University of Alberta

A Zooarchaeological Analysis of a Late Precontact Bison Kill Site in the Bodo Sand Hills of Alberta

by

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ABSTRACT

The Bodo Archaeological Locality, located in east central Alberta, reveals human occupation and utilization of a sand dune environment during the last 3,000 years. Area 5, the 2 x 2 m study area of interest in this thesis, is a bed of bison bones and other artifacts that represent occupation during the Old Women's Phase of the Late Precontact Period.

In this thesis, a zooarchaeological approach is taken to study this faunal assemblage. This analysis suggests that Area 5 is a bison kill site, where at least 16 bison were killed and butchered, most likely in a single episode. Portions of bison that have high food value were recovered less frequently than those with low food value. Adult male and female bison, along with some calves appear to be present. The lack of fetal bone may suggest a summer/early fall site occupation, but dental cementum analyses suggests late fall/winter occupation.

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CHAPTER 1. INTRODUCTION

Bison hunting has occurred throughout the northwest Plains for more than 10,000 years, leaving its archaeological signature on the landscape in the form of bison faunal remains. The Late Precontact Period (approximately 1800 to 200 cal. years BP) on the northwest Plains boasts numerous bison kill sites, where ancient hunters undertook various methods of communal hunting, including the use of drive lanes, pounds, jumps, and ambushes. According to Reeves (1989:170), the "Northern Plains Bison Hunting Culture" reached its peak during the Late Precontact Period. Based on the overwhelming dominance of bison bone in archaeological sites in southern Alberta, southern Saskatchewan, Wyoming, and Montana, bison have been well established as the primary source of human subsistence here during the Late Precontact Period (Quigg 1978:53). Furthermore, archaeological, ethnographic, and historic records demonstrate that not only were bison critical food sources for the Indigenous inhabitants of the northwest Plains, but they were also an important source of raw materials for producing tools, clothing, items of adornment, and living structures. However, relatively few assemblages of faunal remains from bison kill sites have been examined in detail by archaeologists. Some exceptions include Frison (1970, 1974), Kehoe (1973), Reher (1970), Reher and Frison (1980), Brink and Dawe (1989), Shortt (1993), Tischer (2000), and Unfreed and Van Dyke (2005). These investigations demonstrate that faunal remains at kill sites can provide archaeologists with substantial information about people's interaction with bison on the northwest Plains. For example, examination of faunal remains at kill sites has revealed details about butchery patterns, carcass utilization, site seasonality, hunting strategies, and so on.

This thesis examines the Late Precontact use of bison on the northwest Plains as manifested in the faunal remains from Area 5 of the Bodo Archaeological Locality (this locality includes Borden site numbers FaOm-1 and FaOm-22). I will address the following research questions in this thesis using the bison faunal assemblage from Area 5:

1) Was Area 5 a bison kill site or some other sort of habitation site where bison were being utilized?
2) How were bison processed at the site? What were the butchery techniques and body part transportation decisions made at the site?
3) What was the age and sex profile of the sample population from the site?
4) What was the season of site occupation?
5) What were the hunting strategies employed at the site?

In order to answer the above questions, this examination employs a number of zooarchaeological techniques to quantify and describe the bison faunal remains from Area 5. This zooarchaeological analysis provides an opportunity to investigate bison utilization strategies during the Late Precontact period on the northwest Plains.

The topics of the chapters of this thesis are as follows. Chapter two discusses the environmental and cultural-historical setting of the site. Chapter three discusses the archaeology of Area 5 including site discovery and excavation, field methodology, stratigraphy, site chronology, and cultural material recovered. Chapter four is an overview of the bison faunal remains from Area 5. A primary goal here was to determine if Area 5 represents a bison kill site versus some other sort of habitation within which bison were utilized. In this chapter faunal material is quantified and a detailed description of each element is provided in terms of portions recovered. An emphasis is placed on interpreting butchering techniques and transport decisions. Also included is a brief examination of potential taphonomic factors at work at the site. Chapter five explores the bison remains in terms of the age and sex composition of the sample population, and a discussion of the season of site occupation is presented. Chapter six discusses the information presented in the previous chapters. In addition, I evaluate possible hunting strategies employed by the site inhabitants. I also discuss the possibility of an associated processing site near Area 5. Chapter seven concludes the thesis with the postulation of future zooarchaeological research questions of relevance to the Bodo Archaeological Locality, as well as possible directions for future bison kill site studies on the Plains.

