BIOARCHAEOLOGICAL INVESTIGATION OF HUMAN SKELETAL REMAINS

AT THE STIVER RANCH BURIAL SINKHOLE (41KM140)

THESIS

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CHAPTER I

INTRODUCTION

The Stiver Ranch burial sinkhole (41KM140) is a prehistoric burial site located on private land in Kimble County, Texas (figure 1). The site was first identified in late 1996-early 1997 by Mike Walsh, Lee Jay Graves and Spencer Woods of the Texas Cave Conservancy, who found human skeletal remains while examining caves in the area. The site was formally recorded by the landowner Bill Stiver, and Bryant Saner, Jr., of the Texas Archaeological Society in August, 1997, when a surface collection of the remains took place. Complete excavations at the sinkhole and other sites discovered on the ranch (KM200, KM160) were completed by field schools from the Southern Texas Archaeological Association (STAA) in 1999 and 2000, with Dr. Steve Black as principal investigator. Though initial analysis of the remains was begun in 2001 (J. Baker, notes unpublished), no thorough analysis has been completed on the skeletal remains from the sinkhole. Therefore, it is my goal in this study to describe and analyze the skeletal population, and compare the results with those found at similar mortuary sites in the region.

Environment

The site (41KM140) is located in the West Bear Creek Valley in northwest Kimble County, about 1200ft from a spring on West Bear Creek. Its location is such that

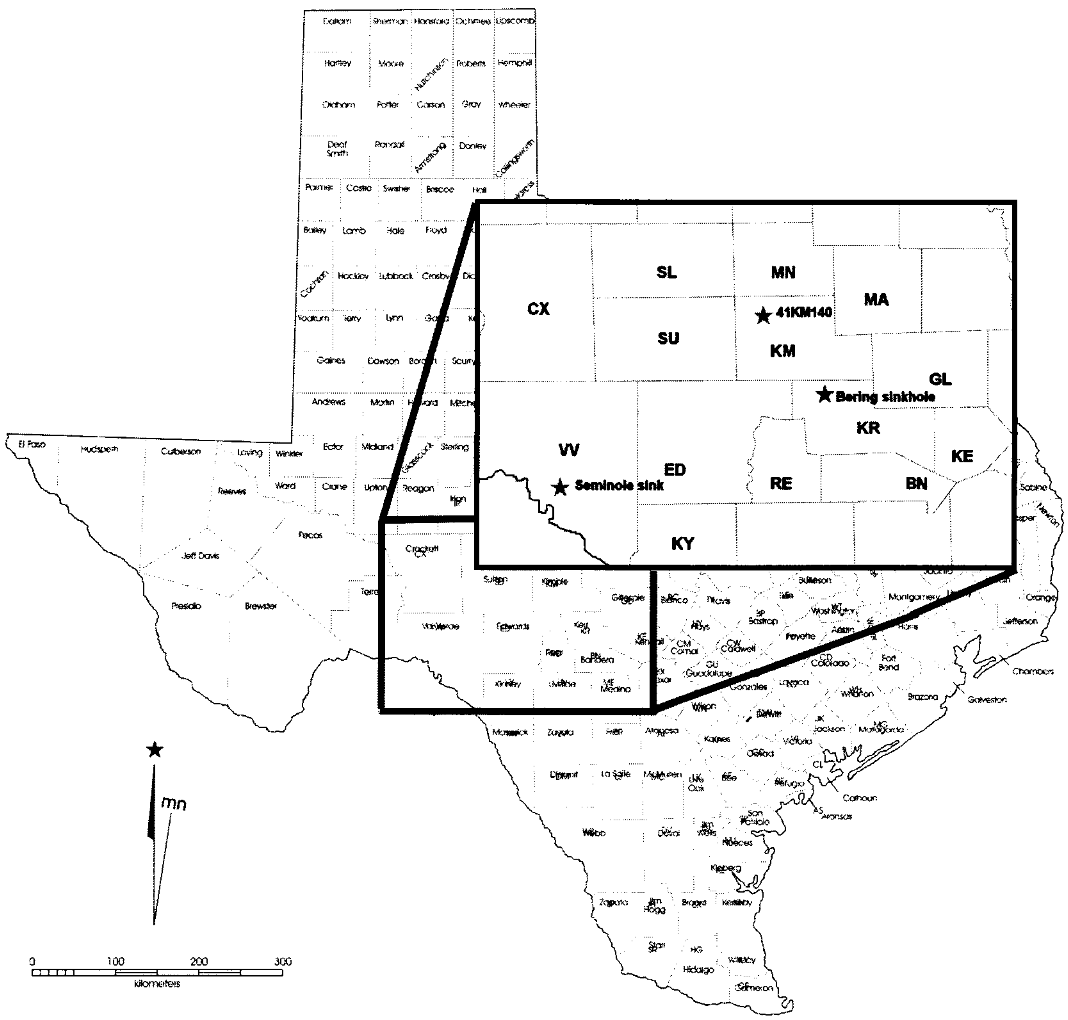


Figure 1. Location of Stiver Ranch Burial Sinkhole (41KM140) and other sinkhole burial sites in Central Texas

it lies within the western part of the Edwards plateau as well as within the southern Plains region.

Geology

The geology of the region is sedimentary. Recent alluvial deposits are made up of small gravel, silt, and clay silt and these occur along the nearby North Llano River and its major tributaries. There are also formations from the Lower Cretaceous age that include the Segovia and Fort Terrett Members of the Edwards Limestone Formation and the Hensell Sand Formation (Johnson 1994). Tarrant soils occur upland and Tarrant-Real-Bracket soils are located on valley slopes. Most alluvial soils occur in the river and creek valleys. Because sinkholes, basins, and caves are commonly formed in the Edwards Formation, it is commonly referred to as karst topography.

Flora

The study area includes a mixture of plants and animals from both the Edwards plateau region and nearby areas such as the plains and desert (Johnson 1994). The Edwards plateau consists of a number of woodland and savanna communities, most of which have been identified by vegetation mapping by McMahan et al (1984) and divided into parks, woods, shrubs and grasslands. Live oak-ashe juniper parks are found on the level to gently rolling uplands and ridgetops and live oak-mesquite-ashe juniper parks are mostly found on shallow limestone soils on the hills and escarpment of the Edwards Plateau. Some commonly associated plants in both of these parks include live oak (*Quercus fusiformis*), shin oak (*Quercus pungens* var. *vaseyana*), ashe juniper (*Juniperus ashei*), Texas persimmon (*Diospyros texana*), twisteleaf yucca (*Yucca pallida*), Texas prickly pear (*Opuntia* spp.), little bluestem (*Schyzachrium scoparium*) and grama (*Bouteloua* spp) (McMahan et al. 1984).

In the northwestern region of the Edwards Plateau there are also Mesquite shrub/grasslands, Mesquite-lotebush shrub and brush, and Mesquite shrub and brush dominated by Juniper or Live oak. In these areas, commonly associated plants include many of those found in the parks mentioned above as well as yucca, sotol (*Dasylirion* spp), prickly pear, grama, little bluestem, western wheatgrass (*Agropyron smithii)* and buffalo grass (*Buchloe dactyloides).*

Fauna

Kimble county lies within the Balconian Biotic Province (Blair 1950), which includes 57 species of mammals such as bison (*Bos bison)*, white-tailed deer (*Odocoileus virginianus*), common raccoon (*Procyon lotor*), bobcat (*Lynx rufus*) and antelope (*Antelocapra americana*). There is also a large variety of reptiles including 16 lizards and 36 species of snakes, as well as diverse avifauna.

Paleoenvironment

Most paleoenvironmental data are expressed in the form of pollen and faunal records which are most sensitive to climatic fluctuations. Pollen and faunal analysis indicate a fluctuating pattern of mesic (wet) and xeric (dry) conditions during the prehistory of Central Texas. Generally, there was a long interval of about 5,000 years during most of the Middle Holocene of mostly xeric conditions, while Late Holocene conditions are thought to be more mesic (Collins 2004). More specific data on paleoenvironmental changes and their effects are discussed in Chapter Two.

CHAPTER II

ARCHEOLOGICAL BACKGROUND

Local Background

There have been no large-scale archaeological excavations in Kimble County to date, and no prehistoric burials or cemetery sites have been recorded with the exception of the Stiver Ranch Burial sinkhole. There have been 219 sites recorded in Kimble County; many of them consist of burned rock middens and lithic scatters. The most significant prehistoric site investigated in Kimble county so far is the Buckhollow site (41KM16), a large Toyah campsite about ten miles southwest of Stiver Ranch. This site was excavated in 1973 by the Texas Highway Department, and in the 1980s and 1990s LeRoy Johnson completed an analysis and report (Johnson 1994).

Stiver ranch contains nine sites, eight of which are prehistoric. Besides the burial sinkhole, the STAA fieldschools in 1999 and 2000 also conducted excavations at the Upland Midden site (KM160), the Valley Midden site (KM159), the Scraper site (KM200), and the Mortar site (KM44). The Midden and Mortar sites did not appear to be associated directly with any significant occupation but were instead likely used for earth oven cooking and other subsistence activities. The Scraper site appears to be a major Toyah campsite, similar to the Buckollow site, and artifacts found there include ceramics, scrapers, drills, blade cores and beveled knives (Black, personal communication, 2004).

Local Chronology

Paleoindian (11,500-8,800 B.P.)

Paleoindian sites and especially isolated artifacts are fairly common in central Texas, and generally the Clovis, Folsom, and Plainview cultural manifestations (from earliest to latest) have been best identified. The Paleoindian time period has usually been characterized by small bands of nomadic hunters who utilized lanceolate projectile points in pursuit of large game animals such as mammoth. However, this view has recently been challenged as being too narrow in its description to accommodate "the diverse material cultural assemblages, projectile point styles, and indicated subsistence behaviors" during this time period (Collins 2004:116). For example, while Folsom people were specialized for hunting big game such as bison, new evidence suggest that the subsistence of the earlier Clovis people was based on more diverse fauna than big game alone. A dependence on more local resources and an increase in the diversity of the material culture, as well as the extinction or departure of many big game animals signaled the end of the Paleoindian way of life and the beginning of the Archaic period in Texas.

Early Archaic (8,800-6,000 B.P.)

During the Early Archaic, bison were scarce or absent, and groups became more dependent on the hunting and gathering of local resources than they were in earlier Paleoindian times, and had a much more diverse material culture including a variety of stemmed dart points, which were used with atlatls (Collins 2004). One important feature, especially in Central Texas, is the increased use of heated rocks in cooking, which are often found archaeologically in middens, hearths, and ovens. Current evidence suggest that during this time people were living "in the better-watered parts of the live-oak savanna habitats on the Edwards plateau" and utilizing a large variety of local plant and animal resources such as deer, acorns and other nuts, fruits and berries, grass seeds, and small animals (Collins 2004:120). In addition, it is during this time period that known sinkhole burial sites such as Seminole sink and Bering sinkhole were first being used (Turpin 1985, Bement 1994).

Middle Archaic (6000-4000 B.P.)

The middle Archaic has usually been divided into three phases, or "style intervals:" Bell-Andice-Calf-Creek, Taylor, and Nolan-Travis; which are based on the changing style of projectile points. During the earliest phase, large burned rock features are present, but climate was more mesic (wet) and bison were again being hunted. In the later Taylor and Nolan-Travis intervals, climate was more xeric (dry) and bison are absent from the record. Burned rock middens during this later period occur more frequently than in earlier times, possibly for cooking plants like sotol, which may have thrived in drier conditions (Collins 2004).

Late Archaic and Transitional Archaic (4000-1300/1200 B.P.)

With the beginning of the Late Archaic, climate was still rather dry, but moisture increased gradually over the period. As a result, the frequency of xeric plants decreased, and likewise the frequency of burned rock middens (which were usually used to cook these plants) decreased as well during most of the period. They were still in use well into Late Prehistoric times, especially in the more western areas of central Texas, where xeric vegetation was still common. The more diverse and complex "archaeological manifestations" seen during this period (including material culture and site usage and frequency) have been suggested to be the result of many possible factors such as increasing population size, however much is still unknown as to the lifestyles of hunter-gatherers during the Late Archaic in central Texas (Collins 2004).

Late Prehistoric (1200-350 B.P.)

Collins (2004) has suggested that the break in time period between the Late Archaic and the Late prehistoric in central Texas has been somewhat arbitrary, but three general defining traits can be used to signify the beginning of the Late Prehistoric: the bow and arrow, pottery, and (of lesser importance) the beginnings of agriculture (Collins 2004). There seems to have been little change in subsistence during this period, and the most obvious change in central Texas is the replacement of the Archaic dart points with Late Prehistoric arrow points. The Late Prehistoric is generally divided into two periods, the Austin Horizon and the Toyah horizon.

Austin Horizon (1150-800 B.P.)

The Austin phase of the Late Prehistoric period is differentiated from the archaic generally by the appearance of the bow and arrow. "Several types of small, light and thin stone projectile points [are] the only artifact class which consistently distinguish the late prehistoric from late/terminal archaic manifestations, and there seems otherwise to have been little change in fundamental lifeways" (Ricklis 1996:80). In light of this fact, researchers still tend to view this period as an extension of the archaic.

The subsistence strategy used was hunting and gathering, and similar kinds of animal and plant resources were available just as they were in the Late Archaic period. However, there is an increased emphasis on faunal exploitation, including white-tailed deer and antelope, but especially bison. Bison abundance in central Texas and adjacent areas apparently fluctuated throughout time; however it became increasingly important by the end of the Austin phase (Collins 2004).

Toyah Horizon (800-350 B.P.)

The Toyah phase, which spread from north central Texas to deep south Texas, is characterized by a lithic assemblage including "the narrow-stemmed Perdiz arrow point, more or less abundant unifacial end scrapers, thin bifacial and often alternately beveled knives, drills/perforators made on thin flakes or prismatic blades, and a prismatic blade-core lithic technology" (Ricklis 1996:86). This specific tool kit is thought to be most useful in exploiting larger game, and this fact is supported by the faunal remains, which suggest "a strong emphasis on hunting of medium and large game" (Ricklis 1996:86). During this time it has been suggested that there was a widespread interaction and/or movement of peoples which is based on the prevalence of the Toyah lithic assemblage. Ricklis (1996) suggests that the spread of people is thought to be related to a major influx of bison into Texas and this is supported by bison remains found with these assemblages as well as the utility of this particular tool kit in procuring and processing large game.

Sinkhole Burial Sites

It is useful to note the unique patterns associated with this particular type of site, i.e., the burial sinkhole. In general, "most known cemetery sites in Central Texas are poorly documented and have been partially or wholly destroyed by looters" (Hester et al. 1989:20). Human remains recovered in sinkholes also tend to be disarticulated and poorly preserved. However, two intact burial sinkhole sites in Central Texas have been excavated and well-documented. The first of these is Bering sinkhole which dates from the Early Archaic through the Late Prehistoric, and the second is Seminole sink, which is an Early Archaic site. It is from these two excavations that most of the data regarding this type of burial site in Texas has been gathered (Bement 1994, Turpin 1985).

Turpin (1985) reports known sinkhole cemeteries to be of two varieties: those easily accessible to humans, and those not easily accessible. In the former case, corpses were laid out on ledges or bundled and laid out. Non-accessible sinkholes are usually the vertical shaft variety, and bodies were thought to be routinely dropped down the shaft for disposal or burial (Turpin 1985). Bering sinkhole, Seminole sink, and the Stiver ranch burial sinkhole are all inaccessible vertical shaft sinkholes. Turpin suggests that sinkholes were regularly used as "corpse disposal areas" and that "this method of corpse disposal was a consistent, patterned response to death" (Turpin 1985:15). Nevertheless, studies on scatter patterns of bone at Seminole sinkhole suggest that individuals were probably "dropped into the sinkhole without having been disarticulated or defleshed" (Turpin 1985:110). Bering sinkhole also seems to display the pattern above, and Bement (1994) adds that large limestone blocks may have been used to cover remains.

Field School Excavations

After the initial discovery of the burial site (41KM140) and the surface collection of prehistoric human skeletal remains in 1997, plans were developed to undertake a complete excavation of the sinkhole. The excavations at the burial sinkhole took place over two field schools, one in 1999 and one in 2000, where the crew chief was Bill Stiver, assisted by bioarchaeologist Joan Baker, and the principal investigator was Dr. Steve Black. The investigative strategy for the site was complete excavation, with some modifications to control for the confined area of the sinkhole. All soil was screened, and unique numbers were assigned to individually collected bones, artifacts and samples.

At the start of the excavations in 1999, the sinkhole was divided into two excavation units, north and south, or Unit N and Unit S, respectively. The vertical control for the north unit was established through the primary datum, a metal caver's tag (tag 01) at the north side of the sinkhole. A screw was set in the south wall as a vertical control for that unit (datum 10). Boundaries of the sinkhole were marked with numbers 4 through 9. Plan maps that were originally created by the cavers who discovered the sinkhole were utilized throughout the excavation.

Excavation levels in each unit were standardized to measure 10 cm in depth. However, for Unit N, level 4, average depth per level reached 15 cm due to a combination of difficult and cramped excavation conditions, rocky matrix, and an eager field crew. At this point in the excavations, rock pile markers were used to designate unit separations and corners and a good deal of bone was being recovered from the sinkhole. Shortly before the end of the 1999 field school a new datum (datum 11) was set much lower in the sinkhole so that one datum was available to measure depth for both units.

Between the 1999 and 2000 field schools, weekend excavations resulted in the north and south units being combined into one center unit where level depth was taken down about 45 cm more. Unfortunately, the only records that were kept were triangulation data for key artifacts and larger bones. During the 2000 field school, the excavation inside the sinkhole expanded beyond the boundaries designated by the original plan map. The north unit was expanded northward and was designated Unit N(A) and the south unit expanded southward as Unit S(A). Level depth of these new units was set at 15 cm increments and was numbered 4 through 8 to match up with the existing levels for Units N and S. Since no profile maps were available, I created a profile map (figure 2) using plan maps, field notes, and the surface profile originally drawn by the cavers.

Soil in most of the sinkhole was dark brown to black clay loam interspersed with gravel and large rocks. Close to the center line of Units N and S near the end of level 4, a small patch of greyish dirt was recorded as possibly ash. A calcined mandible (A131) recovered from Unit S Level 4 indicates that along with the skeletal remains, a cremation was likely included along with the burials. Lastly, Unit N (A) contained finer and lighter soil which occurred in layers of alternating rocks and soil, suggesting that only the north opening of the sinkhole was accessible in the Archaic period, although this possibility will be discussed in a later chapter.

After the field school excavations, the sinkhole was never backfilled, and looters made their way to the sinkhole floor in 2003. Bones and artifacts that were disturbed during this incident were packaged and transferred to the Texas State University—San Marcos bioarchaeology laboratory by Bill Stiver for inventory and analysis.

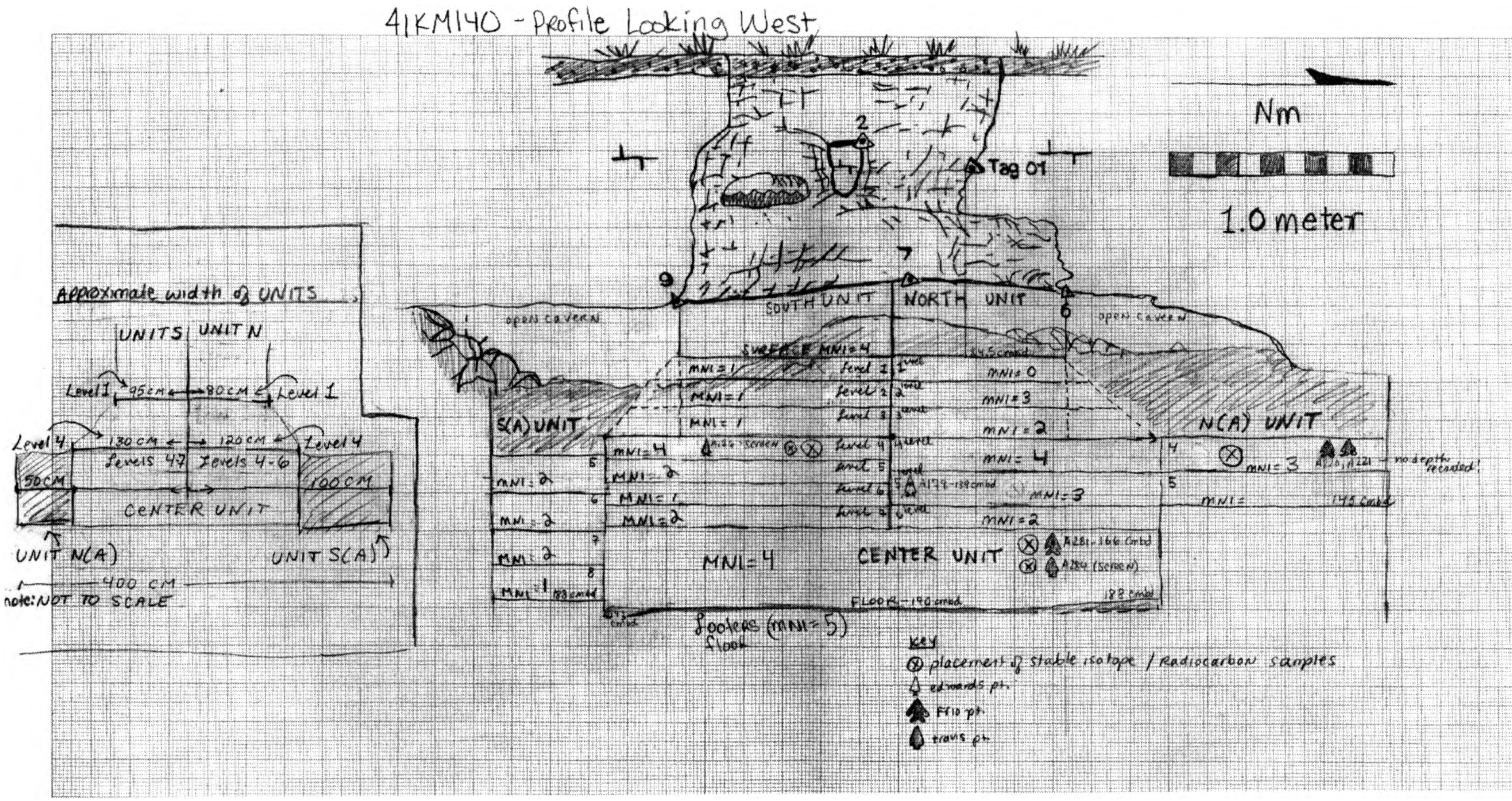


Figure 2. Vertical profile map of the field school excavations at 41KM140

CHAPTER III

MATERIALS AND METHODS

Transfer

In late 2003 skeletal material recovered from the Stiver Ranch Burial Sinkhole was transferred to Texas State University—San Marcos for analysis. The material was stored in boxes and contained human bone, faunal bone, and artifacts recovered by the STAA field schools in 1999 and 2000. This material had been previously washed, assigned unique catalog numbers, tentatively identified, and bagged by Unit and Level. Preliminary inventory and analysis was completed by Joan Baker in 2001, and her field and lab notes were made available to me by Dr. Steve Black, the project investigator for the field schools. Notes and inventory were available for the material collected during the 1999 field schools, but much of it was incomplete for the 2000 field schools. The notes that were available were used to clarify the inventory and catalog numbering process.

Original catalog numbers were retained and assigned to the material during my analysis, even though many of these were lot numbers (thus in some cases multiple bone fragments were labeled with the same catalog number). Also in some cases it was necessary to wash, refit, and rebag the remains, and many of these were already assigned lot numbers, which were retained. Lastly, looters made their way to the site sometime in 2003 and dug up the bottom of the sinkhole which had not been backfilled after the field schools. A box of the remains disturbed during this unfortunate event was transferred to me by Bill Stiver in late 2003. These bones were washed, refitted, and bagged, inventoried and analyzed along with the other remains. Artifacts were also uncovered by the looters but these will be discussed in a subsequent section.

Preservation

It was clear upon initial review of the remains and field notes that the individuals in the sinkhole were commingled and that the majority of the bones were disarticulated and fragmented. Even though fragmented, the bones were well-preserved with little cracking, weathering, or deterioration. A variety of taphonomic and, in some cases, cultural factors account for the state of the remains. Fragmentation of the bone most likely occurred due to the burial setting: the sinkhole comprised of limestone gravel, and rocks ranging in size from small to quite large. These rocks in many cases were placed, thrown, or fell from sinkhole walls directly over bone, causing breakage.

The rocky nature of the sinkhole also left gaps and open spaces where bones could shift from their original position during decomposition, water could flow, and animals could have easy access to the remains. The majority of the bones are free from water damage, indicating that the burial environment was mostly dry and had good drainage. However, a few bones from the northern area of the sinkhole were encrusted with calcinate however this seemed only to effect one or two bone elements in that specific unit level, indicating limited water seepage in that area. A few bones exhibited evidence of rodent predation, usually gnaw-marks on the crests or shafts of the long bones. Most often when observed, only one bone exhibited extreme gnawing, rather than minimal gnawing spread out over the whole sample.

Taking into account the taphonomic processes mentioned above, commingling of individuals and disarticulation of bone does not seem to have been intentional. Similar taphonomic effects on human bone were reported at two other Central Texas sinkhole burial locations: Seminole sink and Bering sinkhole, specifically, fragmented and commingled bone and in some cases water damage and rodent activity. Since taphonomic processes provide the most reasonable cause for commingling and disarticulation, and there occurs a lack of cut mark defects that would indicate secondary burial, it is suggested that the individuals were originally dropped or laid in the sinkhole.

Inventory and MNI

The complete bone inventory for the Stiver Ranch burial sinkhole is included in Appendix A. The inventory was completed by Unit Level using the forms for inventory of commingled remains in the Standards book (Buikstra and Ubelaker 1994). In the initial inventory process, bone was identified and sided when possible and classified as adult or subadult. Bone was also scored for completeness and examined for pathological or taphonomic defects. In some cases bone was so fragmentary that it could not be identified, and in this case it is listed in the inventory as unidentified cranial or postcranial fragments. In most cases, a weight in grams of these fragments is noted.

