mentioned above, the maximum diameters of the foreshaft tapers are also characterized by a similarly low *CV* (10.9%).

Computations of correlation coefficients between the five metric attributes resulted in only one significant value between two closely-associated measurements: maximum socket diameter; and socket diameter at 15mm (r = .919; df = 5; p = .003). As seen in the foreshaft sample, the taper angles of the mainshaft sockets do not significantly co-vary with any other metric attributes.

Table 11. Summary Metric Data for Mainshafts in Study Sample.

Variable	n	Mean	*s*	Minimum	Maximum	Kurtosis	*CV* (%)
Diameter (mm)	9	15.31	2.01	10.3	17.3	6.12	13.1
Taper Angle°	7	9.29	1.44	7.5	11.5	-1.06	15.5
Socket Depth (mm)	8	26.65	4.05	18.5	32.4	2.28	15.2
Max. Socket Dia. (mm)	8	9.61	.80	8.8	11.1	.15	8.3
Socket Dia. at 15 mm (mm)	7	7.19	.92	6.2	8.8	.25	12.8

Non-metric Attributes

The foreshafts and wood points in the study sample were all assumed to be made of various unidentified species of hardwood. But only one mainshaft (Specimen 26) exhibited the tightly-grained growth rings, knots or branch buds, and relatively high density of hardwood. The remaining mainshaft and mainshaft fragments compared favorably with examples of sotol bloom stalks I collected near Seminole Canyon in Val Verde County. This distribution is in line with observations made by Cosgrove (1947:50), who reported that out of the 90 mainshafts collected from Ceremonial Cave, Picture

Cave, Chavez Cave, and Cave 6 (all in the Hueco area), 83 were manufactured from sotol bloom stalks, the remaining seven were made of hardwood.

Only two types of damage were recorded in the sample of nine mainshafts and mainshaft fragments: three appeared to have splintered; the remaining six appeared to have snapped (see Table 4). The relatively high frequency of damage interpreted as resulting from lateral stress, especially near the thicker distal end, seems unusual for components presumably subjected primarily to forces of compression. It should be noted, however, that eight of the nine sample mainshafts were recovered from Ceremonial Cave, where numerous objects were reportedly broken intentionally by looters in 1926 and 1927 (Creel 1997:86).

As mentioned above, five (20%) of the foreshafts in the study sample exhibit traces of pigment. Only one decorated foreshaft was recovered from Ceremonial Cave (Specimen 03). In contrast, eight of the nine mainshafts and mainshaft fragments (ca. 89%) were apparently decorated with paint. Seven of the eight decorated mainshafts were recovered from Ceremonial Cave. The remaining mainshaft, Specimen 21, is from Fate Bell. Cosgrove (1947) provides descriptions of a number of painted Archaic projectile components from Ceremonial Cave and the three other sites he investigated in the Hueco area. Decorations include: "9 shafts painted black,...4 painted red,...1 proximal end fragment...striped spirally with two black lines,...1 painted red and daubed with black,...[and] 1 shaft painted black (Cosgrove 1947:51). An additional unspecified number are reported as being partially or completely painted red, and a single shaft fragment was reported as having "dark brown painting" (Cosgrove 1947:51). Frison's (1965) descriptions of Late Archaic wooden projectile components recovered from

Spring Creek Cave (48WA1) in northern Wyoming, also includes examples of decorative pigment. Of the thirteen foreshafts recovered, "most have a coating of red pigment" (Frison 1965:89). One distal mainshaft fragment has a "heavy coating of red pigment" (Frison 1965:88), and three of the 16 proximal mainshaft fragments are similarly decorated. Although largely outside the purview of this paper, the application of paint, especially the color red, may have symbolic implications. The use of red ochre in the Old World has an unusually long history and has been linked to the evolution of human symbolism (Hovers et al. 2003; Wreschner 1980). In the New World, red ochre was used extensively during the Paleoindian period and the Late Archaic subperiod (Wreschner 1980:633). While red is often thought to represent blood, this association is problematic and depends largely on symbolic contexts (Marshack 1981). Interestingly, Gould "found no evidence to show that [Australian] aborigines attach any special significance to the red ochre they sometimes apply to spear-throwers" (1970:37).