CHAPTER 2: BACKGROUND

In the spring and summer of 2000 Alberta Western Heritage Inc. was commissioned by Murphy Oil Company Ltd. to undertake an archaeological assessment of four well pad localities within the boundaries of an existing archaeological site (Borden site number FaOm-1). This assessment resulted in the discovery and excavation of a dense concentration of bison remains and other cultural material on one part of an existing but abandoned well pad located on LSD 10 of Section 32-36-1 W4M, henceforward referred to as pad # 10-32. A crew from Alberta Western Heritage Inc., under the direction of Dr. Terry Gibson, undertook the assessment and subsequent excavation of this site, now known as Area 5. The Area 5 excavation was 2 x 2 m square in size, revealing a portion of a dense bone bed of bison remains that are likely part of a much larger site (Pers. Comm. Gibson 2006).

Area 5 is an archaeological locality located in a complex of archaeological activity areas that are encompassed by two major archaeological sites, FaOm-1 and FaOm-22 (collectively referred to as the 'Bodo Archaeological Locality') (Figure 1) in east central Alberta, about two kilometers southwest of the hamlet of Bodo. For the purposes of this thesis, Area 5 will be referred to an archaeological 'site' even though it is technically an archaeological locality located within the boundary of a larger archaeological site (FaOm-1). Access to the site is attained from the grid road running west off highway 899 along the tenth base line, approximately 1 km south of the turn off to the hamlet of Bodo (Gibson 2005:8).

Since 1995, the geographic extent of the Bodo Archaeological Locality has expanded with every program of survey and excavation. For example, in 2000 the site was estimated to be approximately 130 hectares, making it one of the largest archaeological site complexes in Alberta (Gibson 2001:32). Near the end of the 2005 field season, it was estimated to be approximately 800 hectares (Pers. Comm. Gibson 2006). The majority of the archaeological deposits appear undisturbed, though it is apparent that in some areas there has been some disturbance due to oil field development.

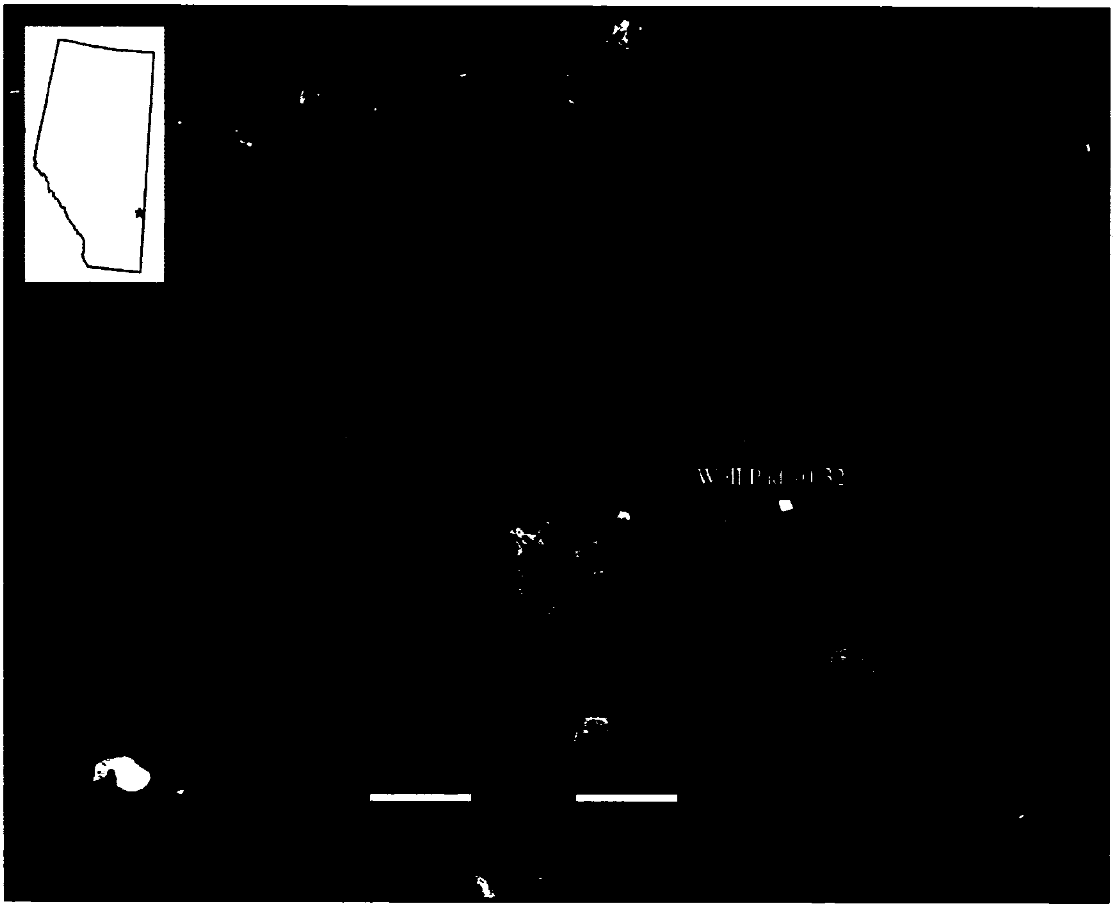


Figure 1: Location of the Bodo Archaeological Locality. Map courtesy of Dr. Terry Gibson.