A separate inventory was completed for loose teeth (Appendix B). Minimum number of individuals (MNI) was calculated based on the highest number of duplicated bone elements for both adults and subadults. Since commingling and fragmentation makes reconstruction of individual skeletons impossible, each fragment was treated as a separate data unit in analysis of age, sex, and pathology.

Age and Sex

Bone was initially separated into adult and subadult through developmental differences in size and morphology. A more detailed inspection of each bone was made in order to determine if a specific age range could be designated. Metric analysis and rates of epiphyseal fusion and dental development were used to determine age ranges in subadults (Scheur and Black 2000). Adult age ranges were determined using the Suchey-Brooks method of changes in the pubic symphysis (Brooks and Suchey 1990), auricular surface changes on the innominate (Lovejoy et al. 1985), and the morphology of the sternal end of ribs (Iscan and Loth 1986).

Sex was determined using methods described by Buikstra and Ubelaker (1994) and Bass (1995). However, in most cases the reliability of distinguishing sex is low since most bone fragments can only provide one or two diagnostic features out of the many used to determine sex. In addition, the commingled nature of the sample makes assigning fragments to specific individuals impossible, and thus the MNI count is used as a reference.

Pathology

All bones were examined for pathological conditions including trauma, infection, metabolic disturbances, and degenerative conditions using comparative collections and standard paleopathological texts (Aufderheide and Rodriguez-Martin 1998, Buikstra and

Ubelaker 1994, Ortner 2003). Affected bones were described and recorded using standard forms, and photographed with a digital camera. Lastly, conditions were diagnosed and grouped into one of the categories listed above for frequency comparison with other skeletal samples of the same time period or region.

Dentition, Attrition and Dental Pathology

Dentition was inventoried and recorded separately to simplify the process of data collection. Attrition, or tooth wear, was recorded for the occlusal surfaces of each tooth using standard methods (Buikstra and Ubelaker 1994). Any unusual tooth wear, including interproximal grooving that suggested causation by tool use was also recorded, described and photographed. Individual teeth were scored for dental pathological conditions including caries, abscesses, and antemortem loss. Teeth were also scored for calculus and developmental defects such as linear enamel hypoplasia.

Metrics and Non-metrics

When possible, measurements of the skull and long bones were taken, as well as non-metric traits using standard methods (Bass 1995, Buikstra and Ubelaker 1994).

Dating Methods

Relative dating of 41KM140 by artifact association was of limited reliability due to the commingling of deposits. This situation made exact associations between individual bones/burials and artifacts impossible. However, temporally diagnostic artifacts were used when available to give a broad range of time during which the site was used for burial, assuming that projectile points and other artifacts were interred with individuals as grave goods. Photos and descriptions of artifacts recovered from the sinkhole are presented in Appendix C.

Diagnostic artifacts indicate that the sinkhole was used during the Middle Archaic through the Late Prehistoric, a period of use of approximately 4,000 years. It should also be noted that artifacts were uncovered in two large deposits, upper and lower, which coincide with large bone deposits (see chapter 4). Generally, projectile points from earlier time periods were recovered from the lower deposits, and those from the later time periods were recovered from the upper deposits. Bone samples from both the upper and lower deposits were selected for absolute dating.

AMS radiocarbon dating of two samples of human bone from the upper and lower deposits gave radiocarbon ages of 800$\pm$40 B.P. and 2130$\pm$40 B.P. respectively. Both dates are well within the range suggested by relative dating (the earlier date falls within the Late Archaic period, the later date within the Late Prehistoric) and support the idea that the site was used over a long period of time.

CHAPTER IV

DATA AND ANALYSIS

While a wealth of information is available from archaeological sites that date from the Middle Archaic through the Late Prehistoric, much of this data stems from analyses of artifacts and site usage, rather than the people themselves. There are no other known burial sites in Kimble County besides 41KM140, (Hester et al. 1989) and the analysis of the skeletal population in the Stiver Ranch burial sinkhole provides a valuable opportunity to study trends in the populations of people utilizing sinkhole burial sites over time in central Texas.

What follows is a basic description of the skeletal remains uncovered in the sinkhole, including inventory and analysis of demography, pathology, and dentition. While commingling and fragmentation of the bones make reconstruction of individuals nearly impossible, tentative associations between individuals and time periods can be made based on patterns in demography, diet and pathology. Using this basic information, trends in health status, diet, and particularly adaptive efficiency are addressed.

Burial Description

The skeletal remains of approximately eleven individuals, including eight adults and three subadults were recovered from the original surface collection, sinkhole excavations, and subsequent disturbance by looters. Excavations were made up of five units totaling 20 levels. During the original surface collection upon discovery of the site, bones were collected that had no provenience information and were never assigned catalog numbers. Bones that were disturbed by looters after the field schools in 2003 were also devoid of contextual information. Both of these collections were washed if necessary, inventoried and analyzed, but were not given catalog numbers. Although these bones are without provenience they do account for a substantial percentage of bone in the sinkhole (15.6%) and they were included in the MNI, summary of analysis, results, and conclusion. For purposes of clarity, it should be assumed that bone fragments from the original surface collection and looter disturbances were included in analysis unless stated otherwise.

The complete inventory of human skeletal remains listed by level is presented in Appendix A. The bone inventory includes each identified individual fragment, groups of smaller similar fragments with the same lot number (ex: five rib shafts all labeled A105), and unidentified cranial or postcranial fragments. The unidentified fragments were mostly small (5.0 cm or less) with no diagnostic features that would allow them to be identified by specific bone element. The inventory also lists initial observations of age, sex, and pathology. Age was separated into three categories on the inventory form, the first separates the bone into adult or subadult, the second refines this age to a broad age range (infant, child, young adult, middle adult, old adult), and the last gives a more specific age range if possible.

A complete inventory of the dentition is listed in Appendix B, where adult teeth were recorded and listed separately from subadult teeth. In the adult inventory, teeth were identified and sided when possible, measured, and scored for attrition (after Scott 1979, Smith 1984), caries (after Buikstra and Ubelaker 1994, Moore and Corbett 1971), calculus (after Brothwell 1991), and the presence of linear enamel hypoplasia. Subadult teeth were scored for stage of formation of each tooth (after Moorees et al. 1963a, 1963b), and using this information given age ranges when possible (after Smith 1991). Subadult teeth were also measured and scored for the presence of linear enamel hypoplasia and rates of attrition where applicable. Results of dental metrics and dental pathology are presented later in this chapter.

On completing the inventory, the minimum number of individuals statistic was calculated from the most frequently duplicated bone element (Table 1). In this case, the distal third of the right humerus was the most frequently occurring bone and provided a MNI for the burial sinkhole of seven adults. However, because the cremation likely represents one separate adult individual in that only one calcined mandible was recovered with no other bones were affected by burning, the MNI is raised to eight individuals. Although there were no repeating bone elements in the subadult category, differences in morphology and development of the subadult bones revealed at least one child and one infant among the skeletal remains. Further review of the dental inventory increased the subadult MNI to three, as it showed that the left mandibular first molar (permanent, but not completely developed) is represented twice, accounting for two children instead of one. The total MNI for the sinkhole including adults, subadults, and the cremation, equals 11 individuals.

Table 2 lists the frequency of identified and unidentified bone fragments per level for adults and subadults. This table shows that of the northern and southern units alone (not including the original surface collection, looters disturbance, or center unit), 65% of bone is located in the northern half of the sinkhole. The greater frequency of bone in the northern half suggests that it was perhaps more accessible than the southern half in prehistoric times. Figure 3 is a diagram based on Table 2, and shows the distribution of remains within the sinkhole classified by amount of bone fragments and level, as well as the location of the cremation. Review of this diagram suggests that there are two large deposits of bone that span the entire sinkhole, at one and two meters from the surface respectively. Associated artifacts (see appendix C) were also recovered from within these two large deposits. Radiocarbon ages of two samples from the upper and lower deposits (see Chapter Three) suggest they may be dated to the Late Prehistoric and Late Archaic periods respectively. However, it should be noted that these deposits are concentrations of greater frequencies of bone fragments, and not discrete burial deposits, and the commingling of bone within and between these concentrations makes any definite chronological associations speculative.

As previously stated, determination of distinct individuals within the seven adults accounted for, not including the cremation, is nearly impossible. While field notes suggest possible articulation of certain joints in two instances, there are no photographs of the articulations *in situ*, and no notes suggesting which bones recovered were in fact articulated. In addition, no professional osteologist was present for the excavations, and as such articulations may not have been recognized even if they were encountered. Bone matching may become slightly easier to determine once age and sex are taken into account, however since these determinations are based on incomplete and fragmentary evidence, they should be considered only suggestive. While current scientific research

Table 1. Minimum number of individuals based on sided bones and bone fragments

Bone Element	Adult	Juvenile	Infant
Complete skull	1		1
Frontal	3		
Left parietal	3		
Right parietal	2		
occipital	1		
Left temporal	1		
Right temporal	2		
Left zygomatic	2		
Left maxilla	1		
Right maxilla	1		
Left Rib #1	1		
Right Rib #1	1		
Complete mandible	3		
Left mandible	3	1	
Right mandible	4		
Axis	3		
Atlas	2	1	
Complete Left clavicle	1		
m1/3		1	
lateral	1		
Complete Right clavicle	1		
m1/3	4		
Right scapula	2		
Left scapula	3		
Left illium	3		
Right illium	4	1	1
Left ischium	1	1	1
Right ischium	2	1	
Left pubis	1	1	
Right pubis	2		
Complete Left humerus	1		
DE	2		
D1/3	2		
M1/3	1		
P1/3	1		

Abbreviations. PE· Proximal epiphysis, P1/3:Proximal 1/3 of shaft, M1/3· Middle 1/3 of shaft; D1/3 Distal 1/3 of shaft, DE Distal Epiphysis.

Table 1, continued. Minimum number of individuals based on sided bones and bone fragments

Bone Element	Adult	Juvenile	Infant
Complete Right humerus	0		
DE	5	1	
D1/3	7		
M1/3	2		
P1/3	3		
PE	1		
Complete Left Ulna	1		
DE	2		
D1/3	1		
M1/3	1		
P1/3	3		
PE	1		
Complete Right Ulna	0		
DE	1		
D1/3	2		
P1/3	1		
PE	2		
Complete Left radius	0		1
DE	2		
D1/3	3		
M1/3	3		
Complete Right radius	2		1
Left patella	2		
Right patella	1		
Complete Left Femur	1		
DE	3		
D1/3	1		
M1/3	5		
P1/3	4		
PE	2		
Complete Right Femur	0		
DE	5		
D1/3	5		
M1/3	5		
P1/3	2		
PE	2		
Complete Left Tibia	1		1
DE	2		
M1/3	4		
P1/3	3		
PE	3		

Abbreviations: PE. Proximal epiphysis; P1/3·Proximal 1/3 of shaft; M1/3· Middle 1/3 of shaft, D1/3. Distal 1/3 of shaft, DE: Distal Epiphysis.

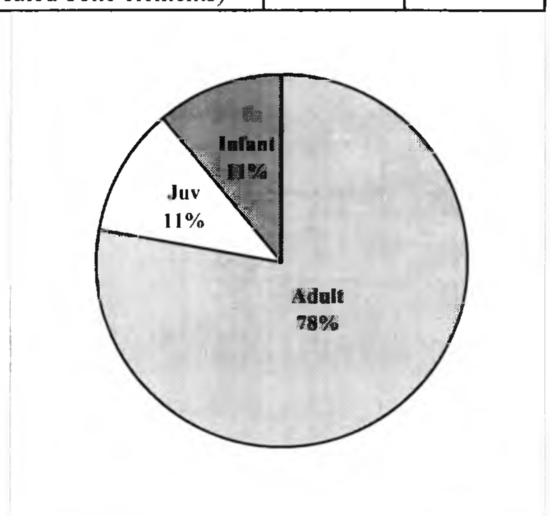
Table 1, continued. Minimum number of individuals based on sided bones and bone fragments

Bone Element	Adult	Juv	Infant
Complete Right Tibia	0		
M1/3	6	1	
P1/3	5		
PE	2		
Complete Left Fibula			
DE	4		
D1/3	3		
M1/3	5		
P1/3	1		
PE	1		
Complete Right Fibula	0		
M1/3	3		
P1/3	1		
PE	1		
Left capitate	2		
left triquetral	1		
left scaphoid	2		
left trapezium	3		
left trapezoid	2		
left metacarpal 2	3		
Left talus	6		
left calcaneus	3		
left navicular	2		
left cuboid	3		
left cuneiform	1		
Left metatarsal 1	3		
left metararsal 2	2		
left metararsal 3	1		
left metararsal 4	2		
left metararsal 5	4		1
Right capitate	2		
right hamate	1		
right lunate	1		
right triquetral	1		
right scaphoid	1		
right trapezium	2		
right trapezoid	0		
right metacarpal 1	2		
right metacarpal 2	3		

Abbreviations· PE· Proximal epiphysis; P1/3 Proximal 1/3 of shaft, M1/3· Middle 1/3 of shaft; D1/3 Distal 1/3 of shaft; DE Distal Epiphysis.

Table 1, continued. Minimum number of individuals based on sided bones and bone fragments

Bone Element	Adult	Juv	Infant
Right metacarpal 3	4		
right metacarpal 4	2		
right metacarpal 5	2		
right talus	1		
right calcaneus	2		
right navicular	2		
right cuboid	1		
right cunieform 1	2		
right cuneiform int.	1		
right metatarsal 1	1		
right metatarsal 2	1		
right metatarsal 3	3		
right metatarsal 4	2		
right metatarsal 5	3		
	Adult	**Juv**	**Infant**
Total MNI:	**7**	**1**	**1**
(Highest number of duplicated bone elements)			



Abbreviations: PE: Proximal epiphysis; P1/3:Proximal 1/3 of shaft; M1/3: Middle 1/3 of shaft; D1/3: Distal 1/3 of shaft; DE: Distal Epiphysis.

Table 2. Number of identified and unidentified adult and subadult bone fragments per level

Location	Age	NISP	Teeth	Cranial frag. (unid)	Postcranial frag. (unid)	Total
Original Surface Collection	A	55	7	0	42	104
	S	0	0	0	0	0
Looters Disturbance	A	125	14	144	227	510
	S	1	0	1	0	2
Unit N, Level 1	A	0	0	0	0	0
	S	0	0	0	0	0
Unit N, Level 2	A	13	0	0	19	32
	S	0	0	0	0	0
Unit N, Level 3	A	218	6	3	408	635
	S	0	0	0	0	0
Unit N, Level 4	A	97	11	3	313	424
	S	5	1	8	7	21
Unit N, Level 5	A	5	3	0	91	99
	S	0	0	0	0	0
Unit N, Level 6	A	3	0	0	15	18
	S	1	0	0	0	1
Unit S, Level 1	A	0	0	0	0	0
	S	0	0	0	0	0
Unit S, Level 2	A	6	0	4	0	10
	S	0	0	0	0	0
Unit S, Level 3	A	3	0	1	0	4
	S	0	0	0	0	0
Unit S, Level 4	A	235	12	8	133	388
	S	0	0	0	0	0
Unit S, Level 5	A	27	11	0	180	218
	S	0	0	0	0	0
Unit S, Level 6	A	25	2	0	37	64
	S	0	0	0	0	0
Unit S, Level 7	A	8	0	1	15	24
	S	1	0	1	0	2
Unit N(A), Level 4	A	52	8	42	503	605
	S	57	15	6	4	82
Unit N(A), Level 5	A	18	3	5	81	107
	S	25	3	7	26	61
Unit S(A), Level 5	A	7	0	0	21	28
	S	0	1	0	0	1
Unit S(A), Level 6	A	3	0	2	75	80
	S	0	2	2	0	4
Unit S(A), Level 7	A	5	0	1	37	43
	S	2	0	0	0	2
Unit S(A), Level 8	A	3	1	0	11	15
	S	0	0	0	0	0
Center Unit	A	57	22	12	234	325
	S	10	1	3	1	15
West Wall	A	2	0	0	1	3
	S	0	0	0	0	0
					Adult Total	3736
					Subadult Total	191
					Total	3927

today allows for more accurate determination of individuals using DNA analysis, the use of this method was cost prohibitive for this research project.

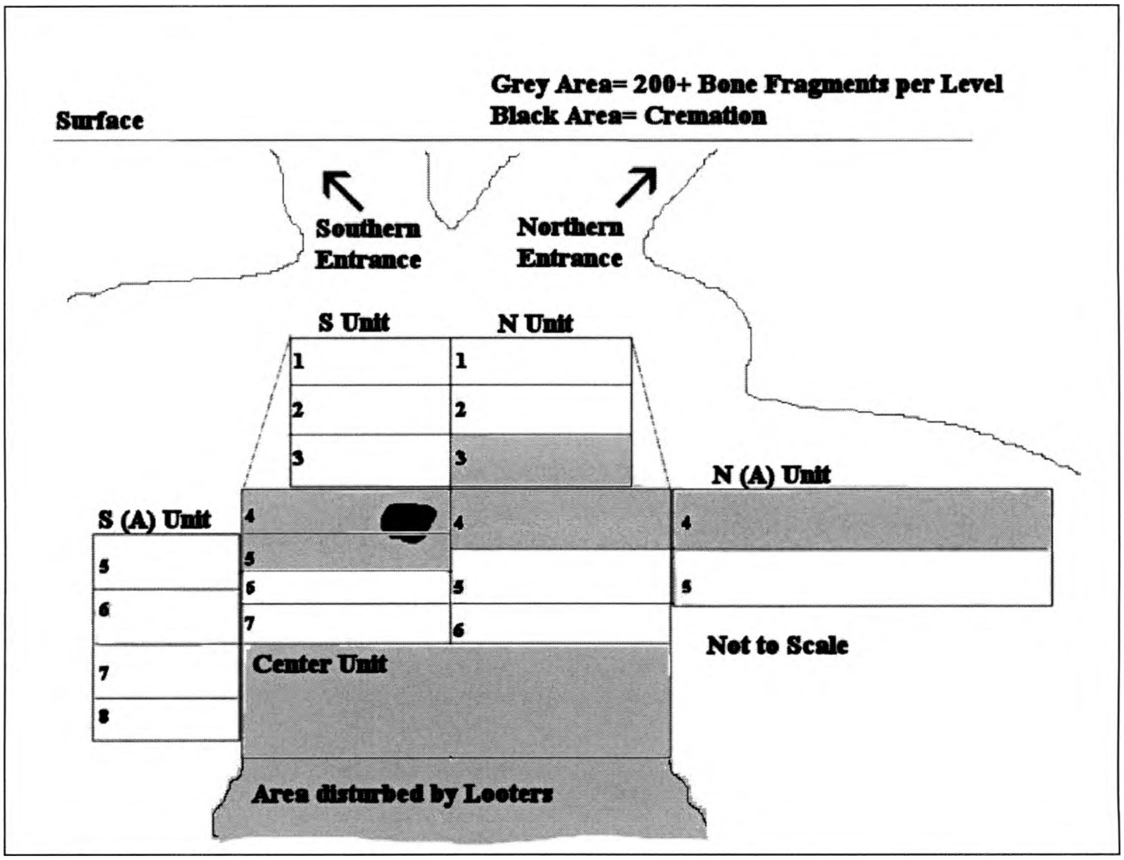


Figure 3. Distribution of remains within the sinkhole classified by amount of bone fragments and level.

Paleodemography: Age and Sex

Age

Age was considered for each bone recovered from the sinkhole. In most cases, the only determination that could be made, if any, was adult or subadult. In certain cases, more specific age ranges were possible and these are listed along with the methods used to determine the age range in Table 3. It is worth noting that the bones listed in the table are fragments, and that more than one fragment (and in some cases all diagnostic fragments) may belong to the same individual. Conservatively speaking, out of the minimum of 8 adult individuals, one is a young adult aged 15-35, one is a middle adult aged 35-50, and one is an older aged adult of greater than 50 years. The single adolescent aged to at least 17 years or younger, may fall into the child category, and thus has been omitted. The age ranges listed for the subadults account for two children within the age range of 3-8 and one infant aged birth to 2 years.

Table 3. Bone fragments with features diagnostic of age, and methods used

Area	ID #	Bone	Side	Segment	Age	Age 2	Age 3
Lo	none	cranial fragments [a]	?		S	Infant	0-2yrs
N4	A160	cervical vertebra 3-7 [a]	?		S	child	3-6yrs
N4	A160	Innominate: Pubis [a]	?		S	child	3-5yrs
NA5	A257	humerus epiphysis [a]	?	unfused	S	child	6-8yrs
S7	A206	Talus [a]	L		S	child	5-8yrs
NA4	A226	cervical vertebra [a]	?	B only	S	child	3-8yrs
SA7	A246	rib #3-9 [b]	?	sternal	S	child/adol.	<17yrs
N4	A160	rib 3-9 frag. [b]	?	sternal	A	young adult	20-35yrs
NA5	A256	innominate:pubis [c]	R		A	young adult	15-35
NA5	A263	rib frag. [b]	?	sternal	A/S	young adult	16-35
SA6	A232	rib #3-9 [b]	?	sternal	A	young adult	15-35yrs
OSC	none	Skull [d]	na		A	Young ad.	20-35yrs
N4	A160	rib 3-9 frag. [b]	?	sternal	A	young adult	20-35yrs
Lo	none	Parietal [d]	R		A	mid. Adult	35+
S5	A145	rib #3-9 [b]	?	sternal	A	middle adult	35-50yrs
S4	A135	innominate:illium [e]	L	auricular	A	old adult	60+
S4	A135	innominate:illium [e]	R	auricular	A	old adult	50-59

References: a=Scheur and Black (2000); b=Iscan and Loth (1986), c=Brooks and Suchey (1990), d=Buikstra and Ubelaker (1994), e=Lovejoy et al. (1985).

In terms of demography, the remains in the sinkhole are not representative of a population where age is equally distributed. One would expect 50% adults and 50% juveniles in a normal distribution (Ortner 2003). In this case, approximately 80% of the remains were adult. Even when accounting for the one adolescent, the percentage of adults is still greater at 70%. While one possible explanation for this occurrence would be differential burial of adults versus children, little is known about prehistoric mortuary practice in this type of context, and it is more likely that children may be underrepresented because of taphonomic factors. It is has been argued that the remains of children and infants do not preserve as well as those of adults due to their size and fragility, especially in a prehistoric context (Scheuer and Black 2000). However, as Scheuer and Black (2000) suggest, the small and unfused subadult remains may be easily overlooked by excavators unfamiliar with the complexities of the subadult skeleton. It is worth noting that the remains at Bering sinkhole are equally unrepresentative at 65% adults and 35% children respectively, due to similar factors (Bement 1994, Marks 1991).

Sex

All bones with diagnostic morphology that could be classified as characteristic of males or females were analyzed, and since these traits are often only evident after the onset of puberty, only adult bones were examined. There are three major areas of the skeleton that were selected to determine sex: the skull, the pelvis, and to a lesser extent, the long bones. In biological anthropology, where most methods of sex determination from the human skeleton have their origin, one considers a suite of traits on the skull or pelvis, and combines these to make a determination of sex (Bass 1995, Buikstra and Ubelaker 1994). In the present project, sex determination proved challenging due to the fragmentary nature of the sample; instead of analyzing complete suites of traits on whole skeletons, only one or two traits may be visible on a fragment, limiting the accuracy of any method. Six morphological traits on the skull and six traits on the pelvis were chosen to suggest a possible sex designation, as well as five separate measurements on the humerus, femur and tibia.

Taking into account the equal distribution of a combination of different traits over a large variety of fragments, of the eight individuals, one was a female, three were probable females, and four were probable males. In the case of the female, there was little doubt that the morphological structures observed represented a female (Plate A-2). Of the probable females, morphological structures and metric analysis indicate that individuals are more likely female than male, while probable males are more likely male than female. Results and methods of determining sex are listed in Table 4.

Table 4. Bone fragments with features diagnostic of sex, and methods used

Location	ID #	Bone	Side	Segment	Trait/Method	Source	Sex
Lo	none	temporal	R	fragmented	mastoid process/morphology	Bass (1995)	F?
Lo	none	temporal	R	fragmented	zygomatic root/morphology	Bass (1995)	M?
S4	A110	temporal	L	fragmented	mastoid process/morphology	Bass (1995)	M?
Lo	none	frontal	?	complete	browridge and slope/morphology	Bass (1995)	M?
S4	A112	frontal	M	complete	frontal only, no browridge/morphology	Bass (1995)	F?
S4	A110	frontal	M	fragmented	traits on frontal only/morphology	Bass (1995)	M?
OSC	none	skull	na	complete	complete suite/morphology	Bass (1995)	F
OSC	none	mandible	na	complete	complete suite/morphology	Bass (1995)	F?
S5	A136	mandible	M	complete	complete suite/morphology	Bass (1995)	F?
OSC	none	femur	L	m1/3	circum midshaft/metric	Black (1978)	F?
OSC	none	femur	R	m1/3	circum midshaft/metric	Black (1978)	F?
OSC	none	femur	R	m1/3	circum midshaft/metric	Black (1978)	M?
OSC	none	femur	L	m1/3	circum midshaft/metric	Black (1978)	F?
OSC	none	femur	L	m1/3	circum midshaft/metric	Black (1978)	M?
OSC	none	femur	R	d1/3-de	circum midshaft/metric	Black (1978)	F?
OSC	none	femur	L	d1/3-de	circum midshaft/metric	Black (1978)	F?
S4	A119	femur	R	p1/3-d1/3	circum midshaft/metric	Black (1978)	F?
S4	A120	femur	L	p1/3-d1/3	circum midshaft/metric	Black (1978)	F?
S5	A134	femur	L	complete	circum midshaft/metric	Black (1978)	M?
N3	A090	femur	L	pe-p1/3	femoral head/metric	Stewart (1979)	F?
N3	A104	femur	L	p1/3	femoral head/metric	Stewart (1979)	F?
OSC	none	tibia	L	m1/3	circum. nutrient foramen/metric	Symes and Jantz (1983)	F?
OSC	none	tibia	L	m1/3	circum nutrient foramen/metric	Symes and Jantz (1983)	F?
OSC	none	tibia	L	p1/3	circum nutrient foramen/metric	Symes and Jantz (1983)	M?
OSC	none	tibia	R	m1/3	circum nutrient foramen/metric	Symes and Jantz (1983)	M?
OSC	none	tibia	R	m1/3	circum nutrient foramen/metric	Symes and Jantz (1983)	F?
OSC	none	tibia	R	m1/3	circum nutrient foramen/metric	Symes and Jantz (1983)	F?
S4	A122	tibia	L	p1/3-m1/3	circum nutrient foramen/metric	Symes and Jantz (1983)	F?
S4	A118	tibia	R	p1/3-m1/3	circum. nutrient foramen/metric	Symes and Jantz (1983)	F?