Lithic Drills

Metric Attributes

Table 12 presents summary statistics for the eight metric variables of lithic drills in the study sample. The *CV*s show that the variables maximum bit width (15.3%) and taper angle (16.6%) exhibit the least relative variation, and thus the most standardization in design. At 36.4%, the variable maximum thickness displays the greatest variation, probably because the sample of complete drills (n = 9) is comprised of two "types" of drills: refurbished dart points; and drills taking various spatulate shapes. Computations of correlation coefficients between all eight metric attributes resulted in four significant values. Not unexpectedly, the variables weight and maximum length (r = .740; df = 7; p = .023), and maximum length and maximum thickness (r = .708; df = 7; p = .033), positively co-vary. Of special interest are the variables pertaining to the bits of the drills. As with the foreshafts and mainshafts, taper angle does not significantly co-vary with any other metric attribute. The only significant correlations between bit measurements are bit length and maximum bit width (r = .710; df = 7; p = .032), and bit length and maximum length (r = .705; df = 7; p = .034).

Table 12. Summary Metric Data for Lithic Drills in Study Sample.

Variable	n	Mean	*s*	Minimum	Maximum	Kurtosis	*CV* (%)
Maximum Length (mm)	9	67.87	13.39	49.5	93.8	.50	19.7
Max. Width (mm)	9	28.43	6.10	22.7	39.5	-.26	21.5
Max. Thickness (mm)	9	9.27	3.37	7.4	18.0	7.56	36.4
Bit Length (mm)	9	41.53	10.57	28.0	57.7	-1.33	25.4
Max. Bit Width (mm)	9	13.32	2.04	10.5	16.9	.23	15.3
Max. Bit Thickness (mm)	9	7.14	1.37	4.2	9.1	2.37	19.2
Taper Angle°	10	11.90	1.98	8.0	14.0	.51	16.6
Weight (gm)	9	9.99	3.28	5.7	14.9	-.68	32.8

Non-metric Attributes

As is evident in Table 7, the are obvious associations between macroscopic tip wear, edge wear, and basal smoothing on the lithic tools that in this study are termed "drills." As previously mentioned, intentionally dulled edges may be associated with manual prehension. In the study sample, basal smoothing is clearly associated with use. The only exception is Specimen 46, which was undoubtedly fashioned from a Pedernales point, and its limited basal grinding is probably indicative of hafting. I suspect that if these tools were used as awls or perforators, then use-wear would be present primary, if not entirely, at the tip of the implement. I also suspect that generally uniform wear from the tip to the base of the bit is consistent with usage as a drilling implement. These views are contrary to that of Goodyear who suggested, among other things, that the uniform wear on the Dalton "final stage" drills he examined was consistent with a "specialized scraping task" (1974:32). It is important to note that the edges of tapered drill bits are subjected to considerable wear. While the tip of a tapered drill presumably takes the brunt of the wear as the hole is initiated, the edges are subjected to increasing amounts of friction as the hole is deepened. In short, it would appear that the lithic drills exhibiting use-wear in the study sample may have been used as actual drilling implements. Specimens exhibiting similar morphology but lacking use wear may have been manufactured with the same functional intention in mind.

Inter-class Comparisons

Although prehistoric darts without foreshafts have been recovered in the study area (Cosgrove 1947:52), it appears that multi-component darts were widely used during the Archaic period in the northern Chihuahuan Desert and other regions of North America. The elegance of this system lies in its advantages: ease of repair/replacement, and flexibility in armament. But this system requires that its components are made to be interchangeable. Interchangeability in turn requires consistency in manufacture, at least within an individual's weapon system. If an individual's foreshafts (or wood points and bunts) are made to be interchangeable with one another, then we would expect similarly-shaped specimens. The specimens described above exhibit considerable consistency in general morphological (and presumably functional) attributes such as taper length, taper degree, diameter, etc. Although the present sample of mainshafts and distal mainshaft fragments with intact sockets (n = 7) is small and was taken from a single site, their sockets are remarkably similar in general morphology and were evidently made to accept the proximal tapers of foreshafts and other distal components. Although the inner surfaces of some of the mainshaft sockets are obscured by ash and other organic residues, traces of adhesive are not apparent. The inner surfaces of the sockets, where visible, appear smooth, as if polished by the repeated insertion and twisting of tapered counterparts. Although spiral incisions were not observed within the sockets, their uniformly symmetrical shapes and generally rounded bases suggest that these tapered sockets were almost certainly drilled into the distal ends of the mainshafts.