2.1 Environmental Setting

Environmental characteristics of given regions play a role in the selection of areas used by humans and animals, and as a result archaeological remains often reflect the environment in which they are (or were) found. Subsistence and settlement choices are partially a reflection of the geology, landforms, climate, soils, fauna, and flora. Unfortunately, in many areas on the northwest Plains, including the Bodo vicinity, little is known about the paleoenvironment, even for the late-Holocene period. Consequently, archaeologists often use recent environmental conditions, as a proxy source of information on the prehistoric environmental context of archaeology sites. Obviously, such environmental information should be viewed with caution as significant changes in land use have occurred in this region since European colonization. These changes likely caused significant (but unknown) changes in the landscape.

The northwest Plains is a vast geographic area that exhibits immense environmental diversity. Within the northwest Plains, Alberta itself has significant geographic and ecological variability that can be examined through the use of land classification systems. In Alberta there are two main ecologically based land classification systems: 1) Natural Regions and Subregions (Achuff 1992) and 2) Ecoregions of Alberta (Strong and Leggatt 1981; Strong 1992). These two systems are very similar, except that the latter emphasizes climate more than the first (Ball and Yeager 2003:15). For this study, I rely on the Natural Regions and Subregions Classification System. In Alberta, there are six natural regions, including Grassland, Parkland, Foothills, Rocky Mountain, Boreal Forest, and Canadian Shield. These are in turn divided into 20 sub-regions. The Bodo Archaeological Locality is located in

Parkland, a region characterized by a north-south transition between boreal forest and dry grasslands and an east-west transition between foothills and grasslands. Bodo is on the southern edge of the Parkland and is in an area that is transitional to the Grasslands Natural Region. Alberta's Parkland is divided into three sub-regions: Central Parkland, Peace River Parkland, and Foothills Parkland (Alberta Environmental Protection1994:8-9). The Bodo Archaeological Locality is located within the Central Parkland sub-region.

The Parkland covers approximately 50,000 km^2 or eight percent of the province of Alberta (Strong 1992:14). Currently, the Parkland embodies one of the most productive agricultural zones in Alberta. True Parkland vegetation, including continuous aspen forest interrupted by grassland, is now very rare due to large scale clearing of land for agriculture (Alberta Environmental Protection 1994:8). Today, less than five percent of the Parkland remains as natural habitat. Surviving patches of unbroken parkland are found on poor soil or rough terrain, including hummocky moraines, river bottomlands, and dune fields (Strong 1992). The Bodo Archaeological Locality, likely because of agriculturally unproductive sandy soil, has not been broken for agricultural purposes, and is one of the few surviving patches of original Parkland.

Landforms

The Sounding Lake Sand Hills and the Eyehill Creek Valley are the main geographic features of the Bodo Archaeological Locality (Gibson 2005:8). The Sounding Lake Sand Hills is one of many bodies of sand hills that exist in Alberta. The Bodo Archaeological Locality is located within the Bodo Sand Dunes, a peripheral isolate of the larger Sounding Lake Sand Hills. The Soundings Lake Sand Hills consists of sand dunes that are currently stabilized by "mixed vegetation, consisting of grasses, prickly rose, willows, aspen, and black poplars" (Gibson 2005:8). Figures 2 and 3 illustrate the current environmental appearance of the terrain surrounding Area 5. Today the sand dunes near Area 5 are stabilized, but much of the Sounding Lake Sand Hills area is erosional, with many blowout hollows and active dunes being present. A blowout occurs when a section of a dune area is deflated and stabilizing vegetation is overwhelmed by sand (Press and Siever 1998:358). The sandy soil and semi-arid climate of the Bodo Archaeological Locality result in sand dunes with minor and extremely vulnerable vegetative cover. Without precipitation to recharge ground water, the dry sandy environment at the Bodo Archaeological Locality allows for unconsolidated sand that is often unstable. Industrial and recreational vehicle activity, fire, wind, and even animal trails and wallows can result in destabilization and devegetation of the dunes (Blaikie 2005:33-4).

From an ecological perspective, sand hill regions are often distinct from the surrounding Parkland. Sand hill ecosystems are unique because of their sandy substrate, water availably, and species carrying capacity. Frequently, sand dune environments are drier than areas around them resulting in a lower species carrying capacity. However, in many interdunal areas groundwater often occurs near the surface. For example, in the Sounding Lake Sand Hills, interdunal areas form traps for runoff and excess water, creating numerous small shallow water catchments. The availability of open water in sand dune environments depends on short-term climatic fluctuations and is therefore seasonal and unpredictable from year to year. The moisture availability in these areas controls the flora available to colonize and stabilize this sand environment.