Table 4, continued. Bone fragments with features diagnostic of sex, and methods used

Location	ID #	Bone	Side	Segment	Trait/Method	Source	Sex
S5	A137	tibia	R	p1/3-pe	circum nutrient foramen/metric	Symes and Jantz (1983)	M?
N2	A009	tibia	L	complete	circum nutrient foramen/metric	Symes and Jantz (1983)	F?
OSC	none	humerus	R	d1/3	diaphyseal diameter/metric	France (1983,1985)	M?
OSC	none	humerus	L	d1/3	diaphyseal diameter/metric	France (1983,1985)	M?
N2	A010a	humerus	R	m1/3-d1/3	diaphyseal dia, biepicondular wdth/metric	France (1983,1985)	M?
N2	A010b	humerus	R	p1/3-m1/3	diaphyseal diameter/metric	France (1983,1985)	F?
N4	A150	humerus	L	complete	diaphyseal diameter/metric	France (1983,1985)	M?
N4	A154/151	humerus	R	p1/3-de	diaphyseal diameter/metric	France (1983,1985)	M?
S2	A022	humerus	L	de-p1/3	diaphyseal diameter/metric	France (1983,1985)	F?
NA4	A209	humerus	R	m1/3-de	diaphyseal dia, biepicondular wdth/metric	France (1983,1985)	M?
S4	A135	humerus//SAMPLE	R	d1/3-de	diaphyseal dia, biepicondular wdth/metric	France (1983,1985)	F?
N3	A102	innominate: illium	L	fragmented	traits on illium only/morphology	Bass (1995)	F?
S4	A109	innominate:illium	R	fragmented	sciatic notch/morphology	Bass (1995)	F?
S4	A135	innominate:illium	R	auricular	preauricular sulcus/morphology	Bass (1995)	M?

Abbreviations: PE: Proximal epiphysis; P1/3: Proximal 1/3 of shaft; M1/3: Middle 1/3 of shaft; D1/3: Distal 1/3 of shaft; DE: Distal Epiphysis

Metric and Nonmetric Data

Since most of the sample was fragmentary, complete measurements of the long bones were not possible. However, as it was more complete, a greater number of metrical and morphological observations could be collected from the skull and mandible recovered from the surface of the sinkhole. These observations are listed in Tables 5 and 6.

Table 5. Measurements of the cranium and mandible recovered from the original surface collection

Measurement	mm
Maximum Cranial Length	189
Maximum Cranial Breadth	125
Maxillo-Alveolar Breadth	57.8
Maxillo-Alveolar length	49.58
Biauricular Breadth	119.72
Upper Facial Height	69.90*
Minimum Frontal Breadth	93.1
Nasal Height	51.02*
Nasal breadth	28.14
Frontal Chord	115.58
Parietal Chord	109.94
Chin Height	29.06
Height of Mandibular Body	25.9
Breadth of Mandibular Body	10.72
Minimum Ramus Breadth	31.75

*estimation

Table 6. Non-metric traits of the cranium and mandible recovered from the original surface collection

Trait	Left	Middle	Right
Metopic suture		absent	
Supraorbital notch	absent		present
supraorbital foramen	present		absent
infraorbital suture	unobservable		unobservable
multiple infraorbital foramina	absent		absent
zygomatico-facial foramina	unobservable		small, 1 present
parietal foramen	absent		absent
epipteric bone	absent		absent
coronal ossicle	absent		absent
bregmatic bone		absent	
sagittal ossicle		absent	
apical bone		absent	
lambdoid ossicle	unobservable		present
asterionic bone	unobservable		absent
ossicle in occipito-mastoid sut.	absent		unobservable
parietal notch bone	absent		absent
inca bone		absent	
condylar canal	unobservable		unobservable
divided hypoglossal canal	unobservable		unobservable
flexure of superior sagittal sulcus		unobservable	
foramen ovale incomplete	absent		absent
foramen spinosum incomplete	absent		absent
tympanic dihiscence	absent		absent
auditory exostosis	absent		absent
mastoid foramen and number	sutural/temporal, 1 present		absent
mental foramen	present		present
mandibular torus	absent		trace
mylohyoid bridge	absent		unobservable

Paleopathology

All remains were analyzed for any pathological conditions and each condition was photographed and recorded using standard methods (Buikstra and Ubelaker 1994). Pathological conditions in bone involve abnormal activity of the bone cells (osteoblasts and osteoclasts), which include abnormal bone formation, abnormal bone destruction, failure to form or replace bone, or failure to destroy bone. The abnormal activity of bone cells create a unique morphology on the bone that can in many cases be attributed to a specific type of disease process. Diagnosis of pathological conditions is dependent on the shape and form of the abnormality, its location on the skeleton, its frequency, and in some cases the age and sex of the individual (Ortner 2003).

Pathological conditions usually fall into several diagnostic categories, each of which will be discussed below, including trauma, infectious disease, osteoarthritis, and metabolic disturbances. Frequencies of occurrence for each type of pathological condition were calculated to assess general health and adaptive efficiency, as well as to facilitate comparison with data collected from other mortuary sites in the region.

Trauma

There are a variety of different kinds of trauma that can affect the skeleton, but the most common type is the fracture, defined as a partial to complete break in the bone. Fractures are caused by the application of different kinds of stress to the bone, including forces of tension, compression, torsion, bending and shearing, all of which are associated with different types of fracture patterns (Ortner 2003). For example, compression forces such as those created with a blow to the head with a blunt object will create a depression fracture; while the shearing, bending or twisting forces created from a fall can result in an incomplete or complete fracture to the arm or leg.

Another important factor in assessing fracture patterns includes not only the type of force involved, but also the initial cause of the fracture. Trauma to the skeleton is either the result of accidental trauma or intentional trauma. In many cases, accidental fractures cannot be easily distinguished from intentional fractures. However, certain types of fractures have been shown to be associated with violence (Filer 1997, Ortner 2003, Wakely 1997). These include cranial injuries and defense injuries to the forearm. Most cranial injuries "appear to be related to intentional violence rather than accident" (Ortner 2003:141). The most common violent injuries to the head are caused by both sharp force trauma, where a knife or other bladed instrument is used to strike the cranium, and blunt force trauma, where blunt weapons such as rocks or clubs are used (Wakely 1997). Defensive fractures of the forearm, usually of the ulna, are called parry fractures; these fractures occur when a victim wards off a blow from an assailant. While they can be associated with violence, many fractures of the forearm may reflect accidental actions, such as Colles' fracture, which is a distinctive accidental fracture occurring on the distal radius.

Another important factor in assessing fractures is the severity of the fracture (whether fatal or non-fatal), and the degree of healing, if any, which has occurred. Along with the overall shape of the fracture, oftentimes its severity will indicate the kind of weapon used, and the force of the blow. For example, sufficient force with a large sharp or blunt weapon can result in a fatal blow that crushes or shatters the skull, leaving no signs of healing in dry bone. Weaker blows or smaller weapons may leave only small circular depression fractures, most of which are not fatal to the victim and are well healed (Ortner 2003).

Fractures that occurred at or near the time of death are very difficult to distinguish in an archaeological setting from breakage that has occurred after death, especially if taphonomic processes have resulted in fragmentation of most of the skeletal remains. In contrast, any evidence of older fractures that were well-aligned and healed properly may be completely obliterated by bone remodeling processes. In most archaeological skeletal collections however, healed fractures in adults are easily distinguishable and are among the most common types of trauma observed (Ortner 2003).

The skeletal remains from 41KM140 were observed for traumatic conditions, and the frequency of fractures observed in the sample is listed in Table 7. In order to ensure that the reported occurrence of fractures is representative, the number (N) of bone elements was determined using totals for identified specimens used to calculate MNI, which excludes incomplete and unidentified fragments.

Table 7. Frequency of healed fractures on adult bone elements

Location	N of bones	Healed/Healing Fractures	% Frequency
Humeri, radii, ulnae, metacarpals	84	3	3.57%
Femora, tibiae, fibulae, patellae, metatarsals	129	0	0%
Arms and Legs combined	213	3	1%
Scapula, Clavicles, ribs 1 and 2, rib fragments (ribs n=99)	126	2	1.59%
Cranial bones, mandible	27	4	14.80%

As expected, most of the trauma observed included well-aligned, well-healed fractures, and no presumably fatal or serious fractures were observed (Plates B-1, B-2). In addition, no trauma was observed on any of the subadult remains. The frequency of occurrence of fractures was quite low for the appendages, at fewer than 5%, and no fractures were observed on the bones of the lower limbs. Fractures of the upper limbs were relatively minor, and included a healed parry fracture to the ulna, and a healed Colles' fracture to the radius. Fractures to the torso region included two broken ribs, which were in the process of healing at the time of death. Fractures to the upper limbs and torso most likely were a result of accident, and although violence cannot be ruled out as a possible cause, the degree of healing for each fracture suggests individuals survived well after the initial trauma.

In addition to the parry fracture, other more concrete evidence of interpersonal violence included a series of four healed depression fractures on the frontal and parietal bones of one individual (Plate B-3). The exact age of the individual could not be determined, and as only the frontal and parietal bones were recovered, not enough traits were available to make an accurate determination of sex. However, the size and gracility of the cranial region along with frontal bossing and a poorly developed supraorbital ridge suggest the individual may be female. The four fractures observed account for the full 14.8% of cranial fractures, a percentage which is inflated due to the high number of fractures on one individual, and also the smaller sample size of complete cranial bones.

All of the cranial fractures are circular depression fractures, a fracture type that is consistent with blunt force trauma to the cranium (Filer 1997, Ortner 2003, Wakely 1997). The location of the fractures in the fronto-parietal region also suggests that violence may have had a role, as this location is the usual site of injury in violent encounters (Filer 1997, Wakely 1997). Other convincing evidence that the fractures were caused by violence is the fact that three fractures occurred in a series on the parietal bone (a pattern less likely in an accident), all fractures were roughly the same size (9.5mm by

7.5 mm), and all fractures were healing roughly at the same rate. When all is considered, it is highly likely that the cranial fractures were due to a violent attack. Interestingly enough, evidence of healing on the cranial fractures shows that they were not fatal and the individual survived long after the incident.

Infection

Infections are caused by the presence of pathogenic microorganisms and result in inflammation to the bone, generally termed osteitis. Infection that affects the periosteum and outer surfaces of the bone is called periostitis, while infection to the inner surface, or bone marrow cavity, is termed osteomyelitis. Both conditions may result in bone destruction and or bone formation in the affected area (Aufderheide and Rodriguez-Martin 1998, Mays 2002, Ortner 2003).

Periostitis affects the outer surface of the bone, and the condition is usually expressed as an area of bone formation. Periostitis can be primary, as a specific disease itself, or secondary, as part of other disease syndromes such as syphilis. Primary periostitis is caused by either infection or trauma, but differentiating between the two in archaeological skeletons is nearly impossible. Unlike osteomyelitis, periostitis is usually superficial and does not affect the marrow cavity.

Osteomyelitis is most often the result of "the introduction of pyogenic bacteria into bone" (Ortner 2003:181). The bacteria may enter the system through the direct infection of an injury, extension from nearby soft tissue infections, or through the blood (hematogenous) from an infection elsewhere in the body. It is expressed as a combination of periosteal bone formation (involucrum), and a diagnostic cloaca, or drainage canal in the bone, where pus from the marrow cavity can be expelled. Infections caused by direct trauma or nearby infections are usually more localized near the area of the injury, and can occur anywhere on the skeleton to individuals of all ages. In contrast, hematogenous osteomyelitis is rare in adults and usually affects the metaphyseal areas of the long bones, especially the femur and tibia. Also, inflammation is usually less acute and less extensive than direct infection through injury.

It may be difficult to determine the exact microorganisms responsible for an infection, and in such cases lesions may be referred to as non-specific periostitis or osteomyelitis. However, the causative organism in "close to 90% of the cases is *Staphylococcus aureaus*, the second in frequency is *Streptococcus*" (Ortner 2003:181). Other microorganisms produce distinctive lesions, or patterns of lesions, such as tuberculosis and syphilis (Mays 2002, Ortner 2003). Most infectious conditions are usually subacute, chronic diseases, and may not be the immediate cause of death (Ortner 2003).

The skeletal remains from 41KM140 were observed for infectious conditions including osteomyelitis and periostitis. The frequency of infectious lesions observed in the sample is listed in Table 8. In order to ensure that the reported occurrence of lesions is representative, the number (N) of bone elements was determined using totals for identified specimens used to calculate MNI, which excludes incomplete and unidentified fragments.

Of the six cases observed, three were relatively minor cases of periostitis on the long bones, one was a direct infection through a minor fracture to the ribs, and one was a case of non-specific osteitis on a right proximal tibia (Plates B-4 and B-5). The osteitis observed on the right tibia showed active inflammation, with an unusual depression which may be taphonomic, or possibly a healed cloaca. With the exception of the ribs, all cases of infection were present on the legs only, and the frequency of occurrence was quite low at fewer than 3.1%. No infectious lesions were observed on subadults, and all lesions observed on adults appeared to be either active or only partially healed at the time of death.

Table 8. Frequency of osteomyelitis and periostitis on adult bone elements

Location	N of bones	Infection (Osteomyelitis/Periostitis)	% Frequency
Humeri, radii, ulnae, metacarpals	84	0	0%
Femora, tibiae, fibulae, patellae, metatarsals	129	4	3.1%
Arms and Legs combined	213	4	1.9%
Scapula, Clavicles, ribs 1 and 2, rib fragments (n=99)	126	1	1%
Cranial bones, mandible	27	0	0%

Osteoarthritis

Osteoarthritis primarily occurs later in life and is caused by factors including biomechanical stress and trauma over time to multiple joints. Osteoarthritis may also occur earlier in life due to pathological conditions, but in this case usually only one joint is affected. Osteoarthritis occurs in three different stages, first the breakdown of articular cartilage, which allows abnormal contact of bone with bone. Second, reactive bone formation (sclerosis) occurs as a result, and mechanical action may cause bone surfaces to rub against each other until the surface appears polished (eburnation). Lastly, osteophytes are formed as new cartilage and bone grow at the joint margins (Ortner 2003).

These last two stages produce the only effects visible on archaeological skeletons—specifically bone porosity, eburnation and osteophyte activity—however these features reflect the later, more severe stages of osteoarthritis (Ortner 2003). In archaeological collections, osteoarthritis is most common in the hands and wrists, then the knee, the hip, the spine, and the elbow. In all but the spine, joints pass through the three stages mentioned above. Since the pattern of articulation for vertebrae is different than that of the other joints, eburnation is relatively rare. Instead, disk herniation between the vertebrae is a common occurrence, and this affects the centrum, or body, of the vertebrae. Along with osteophyte activity on the margins of the centrum from disk herniation, it may also take on a compressed appearance.

The skeletal remains from 41KM140 were observed for degenerative conditions including arthritis of the major joints such as the elbow, knee, and spine. The frequency of these conditions is listed in Table 9. In order to ensure that the reported occurrence of arthritis is representative, the number (N) of bone elements was determined using totals for identified specimens used to calculate MNI, which excludes incomplete and unidentified fragments. The number of bone elements was also recalculated for each joint to include bones which overlap, for example the radius is active in both the elbow joint and the wrist.

All cases of osteoarthritis were observed in adults, and no subadults were affected, suggesting that the osteoarthritis is late-onset, and a result of stress to the joints over time. The most common expressions of the condition included porosity and osteophyte activity at the articular margins. In general, frequencies for arthritis ranged from moderate, with the highest frequency in the vertebrae at 20%, followed by the moderate to low frequencies in the elbow and wrist (8-7%), and lastly the knee and the ankle showed the lowest frequencies at fewer than 5%. Most cases were not very severe, however, pronounced eburnation was observed on a left trapezium, a left trapezoid, and a right trapezium, on the surfaces where they articulate with metacarpals 1 and 2 (the thumb and index finger) indicating a more advanced stage of arthritis (Plate B-6). Osteophyte activity in the vertebrae was slight to moderate, and the worst case involved a possible disk herniation, where the centrum of one lumbar vertebra is poorly defined, shows flaring margins and osteophyte activity anteriorly, and has a compressed appearance (Plate B-7).

Table 9. Frequency of osteoarthritis on the adult vertebrae and bone elements that comprise major joints

Location	N of bones	Osteoarthritis	% Frequency
Elbow: distal humeri, proximal radii, proximal ulnae	50	4	8%
Wrist: distal radius, distal ulnae, carpals, metacarpals	59	4	6.8%
Knee: distal femora, proximal tibiae, patellae	64	3	4.7%
Ankle: tarsals, distal fibulae, distal tibiae	91	2	2.2%
Vertebrae (1-12)	30	6	20%

Porotic Hyperostosis

Porotic hyperostosis involves the porous enlargement of bone tissue. It is most commonly associated with porosity on the frontal and parietal bones of the cranium, which usually occur as a result of iron-deficiency anemia (Ortner 2003). However, it may also occur in cases of other dietary deficiencies such as scurvy or rickets (Ortner 2003). Porotic hyperostosis as a result of iron-deficiency anemia has been frequently reported for prehistoric populations in the U.S. southwest (Buikstra and Ubelaker 1994, Mays 2000, Ortner 2003). The deficiency may be due to a lack of iron in the diet, but also from gastro-intestinal infections, which do not allow proper absorption of nutrients, or parasites, which may lead to chronic blood loss (Mays 2000).

Table 10. Frequency of Porotic Hyperostosis on cranial bone elements

Location/ Activity	N of bones	Porotic Hyperostosis	% Frequency
Skull/ healed area	27	4	14.8%
Skull/ active area	27	1	3.70%

The skeletal remains from 41KM140 were observed for both healed and active areas of porotic hyperostosis. The frequency of porotic hyperostosis is reported in Table 10. The number (N) of bone elements was determined using the totals for the bones of the skull used to calculate MNI, which excludes incomplete and unidentified fragments. It is worth noting that the sample size for complete cranial bones is rather small at 27, and frequencies may not be as representative as in some of the previous pathological conditions reported.

Porotic hyperostosis was not observed on any subadult remains. The frequency for active porotic hyperostosis in adults was relatively low at 3.7%. Active lesions suggest that the individual represented by porotic hyperostosis was affected by the condition at the time of death. The healed lesions show a much greater frequency at 14.8%, however healed lesions suggest the condition was no longer active and probably not involved in the death of the individual. Without radiographic evidence, cross-sectioning of the bone, and additional studies of nutrition such as coprolite analysis, the exact cause of the porosity in these five cases is indeterminate.

Dental Pathology

Dental pathological conditions were scored during the inventory process and are reported along with dental measurements in Appendix B. Frequencies of occurrence for calculus, caries and linear enamel hypoplasia were calculated using the total number of teeth present, while abscesses and antemortem tooth loss were scored by number of sockets, regardless of presence of teeth.

Dental attrition

Dental attrition, or wear, is not a pathological condition, but is an important factor in the study of pathology in dentition. For example, high rates of dental attrition are associated with increased antemortem loss of teeth and decreased frequency of caries (Lukacs 1989). Attrition for the dentition of individuals at 41KM140 was scored for each tooth using the method outlined by Smith (1984).

Table 11. Mean dental attrition rates and measurements at 41KM140

Category	N	Mean stage attrition	Mean Mesiodistal diameter	Mean Buccolingual diameter	Mean crown Height
Adult Molars	40	23.6	9.0	9.7	5.1
Adult Premolars	19	5.9	6.1	8.3	4.6
Adult Canines/Incisors	41	6.3	5.6	7.0	3.3
Subadult permanent	16	0.8	10.1	9.4	7.5
Subadult deciduous	7	2.3	8.7	7.1	6.4

Mean dental attrition rates for adults and subadults are reported in Table 11 along with mean measurements for each class of tooth. The mean rate of attrition was moderate to high for both posterior and anterior teeth in the sample, since at their respective stages of 25 and 6, a significant portion of the enamel would have already been worn away, exposing underlying dentine. Some teeth exhibited unusually angled tooth wear (plate C-1), possibly caused by alteration of the regular chewing pattern due to lost teeth (Hartnady 1988). The prevalence of observable shovel-shaped incisors, a trait often found in Asian and Native American populations where the lingual marginal ridges flare inward, was also greatly affected by attrition. Of all of the adult incisors recovered, not enough of the crown of each tooth remained to observe the trait. Shovel-shaping was observed in the mixed subadult dentition recovered, on one permanent incisor, and two deciduous incisors (Plate C-4).

Caries

Dental caries are caused by the destruction of tooth enamel, dentine and cementum resulting from acid production by bacteria in dental plaque (Hillson 1996). This process leads to the formation of a cavity in the either the tooth crown or root surface, where the subsequent destruction of the tooth usually progresses slowly. Caries are reported by location and can occur on the occlusal surface, the root surface, and also interproximally (between teeth). In general, caries usually affect the posterior teeth more often than the anterior teeth.

High caries rates have been associated with diets rich in starchy carbohydrates, such as those consumed by groups dependent on horticulture and agricultural subsistence practices (Hillson, 1996). Many groups with high attrition rates have been associated with lower rates of caries (Larsen 1985, Lucaks 1989, Powell 1985). Hillson (1996) suggests that this is not necessarily a causal relationship. While occlusal attrition might remove rapidly progressing fissure caries on the occlusal surface, caries rates on cervical sites remain unaffected (Hillson 1996).

The frequency of caries from the 41KM140 population is reported in Table 12. As expected, the frequency of caries of the posterior teeth (6.8%) is much greater than that of the anterior teeth (2.4%), although both frequencies are relatively low. No carious activity was observed on any subadult teeth. Out of all the teeth examined, three caries were found interproximally, and two were found on occlusal surfaces. Furthermore, three of the reported caries were observed on the same molar. The carious activity that occurred interproximally (Plate C-3) was far more serious than the activity seen occlusally, which was comprised of two pinprick sized dots. This lends credence to the idea that those groups with high rates of attrition experience far less occlusal surface caries, however as Hillson (1996) suggests, rates of interproximal caries were not affected.

Table 12. Frequency of carious activity on adult and subadult dentition

Category	N	Caries	% Frequency
All adult teeth	100	5	5%
Adult posterior teeth	59	4	6.8%
Adult anterior teeth	41	1	2.4%
Subadult permanent	16	0	0%
Subadult deciduous	7	0	0

Linear Enamel Hypoplasia

Linear enamel hypoplasia (LEH) is a developmental defect of the tooth enamel, expressed as a series of horizontal lines on the tooth. The lines are caused by physiological stress during childhood when the teeth are forming before eruption. Stresses such as disease and dietary deficiency, fever, parasites, measles, pneumonia, vitamin deficiency, and general malnutrition are expressed through LEH (Mays 2000). LEH usually occurs most often on the incisors and canines, and is most commonly expressed in subadults in a skeletal sample (Ortner and Puschtar 1981).

The frequency of linear enamel hypoplasia is listed in Table 13 for adult and subadult teeth. As expected, LEH was observed only on anterior teeth in adults at a low to moderate frequency of 9.8% for anterior teeth only, and 6% for the entire sample (Plate C-4). Permanent teeth which were not completely developed and which would have still been located within subadult jaws were not affected by LEH. However, one deciduous canine was affected, and thus the frequency of LEH for subadults, taking into account the small sample size of seven, was moderate at 14.3%.

Table 13. Frequency of LEH on adult and subadult dentition

Category	N	LEH	% Frequency
All adult teeth	100	6	6%
Adult posterior teeth	59	2	3.4%
Adult anterior teeth	41	4	9.8%
Subadult permanent	16	0	0%
Subadult deciduous	7	1	14.3%

Calculus

Calculus is the mineralization of bacterial plaque, which consists of food particles, proteins, and living and dead microorganisms. Calculus forms when plaque builds up near and around the teeth from food and bacteria that are never cleaned away from the teeth. Over time this plaque hardens and becomes calculus. It provides a space for bacteria to thrive as well as a rough surface that irritates the gums, leading to periodontal disease (Ortner and Puschtar 1981).

The frequency of calculus was calculated for all adult and subadult teeth using scoring stages defined by Brothwell (1981) and is listed in Table 14. Calculus can range from a small band that surrounds the tooth (stage 1), a large band that surrounds the tooth (stage 2), or an encrustation that surrounds the entire tooth surface (stage 3). Calculus was not observed on any subadult teeth. Calculus more frequently affected the posterior teeth, which is consistent with the fact that food particles are more likely to be trapped between teeth in the rear of the mouth. Of all the adult teeth, stage 1 calculus formation was most prevalent at 16%, and the number of affected posterior teeth (21%) was greater than anterior teeth. Stage 2 calculus was less frequent, at 8%; and posterior teeth again were more often affected. Lastly, stage 3 calculus was infrequent and restricted to the posterior dentition.

Table 14. Frequency of calculus on adult dentition

Category	**N**	**Calculus 1**	**%freq**	**Calculus 2**	**%freq**	**Calculus 3**	**%freq**
all adult teeth	100	16	16%	8	8%	2	2%
adult posterior teeth	51	11	21.5%	5	9.8%	2	3.9%
adult anterior teeth	49	5	13.2%	3	7.9%	0	0

Abscesses

An abscess is an inflammatory infection caused by exposure of the pulp chamber to bacteria. An abscess often progresses to tooth loss followed by repair and resorption of the alveolar bone, or bone of the mandible or maxilla surrounding the root (Ortner and Puschtar 1981). Two kinds of abscesses are noted, periapical abscesses and periodontal abscesses. Periapical abscesses occur primarily through carious infection, but in samples where attrition is high, infection through exposure of the pulp from attrition is most likely. Periapical abscesses occur below the gumline and are a visible lesion near the tooth root. They are usually caused by bacteria entering the pulp cavity due to caries. As the condition worsens, the infection spreads to the bone in the mandible, causing alveolar resorption. Inflammation results, which appears in dry bone as heavy porosity. Over time an abscess can weaken the immune system, and the infection can spread through the bloodstream, causing complications like meningitis and even death. Usually the tooth at the site of the abscess is lost.