Statistical methods were employed to test the hypothesized relationships between the three functionally-grouped artifact classes: (1) foreshafts, points, and bunts (FPBs); (2) mainshafts; and (3) lithic drills. As previously mentioned, no significant correlations were identified between taper angles and the other metric attributes of foreshafts, mainshafts, and drills. The lack of correlations suggests that the taper angles of functional groups may be conditioned by functional necessity rather than intra-class metrics. Table 13 summarizes the individual taper angles and the means and standard deviations of the three functionally-grouped artifact classes. Although the study sample was not randomly selected, box plots of the taper angles suggest that the measurements are amenable to parametric tests of sample means (Figure 45). This observation is confirmed by Kolmogorov-Smirnov tests of normality ($W = .192$, $df = 17$, $p = .095$; $W = .150$, $df = 7$, $p = .200$; $W = .220$, $df = 10$, $p = .186$) and the Levene test of homogeneity of variances ($F = .684$; $df = 2, 31$; $p = .512$). An ANOVA test revealed no significant difference in the taper angles of the three groups ($F = 3.070$; $df = 2, 31$; $p = .061$). This similarity in mean taper angles between functional groups does not discount the hypothesis that these artifacts are elements of similarly-structured weapon systems.

Modern applications of conical press-fit joints, as seen for example in multi-piece vacuum cleaner hoses and fishing rods, are characterized by very close tolerances and very low angles of taper. But it is extremely unlikely that these characteristics should be present in wooden artifacts manufactured with stone tools, especially without the use of precise measuring instruments. The tapers of prehistoric press-fit joints should, however, reflect an optimal design conditioned by functionality and convention, but with the variation one would expect in objects manufactured by hand and measured by eye (see Eerkens and Bettinger 2001). During his experimentations with Clovis weaponry on wounded and freshly killed elephants, Frison (1989:770) noted that tapered foreshaft-mainshaft connections work satisfactorily if the angles of the foreshaft and mainshaft closely match and measure 9° to 11° along one edge. If measured by the methods used in this study, Frison's "satisfactory" angles would measure 18° to 22°, considerably higher than any of the angles in the present sample. It should be noted, however, that over twenty years earlier Frison (1965:89) reported that the tapers of the foreshafts recovered from Spring Creek Cave varied between 5° and 6° (or 10° to 12° by the methods used here). These measurements are much more in line with the tapers of the foreshafts in this study's sample, which vary from 5° to 15°. This range probably more accurately represents the variation in this functionally-constrained attribute than Frison's (1989) experiments or site-specific observations (Frison 1965) suggest.

Table 13. Taper Angles Listed by Specimen Number and Grouped Artifact Class.

Group 1 (FPBs)						Group 2		Group 3	
Foreshafts		Points		Bunts		Mainshafts		Drills	
Spec. No.	Taper Angle°	Spec. No.	Taper Angle°	Spec. No.	Taper Angle°	Spec. No.	Taper Angle°	Spec. No.	Taper Angle°
01	13.0	06	12.5	04	12.0	07	9.0	10	11.5
02	12.0			05	13.5	08	7.5	33	14.0
16	11.0					09	8.0	34	13.0
17	10.5					14	11.5	35	13.0
18	9.0					26	10.0	36	9.0
29	11.5					51	10.5	37	8.0
30	15.0					52	8.5	38	12.5
31	13.5							44	12.0
39	5.0							45	12.0
40	6.5							46	14.0
41	12.0								
42	12.0								
43	13.5								
47	10.0								
n = 17 mean = 11.32 s = 2.56						n = 7 mean = 9.29 s = 1.44		n = 10 mean = 11.90 s = .1.98	

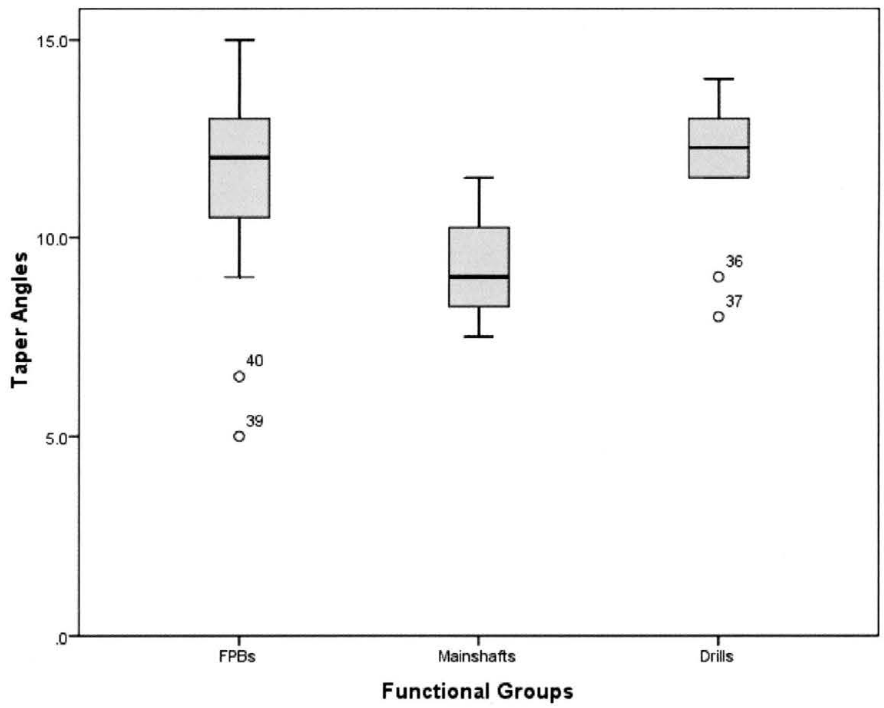

Figure 44. Box plots showing distribution of taper angles for each of the grouped artifact classes. Outliers are labeled individually with their specimen numbers.

It is clearly evident that the sample FPBs were made to be inserted into the distal sockets of mainshafts. But if this interchangeability between FPBs was facilitated by the use of certain lithic drills in the manufacture of mainshaft sockets, then these drills and mainshafts should exhibit not only similar taper angles, but also similar taper width:length ratios. Table 14 provides the width:length ratios and their means and standard deviations, all rounded to four decimals, for the drills (maximum bit width:bit length) and mainshafts (maximum socket diameter:socket depth). An independent samples t-test for equality of means revealed no significant difference between drills and mainshafts in width:length ratios ($t = -1.279$; $df = 15$; two-tailed $p = .220$, equal variances assumed).

Table 14. Width:Length Ratios of Lithic Drill Bits and Mainshaft Sockets Listed by Specimen Number and Artifact Class.

Lithic Drills Bits		Mainshaft Sockets	
Spec. No.	Width:Length Ratio (mm)	Spec. No.	Width:Length Ratio (mm)
33	0.3562	07	.4081
34	0.3750	08	.2716
35	0.4094	09	.3725
36	0.2887	14	.3636
37	0.2322	15	.3593
38	0.3927	26	.3448
44	0.3247	51	.4811
45	0.2881	52	.3423
46	0.3177		
n = 9		n = 8	
mean = .3316		mean = .3679	
s = .0571		*s* = .0598	

While not conclusive, these data do not discount a functional association between bifacially-flaked lithic drills and mainshaft socket manufacture. The possible association between bifacial drills and mainshaft manufacture is also supported, albeit indirectly, by general patterns in drill morphology. Turner and Hester note that, in Texas, "the bases of Archaic drills are frequently the same as those of projectile points, suggesting that they probably began as points and were later reworked into drills" (1999:270). In contrast, "Late Prehistoric perforators are smaller than the large Archaic bifaces, and are most commonly made on flakes" (Turner and Hester 1999:270). Richard Gramly notes that drills are commonly found in Clovis and Folsom assemblages, but are "much rarer in the Agate Basin and later Paleoindian phases" (1992:26). Agate Basin points are widely distributed throughout the Mid-West and are characterized by contracting stems similar to those of Angostura points (Justice 1995:33). According to Musil's (1988) hafting model, Late Paleoindian points exhibiting contracting stems may have been hafted directly to mainshafts, eliminating the need for distal conical sockets.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study has sought to increase our understanding of Archaic weapon systems through the systematic analysis of wooden projectile components from the northern Chihuahuan Desert. Although the sample was limited in size and scope, the data offer insights into the parameters of several attributes, some previously uninvestigated. Patterns of use-wear and damage offer additional insights into the functions and life-histories of normally-perishable projectile components. Unfortunately, the few objects in the study sample that were recovered through controlled excavations came from mixed contexts, and definitively assigning temporal affiliations to most of the artifacts through stratigraphic association proved impossible. While the sample was treated as representative of Archaic technology in general, and while there is evidence to suggest that some of the specimens date to the Middle Archaic, the majority of the specimens probably date to the latter half of the Late Archaic. Without radiocarbon assays, the data presented above are not amenable to temporally-controlled comparative studies. But the data do illustrate aspects of an apparently well-organized weapon system that featured intentional flexibility and easy repair as design elements.

Interestingly, the flexibility in Archaic dart design appears to have been facilitated by interchangeable, highly standardized junctures between mainshafts and other components. Preliminary data gleaned from a painfully small sample of lithic drills suggest that tools exhibiting well-made, bifacially-flaked bits with relatively low taper angles may have been used to manufacture mainshaft sockets. This is not to say that lithic tools exhibiting these characteristics were only used for this purpose. On the contrary, these tools probably served a variety of functions. But the drilling of mainshaft sockets may have been one of the primary uses of these tools, and the refurbishing of projectile points into drills might be associated with mainshaft manufacture.

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