Periodontal abscesses occur outside the pulp cavity, between roots of multi-rooted teeth. Such abscesses are not due to caries, yet still cause local or general alveolar resorption. Because of postmortem tooth loss it is difficult to ascertain which abscesses are periapical and which are periodontal, so for the purposes of this study both were scored equally, though Ortner and Puschtar (1981) affirm that in samples where there is heavy wear on the teeth and occurrence of caries is low, the majority of abscesses are usually periodontal in nature.

The frequency of abscesses is listed in Table 15 for adult dentition. No abscesses were observed on any subadults. Of the two abscesses that were recorded, both affected maxillary canines, and one was so severe that the canine was likely lost at the site of the abscess (Plate C-3). The overall frequency of abscesses is low at 2.1% for anterior dentition, and very low at nearly 1% for all adult dentition.

Table 15. Frequency of abscesses on adult dentition

Category	N*	Abscesses	% Frequency
all adult dentition	256	2	0.8%
adult posterior dentition	160	0	0
adult anterior dentition	96	2	2.1%

*N was determined by calculating number of tooth sockets for MNI of 8 adults

Antemortem Tooth loss

Tooth loss can occur due to a variety of factors, including trauma, periodontal disease, abscesses, and heavy wear. Often in prehistoric populations with heavy tooth wear, much of the antemortem tooth loss is due to exposure of the pulp cavity and subsequent infection through attrition (Ortner and Puschtar 1981). The frequency of antemortem tooth loss is listed in Table 16 for adult dentition. Overall, the frequency of tooth loss was low to moderate at 10.2%, with posterior teeth lost more frequently (11.9%) than anterior teeth (7.3%). No antemortem tooth loss was observed on any subadults. The antemortem tooth loss observed in all cases was either healing or completely healed, and in some cases, especially for posterior mandibular teeth, remodeling by alveolar bone had already completely obliterated the tooth socket (Plate C-2).

Table 16. Frequency of antemortem loss of adult dentition

Category	N*	Antemortem Loss	% Frequency
all adult dentition	256	26	10.2%
adult posterior dentition	160	19	11.9%
adult anterior dentition	96	7	7.3%

*N was determined by calculating number of tooth sockets for MNI of 8 adults

Summary and Discussion

Age and Sex

While assigning specific ages was not possible for all individuals recovered, division of the skeletal material into adult and subadult bone elements show that the majority of the sinkhole is comprised of adult burials. The distribution of age is important in interpretation of the frequency of pathological conditions. For example, the small sample size of subadult individuals (2 children, 1 infant), along with relatively poor preservation of subadult remains, may explain why no pathological conditions were observed on any of the bone elements, greatly reducing any possible inferences about the health status of children at the burial sinkhole. Another way in which age distribution has an effect on interpretation of the results has to do with conditions which are age-specific, such as arthritis. Since most osteoarthritis is age-related, the frequency of arthritic conditions may be expected to increase as the mean age of the skeletal sample increases.

While in many cases frequencies of pathological conditions can be compared on the basis of sex of the individual, this is usually done at sites in which sex can be accurately determined, and burials are discrete in nature. While noting that the distribution of sex at 41KM140 is likely to be normal (50% males, 50%females), further discussion regarding differences in sex and other factors such as pathology is not appropriate for this study.

Health, Disease, and Stress

Ortner states that "in typical archaeological human skeletal samples, about 15% of the burials will show evidence of significant disease" and that most (80-90%) pathological burials will vary in proportion in the major categories of pathology discussed in this study: trauma, infection, and arthritis (Ortner 2003:112). As expected, most pathological conditions fell within the three major categories described by Ortner. Overall, the results of pathological conditions on bone, as well as dental pathological conditions, expressed as frequencies of occurrence, indicate a healthy, well adapted population at 41KM140. This conclusion is based on the assumption that if a group is experiencing a low amount of environmental stress, frequency of skeletal lesions will be low, and thus the health of the population as a whole can be said to be relatively good. Criticisms of this assumption have been presented by Wood et al. (1992), who argue that because of differences in frailty, a higher frequency of skeletal lesions may indicate that those individuals survived stresses and were in good health. Conversely, those individuals with little or no lesions at all may have been so unhealthy as to have died before the lesions even developed.

The paradox that "Better health makes for worse skeletons" stems from the fact that any archaeological skeletal sample under study is an example of selective mortality, and does not represent the entire population of those at risk, but rather those who did not survive (Wood et al. 1992:356). Convinced that the case was not quite so bleak for bioarchaeologists and paleopathologists, Goodman (1993) in his refutation of Wood et al.'s argument states that the paradox model ignores the relationships between morbidity, or the relative incidence of disease, and mortality in individual-level analysis.

Furthermore, approaches that use multiple-indicators of health besides skeletal lesions are also overlooked, and mathematical models are readily favored even when they contradict cultural and biological processes. While an interesting subject of debate, the paradox proposed by Wood et al. is not readily adaptable for research and has little practical value in interpretation except as a caveat.

All things considered, the results of pathological conditions on bone, as well as dental pathological conditions, expressed as frequencies of occurrence, likely indicate a healthy, well adapted population at 41KM140. Rates of antemortem trauma in the form of healing or healed fractures were relatively low, at approximately 4%, with most fractures occurring on the arms and skull. While most causes of fracture in the sample are likely to be accidental, fractures to the cranium of one adult individual suggest at least one individual at the burial sinkhole was subjected to interpersonal violence. While likely the victim of an attack rather than accident, the individual nevertheless survived the incident.

Although analysis of trauma is often used to provide insight into behavior in a population, the frequency of infection is a better indicator of general health. For example, Ortner (2003) and others (Larsen 1997, Powell 1988) suggest that the prevalence of periostitis increases as stressful conditions increase. The rate of infection at 41KM140 (limited solely to the lower limbs) was low at 3.1%, and this frequency suggests that overall environmental stress was low. The reported frequency included three cases of periostitis and one case of osteitis. In the absence of any other evidence, both the periostitis and osteitis were found to be non-specific, and could either be caused by trauma or infection.

Frequencies of osteoarthritis were low to moderate at roughly 2-8% for the major joint categories, and 20% for the vertebrae. Most cases of osteoarthritis observed were slight to moderate, and only three cases (all of which could have occured on one individual) were more severe and involved eburnation and extensive osteophyte activity on the carpals. Overall, the cases of arthritis appeared to be consistent with a sample comprised of older individuals, since most individuals over 40 experience some form of osteoarthritis, especially in the spine (Ortner 2003).

In addition, frequencies of dental pathological conditions can also provide clues as to the general health of a population. Specifically, frequencies of linear enamel hypoplasia (LEH) are a useful indicator of the relative health of the population. As previously stated, LEH can be caused by a variety of diseases and dietary deficiencies throughout early childhood. High rates of LEH (>50%) suggest that individuals were exposed to high levels of physiological and nutritional stress through their early development. Adult individuals at 41KM140 show a relatively low frequency of LEH at 6.5% for all adult teeth, and 14% for subadult deciduous teeth, suggesting that while physiological and/or nutritional stress was present during childhood, it was not severe or rampant.

Other dental pathological conditions which would have an impact on the general health of a population include abscesses, since the infection caused by an abscess can cause considerable pain, limit proper nutrition, and infection, which can potentially spread through the blood system. The frequency of abscesses for the Stiver Ranch sample was very low at 0.8%. Of the two abscesses observed, both were located on the anterior dentition, and thus it is more likely that they were caused by attrition rather than carious activity.

The low frequencies of pathological conditions such as infection, osteoarthritis, and trauma, as well as dental pathological conditions such as LEH and abscesses, indicate the individuals interred at the Stiver Ranch burial sinkhole comprised of a well-adapted, successful population.

Diet

The presence of certain pathological conditions can be good indicators of what a population's diet was lacking. For example, porotic hyperostosis is usually a characteristic of dietary deficiency, and in the Americas, usually the cause is iron-deficiency anemia (Ortner 2003). While the exact cause of the cases of porotic hyperostosis on individuals at 41KM140 is unknown, the frequency of active lesions is relatively low at fewer than 4%. These results suggest that for most individuals at the sinkhole, dietary deficiency was not extremely serious, and that most individuals were likely consuming a sufficiently nutritious diet.

The best bioarchaeological indicator of diet and nutrition, in the absence of evidence on bone elements themselves, is the dentition. Rates of attrition can illustrate whether a diet is processed or not (for a more thorough treatment of food processing, attrition, and diet, see Smith 1984). Mean rates of attrition for adults at 41KM140 were moderate to high, with dentine exposure on almost all recovered teeth. Such a high level of attrition signifies an abrasive diet, with little processing. Since hunter-gatherer groups tend to have much higher rates of dental attrition due to consumption of course, unprocessed foods (Lukacs 1989, Smith 1984), decreased rates of caries and increased antemortem tooth loss usually follow.

As expected, the rate of carious activity was low at 5% for all adult teeth. Lower frequencies of caries not only coincide with an abrasive diet, but also a diet which lacks foods rich in starchy carbohydrates, which tend to dramatically increase caries rates (Hillson 1996). While antemortem tooth loss may have been caused by carious activity in the molars, thereby reducing the number of affected teeth available as well as reducing the frequency of caries observed, it is more likely that the tooth loss was a result of the high levels of attrition, which in many cases wore the teeth down to the tooth root. Moderate levels of calculus (observed at about 8-20%) may have also played a factor in antemortem tooth loss, as it can harbor bacteria and cause mechanical abrasion to the gum line, triggering infection.

In general, the results suggest that the diet at 41KM140 consisted of coarse, unprocessed foods, which were likely low in starchy carbohydrates. Low frequencies of pathological indicators such as porotic hyperostosis suggest that the diet was, for the most part, nutritious and not severely deficient in necessary nutrients. Stable carbon isotope analysis of bone elements, presented in the following chapter, elaborates on the diet consumed by individuals at 41KM140, as well as dietary patterns in the region.

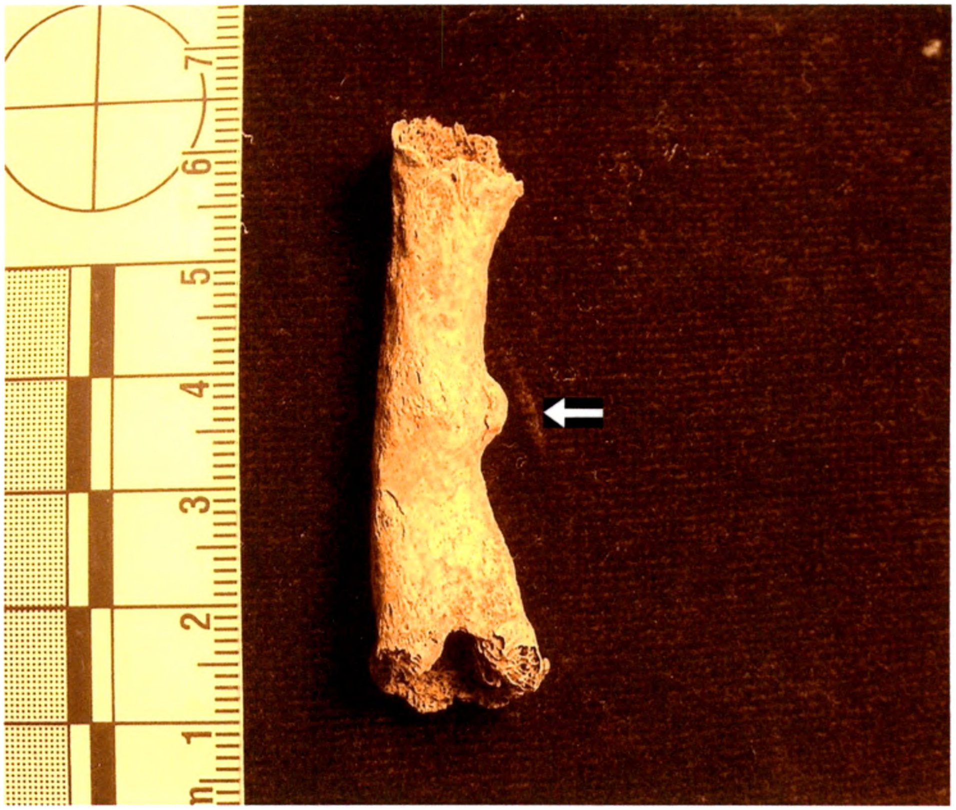
NA4-collection

NA4-#A243

NA4-#A226

Plate A-1. Collection of subadult skeletal fragments from unit NA level; child's right ischium A243, and infant right radius A226.

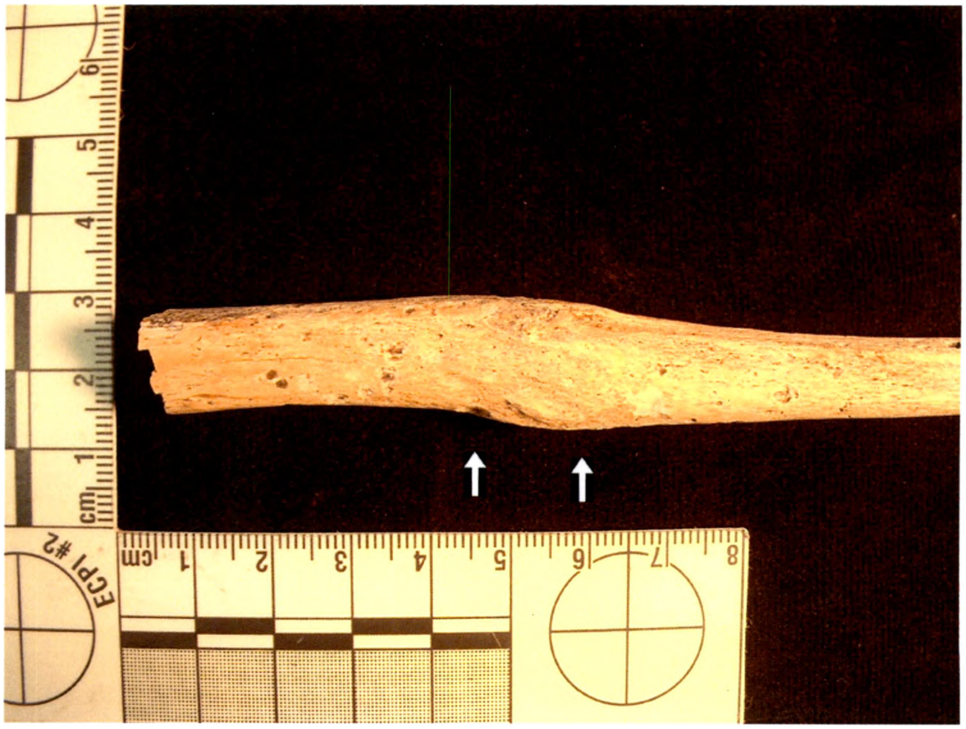
Plate A-2. Female cranium aged 20-35 years from the original surface collection, broken cranium of probable male #A110.



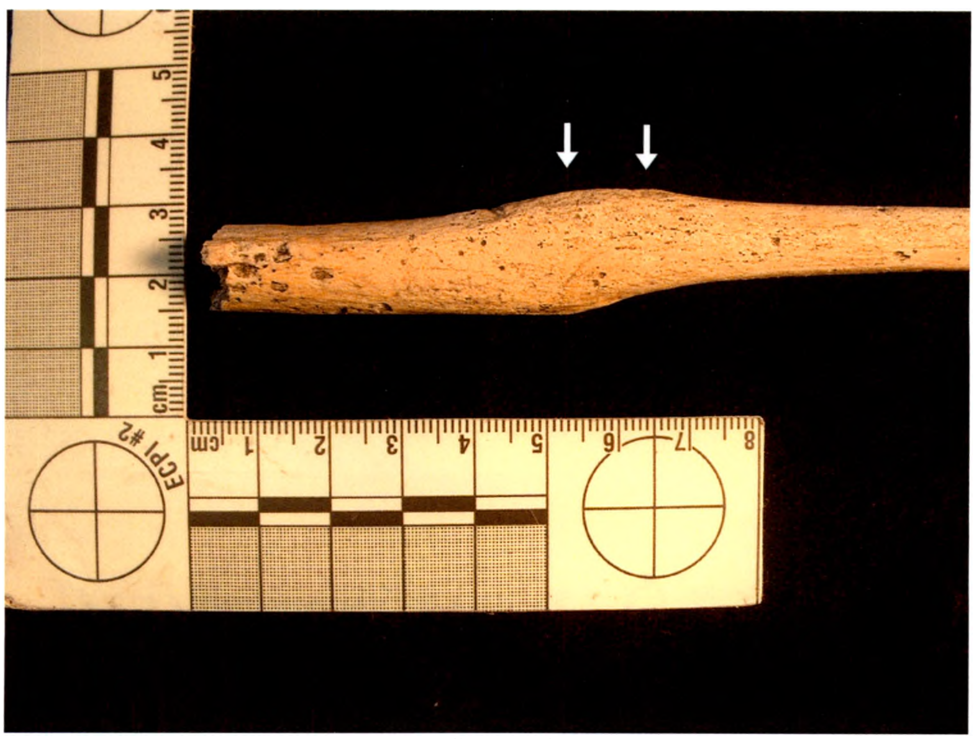
N4-#A160

N4-#A152

Plate B-1. Healed fractures on metacarpal shaft A160 and ulna shaft A152.

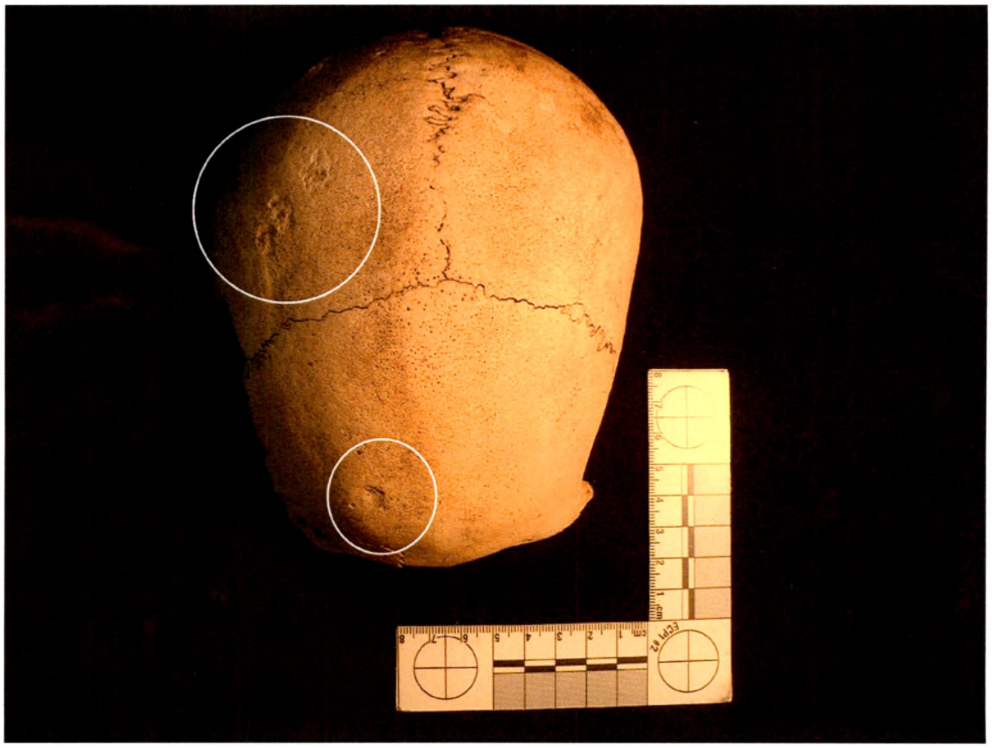


S5-#A147 (a)

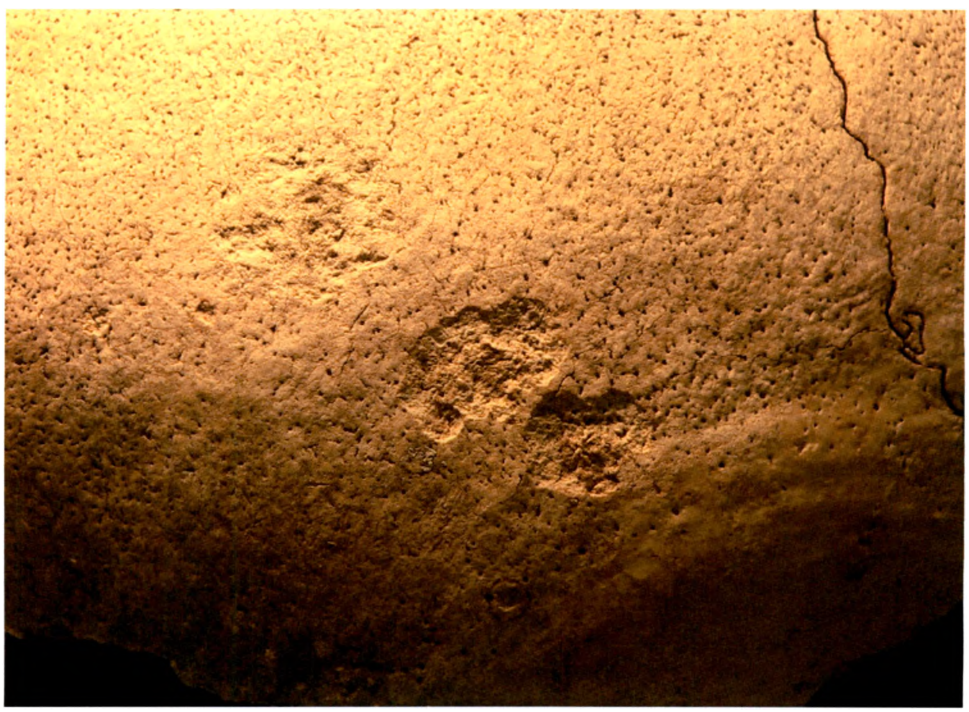


S5-#A147(b)

Plate B-2. Parry fracture to left distal ulna A147. Anterior (a) and posterior (b) views.



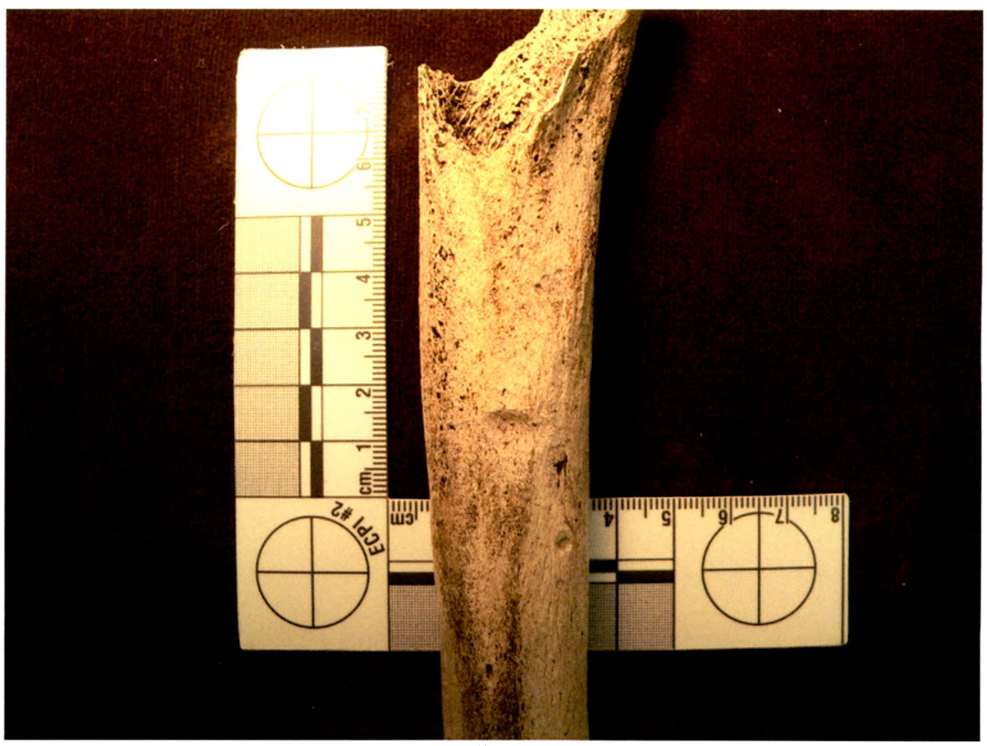
S4-#A112



S4-#A112

Plate B-3. Healed depression fractures on the frontal and parietal bones of skull A112, and a closer view of the three parietal fractures.

Original Surface Collection

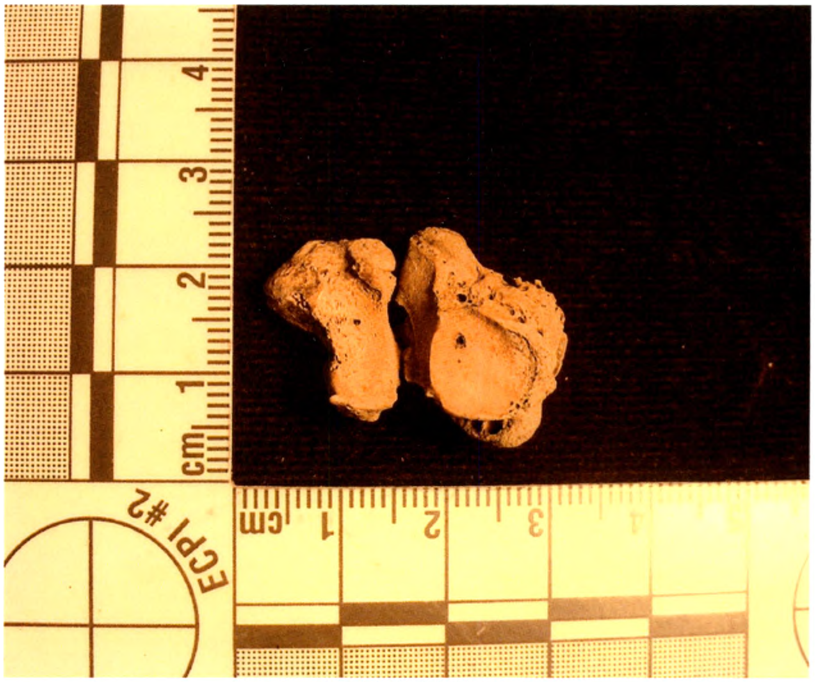


S4-#A120

Plate B-4. Osteitis (infection) on a right proximal tibia with severe rodent gnawing down the anterior surface of the shaft and unusual surface depression; left proximal femur A120 with similar depression, but likely caused postmortem.

Original Surface Collection

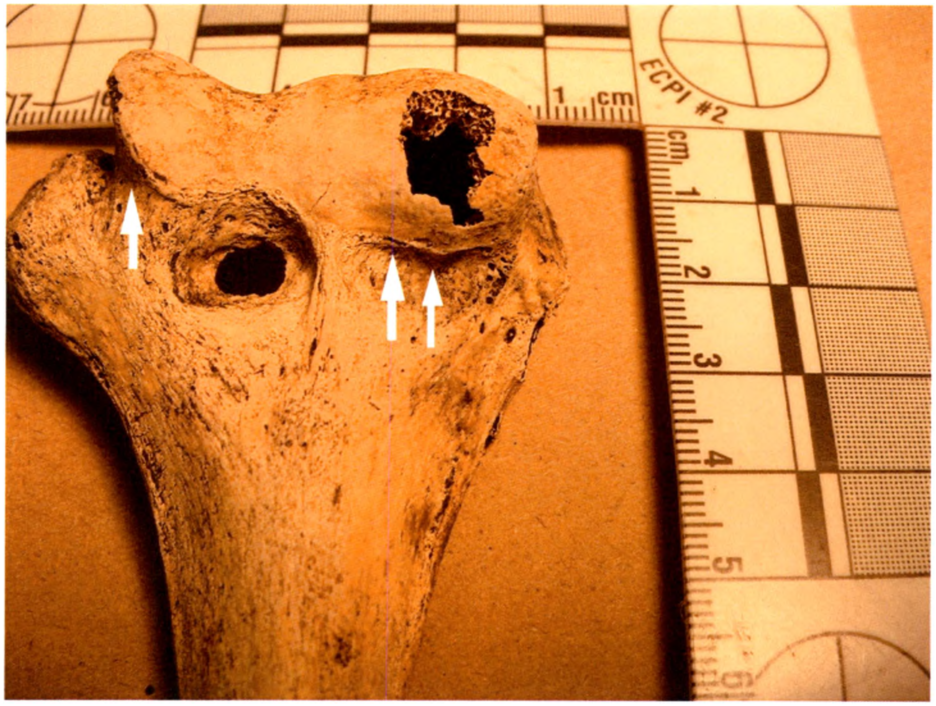
Plate B-5. Small area of periostitis on a right proximal femur, anterior surface.



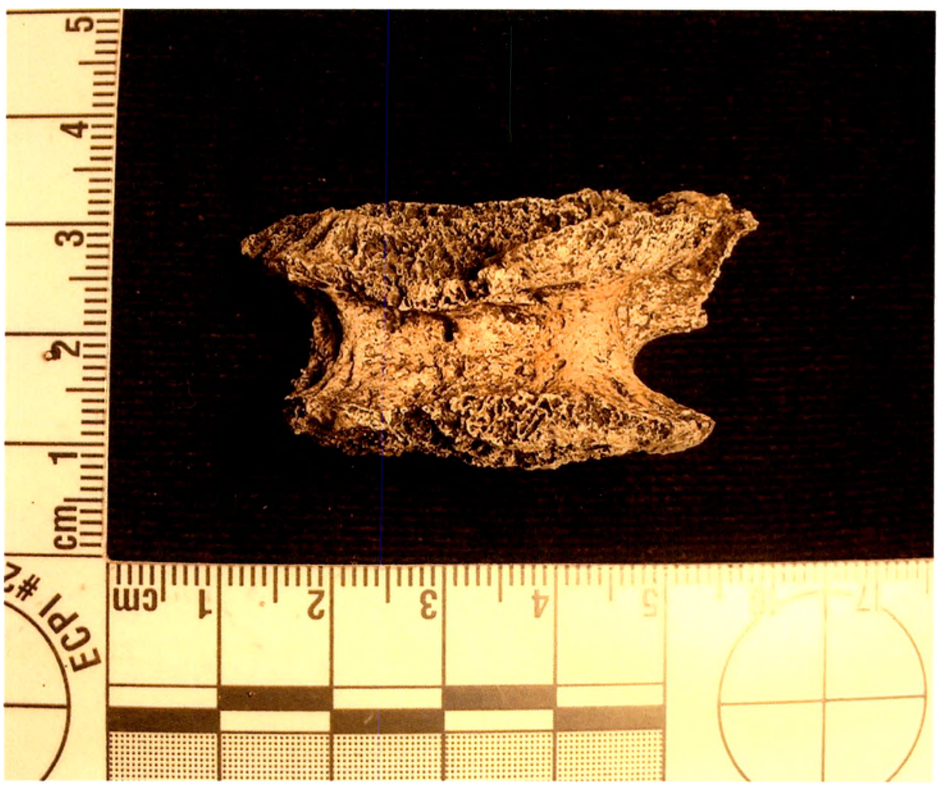
N4-#A160

S4#A125

Plate B-6. Arthritis with characteristic eburnation and osteophyte activity on probable articulated left trapezium and trapezoid; left patella with arthritic lipping.

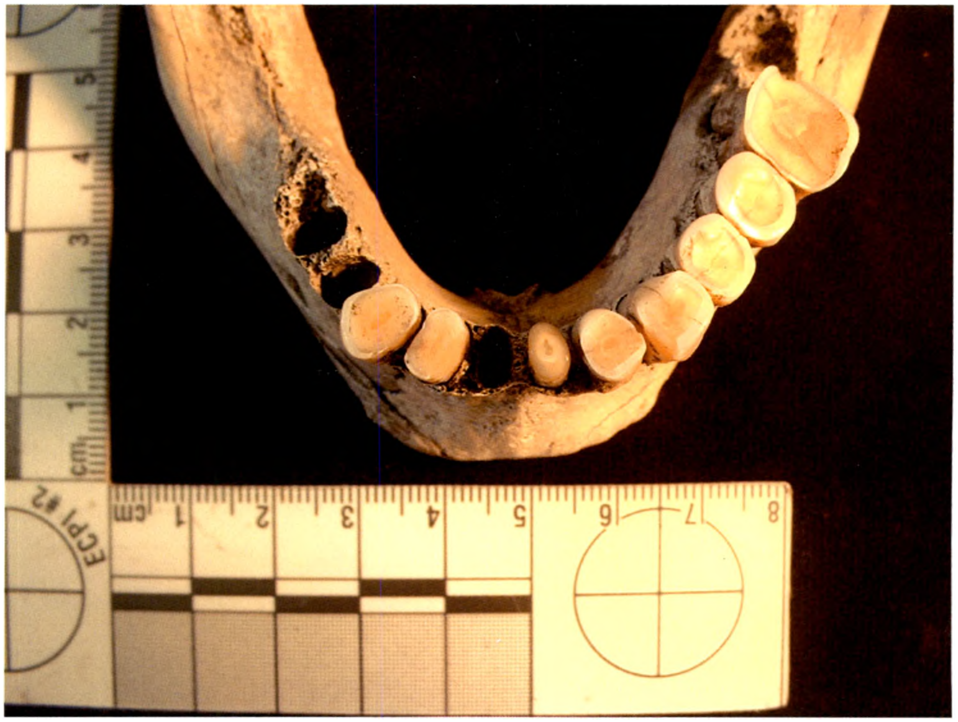


N3-no #



S4-#A135

Plate B-7. Arthritic lipping on a distal humerus (breakage occurred postmortem), and centrum of a lumbar vertebra affected by vertebral osteoarthritis.



S5-#A136

N4-#A161, S5-#A139

Plate C-1. Moderate to severe dental attrition and healed antemortem tooth loss on mandible A136; severely angled tooth wear on a maxillary canine and molar, parts of root well worn to a high polish.

No provenience, disturbed by looters

Original Surface Collection

Plate C-2. Healed antemortem loss of nearly all posterior teeth on two mandibles.

S4-#A110

N4-#A161

Plate C-3. Large abscess and antemortem loss of premolar affecting maxilla A110, large interproximal carie on maxillary molar A161.

C-#A277

Top, left to right: NA4-#A240, SA6-#A23; Bottom:NA4-#A258

Plate C-4. Linear enamel hypoplasia on canine and premolar of mandible A277, shovel shaping on subadult permanent incisors (top) and deciduous incisor.

CHAPTER V

STABLE CARBON ISOTOPE ANALYSIS

Results of a stable carbon isotope analysis on the individuals at the Stiver Ranch burial site suggests they shared a mixed diet of predominately C_3 plants and those animals that eat these plants, and lesser amounts of CAM/C_4 plants. Furthermore, the distribution of δC^{13} values at 41KM140 indicate a single dietary population among the mortuary sample interred at the site. Comparison with δC13 values from other Central Texas mortuary sites reveals dietary trends for hunter-gatherer populations which warrant further stable carbon isotope research in the Central Texas region.

Stable Carbon Isotopes

All living organisms use carbon and its isotopes (^{14}C, ^{13}C and ^{12}C) in the normal processes of metabolism (Ambrose 1993). Carbon and its isotopes can enter a consumer's diet through three possible sources, depending on the photosynthetic pathway of the plants consumed. C_3 plants utilize a photosynthetic pathway with three carbon atoms, C_4 plants use four atoms, and CAM (Crassulacean Acid Metabolism) plants can utilize both pathways but usually use the C_4 pathway. C_4 plants include many grasses and agricultural crops, while C_3 plants include all trees, many bushes and leaf plants. Lastly CAM plants include most cacti and desert succulents (Pate 1994).

The ^{13}C and ^{12}C isotopes of carbon in C_3, C_4 and CAM plants are stored in different amounts in each of these plants because of fractionation, or the preferred incorporation or exclusion of one isotope or another in a chemical reaction (Price et al. 1985). Because lighter isotopes react more quickly in a reaction than heavier ones, collagen will reflect different proportions for different isotopes. Stable carbon isotope values for C_4 plants (mean of -12.5 ‰), are less negative than C_3 plants (mean -27 ‰) because they are less depleted in carbon. CAM plants have values similar to C_4 plants (Ambrose 1993).

Environment and Diet

Stable isotope analysis of carbon and its use in reconstructing the diet of prehistoric populations has been given thorough attention elsewhere (Ambrose 1993, Mays 2002, Pate 1994, Price et al. 1985, Schwarcz and Schoeninger 1991). However, a brief review of some of the most common dietary resources available in the Central Texas region is presented. The range of carbon isotope values (δC^{13}) for these resources is also indicated.

Plants and animals which may have been utilized as part of the diet in Central Texas include a variety of C_3 plants which are abundant in the Edwards Plateau and neighboring regions. C_3 plants include acorns harvested from live oak and shin oak, sotol, onion, and persimmon. Edible CAM plants in the region, many of which yield δC^{13} values in the C_4 plant range, include prickly pear and yucca (Huebner 1991). Deer, which consume a diet of C_3 plants, were also part of the Central Texas diet, along with a variety of other animals including bison, rabbits, and turtles (Baker 1998, Bement 1994).

The abundance of C_3 plants and some CAM plants suggest that hunter gatherers utilizing plant resources in this region should have an isotopic signature indicating a diet which includes a mixture of predominately C_3 plants, and lesser amounts of C_4 or CAM plants. The assumed dividing point in human δC^{13} values for a C_3 dominant diet vs. a C_4 dominant diet is approximately -14‰ (Huebner 1991). Therefore, values with a negative greater than -14‰ would suggest a diet similar to Central Texas mixed $C_3$and C_4/CAM diets, and values more positive than the -14‰ dividing point would reflect a C_4/CAM diet similar to those found in the Lower Pecos region of Texas (Huebner 1991).

Sample Submission and Results

Of the entire skeletal sample, five samples were carefully selected to avoid accidental inclusion of the same individual twice. This was particularly difficult due to the fragmented and commingled nature of the sample. To avoid this problem, three samples included right distal humeri and two right mandibular bodies. The intention was to include the highest amount of duplicated bone elements possible, as well as including samples from both upper and lower deposits of the sinkhole. Accounting for the most probable possibility of double inclusion (two samples taken from the same unit and level), the samples submitted represent 4 out of 8 adult individuals from the sinkhole.

Two additional samples, from the upper and lower deposits of the sinkhole respectively, provided both δC^{13} values and AMS radiocarbon ages (Table 18). Inclusion of these two samples added two additional δC^{13} values, which lie within or near the range of values given for the undated samples. The results show a range of δC^{13} values with a mean of –17.22 ‰ and a standard deviation of 0.92 ‰ (Table 17). Since the distribution of values lie so close to the sample mean, it is likely that only one dietary population is represented (Bousman and Quigg, n.d.).

Table 17. Stable carbon isotope samples from 41KM140

Sample #	Description	δC^{13}
41KM140-C-1	Right Mandible, collagen	-18.2 ‰
41KM140-C-2	Right Humerus, collagen	-17.3 ‰
41KM140-S4-3	Right Humerus, collagen	-17.4 ‰
41KM140-S4-5	Right Mandible, collagen	-17.5‰
41KM140-NA4-4	Right Humerus, collagen	-15.7‰
Mean		**-17.22‰ ± .92**

Table 18. Stable carbon isotope samples from 41KM140 of known radiocarbon age

Sample #	Description	Radiocarbon Age	δC^{13}
41KM140-S4-H	Human bone, collagen	800 ± 40 Years B.P.	-18.6 ‰
41KM140-CT	Human teeth, collagen	2130 ± 40 Years B.P.	-17.2 ‰

Patterns, Comparison, and Discussion

The values from the Stiver Ranch sinkhole indicate that individuals had a mixed diet of C_3 and C_4 plants, with a greater dependence on C_3 plants and probably animals which ate C_3 plants such as deer. Since the mean δC^{13} value (-17.2 ‰) for the 41KM140 sample series was more negative than the dividing point in human δC^{13} values for a C_3 dominant diet vs. a C_4 dominant diet (-14‰), the results suggest that the individuals interred at the Stiver ranch burial sinkhole consumed a diet similar to Central Texas mixed $C_3$and C_4/CAM diets(Huebner 1991). The sample values also fall well within the range of δC^{13} values reported from mortuary sites in the Central Texas region, which are reported in Table 19 along with δC^{13}values from South Texas and the Lower Pecos.

Table 19. Stable Isotope Analyses from the Edwards Plateau, South Texas, and the Lower Pecos*

Area	Stable Carbon	Reference
Edwards Plateau		
Stiver Ranch (41KM140)	-17.22 + .92 (5)	
Bering Sinkhole (41KR241)	-15.8 + .97 (16)	Bement 1994
South Texas		
41KA89	-16.9 (1)	Huebner et al.1996
41BX917	-12.1 (1)	Tennis 1994
Lower Pecos		
Various Sites	-14.0 + 1.23(6)	Huebner 1991
Seminole Sink	-16.8 + 3.3 (8)	Turpin 1985

Modified from Pertulla (2001: Table 12)
*Mean values, sample size given in parenthesis

Of specific interest are the values reported from Bering Sinkhole burial site (41KR241), also located in Central Texas (Bement 1994). Stable carbon isotope samples from Bering sinkhole were dated to the Early, Middle and Late Archaic, showing a distribution of values that become more negative over time (Figure 4). Stable carbon isotope values from 41KM140 with known radiocarbon ages indicate that the diet of individuals at 41KM140 falls within the pattern of increasing negativity over time as seen at Bering. However, the sample size is very small, and the majority of the 41KM140 samples are undated. Thus, the hypothesis that the diets in Central Texas become more dependent on C_3 plants and animals over time can only be tentatively supported by the data.

Without further AMS radiocarbon dates which can confirm the chronology at 41KM140, additional inferences based on stable carbon isotope data would be speculative at best. The undated values imply that samples from 41KM140 could date to the Late Prehistoric period, assuming later ages all show more negative values. However for this to be the case, one must also assume that the dietary pattern at the Stiver Ranch sinkhole is identical to that at Bering sinkhole. In another scenario, where the undated values are representative of the entire span of use at the sinkhole, diets of individuals at 41KM140 may be more consistent, with more negative δC^{13} values, over time than those at Bering sinkhole.

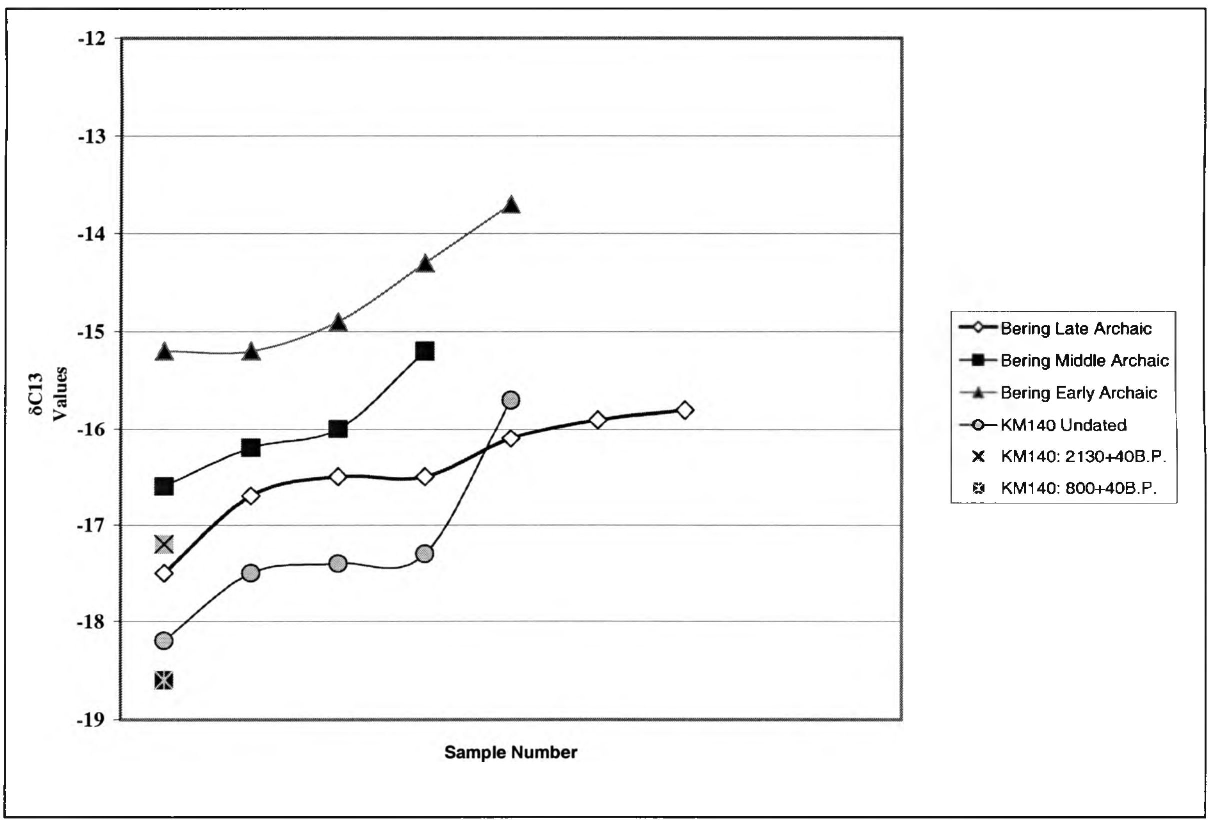


Figure 4. Stable carbon isotope values for Bering sinkhole and 41KM140

Conclusion

The stable carbon isotope analysis of the individuals at the Stiver Ranch burial site suggests they shared a diet of predominately C_3 plants and animals that eat these plants, and lesser amounts of CAM/ C_4 plants. Furthermore, the distribution of δC^{13} values at 41KM140 indicate a single dietary population among the mortuary sample interred at the site. Results from this study are similar to those found at other mortuary sites in Central Texas, such as Bering sinkhole, which also suggest a mixed diet with a dependence on C_3 plants and animals. However, stable isotope data from 41KM140 can only tentatively support the idea that this dependence increases from the Archaic period through the Late Prehistoric period. It may also be the case that the diets of groups utilizing the Stiver Ranch burial sinkhole may have been more consistently dependent on C_3 plants and animals throughout time.

CHAPTER VI

COMPARATIVE ANALYSIS

Comparative Texas Mortuary Sample

While a large number of prehistoric mortuary sites have been excavated in Texas (see Pertulla 2001), not all of them are directly comparable to 41KM140. Table 21 lists those sites that are located in the same region as 41KM140 or nearby regions, those that are roughly contemporaneous, and those which include bioarchaeological analysis. Further discussion of these sites is presented below.

Seminole Sink

One of the most well-recognized sinkhole burial sites in Texas is Seminole sink, a vertical shaft sinkhole in Val Verde County that contained at least 22 individuals. Turpin (1985) reports known sinkhole cemeteries to be of two varieties: those easily accessible to humans, and those not easily accessible. In the former case, corpses were laid out on ledges or bundled and laid out. Non-accessible sinkholes are usually the vertical shaft variety, and bodies were thought to be routinely dropped down the shaft for disposal or burial (Turpin 1985). Turpin suggests that sinkholes were regularly used as “corpse

Table 21. Texas Mortuary sites comparable to Stiver Ranch (41KM140) and results of bioarchaeological analysis

Location	**Seminole sink**	**Bering Sinkhole**	**Loeve Fox**	**Blue-Bayou**	**Stiver Ranch**
Region	Lower Pecos	Central Texas-inland	Central Texas-inland	Central Texas-coastal	Central Texas-inland
Site Type	sinkhole	sinkhole	cemetery	cemetery	sinkhole
Time period	Early Archaic	Early Arch.-Late Prehistoric	Late Prehistoric	Late Arch.-Late Prehistoric	Mid. Archaic-Late Prehistoric
MNI	22	62	25	45	11
Pathology/Adults	**N=10 adults**	**N=x bone elements**	**N=19 adults**	**N=52 adults**	**N=x bone elements**
Infection	10%-20%	6.0%	4.1%	3.8%	1.9%-3%
Trauma	20.0%	1.0%	12.5%	3.8%	1.5%-3.5%
Intentional Trauma	(included above)	(included above)	25.0%	1.9%	14% (skull only)
Porotic Hyperostosis	10-20%	7.0%	n/a	n/a	3.7% (active)
General Osteoarthritis	n/a	2.0%	20.8%	1.9%	2%-8%
Vertebral Osteoarthritis	n/a	(included above)	50%	(included above)	20.0%
Reference	**Turpin (1985)**	**Bement (1994)**	**Prewitt (1974)**	**Huebner and Comuzzie (1992)**	

disposal areas" and that "this method of corpse disposal was a consistent, patterned response to death" (Turpin 1985:15). While mortuary practices at Seminole sink and Stiver Ranch sinkhole are similar, regional and temporal disparity make for large differences between these populations. Seminole sink was utilized as a burial sinkhole during the Early Archaic, and it is located in the Lower Pecos region of Texas, a much different environment than 41KM140. Nevertheless, comparison of the populations using these two sinkholes is useful.

The burial population at Seminole sink is comprised of roughly 50% adult burials and 50% subadult burials. This suggests that the sinkhole was used for general burial of a population group and was not a specialized burial area. In general, frequency of pathological conditions at Seminole sink suggest that the "Archaic way of life, even in the environment of West Texas, provided adequate cultural adaptation," yet even if this is the case, most individuals seemed to experience "relatively severe childhood stress" (Turpin 1985:133). When compared with 41KM140, it is clear that rates of infection and trauma are much higher at Seminole sink, suggesting that individuals at Seminole sink were under more environmental stress, and were less healthy than those at 41KM140. Diet may have also played a role in this difference, since a high frequency of carious lesions (37% of molars), high levels of antemortem tooth loss (22-95%), and high rates of abscess (29-50%), all indicate these individuals most likely ate fibrous, gritty foods with "large amounts of sugar and carbohydrates" (Turpin 1985:146).

Blue Bayou

Another mortuary site that is useful in comparison with 41KM140 is the Blue Bayou cemetery, located in Victoria county. The population at Blue Bayou was utilizing the cemetery from the Late Archaic through the Late Prehistoric, a time period contemporaneous with 41KM140. Similar to conditions seen at 41KM140, individuals at Blue Bayou were fairly robust, and the "general lack of osteological evidence of pathologies suggests that this population might have enjoyed relative freedom from disease and metabolic stress" (Huebner and Comuzzie 1992: 96). While the Blue Bayou population is similar to the 41KM140 population in regards to health, the site is a much larger cemetery site located on the Central Texas coast.

Loeve-Fox

The Loeve-Fox site is located in inland Central Texas, and has been dated to the Late Prehistoric period, a setting much more relevant for comparison with 41KM140. The site is a cemetery rather than a sinkhole and contained 25 individual skeletons, 19 of which were single internments (Prewitt 1974). While only a preliminary analysis of the skeletal remains was available, the cemetery shows overwhelming evidence of interpersonal violence. Six individuals were associated with arrow points found in "such a manner as to suggest that the penetration of the projectiles was the cause of death," and the "general direction of entry for projectiles appears to be from the rear" (Prewitt 1974:46).

In the appendix of the Loeve-Fox site preliminary report (Prewitt 1974), Butler gives a brief description of 24 of the 25 individual burials and reports that 65% of the individuals were male, and 83% were adults. She proposes that either "a combination of an unusually high incidence of disease and overt hostility" or a "non-random spatial placement of burials" may account for their unusual age distribution. While she does not include frequencies of pathological conditions, Butler provided enough information for a calculation of frequencies of pathological conditions for the individuals interred at the cemetery based on the MNI reported and a listing of conditions observed for each individual. The results show that the health status of individuals at Loeve-Fox is similar to 41KM140 with regards to infection and arthritis, but much higher levels of fatal trauma and violence suggest that the social setting was far more unstable than at the Stiver Ranch sinkhole.

Bering Sinkhole

Of the comparative sample cemeteries discussed thus far, Bering sinkhole (Bement 1994) is most easily comparable to 41KM140. Bering sinkhole is located in Kerr County, in inland Central Texas. Also, Bering sinkhole was used as a cemetery over a longer period of time, a similar usage pattern to that seen at 41KM140. Bement (1994) provides only a short analysis of the skeletal remains, yet separates burials by time period, showing a clear pattern of decreased use of the site as a cemetery over time. For example the site contains 20 burials from the Early Archaic, but only six for the Late Archaic, and two for the Late Prehistoric period (Bement 1994). The complexity of the artifacts contained with the burials also decreases, suggesting decreased ritual use.

Bement reports that the MNI of Bering sinkhole totaled 62 individuals, however bioarchaeological analysis by Marks (1991) concluded that a minimum of 34 individuals were recovered. It is unclear whether frequencies reported by Bement (1994) for pathological conditions were recalculated to add additional bone fragments, which would account for the extra individuals. Even so, while Bement separates burial deposits by time period to compare patterns, Marks notes that there are no demographic differences between the burial levels, and that the frequencies for pathology were calculated using bone fragments from the entire population as a whole (regardless of time period) (Marks 1991).

Similar to conditions seen at 41KM140, the disarticulated and fragmented nature of the remains made age, sex, and stature determinations difficult. Overall, the demography of the two sinkholes is similar, with both sharing a slightly larger proportion of adults to subadults. Proportions of males and females for both sinkholes also neared a normal distribution. Both sinkhole burial sites also included cremations and utilitarian grave goods, which suggest that mortuary practices at the two sinkholes were similar. The number of individuals buried per time period at Bering sinkhole shows that starting at the Middle Archaic only about ten individuals were buried during each individual period, a pattern which Bement suggests indicates that "small local groups in fixed territories occupied the area" (Bement 1994:129). While chronological evidence is not as reliable as that for Bering sinkhole, evidence at 41KM140 shows a similar pattern.

Pathological conditions noted at Bering are very similar to those at 41KM140, and both populations appear to be healthy and well adapted, except for a much higher occurrence of childhood stress at Bering sinkhole, as expressed by the greater frequency of linear enamel hypoplasias. In addition, the burial population at Bering sinkhole also differs in regards to diet. More comprehensive data on dental pathological conditions at Bering sinkhole are reported in Table 22 along with dietary content data. Unfortunately, most likely due to the small sample size, Bement does not include data on the dentition from the Late Prehistoric burials at Bering Sinkhole, thus comparisons can only be made for the Late Archaic and Terminal Archaic (or Early Prehistoric) skeletal remains.

Table 22. Dental pathological conditions and diet at Bering Sinkhole

	Early Arch. (n=20)	Mid Arch. (n=10)	Late Arch. (n=9)	Terminal Arch. (n=6)	Late Prehistoric (n=2)
Hypoplasias	48%	45%	64%	66%	n/a
Caries/person	.69	.71	1.62	1.60	n/a
Diet: C-3 foods*	54.1%	63.7%	64.4%	70.4%	n/a
Diet: C-4 foods/CAM*	45.9%	36.3%	35.6%	29.6%	n/a

Modified from Table 17 (Bement 1994:126)
*Based on stable carbon isotope analysis

The higher rate of caries at Bering sinkhole, much like Seminole sinkhole, is associated with a diet of carbohydrate rich foods. Interestingly, while the stable isotope values for individuals at Bering sinkhole and Stiver Ranch sinkhole are very similar, the higher caries rate suggests that individuals at Bering were eating a much larger amount of C_3 plants rich in carbohydrates such as acorns and sotol (Bement 1994). Individuals at 41KM140, with a much lower caries rate, were probably eating more meat or far less high-carbohydrate C_3 plants.

From a comparative perspective, the burial population at 41KM140 is generally consistent with the limited information available from other studies. While sites such as Seminole sink and the Loeve-Fox site are of interest, the burial population at Bering sinkhole is most similar with Stiver Ranch sinkhole. One notable difference between the two populations is the presence of high-carbohydrate foods in the Bering diet. These differences may be due to the temporal variation in both of the sinkhole sites, and other environmental conditions such as moisture and vegetation patterns.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The Stiver Ranch burial sinkhole is a limestone sinkhole located on private property in Kimble County, Texas. Relative dating using projectile points and AMS radiocarbon dating shows that the sinkhole was used as a burial location from the Middle Archaic through the Late Prehistoric period, a span of roughly 4,000 years. During this time, both adults and subadults were either dropped in or lowered into the sinkhole by hunter-gatherer groups which inhabited the area. Bodies were either left exposed, or large rocks may have been dropped in to cover the remains. Excavations at the sinkhole took place over two field schools organized by the STAA in 1999 and 2000.

Inventory of the skeletal remains included the material recovered during the initial surface collection at discovery of the site, subsequent excavation, and looter disturbance. Analysis of the remains revealed that they were highly fragmented and commingled, and reconstruction of specific individuals was impossible. There were a minimum of 11 total individuals interred at the site, including the skeletal remains of seven adults and three subadults, and one adult cremation. The age distribution of individuals was uneven; with nearly 80% of the remains representing adults. Though the data is much more tentative, approximately 50% of the adult individuals were male, and 50% female.

Analysis of pathological conditions of individuals interred at the burial sinkhole provided a profile of population health. Low frequencies of infection, trauma, arthritis, and linear enamel hypoplasia suggested that the population was in good health, experienced only minor childhood stress, and was well adapted to their environment. However, evidence of interpersonal violence in the form of four healed depression fractures to the skull of one individual (possibly a female), suggest that the social setting may not have been completely stable.

Analysis of the dentition and stable carbon isotope analysis provided a dietary profile of the individuals at 41KM140. As evidenced by the high mean attrition rates, and moderate rates of antemortem loss of dentition, the diet was primarily composed of coarse, unprocessed foods. Stable isotope analysis confirmed that the diet was a mixed C_3/C_4 diet with a greater dependence on C_3 plants and animals that eat C_3 plants. Possible C_3 diet foods include acorns, sotol, onions, and persimmon, as well as deer. C_4 diet plants include prickly pear and lecheguilla. The relatively low rates of caries for individuals at 41KM140 suggests that the diet was probably not focused on high-carbohydrate C3 foods such as acorns, since these would produce higher caries rates similar to those seen at Bering sinkhole. Instead, individuals at 41KM140 may have been eating more meat, or C3 plants low in the carbohydrates which lead to carious activity.

Projectile points uncovered at the site included Edwards, Frio, and Travis/Nolan, and it is most likely that all of these were included with the burials as utilitarian grave goods. One other artifact uncovered during laboratory analysis of the skeletal remains was a bone bead with two small incisions (Appendix C). The surface of the bead was worn to a slight polish, and the size of the shaft is consistent with either human bone, or faunal bone such as deer, although the exact type of bone could not be determined.

One major problem underlying the research at this site was the lack of discrete burial deposits, and thus a chronological profile of the site could not be identified. While two large deposits with greater frequencies of human bone show that two discrete burial deposits may have existed at one time, excavations revealed that commingling between these deposits was rather severe. AMS radiocarbon dates taken from samples within these two large deposits suggest the lower deposit can be dated to the Late Archaic, and the Upper to the Late Prehistoric. However, more detailed statements which can link the patterns of pathological conditions and diet at the site to specific time periods is not possible given the data set available.

In general, results from the Stiver Ranch burial sinkhole support the trends proposed for other sinkhole burial sites in Texas. Just as Turpin (1985) states, the use of sinkholes as burial sites does seem to be a consistent and patterned response to death. The Stiver Ranch burial sinkhole data set is an important addition to this emerging pattern. The results of this work, and the work completed at the other mortuary sites discussed herein show that the importance of bioarchaeological analysis in sites with mortuary components cannot be overstated.

APPENDIX A:

COMPLETE BONE INVENTORY

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
Lo		tibia	?	m1/3	2	1		A				
Lo		tibia	L	m1/3	2	1		A				
Lo		tibia	R	pe	2	1		A				
Lo		tibia	L	pe	3	1		A				
Lo		tibia	?	?	2	1		A				
Lo		tibia	?	m1/3	2	1		A				
Lo		tibia	L	p1/3	2	1		A				
Lo		fibula	R	m1/3	1	1		A				
Lo		fibula	R	d1/3	2	1		A				
Lo		fibula	R	d1/3	2	1		A				
Lo		ulna	L	m1/3	1	1		A				
Lo		humerus	?	m1/3	2	1		A				
Lo		humerus	L	d1/3	1	1		A				
Lo		humerus	L	m1/3	2	1		A				
Lo		humerus	R	m1/3	1	1		A				
Lo		humerus	L	p1/3	2	1		A				
Lo		humerus	R	m1/3	2	1		A				
Lo		humerus	L	p1/3	2	1		A				
Lo		humerus	?	pe	3	1		A				
Lo		femur	R	pe	3	1		A				
Lo		femur	R	m1/3	1	1		A				
Lo		femur	R	m1/3	1	1		A				
Lo		femur	L	pe	1	1		A				
Lo		femur	L	m1/3	2	1		A				
Lo		femur	R	m1/3	2	1		A				
Lo		femur	L	de	3	1		A				
Lo		femur	L	de	3	1		A				
Lo		femur	L	de	3	1		A				
Lo		femur	L	d1/3	3	1		A				
Lo		femur	L	de	3	1		A				
Lo		femur	L	de	3	1		A				
Lo		femur	R	de	3	1		A				
Lo		femur	L	m1/3	2	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
Lo		femur	?	m1/3	2	1		A				
Lo		femur	?	de	3	1		A				
Lo		femur	?	de	3	1		A				
Lo		femur	?	de	3	1		A				
Lo		femur	?	de	3	1		A				
Lo		femur	?	de	3	1		A				
Lo		femur	?	de	3	1		A				
Lo		femur	?	m1/3	2	1		A				
Lo		clavicle	L	lat 1/3	3	1		A				
Lo		clavicle	L	m1/3	1	1		A				
Lo		foot phalanx	?		1	1		A				
Lo		foot phalanx	?		1	1		A				
Lo		foot phalanx	?		1	1		A				
Lo		phalanx	?		1	1		A				
Lo		phalanx	?		1	1		A				
Lo		phalanx	?		1	1		A				
Lo		phalanx	?		1	1		A				
Lo		phalanx	?		1	1		A				
Lo		hand phalanx	?		1	1		A				
Lo		hand phalanx	?		1	1		A				
Lo		hand phalanx	?		1	1		A				
Lo		hand phalanx	?		1	1		A				
Lo		hand phalanx	?		1	1		A				
Lo		hand phalanx	?		1	1		A				
Lo		metacarpal	?		1	1		A				
Lo		metatarsal	?		2	1		A				
Lo		metatarsal 5	R		2	1		A				
Lo		metatarsal 2	R		1	1		A				
Lo		metatarsal 1	R		1	1		A				
Lo		metatarsal	?		1	1		A				
Lo		metatarsal	?		1	1		A				
Lo		metatarsal	?		1	1		A				
Lo		calcaneus	L		1	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
Lo		navicular	R		1	1		A				
Lo		unid. Tarsal	?		2	1		A				
Lo		innominate	L		3	1		A				
Lo		scapula	?		3	1		A				
Lo		scapula	?		3	1		A				
Lo		scapula	L		2	1		A				
Lo		maxilla	L	palate	1	1		A				
Lo		maxilla	R	posterior	2	1		A				
Lo		maxilla	R	orbit	2	1		A				
Lo		maxilla	?		3	1		A				
Lo		mandible	L		1	1		A				
Lo		mandible	L		1	1		A				
Lo		mandible	L		1	1		A				
Lo		mandible	R		2	1		A				
Lo		mandible	R		2	1		A				
Lo		mandible	R		2	1		A				
Lo		mandible	L		2	1		A				
Lo		mandible	R		3	1		A				
Lo		temporal	R		3	1		A				
Lo		temporal	L		2	1		A				
Lo		temporal	R		3	1		A				
Lo		temporal	R		2	1		A			F?	
Lo		temporal	?		2	1		A				
Lo		temporal	R		2	1		A			M?	
Lo		frontal	?		1	1		A			M?	
Lo		frontal	?		3	1		A				
Lo		occipital			2	1		A				
Lo		occipital			2	1		A				
Lo		occipital			3	1		A				
Lo		parietal	R		2	1		A	mid. Adult	35+		
Lo		parietal	?		2	1		A				
Lo		parietal	?		2	1		A				
Lo		parietal	?		2	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
Lo		parietal	?		2	1		A				
Lo		parietal	?		2	1		A				
Lo		parietal	?		2	1		A				
Lo		parietal	?		2	1		A				
Lo		parietal	?		2	1		A				
Lo		parietal	?		2	1		A				
Lo		parietal	?		2	1		A				
Lo		parietal	?		2	1		A				
Lo		parietal	?		3	1		A				
Lo		parietal	?		3	1		A				
Lo		radius	?	m1/3	2	1		A				
Lo		radius	R	m1/3	2	1		S	child			
Lo		sphenoid			2	1		A				
Lo		rib	R		1	1		A				
Lo		rib	R		2	1		A				
Lo		rib	L		2	1		A				
Lo		rib	L		2	1		A				
Lo		rib	R		2	1		A				
Lo		rib	R		2	1		A				
Lo		rib	?		3	1		A				
Lo		rib	?		3	1		A				
Lo		rib	?		3	1		A				
Lo		rib	?		3	1		A				
Lo		rib	?		3	1		A				
Lo		rib	?		3	1		A				
Lo		rib	?		3	1		A				
Lo		postrcranial frags.	?		3cm-10cm	128ct		A				
Lo		postrcranial frags.	?		2cm-5cm	99ct		A				
Lo		cranial frags.	?		2cm-5cm	42ct		S	Infant	0-2yrs		
Lo		cranial frags.	?		2cm-5cm	101ct		A				
Lo		cranial frags.	?		<1cm	x	7g	A				
OSC		clavicle	R		1	1		A				
OSC		clavicle	L		2	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
OSC		scapula	R		2	1		A				
OSC		skull			1	1		A	Young ad.	20-35yrs	F	dental pathology
OSC		cervical vertebra	NA		1	1		A				
OSC		cervical vertebra	NA		2	1		A				
OSC		cervical vertebra	B		1	1		A				
OSC		cervical vert. #7			1	1		A				
OSC		atlas			1	1		A				
OSC		thoracic vert.			1	1		A				
OSC		thoracic vert.			1	1		A				
OSC		thoracic vert.	NA		2	1		A				
OSC		mandible			1	1		A	Mid ad.	35 +	F?	am toothloss
OSC		femur	L	m1/3	1	1		A			F?	
OSC		femur	R	m1/3	1	1		A			F?	periostitis
OSC		femur	R	m1/3	1	1		A			M?	
OSC		femur	L	m1/3	1	1		A			F?	
OSC		femur	L	m1/3	1	1		A			M?	
OSC		femur	R	d1/3-de	1	1		A			F?	
OSC		femur	L	d1/3-de	1	1		A			F?	
OSC		femur	R	d1/3	2	1		A				
OSC		femur	R	de	2	1		A				
OSC		femur	R	de	2	1		A				
OSC		femur	L	de	2	1		A				
OSC		femur	L	de	2	1		A				
OSC		femur	L	de	2	1		A				
OSC		femur	L	de	2	1		A				
OSC		femur	?	de	3	1		A				
OSC		femur	?	de	3	1		A				
OSC		femur	?	de	3	1		A				
OSC		femur	?	p1/3	2	1		A				
OSC		fibula	L	m1/3	1	1		A				
OSC		fibula	R	m1/3	1	1		A				
OSC		metacarpal 3	R		1	1		A				
OSC		metacarpal 2	R		1	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
OSC		metacarpal	R		1	1		A				
OSC		metacarpal	?		1	1		A				
OSC		metacarpal	?		2	1		A				
OSC		tibia	L	m1/3	1	1		A			F?	
OSC		tibia	L	m1/3	1	1		A			F?	
OSC		tibia	L	p1/3	2	1		A			M?	
OSC		tibia	?	m1/3	3	1		A				
OSC		tibia	R	p1/3	1	1		A				osteitis w/ depression
OSC		tibia	R	m1/3	1	1		A			M?	
OSC		tibia	R	m1/3	1	1		A			F?	
OSC		tibia	R	m1/3	1	1		A			F?	
OSC		tibia	L	pe	2	1		A				
OSC		tibia	L	pe	2	1		A				
OSC		tibia	?	pe	3	1		A				
OSC		tibia	?	m1/3	3	1		A				
OSC		humerus	R	d1/3	1	1		A			M?	
OSC		humerus	L	d1/3	1	1		A			M?	
OSC		humerus	R	d1/3	3	1		A				
OSC		calcaneus	R		3	1		A				
OSC		medial cuneiform	?		2	1		A				
OSC		long bone frag.	?		2 and 3	22ct		A				
OSC		postcranial frag.	?		<3cm	20ct		A				
N2	A015	hamate	R		1	1		A				
N2	A013	fibula	?		3	1		A				
N2	A014	metacarpal	L		1	1		A				
N2	A016	ulna	R		3	1		A				
N2	A008	ulna	L		1	1		A				
N2	A009	tibia	L		1	1		A			F?	
N2	A025	humerus	L		3	1		A				
N2	A010a	humerus	R	m1/3-d1/3	2	1		A			M?	
N2	A010b	humerus	R	p1/3-m1/3	2	1		A			F?	
N2	A004	humerus	R	d1/3	3	1		A				arthritis
N2	A004	humerus	?	d1/3	3	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
N2	A004	humerus	R	d1/3	3	1		A				
N2	A006	femur	?	d1/3	3	1		A				
N2	A006	postcranial frags.	?		3	6ct		A				
N2	A004	long bone frags.	?		3	10ct		A				
N2	A005	long bone frags.	?		3	3ct		A				
N3	A060	cranial fragments	?		3	1		A				
N3	A088	cranial fragments	?		3	1		A				
N3	A052	cranial fragments	?		3	1		A				
N3	A106	mandible	L		3	1		A				
N3	A081	mandible	R	coronoid	2	1		A				
N3	A054	clavicle	R		2	1		A				
N3	A095	clavicle	L		1	1		A				
N3	A075	clavicle	R		1	1		A				
N3	A085/101	scapula	L		2	1		A				
N3	A105	scapula	?		3	1		A				
N3	NO #	scapula frag.	?		3	1		A				
N3	A088	scapula	?	lat. Border	2	1		A				
N3	A088	scapula frag.	?		3	2ct		A				
N3	A106	humerus	?	p1/3	3	1		A				
N3	A051	humerus	?	pe	2	1		A				
N3	A094	humerus	?	pe	2	1		A				
N3	NO #	humerus	?	de	3	1		A				arthritis
N3	A050	ulna	?	m1/3	1	1		A				
N3	NO #	radius	?	pe	3	1		A				
N3	A088	radius	?	pe	3	1		A				
N3	A090	femur frag.	?		3	1		A				
N3	A090	femur frag.	?	d1/3	3	1		A				
N3	A090	femur	L	pe	2	1		A			F?	
N3	A062	femur	L	p1/3	2	1		A				
N3	A106	femur	?	d1/3	3	1		A				
N3	A106	femur	L	de	3	1		A				
N3	A106	femur	R	de	3	1		A				
N3	A082	femur	R	m1/3	2	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
N3	A104	femur	L	p1/3	1	1		A			F?	
N3	A069	femur	?	de	3	2ct		A				
N3	A088	femur	R	de	2	1		A				
N3	A088	femur frag.	?	m1/3	2	1		A				
N3	A065	patella	?		3	1		A				
N3	A087	patella	L		2	1		A				
N3	A090	tibia	R	p1/3	3	1		A				
N3	A105	tibia	?	pe	2	1		A				
N3	A088	tibia	L	de	3	1		A				
N3	A048	fibula	L	pe	2	1		A				
N3	A103	fibula	R	m1/3	1	1		A				
N3	A092	rib 3-12	L	pe	2	1		A				
N3	A092	rib 3-12	L	p1/3	2	1		A				
N3	A092	rib 3-12	?	m1/3	2	1		A				
N3	A070	rib 3-12	?	m1/3	3	1		A				
N3	A050	rib 3-12	?	m1/3	3	1		A				
N3	A086	rib 3-12	?	m1/3	3	5ct		A				
N3	A060	rib 3-12	R	vert. end	2	1		A				
N3	A105	rib #1	?	m1/3	2	1		A				
N3	A088	Axis frag.	?	dens	2	1		A				
N3	A097	Cervical vert. 3-6	?		1	1		A				
N3	A084	cervical vert. 3-7	M	NA	3	1		A				
N3	A053	cervical vert. 3-7	M	NA	3	1		A				
N3	A105	Atlas	M	NA	3	1		A				
N3	A088	Axis frag.	L	near dens	2	1		A				
N3	A097	Thoracic vert. 1-9	?	B	2	1		A				
N3	A097	Thoracic vert. 1-9	?	B	2	1		A				
N3	A097	Thoracic vert. 1-9	?	NA	2	1		A				
N3	A060	Thoracic vert.frag.	?	NA	3	1		A				
N3	A097	Thoracic vert.frag.	?		1	1		A				
N3	A097	Thoracic vert.frag.	?		1	1		A				
N3	A097	Thoracic vert.frag.	?	process	2	1		A				
N3	A084	Thoracic vert.frag.	M	NA	2	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
N3	A084	Thoracic vert.frag.	M	NA	2	1		A				
N3	A088	Thoracic vert.frag.	?	B	2	2ct		A				
N3	A084	Lumbar vert. frag	M	NA	2	1		A				
N3	A084	Lumbar vert. frag.	M	NA	2	1		A				
N3	A084	Lumbar vert. frag.	M	NA	2	1		A				
N3	A084	Lumbar vert. frag.	M	NA	2	1		A				
N3	A053	Lumbar vert. frag.	M	NA	3	1		A				
N3	A106	vertebrae frag.	?	B	3	3ct		A				
N3	A097	vertebrae frag.	?		3	2ct		A				
N3	A105	vertebrae frag.	?	NA	3	1		A				
N3	NO #	vertebrae frag.	?		3	3ct		A				
N3	A060	vertebrae frag.	?	B	3	1		A				
N3	A088	vertebrae frag.	?		3	3ct		A				
N3	A106	innominate: illium	?	acetab.	3	1		A				
N3	A165	innominate: illium	?	acetab.	3	1		A				
N3	A060	innominate: illium	?	acetab.	2	1		A				
N3	A060	innominate: illium	R	sciatic n.	2	2ct		A				
N3	A088	innominate: illium	?	illiac crest	3	1		A				
N3	A106	innominate: illium	L	acetab.	3	1		A				
N3	A102	innominate: illium	L		2	1		A				
N3	A091	innominate: ischium	L		2	1		A			F?	
N3	A060	innominate frag.	?		3	60ct	29g	A				
N3	A096	sacrum frag.	?		2	9ct	6g	A				
N3	A107	lunate	R		1	1		A				
N3	A107	capitate	R		1	1		A				
N3	A078	trapezium	R		1	1		A				
N3	A107	trapezium	R		1	1		A				arthritis
N3	A107	scaphoid	R		1	1		A				
N3	A107	triquetral	R		1	1		A				
N3	A106	metacarpal 1	R	pe	3	1						
N3	A107	metacarpal 1	R	m1/3	1	1						
N3	A106	metacarpal 2	R	pe	3	1						arthritis
N3	A066	metacarpal 4	R		1	1						

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
N3	A107	metacarpal 4	R		1	1						
N3	A107	metacarpal 5	R	pe-d1/3	1	1						
N3	A104	metacarpal	?	m1/3	2	1						
N3	A079	metacarpal	?	m1/3	2	1						
N3	A060	metacarpal	?	m1/3	2	1						
N3	NO #	metacarpal	?	de	3	1						
N3	A063	prox. Hand phalanx	?		1	1						
N3	A061	prox. Hand phalanx	?		1	3ct						
N3	A088	prox. Hand phalanx	?	de	2	1						
N3	A061	mid. Hand phalanx	?		1	3ct						
N3	A061	distal hand phalanx	?		1	1						
N3	A088	hand phalanx	?	m1/3	3	1						
N3	A072	navicular	R		2							
N3	A083	navicular	L		2							
N3	A060	talus	L		2	2ct						
N3	A088	talus frag.	?		2							
N3	A060	calcaneus	L		2							
N3	A064	cuboid	L		1							
N3	A083	cuneiform 1	L		1							
N3	A088	cuneiform ?	?		2							
N3	A055	tarsal frags.	?		3	12ct	5g					
N3	A059	metatarsal 1	L		1							
N3	A057	metatarsal 2	L		1							
N3	A088	metatarsal	L	pe	2							
N3	A074	metatarsal	?	de	2							
N3	A063	prox foot phal. 1	?		1							
N3	A088	prox foot phal 1.	?		1							
N3	A063	foot phalanx	?	d1/3	2							
N3	A062	long bone frags	?		3	2ct						
N3	A106	long bone frags	?		3	11ct						
N3	A088	long bone frags	?	m1/3	3							
N3	A060	long bone frags	?		3							
N3	A088	postcranial frags	?		3	12ct						

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
N3	A106	postcranial frags	?		3	19ct						
N3	A069	postcranial frags	?		3	8ct	5g					
N3	NO #	postcranial frags	?		3	80ct	15g					
N3	A088	postcranial frags	?		3	10ct						
N3	A088	postcranial frags	?		3	25ct	7g					
N3	A053	postcranial frags	?		3	15ct	3g					
N3	A058	postcranial frags	?		3	130ct	14g					
N3	A049	postcranial frags	?		3	24ct	6g					
N3	A105	postcranial frags	?		3	70ct	17g					
N4	A160	thoracic vertebra	?	C	2	2ct		A				
N4	A160	thoracic vertebra	?	NA	2	a		A				
N4	A160	cervical vert. frags.	?	C	3	4ct		A				
N4	A160	cervical vert. frags.	?	NA	3	2ct		A				
N4	A160	cervical vert 3-6	?	C and NA	2	1		A				
N4	A160	axis-dens only	?		2	1		A				
N4	A160	vertebrae-art.facet	?		3	4ct		A				
N4	A160	vertebral process	?		3	3ct		A				
N4	A160	lumbar vertebra 1-5	?	C	2	1		A				
N4	A160	lumbar vertebra 1-5	?	NA	2	1		A				
N4	A160	cervical vertebra 3-7	?		1	1		S	child	3-6yrs		
N4	A159	cranial fragments	?		3	3ct		S	infant			
N4	A160	cranial fragments	?		3	5ct		S	infant			
N4	A160	cranial fragments	?		3	3ct		A				
N4	A160	mandible fragments	?		2	1		S	child			
N4	A160	clavicle	L	m1/3	2	1		S	child			
N4	A160	clavicle	R	m1/3	2	1		A				
N4	A150	humerus	L		1	1		A			M?	
N4	A154/151	humerus	R	p1/3-de	1	1		A			M?	
N4	A151	humerus	R	pe	1	1		A				
N4	A152	ulna	?	p1/3	2	1		A				healed fracture
N4	A149	ulna	R	pe-p1/3	2	1		A				
N4	A160	ulna	L	p1/3	2	1		A				
N4	A153	radius	?	m1/3	2	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
N4	A165	femur	L	pe	2	1		A				arthritis
N4	A148	femur	?	pe	2	1		A				
N4	A160	femur	?	de	3	1		A				
N4	A160	tibia	?	pe	3	2ct		A				
N4	A155	fibula	L	m1/3	2	1		A				
N4	A160	fibula	?	m1/3	3	1		A				
N4	A160	fibula	R	pe	2	1		A				
N4	A160	rib 3-9 frag.	?	m1/3	2	9ct		A				
N4	A160	rib 3-9 frag.	?	vert. end	2	2ct		A				
N4	A160	rib 3-9 frag.	?	sternal	2	1		A	young adult	20-35yrs		
N4	A160	rib 3-9 frag.	?	sternal	2	1		A	young adult	20-35yrs		
N4	A160	rib #1 frag.	?	m1/3	2	1		A				
N4	A160	Innominate: Pubis	?		2	1		S	child	3-5yrs		
N4	A160	Innominate:Illium	?	sciatic n.	3	1		A				
N4	A160	sacrum frags.	?		3	7ct		A				
N4	A160	distal hand phalanx	?		1	6ct		A				
N4	A160	middle hand phalanx	?		1	4ct		A				
N4	A160	prox. Hand phalanx	?		1	6ct		A				
N4	A165	metacarpal	?	m1/3	2	1		A				
N4	A160	metacarpal	?	m1/3	2	1		A				
N4	A160	metacarpal 3	R		1	1		A				
N4	A160	metacarpal 3	R	not repeat	1	1		A				
N4	A160	metacarpal 2	L		1	1		A				healed fracture
N4	A160	pisiform	?		1	1		A				
N4	A160	trapezium	L		1	1		A				arthritis
N4	A160	trapezoid	L		1	1		A				arthritis
N4	A160	carpal	?		2	1		A				
N4	A160	phalanx	?		3	4ct		A				
N4	A165	talus	R		2	1		A				
N4	A160	talus	L		2	1		A				
N4	A160	talus	L	not repeat	2	1		A				
N4	A160	cuboid	L		2	1		A				
N4	A160	cuneiform	?		2	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
N4	A160	metatarsal 4	L		1	1		A				
N4	A160	metatarsal 4	L	not repeat	1	1		A				
N4	A160	metatarsal	?	m1/3	2	1		A				
N4	A160	prox foot phal. 1	?	m1/3	2	1		A				
N4	A160	prox foot phal.	?		1	1		A				
N4	A165	long bone frag.	?	?	3	6ct		A				
N4	A160	long bone frag.	?	m1/3	3	5ct		S	child			
N4	A160	long bone frag.	?	pe	2	2ct		S	child			
N4	A160	long bone frag.	?		3	7ct		A				
N4	A160	long bone epiphysis	?	unfused	1	1		S	child			
N4	A160	postcranial frags.	?		3	300ct	107g	A				
N5	A176	cranial frag.	?		3	1		S	infant			
N5	A193	cranial frag.	?		3	2ct		A				
N5	A193	cranial frag.	?		3	1		S	infant			
N5	A180	cranial frag.	?		3	1		S	infant			
N5	A193	parietal	?		3	1		A				
N5	A180	parietal	?		3	1		A				
N5	A180	occipital	?		3	1		A				
N5	A175	humerus	?	m1/3	2	1		A				
N5	A175	ulna	?	m1/3	2	2ct		A				
N5	A179	radius	?	d1/3	2	1		S	child			
N5	A180	radius	?	pe	1	2ct		A				arthritis
N5	A180	rib 3-10	?	m1/3	3	2ct		A				
N5	A180	rib 3-10	?	sternal	3	1		A				
N5	A180	rib 3-10	R	vertebral	3	1		A				
N5	A193	rib 3-10	?		3	1		A				
N5	A180	femur	?		3	1		A				
N5	A193	femur	?		3	2ct		A				
N5	A183	fibula	?		3	1		A				arthritis
N5	A180	lumbar vertebra	M	B	2	1		A				arthritis
N5	A180	lumbar vertebra	M	NA	3	1		A				
N5	A193	sacrum	M		3	1		A				
N5	A193	innominate frag.	?	acetab.	3	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
N5	A181	prox hand phalanx	?		1	1		S	child			
N5	A177	prox hand phal. 2	L		1	1		A				
N5	A180	distal hand phal.	?		1	1		A				
N5	A180	prox hand phal. 1	?		1	1		A				
N5	A180	trapezium	?		1	1		A				
N5	A180	triquetral	L		1	1		A				
N5	A193	mid. Hand phalanx	?		1	1		A				
N5	A193	prox. Foot phalanx	?	pe-d1/3	1	1		A				
N5	A193	mid. Foot phalanx	?		1	1		A				
N5	A180	prox. Foot phalanx	?		2	1		A				
N5	A180	talus	L		3	1		A				
N5	A192	postcranial frags	?		3	2ct		A				
N5	A193	postcranial frags	?		3	70ct	22g	A				
N5	A180	long bone frags.	?		3	19ct		A				
N6	A189	interm. Cuneiform	R		1	1		A				
N6	A189	rib 3-10 frag	L		3	1		A				
N6	A189	prox. Hand phalanx	?	d1/3	1	1		A				
N6	A189	postcranial frags	?		3	4ct		A				
N6	A185	metatarsal	?	m1/3	1	1c		S	child			
N6	A185	postcranial frags	?		3	11ct		A				
S2	A022	humerus	L	de-p1/3	1	1		A			F?	
S2	A020	ulna	?	m1/3	3	1		A				
S2	A028	metatarsal 4	L	pe-d1/3	2	1		A				
S2	A019	cuboid	R		1	1		A				
S2	A022	metatarsal 5	L	p1/3-d1/3	1	1		A				
S2	A024	cranial frags.	?	?	3	4ct		A				
S2	A021	prox. Hand phalanx	?	p1/3-de	2	1		A				
S3	A034	metacarpal 2	L	de-p1/3	1	1		A				
S3	A33	radius	L	m1/3-de	2	1		A				
S3	A035	cranial frag.	?		3	1		A				
S3	NO #	sacrum	?		3	1		A				
		*****A110 and A112**	**are**	**skulls******								
S4	A112	frontal	M		1	1		A			F?	healed PH +fracture

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
S4	A112	parietal	R		2	1		A				HealPH+fracture 3ct!
S4	A112	parietal	L		2	1		A				healed PH
S4	A112	cranial frags.	?		3	3ct		A				
S4	A110	frontal	M		2	1		A			M?	healed PH
S4	A110	temporal	R		3	1		A				
S4	A110	temporal	L		2(broke/refit)	2ct		A			M?	
S4	A110	occipital	M		3	1		A				
S4	A110	parietal	R		3	1		A				
S4	A110	parietal	L		3	2ct		A				
S4	A110	parietal frags.	?		3	15ct		A				
S4	A110	occipital frags.	?		3	9ct		A				
S4	A110	zygomatic	L		2	1		A				
S4	A110	sphenoid	?		3	3ct		A				
S4	A110	temporal frags.	?		3	1		A				
S4	A110	maxilla	R	orbit	2	1		A				
S4	A110	maxilla	L	alveolus	3	1		A				severe abscess
S4	A110	maxilla frags.	?		3	1		A				
S4	A110	cranial frags.	?		3	1	25g	A				
S4	NO #	cranial frags.	?		3	2ct		A				
S4	A131	cranial frags.	?		3	1		A				
S4	A135	cranial frags.	?		3	1		A				
S4	A131	mandible	R	coronoid	3	2ct.		A				
S4	A121	mandible//SAMPLE	R/M	body	2	1ct		A				
S4	A110	scapula	R		3	1		A				
S4	A135	scapula	L	glenoid	2	1		A				
S4	A135	scapula	L	acromion	3	1		A				
S4	A135	scapula	?	frags	3	4ct		A				
S4	A135	clavicle	L	lateral	2	1		A				
S4	A135	humerus//SAMPLE	R	d1/3-de	1	1		A			F?	arthritis
S4	A135	humerus	L	d1/3-de	1	1		A				
S4	A135	radius	R		1	1		A				healed fracture
S4	A135	radius	L	m1/3	1	1		A				
S4	A135	ulna	L	p1/3-pe	1	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
S4	A135	ulna	L	p1/3	1	1		A				
S4	A135	ulna	R	p1/3	1	1		A				
S4	A131	rib #3-9	?	m1/3	3	2ct		A				
S4	A131	rib #3-9	?	sternal	3	1		A				
S4	A135	rib #3-9	L	vertebral	2	3ct		A				
S4	A135	rib #11-12	R	vertebral	2	1		A				
S4	A135	rib #3-9	?	m1/3	3	1		A				
S4	A135	rib #3-9	?	sternal	3	1		A				infection
S4	A135	rib #3-9	?	m1/3	2	1		A				healing fracture
S4	A123	cervical vert. #7	M		1	1		A				
S4	A135	cervical vert #3-6	M		1	1		A				
S4	A135	cervical vert #3-6	M	NA	2	4ct		A				arthritis (1ct)
S4	A135	cervical vert #3-6	M	B	3	2ct		A				
S4	A135	thoracic vert. #7-12	M	NA	2	4ct		A				arthritis (2ct)
S4	A135	thoracic vert. #7-12	M	B	2	2ct		A				
S4	A123	thoracic vertebra	?	process	2	2ct		A				
S4	A135	lumbar vert. 4 or 5	M		1	1		A				arthritis
S4	A135	lumbar vert #1-4	M	NA	2	3ct		A				
S4	A135	lumbar vert #1-5	M	B	3	3ct		A				
S4	A135	vertebra frags	M	B	3	6ct		A				
S4	A135	vertebra frags	M	NA	3	4ct		A				
S4	A135	femur	R	de	2	1		A				
S4	A135	femur	R	pe	3	1		A				
S4	NO #	femur	?	pe	1	1		A				
S4	A119	femur	R	p1/3-d1/3	1	1		A			F?	
S4	A120	femur	L	p1/3-d1/3	1	1		A			F?	
S4	A117	femur	R	pe-m1/3	1	1		A				
S4	A108	femur	R	d1/3	1	1		A				
S4	A116	femur	R	d1/3	3(broke/refit)	2ct		A				
S4	A131	femur	L	p1/3	3	1		A				
S4	A131	femur	L	de	3	1		A				
S4	NO #	tibia	?	pe	3	1		A				
S4	A122	tibia	L	p1/3-m1/3	1	1		A			F?	

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
S4	A118	tibia	R	p1/3-m1/3	1	1		A			F?	
S4	A108	tibia	R	p1/3	1	1		A				
S4	A127	tibia	R	m1/3	3(broke/refit)	34ct		A				
S4	A132	tibia	L	pe-m1/3	2(broke/refit)	3ct		A				
S4	A132	tibia	?	?	3	20ct		A				
S4	A131	tibia	L	de	3	2ct		A				
S4	NO #	fibula	L	de	3	1		A				
S4	A124	fibula	R	p1/3-m1/3	1	1		A				
S4	A117	fibula	L	de-d1/3	1			A				
S4	A117	fibula	L	de-p1/3	1			A				periostitis
S4	A115	fibula	L	m1/3	2			A				
S4	A132	fibula	L	m1/3-de	2(broke/refit)	2ct		A				
S4	A131	fibula	?	?	3	4ct		A				
S4	A125	patella	L		1	1		A				arthritis
S4	A109	innominate:illium	R		2	1		A			F?	
S4	A109	innominate:ischium	R		1	1		A				
S4	NO #	innominate:pubis	L	sp.ramus	2	1		A				
S4	A135	innominate:illium	L	auricular	3	1		A	old adult	60+		
S4	A135	innominate:illium	R	auricular	2	1		A	old adult	50-59	M?	
S4	A135	innominate	R	acetab.	2(broke/refit)	3ct		A				
S4	A135	innominate	?	acetab.	2(broke/refit)	2ct		A				
S4	A135	innominate:pubis	R	sp.ramus	2	1		A				
S4	A135	innominate:illium	?	frags	3	7ct		A				
S4	NO #	capitate	R		1	1		A				
S4	A135	metacarpal 2 or 3	L	pe-m1/3	2	1		A				
S4	A135	metacarpal 1	L	pe-p1/3	2	1		A				
S4	A135	metacarpal	L	de	2	1		A				
S4	A135	metacarpal	?	m1/3-de	2	1		A				crush fracture
S4	A115	metacarpal 2	L		1	1		A				
S4	A115	distal hand phalanx	?		1	1		A				
S4	A135	prox. Hand phalanx	?	m1/3	2	3ct		A				
S4	A135	mid. Hand phalanx	?		2	1		A				
S4	NO #	distal hand phalanx	?		1	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
S4	NO #	mid. Hand phalanx	?		1	1		A				
S4	NO #	prox hand phal. 1	?	pe	2	1		A				
S4	NO #	metatarsal	?	p1/3	2	1		A				
S4	A135	metatarsal 2	R		2	1		A				
S4	A135	metatarsal	?	m1/3	2	1		A				
S4	A135	prox. Foot phalanx	?		1	1		A				abnormal shape
S4	NO #	calcaneus	L		2	1		A				
S4	A135	talus	L		2	1		A				
S4	A135	talus	?		3	2ct		A				
S4	A128	metatarsal 2	L		1	1		A				
S4	A128	metatarsal 3	R		1	1		A				
S4	A128	metatarsal 5	L		1	1		A				
S4	A128	prox Foot phalanx	?		1	1		A				
S4	A115	prox foot phal. 1	?		1	1		A				
S4	A115	metatarsal 5	R	de	3	1		A				
S4	A115	metatarsal 1	L	pe	2	1		A				
S4	A131	distal foot phalanx	?		1	1		A				
S4	A108	long bone frags.	?		3	3ct		A				
S4	A115	postcranial frags	?		3	13ct		A				
S4	A131	postcranial frags	?		3	80ct	25g	A				
S4	A135	postcranial frags	?		3	x	40g	A				
S4	A135	postcranial frags	?		3	35ct		A				
S4	NO #	postcranial frags	?		3	x	30g	A				
S5	A134	femur	L		1	1		A			M?	
S5	A137	tibia	R	p1/3-pe	1	1		A			M?	
S5	A147	ulna	L	m1/3-de	1	1		A				healed fracture
S5	A136	mandible	M		1	1		A			F?	
S5	A142	mid. Hand phalanx	?		1	1		A				
S5	A136	occipital frag.	?		3	1		A				
S5	A136	maxilla	?		3	3ct		A				
S5	A145	rib #3-9	?	m1/3	2	1		A				
S5	A145	rib #3-9	?	sternal	3	1		A	middle adult	35-50yrs		
S5	A145	capitate	L		1	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
S5	A145	trapezoid	L		1	1		A				
S5	A145	mid. Hand phalanx	?		1	1		A				
S5	A145	distal hand phalanx	?		1	1		A				
S5	A145	tibia	?	pe	2	1		A				
S5	A145	ulna	L	de	3	1		A				
S5	A145	postcranial frags	?		3	165ct		A				
S5	A144	ulna	R	pe	2	1		A				
S5	A144	prox. Foot phalanx	?		1	1		A				
S5	A144	prox. Foot phalanx	?		1	1		A				
S5	A144	prox. Foot phalanx	?		1	1		A				
S5	A144	cuneiform #?	?		2	1		A				
S5	A144	metatarsal 1	L	p1/3-pe	1	1		A				
S5	A144	metatarsal 4	R		1	1		A				
S5	A144	metatarsal 3	L		1	1		A				
S5	A144	metatarsal 5	R		1	1		A				
S5	A144	innominate:ischium	R	tuberos.	2	1		A				
S5	A144	postcranial frags	?		3	15ct		A				
S6	A170	atlas	M	facets	2(broke/refit)	2ct		A				
S6	A170	vertebra frags	?	NA	3	2ct		A				
S6	A167	lumbar vert. frags	?	NA	3	1		A				
S6	A167	thoracic vert. frags	?	NA	3	2ct		A				
S6	A170	rib #3-9	R	m1/3	3	2ct		A				
S6	A170	rib	?	m1/3	3	4ct		A				
S6	A167	rib #11-12	L	vertebral	3	1		A				
S6	A170	metacarpal	?	m1/3	3	1		A				
S6	A170	metacarpal	?	m1/3	3	1		A				
S6	A167	capitate	L		1	1		A				
S6	A167	mid. Hand phalanx	?	p1/3-de	2	1		A				
S6	A166	talus	L		1	1		A				
S6	A170	navicular	R		1	1		A				
S6	A170	talus frags	?		3	2ct		A				
S6	A170	metatarsal 5	R	pe-d1/3	1	1		A				
S6	A170	long bone frags.	?	m1/3	3	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
S6	A170	postcranial frags	?		3	22ct		A				
S6	A167	postcranial frags	?		3	15ct		A				
no #	A199	metatarsal 1	R		1	1		A				
S7	A206	talus	L		1	1		S	child	5-8yrs		
S7	A205	distal hand phal. 1	?		1	1		A				
S7	A205	prox. Hand phalanx	?		1	1		A				
S7	A207	1st rib	R		2	1		A				
S7	A207	long bone frag.	?	m1/3	3	1		A				
S7	A207	rib	?	sternal	3	1		A				
S7	A207	thoracic vert. frag	?	NA	3	1		A				
S7	A207	cranial frag.	?		3	1		A				
S7	A201	postcranial frags.	?		3	15ct		A				
S7	A201	cranial frag.	?		3	1		S	child			
S7	A201	axis	M	dens	1	1		A				
S7	A201	vertebra frag.	?	facet	3	1		A				
S7	A201	scaphoid	L		2	1		A				
NA4	A218	cranial frags.	?		3	4ct		A				
NA4	A226	cranial frags.	?		3	13ct		A				
NA4	A241	cranial frags.	?		3	8ct		A				
NA4	A226	cranial frags.	?		3	1		S	infant			
NA4	A226	cranial frags.	?		3	2ct		A				
NA4	A243	cranial frags.	?		3	2ct		A				
NA4	A243	cranial frags.	?		3	5ct		S	infant			
NA4	A227	cranial frags.	?		3	3ct		A				
NA4	A243	cranial frags.	?		3	1		A				
NA4	A211	cranial frags.	?		3	9ct		A				
NA4	A237	mandible frags.	L		3	1		S	child			
NA4	A243	mandible frags.	?		3(broke/refit)	4ct		S	infant			
NA4	A218	clavicle	?	m1/3	3	1		A				
NA4	A241	clavicle	?	m1/3	2	1		S				
NA4	A226	clavicle	?		2	1		S	infant			
NA4	A227	clavicle	?	sternal	2	1		A	child			
NA4	A226	rib frags.	?	m1/3	3	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
NA4	A243	rib frags.	?	m1/3	3	2		A				
NA4	A243	rib frags.	?		3	8ct		S	child			
NA4	A227	rib frags.	?	m1/3-ster.	2	8ct		S	child			
NA4	A227	rib frags.	R	vertebral	2	1		S	child			
NA4	A227	rib frags.	L	vertebral	2	1		S	child			
NA4	A227	rib #1	L		2	1		S	child			
NA4	A240	rib #?	?	m1/3	2	1		S	child			
NA4	A223	rib frags.	?	m1/3	2	4ct		A				
NA4	A219	rib frags.	?	m1/3	3	3ct		A				
NA4	A243	rib frags.	?	m1/3	2	4ct		S	child			
NA4	A223	rib #3-10	L	m1/3-ver	1	1		A				
NA4	A223	rib #3-10	R	vertebral	2	1		A				
NA4	A218	rib frags.	?	m1/3	3	9ct		S	child			
NA4	A218	rib	L	pe	3	1		S	child			
NA4	A226	rib frags.	?	m1/3	3	3ct		A				
NA4	A226	rib frags.	?	m1/3-ver	2	4ct		S	child			
NA4	A226	rib frags.	?	vertebral	2	1		S	infant			
NA4	A227	cervical vert #3-6	?	B	2	1		A				
NA4	A227	vertebra frag.	?	facet	3	2ct		A				
NA4	A243	cervical vert #3-6	?		1	1		S	child			
NA4	A226	cervical vertebra	?	B only	1	1		S	child	3-8yrs		
NA4	A209	humerus	R	m1/3-de	2	1		A			M?	
NA4	A226	humerus	?	pe	3	1		A				
NA4	A226	radius	L	m1/3	2	1		A				
NA4	A241	radius	?	m1/3	2	1		A				
NA4	A210	radius	L	d1/3-de	2	1		A				
NA4	A226	radius	L		1	1		S	infant			
NA4	A243	radius	?	pe	2	1		A				
NA4	A227	ulna	R	d1/3-de	2	1		A				
NA4	A227	patella	R		1	1		A				
NA4	A226	femur frag.	?	d1/3	3	1		A				
NA4	A243	femur epiphysis	?		2	1		S	child			
NA4	A226	epiphysis(fem/hum)	?		3	1		S	child			

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
NA4	A226	tibia	?	p1/3-pe	2	1		S	infant			
NA4	A225	tibia	R	m1/3	2	1		S	child			
NA4	A227	fibula	?	d1/3	2	1		A				
NA4	A237	innominate	?	acetab.	3	1		A				
NA4	A226	innominate:ischium	R	unfused	1	1		S	child			
NA4	A243	innominate:illium	R		2	1		S	child			
NA4	A243	innominate:illium	?	crest	2	1		S	child			
NA4	A218	metatarsal 3	R		1			A				
NA4	A218	metatarsal	?	pe	2			A				
NA4	A218	metatarsal	?	pe	3			A				
NA4	A218	metatarsal	?	m1/3	3			A				
NA4	A226	metatarsal	?	de	3			A				
NA4	A238	navicular	L		1			A				
NA4	A243	cuboid	L		1			A				
NA4	A243	metatarsal 5	L	pe-p1/3	1			A				
NA4	A226	cuneiform #?	?		3			A				
NA4	A218	foot phalanx	?		1			A				
NA4	A241	distal foot phal. 1	?		1			A				
NA4	A226	foot phalanges	?		1	2ct		A				
NA4	A241	foot phalanx	?	pe	2			A				
NA4	A242	prox. Foot phalanx	?		1			A				arthritis
NA4	A243	foot phalanx	?		1			A				
NA4	A218	hand or foot phal.	?		2			A				
NA4	A226	distal hand phalanx	?		1			A				
NA4	A226	metacarpal	?		1			S	infant			
NA4	A226	mid. Hand phalanx	?	m1/3	2			A				
NA4	A227	metacarpal	?	pe	2			A				
NA4	A241	distal hand phalanx	?		1	1		A				
NA4	A218	long bone frags	?		3			A				
NA4	A218	long bone frags	?		2	11ct		A				
NA4	A241	long bone frags	?		3	2ct		S	child			
NA4	A226	long bone frags	?		3	3ct		A				
NA4	A227	epiphysis unident.	?		1	3ct		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
NA4	A218	postcranial frags	?		3	140ct	70g	A				
NA4	A226	postcranial frags.	?		3	170ct	65g	A				
NA4	A227	postcranial frags	?		3	100ct	43g	A				
NA4	A218	postcranial frags.	?		3	9ct		A				
NA4	A226	postcranial frags	?		3	26ct		A				
NA4	A243	postcranial frags.	?		3	20ct		A				
NA4	A227	postcranial frags	?		3	10ct		A				
NA4	A243	postcranial frags.	?		3	10ct		A				
NA4	A243	long bone frag	?	m1/3	2	1		S	infant			
NA4	A243	long bone frag.	?	de	2	1		S	infant			
NA5	A262	cervical vert.	?	B	2	1		S	child	6-8yrs		
NA5	A262	rib	?		2	1		S	child			
NA5	A262	rib	L	vertebral	2	1		A				
NA5	A262	long bone frag.	?		2	1		S	child			
NA5	A262	prox. Foot phalanx	?		1	1		A				
NA5	A262	postcranial frags.	?		3	21ct		A				
NA5	A260	innominate:ischium	L		1	1		S	child			
NA5	A264	postcranial frags.	?		3	19ct		A				
NA5	A264	rib	?	m1/3	2	1		S	child			
NA5	A264	rib	?	vertebral	3	1		S	child			
NA5	A256	innominate:pubis	R		2	1		A	young adult	15-35		
NA5	A256	postcranial frags.	?		2	2ct		A				
NA5	A217	postcranial frags.	?		3	x	109g	A				
NA5	A259	thoracic vert.	?	NA	2	1		S	infant			
NA5	A259	thoracic vert.	?	NA	3	1		S	infant			
NA5	A259	maxilla frag.	?	socket	3	1		A				
NA5	A298	postcranial frags.	?		3	8ct		A				
NA5	A298	humerus	R	de	2	1		S	child	6-8yrs		
NA5	A298	atlas	R	facets	2	1		S	child			
NA5	A295	rib frag.	?	m1/3	3	1		A				
NA5	A295	postcranial frags.	?		3	11ct		A				
NA5	A295	cranial frags.	?		2	2ct		S	infant			
NA5	A295	metacarpal	?	pe-p1/3	2	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
NA5	A295	thoracic vert.	?	B	1	1		S	child	6-8yrs		
NA5	A295	radius	R	pe-d1/3	1	1		S	infant			
NA5	A295	tibia	L	pe-d1/3	1	1		S	infant			
NA5	A257	cranial frags.	?		3	1		S	child			
NA5	A257	postcranial frags.	?		3	25ct		S	child			
NA5	A257	rib	?	m1/3	2	1		S	child			
NA5	A257	rib	?	sternal	2	1		S	infant			
NA5	A257	humerus epiphysis	?	unfused	1	1		S	child	6-8yrs		
NA5	A217	cranial frags.	?		3	4ct		S	child			
NA5	A217	cranial frags.	?		3	5ct		A				
NA5	A217	long bone frag.	?		3	6ct		A				
NA5	A217	rib frag.	?		3	4ct		S	child			
NA5	A217	rib frag.	?		3	1		S	child			
NA5	A217	rib frag.	L	sternal	2	1		S	infant			
NA5	A217	rib frag.	R	sternal	2	1		S	infant			
NA5	A217	scaphoid	L		1	1		A				
NA5	A217	pisiform	?		1	1		A				
NA5	A217	innominate:ischium	L		2	1		S	infant			
NA5	A263	prox hand phalanx	?		1	1		A				
NA5	A263	longbone epiphys.	?		3	1		A				
NA5	A263	postcranial frags.	?		3	3ct		A				
NA5	A263	rib frag.	?	m1/3	3	2ct		A				
NA5	A263	rib frag.	?	sternal	2	1		A/S	young adult	16-35		
NA5	A217	postcranial frags.	?		3	10ct		A				
NA5	A217	vertebral frag	?	NA	3	3ct		A				
NA5	A217	vertebral frag	?	B	3	1		A				
NA5	A217	cervical vert.	?	B	2	1		S	child	6-8yrs		
NA5	A217	thor/lumbar vert.	?	B	1	1		S	child	6-8yrs		
NA5	A217	talus	?		3	1		?				
SA5-SW	A250	prox. Hand phalanx	?	p1/3-de	2	1		A				
SA5-SW	A250	postcranial frags	?		3	4ct		A				
SA5-SW	A250	rib frag.	?		3	1		A				
SA5-SW	A250	metacarpal 3	R		2	1		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
SA5-SW	A250	metacarpal	?		2	1		A				
SA5-SW	A250	postcranial frag	?		2	1		A				
SA5-SW	A250	postcranial frags	?		3 (<1cm)	15ct		A				
SA5-SW	A250	femur	?	de	3	1		A				arthritis
SA5	A217	innominate:illium	?		3	1		A				
SA5	A217	femur	?	de	3	1		A				
SA5	A217	postcranial frags	?		3	1		A				
SA6	A236	cranial frag.	?		3	1		S	child			
SA6	A232	cranial frag.	?		3	1		S	child			
SA6	A222	parietal	L		2	1		A				
SA6	A232	long bone frag.	?	m1/3	3	4ct		A				
SA6	A232	postcranial frag.	?		3	1		A				
SA6	A222	cranial frag.	?		3	2ct		A				
SA6	A232	rib #3-9	?	sternal	3	1		A	young adult	15-35yrs		healing fracture
SA6	NO #	postcranial frag.	?		3	26ct		A				
SA6	A235	postcranial frag.	?		3	1ct		A				
SA6-SW	A232	postcranial frag.	?		3	37ct		A				
SA6-SW	A232	long bone frag.	?		2	6ct		A				
SA6-SW	A232	radius	?	d1/3	1	1		A				
SA7	A291	postcranial frags	?		3	17ct		A				
SA7	A291	cranial frag.	?		3	1		A				
SA7	A291	vertebra frag.	M	B	3	1		A				
SA7	A246	postcranial frags	?		3	9ct		A				
SA7	A246	long bone frag.	?	m1/3	3	1		A				
SA7	A246	rib #3-9	?	sternal	2	1		S	child/adol.	<17yrs		
SA7	A290	postcranial frags	?		3	10ct		A				
SA7	A290	cervical vert. #3-6	M	B/NA	2	1		A				
SA7	A290	possible pisiform	?		1	1		?				
SA7	A290	hand phalange	?	pe	3	1		A				
SA7	A265	radius	L	d1/3	2	1		A/S	child/adol.			
SA7	A265	navicular	R		1	1		A				
SA8	A302	prox hand phal. 1	?		1	1		A				
SA8	A302	postcranial frags	?		3	8ct		A				

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
SA8	A301	postcranial frags	?		3 (<1cm)	3ct		A				
SA8	A296	mandible	L	body	2	1		A				
SA8	A296	thoracic vert. frag.	?		3	1		A				
WW	A244	long bone frags	?	m1/3	3	1		A				
WW	A245	mandible	L	condyle	2	1		A				
WW	A249	metatarsal 3	R	de-p1/3	1	1		A				
C	A275	prox. Foot phal. 1	?		1	1		A				
C	A275	prox. Hand phal. 1	?		1	1		A				
C	A275	mid. Foot phalanx	?		1	1		A				
C	A275	prox. Hand phalanx	?	m1/3	2	1		A				
C	A275	mid. Hand phalanx	?	pe-d1/3	1	1		A				
C	A275	mid foot phalanx	?	m1/3	2	1		A				
C	A275	mid hand phalanx	?	m1/3	3	1		A				
C	A275	metatarsal	?	d1/3	2	1		A				
C	A275	metacarpal 2	L	de-p1/3	1	1		A				
C	A275	metatarsal 4	R	de-p1/3	1	1		A				
C	A275	postcranial frags	?		3	100ct		A				
C	A279	femur	?	m1/3	2	1		A				
C	A279	femur	?	m1/3	2	1		A				
C	A279	humerus	?	m1/3	3	1		A/S				
C	A279	cervical vert. #7	?		1	1		A				
C	A279	femur	?	d1/3	3	1		A				
C	A279	radius	?	pe-d1/3	3	1		A				
C	A279	vertebra frags.	?	B	3	1		A				
C	A279	cervical vert.	M	NA	2	1		S	infant			
C	A279	rib #3-9	?	m1/3	2	1		S	child			
C	A279	cuneiform 1	R		2	1		A				
C	A279	prox. Foot phalanx	?		1	2ct		A				
C	A279	mid. Hand phalanx	?		1	1		A				
C	A279	prox. Hand phalanx	?	m1/3	1	1		A				
C	A279	prox. Hand phal. 1	?	pe-d1/3	1	1		A				
C	A279	metacarpal 1	?	p1/3-de	2	1		A				
C	A279	metatarsal 5	L		1	1		S	child			

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
C	A279	cranial frags	?		3	3ct		A				
C	A279	frontal	R	browridge	2	1		A				
C	A279	zygomatic	L	foramen	2	1		A				
C	A279	postcranial frags	?		3	60ct		A				
C	A277	mandible//sample	R	body	1	1		A				
C	A277	maxilla (match 277)	R	w/incisors	1	1		A				
C	A279	humerus	R	p1/3-m1/3	2	1		A				
C	A273	long bone frags.	?		3	3ct		A				
C	A276	calcaneus	L		2	1		A				
C	A274	long bone frags.	?		3	4ct		A				
C	A272	humerus	?	m1/3	2	1		A				
C	A280	cranial frags	?		3	2ct		A				
C	A280	innominate:illium	R		2	1		S	infant			
C	A280	cervical vertebra	M		1	1		S	child			
C	A280	thoracic vertebra	M	B/unfused	1	1		S	child			
C	A280	rib #3-9	?	m1/3	3	4ct		S	child			
C	A280	rib #3-9	?	m1/3	3	1		A				
C	A280	prox. Hand phalanx	?	m1/3-de	2	1		A				
C	A280	prox. Hand phalanx	?	m1/3	2	1		A				
C	A280	metatarsal	?	m1/3	2	1		A				
C	A280	metacarpal	?	m1/3	2	1		A				
C	A280	mid. Hand phalanx	?	pe-d1/3	1	1		A				
C	A280	ulna	?	d1/3	3	1		A				
C	A280	long bone frags.	?		3	19ct		A				
C	A280	postcranial frags	?		3	23ct		A				
C	A278	zygomatic	R		2	1ct		A				
C	A278	mandible	L	gonial	2	1		A				
C	A278	mandible	L	alveolus	2	1		A				
C	A278	mandible frag.	?		3	1		A				
C	A278	mandible frag.	?	ramus	3	1		A				
C	A278	maxilla	?	alveolus	3	4ct		A				
C	A278	cranial frags	?		3	2ct		A				
C	A278	cranial frags	?		3	1		S	child			

Appendix A: Complete Bone Inventory

Location	Catalog #	Bone	Side	Segment	Completeness	Ct	Wt	Age	Age 2	Age 3	Sex	Pathology
C	A278	frontal	R	browridge	3	1		A				active porotic hyp.
C	A278	rib #3-9	?	m1/3	3	1		A				
C	A278	temporal	?	mastoid	3	2ct		A				
C	A278	trapezium	L		2	1		A				
C	A278	cuneiform inter.	R		3	1		A				
C	A278	postcranial frags	?		3	25ct		A				
C	A278	long bone frag.	?	m1/3	2	1		S	infant			
C	A275	cranial frags	?		3	5ct		A				
C	A275	cranial frags	?		3	2ct		S	child			
C	A275	lumbar vertebra	?	NA	2	1		A				
C	A275	mandible	?	ramus	3	1		A				
C	A275	rib #5-7	R	vertebral	2	1		A				
C	A275	rib #3-12	?	m1/3	3	1		A				
C	A275	rib #1	?	m1/3	3	1		A				

Appendix A: Complete Bone Inventory

APPENDIX B:

COMPLETE DENTAL INVENTORY

Location	Catalog #	Tooth	Side	Attrition	calculus	caries	leh	M-D dia	B-L dia	Crown ht	comment
C	A280	Maxillary Molar 2	L	14 (2.3.4.5)	0	0	0	10.02	12.64	7.87	encrustation
C	A275	Maxillary molar 3	L	7 (1.2.2.2)	0	0	0	9.32	12.71	6.12	
C	A275	Maxillary molar 3	R	4 (1.1.1.1)	n/a	0	0	n/a	n/a	7.41	
C	A275	Mandibular Molar 3	?	30 (5.7.9.9)	0	0	0	9.56	11.25	6.22	
C	A275	canine	?	6	0	0	0	6.5	6.25	5.34	
C	A277	Mandibular canine	L	3	0	0	1	6.96	5.99	8.94	
C	A277	Mandibular incisor	R	4	0	0	1	6	4.52	6.93	
C	A279	ant tooth root	?	8	0	0	0	6.58	8.26	0	
C	A277	Mandibular incisor	R	4	0	0	0	5	4.15	6.24	
C	A277	Mandibular incisor	L	4	0	0	0	4.93	5.23	5.8	
C	A277	mandibular canine	R	5	0	0	1	6.89	6.68	8.15	
C	A277	mandibular pm1	R	4	0	0	1	7.31	7.93	6.09	
C	A277	mandibular molar 1	R	28 (6.7.7.8)	0	0	0	12.46	11	5.25	*radiocarbon sample
C	A277	mandibular molar 2	R	18 (3.4.5.6)	1(ip)	0	0	11.86	10.81	5.39	*radiocarbon sample
C	A277	maxillary incisor 1	R	5	0	0	0	8.38	6.54	6.73	
C	A277	maxillary incisor 2	R	5	0	0	0	6.33	6.09	6.17	
C	A277	maxillary canine	R	5	0	0	1	7.07	8.07	7.26	
C	A277	maxillary premolar 1	R	5	0	0	1	5.93	9.64	6.65	
C	A277	maxillary premolar 2	R	5	0	0	0	6.77	9.72	6.08	
C	A277	maxillary molar 1	R	30 (8.8.7.7)	0	0	0	11.04	11.84	6.23	
C	A277	maxillary molar 1	L	29 (8.8.7.6)	0	0	0	10.32	12.66	6.22	
C	A275	maxillary molar 2	R	13 (2.3.3.5)	0	0	0	9.57	12.33	7.82	
N3	A099	anterior tooth	?	8	0	0	0	5.18	4.36	0	
N3	A099	anterior tooth	?	8	0	0	0	3.41	5.86	0	
N3	A099	anterior tooth	?	8	0	0	0	3.93	6.75	0	
N3	A099	premolar	?	7	0	0	0	4.07	7.1	2.33	
N3	A099	premolar	?	7	2	0	0	5.58	8.14	5.4	
N3	A073	maxillary molar 1 or 2	?	26(5.5.8.8)	1	0	0	11.29	12.57	6.19	
N4	A161	anterior tooth	?	8	0	0	0	4.56	9.54	0	
N4	A161	anterior tooth	?	8	0	0	0	5.95	8.5	0	
N4	A161	anterior tooth	?	8	0	0	0	4.93	7.99	0	
N4	A161	anterior tooth	?	7	1(b)	0	0	6.64	6.94	3.37	
N4	A161	anterior tooth	?	7	0	1 (b/ip)	0	5.12	7.6	2.11	carie=1 45mm x 2 38mm

Appendix B: Complete dental inventory--Adults

Location	Catalog #	Tooth	Side	Attrition	calculus	caries	leh	M-D dia	B-L dia	Crown ht	comment
N4	A161	premolar	?	7	0	0	0	5.7	8.13	2.87	
N4	A161	premolar	?	6	0	0	0	5.76	7.91	6.16	
N4	A161	anterior tooth	?	6	1(ip)	0	0	5.74	8	4.61	
N4	A161	maxillary molar 3	?	18 (4.4.5.5)	0	3	0	8.56	11.58	7.46	2sm caries,1 lrg carie=6 4x5 25
N4	A161	mandibular molar 1	L	29 (6.7.8.8)	0	0	0	12	11.8	6.05	ip grooving
N4	A161	maxillary canine	?	7	0	0	0	8.17	4.89	5.33	unusual wear
N5	A191	maxillar canine	L	1	0	0	0	6.39	5.04	8.81	
N5	A179	premolar	?	6	0	0	0	6.8	9.71	5.98	
N5	A173	mandibular molar 3	R	n/a calculs	2 (l,oc,b)	0	0	10.79	9.82	6.83	
NA4	none	mandibular molar 3	R	8 (2.2.2.2)	0	0	0	12.09	11.56	6.65	
NA4	A227	premolar	?	8	0	0	0	5.59	7.88	0	
NA4	A227	premolar	?	6	0	0	0	6.21	8.47	4.26	
NA4	A211	molar 1 or 2	?	28 (4.6.9.9)	0	0	0	11.29	11.74	5.19	
NA4	A211	mandibular molar 2	R	27 (4.8.7.8)	1 (b)	0	0	11.05	11.03	6.64	
NA4	A233	molar 1 or 2 crown	?	26 (5.5.8.8)	1 (b)	0	0	10.74	10.94	5.69	
NA4	A233	anterior tooth	?	7	1(b)	0	0	5.51	6.25	3.87	
NA4	A258	anterior tooth	?	8	0	0	0	6.05	4.99	0	
NA5	A217	anterior tooth	?	6	0	0	0	4.94	6.82	3.35	
NA5	A261	mandibular molar	?	36(8.9.9.10)	0	0	0	11.41	10.79	5.29	
NA5	A255	mandibular molar 1	?	36 (9.9.9.9)	0	0	0	8.38	10.06	2.43	
S4	A131	anterior tooth	?	8	0	0	0	4.04	8.38	0	
S4	A111	anterior tooth	?	7	0	0	0	5.97	8.31	2.5	
S4	none	mandibular molar 3	L	4(1.1.1.1)	1(ip)	0	0	8.88	11.32	7.1	
S4	none	anterior tooth	?	8	0	0	0	4.53	7.57	0	
S4	none	anterior tooth	?	8	0	0	0	4.02	8.2	0	
S4	none	molar root	?	40	0	0	0	na	na	0	
S4	none	molar root	?	40	0	0	0	na	na	0	
S4	none	molar root	?	40	0	0	0	na	na	0	
S4	A133	anterior tooth	?	6	0	0	0	6.56	8.91	4.43	
S4	A110	anterior tooth	?	7	0	0	0	6.15	9.33	0	
S4	A110	maxillary molar	?	34 (8.8.9.9)	0	0	0	10.85	12.61	5.09	
S4	A110	maxillary premolar 2	R	8	0	0	0	4.34	7.47	1.4	
S5	A138	maxillary anterior	?	8	0	0	0	4.72	7.2	0	sm abscess

Appendix B: Complete dental inventory--Adults

Location	Catalog #	Tooth	Side	Attrition	calculus	caries	leh	M-D dia	B-L dia	Crown ht	comment
S5	A139	maxillary molar	?	38(10.10.9.9)	0	0	0	11.36	4.7	4.52	occ wear unusual=12 84mm
S5	A136	mandibular canine	L	5	2(b,l)	0	0	5.83	6.63	5.41	A136=complete mandible,
S5	A136	mandibular incisor 2	L	6	2(b,l)	0	0	5	6.41	4.53	Mandible with Antemortem
S5	A136	mandibular incisor 1	L	8	0	0	0	3.33	5.19	0	tooth loss
S5	A136	mandibular premolar 1	L	6	2(b,l)	0	0	5.82	7.09	3.58	
S5	A136	mandibular premolar 2	L	6	2(b,l)	0	0	6.41	7.83	3.73	
S5	A136	mandibular molar 1	L	34 (8.8.9.9)	2(b,l)	0	0	9.35	10 8	3.64	
S5	A136	mandibular incisor 2	R	7	0	0	0	4.07	6.2	1.1	
S5	A136	mandibular canine	R	6	0	0	0	5.16	7.37	3.59	
S5	A136	anterior tooth	?	6	2(b,l)	0	0	4.96	7.24	3.76	
S6	A171	mandibular molar 1	R	30 (7.7.8.8)	0	1 (ip)	0	11.03	11.81	4.91	
S6	A171	anterior tooth root	?	8	0	0	0	7.14	7.84	0	unusual wear=9 34mm
SA8	A297	mandibular molar 2	L	16 (3.3.5.5)	1 (b)	0	0	10.97	11.65	6.14	carie=3mm x2 2mm
OSC	none	maxillary molar 1	R	33 (8.8.8.9)	3	0	0	9.77	12.09	7.7	
OSC	none	Maxillary molar 2	R	28 (8.8.6.6)	3	0	0	9.93	12.19	7	OSC=complete skull dentition,
OSC	none	maxillary premolar 1	R	8	1	0	0	4.33	8.26	2.82	antemortem tooth loss
OSC	none	maxillary canine	R	8	1	0	0	4.76	8.68	3.37	
OSC	none	maxillary incisor 1	R	7	1	0	0	6.17	6.31	2.29	
OSC	none	maxillary molar 2	L	n/a	0	0	0	7.06	8.87	n/a	deformed/dead tooth
OSC	none	mandibular premolar 1	L	6	1	0	0	6.33	7.88	3.21	
Lo	none	mandibular molar 1	R	30(7.7.8.8)	0	0	0	10.19	10.86	4.78	
Lo	none	mandibular molar 2	R	26(4.5.8.9)	0	0	0	11.09	11.4	5.31	
Lo	none	mandibular premolar 1	R	5	1	0	0	6.4	7.46	6.33	
Lo	none	mandibular premolar 2	R	5	1	0	0	7.05	8.24	5.35	
Lo	none	mandibular molar 1	L	30(7.7.8.8)	0	0	0	10.29	10.64	4.42	
Lo	none	mandibular premolar 1	L	5	1	0	0	6.38	7.44	6.43	
Lo	none	mandibular canine	L	6	0	0	0	7.26	8.44	7.14	
Lo	none	maxillary molar 2	R	15 (3.3.4.5)	0	0	0	10.03	11.71	6.62	
Lo	none	maxillary molar 3	R	8 (1.1.3.3)	0	0	0	10.13	11.89	7.37	
Lo	none	mandibular premolar 1	L	5	0	0	0	7.04	9.27	5.57	
Lo	none	maxillary molar 3	L	n/a	1	0	0	11.25	10.74	6.37	
Lo	none	mandibular molar 1	R	16(3.3.5.5)	0	0	0	11.42	11.97	6.38	
Lo	none	mandibular molar 3	?	40	0	0	0	8.1	7.81	1.36	

Appendix B: Complete dental inventory--Adults

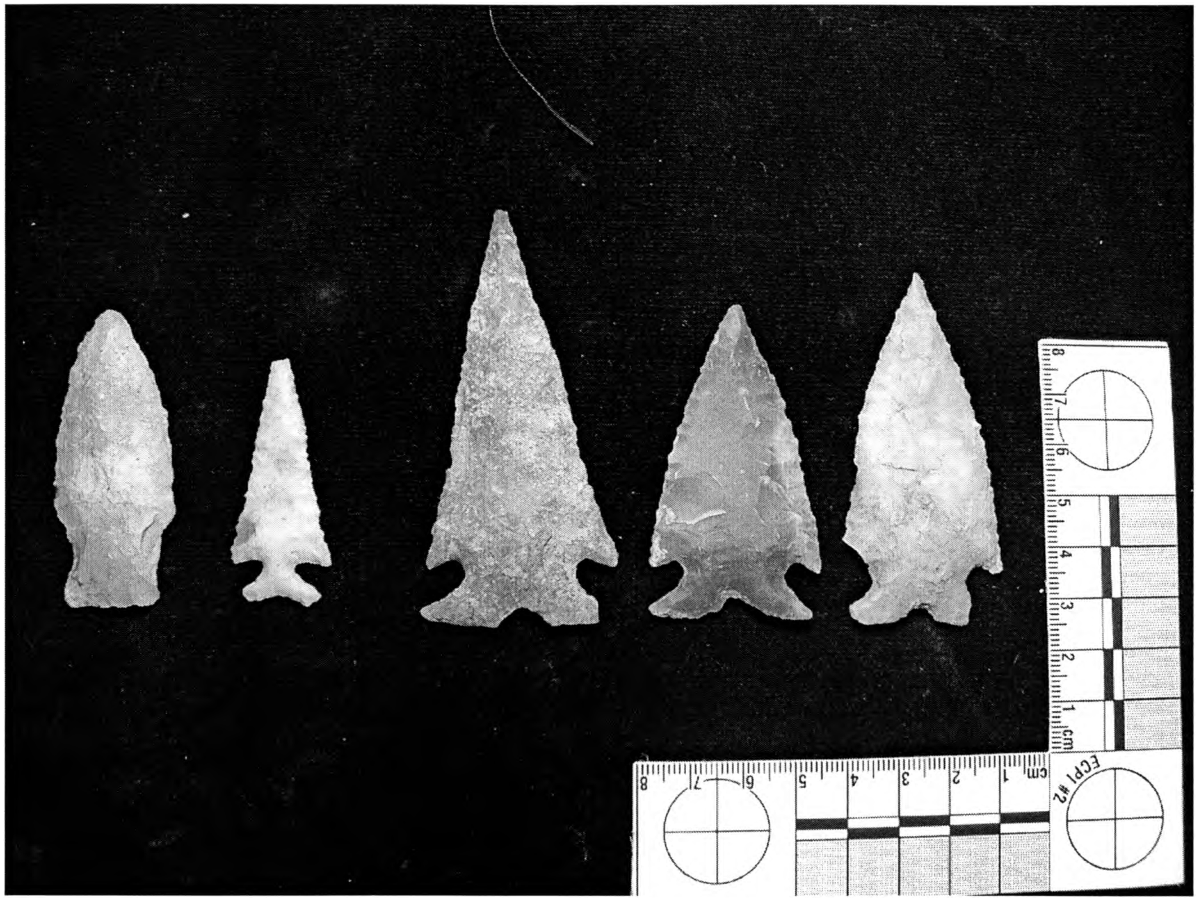
Location	Catalog #	Tooth	Side	Attrition	calculus	caries	leh	M-D dia	B-L dia	Crown ht	comment
Lo	none	maxillary molar 1	?	40	0	0	0	na	na	0	

Appendix B: Complete dental inventory--Adults

APPENDIX C:

ARTIFACTS FOUND WITHIN THE BURIAL SINKHOLE

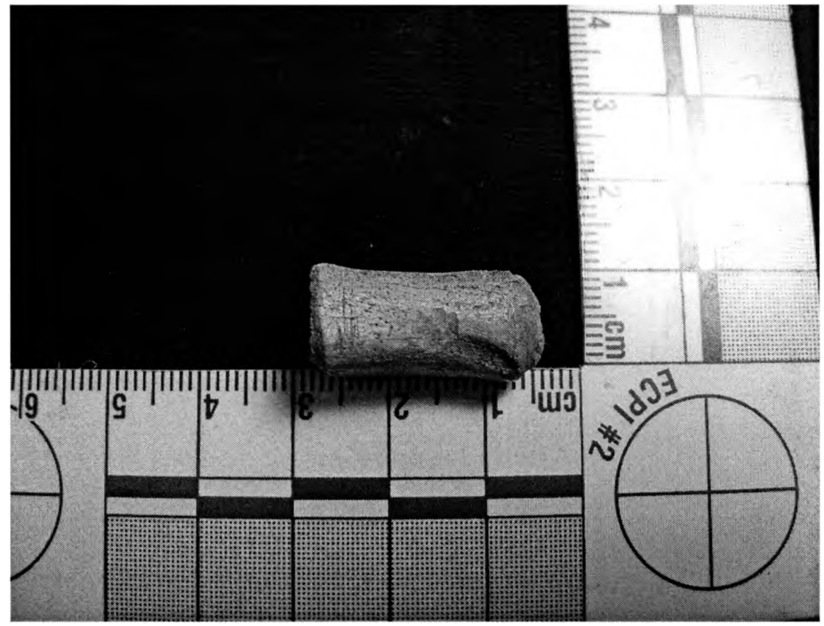
Appendix C: Artifacts found within the burial sinkhole



Artifacts uncovered during original excavation, from left to right: Travis/Nolan C-#A284, Edwards N5-#A178 (tip missing), Frio NA4-#A220, Frio C-#281, and Frio NA4-#221. Not shown: Edwards S4-#A126 is identical to A178, but tip is intact.

Appendix C: Artifacts found within the burial sinkhole

Artifacts unearthed by looters, including one biface and three Frio points



Bone bead found in Unit SA, Level 5 among human bones, bone may be human, but likely to be faunal

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