The Bodo Sand Dunes rest on a shelf of clay that overlooks a Pleistocene river valley called the Eyehill Creek Valley (Blaikie 2005:6). Eyehill Creek Valley is located north of the Bodo Archaeological Locality and flows from Sounding Lake in the west to Manitou Lake in the northeast (Blaikie 2005:6). Eyehill Creek is considered a misfit stream in a larger glacial outwash channel. The walls of the Eyehill Creek Valley and the uplands surrounding it expose a "bouldery glacial till with a sandy matrix" (Amundson 1997:3). Currently Eyehill Creek, in most sections near the Bodo Archaeological Locality, is devoid of water for most of the year. In the past this creek may have held larger quantities of fresh water that could have drawn both people and animals to this area.

Figure 2: View of Area 5 looking south.

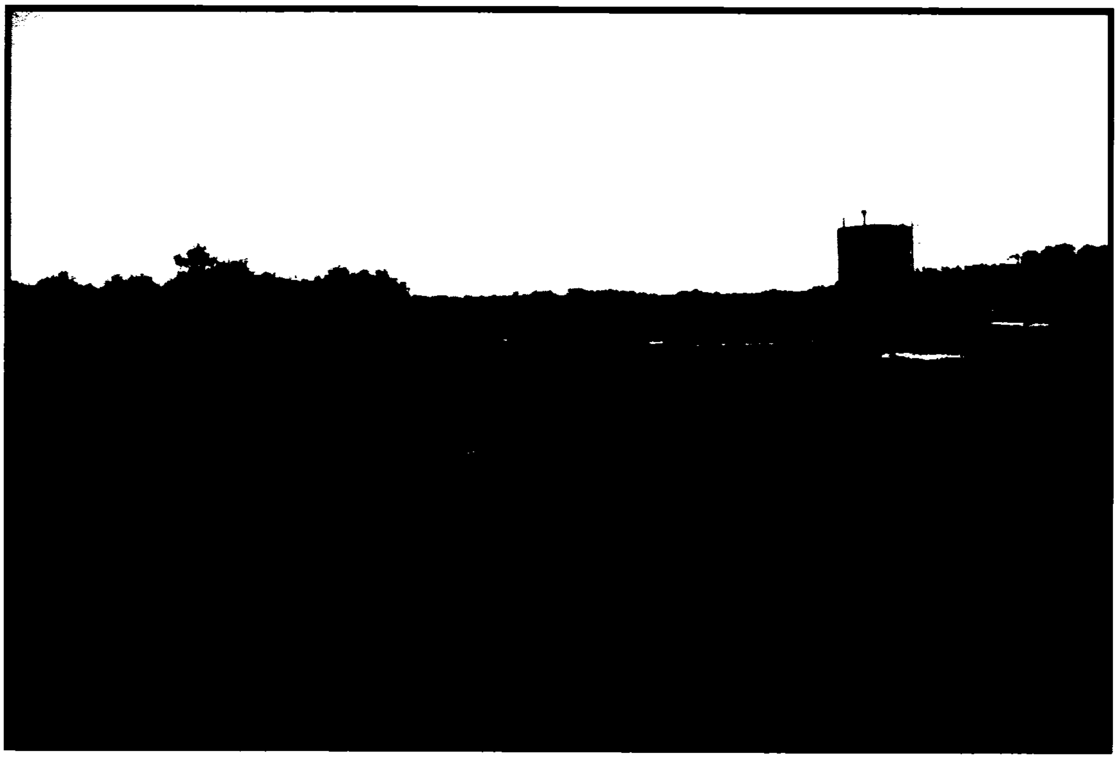


Figure 3: View of Area 5 looking east.

Geology and Soils

The surficial deposits of the Central Parkland region include fine-textured glaciolacustrian deposits, intermediately textured hummocky and ground moraines, coarse outwash, kame moraines, and dune field materials (Alberta Environmental Protection 1994:8). Soils of the Central Parkland vary. Black and dark brown chernozems dominate under grassland vegetation, while under the moister aspen woodlands dark gray chernozems and luvisols are most common (Alberta Environmental Protection 1994:8). Dark brown chernozems occur under woodland vegetation with sandy parent materials (Alberta Environmental Protection 1994:8). Solonetzic soils also often occur in the Central Parkland. These soils produce the alkaline quality that characterizes many sloughs and lakes in the Parkland region (McGillivray 1998:97).

Climate

Alberta's boreal and grassland climates interact to produce the regional climate of the Parkland (Strong 1992:14). The climate of the Central Parkland is typical of continental prairie landscapes. It is "transitional northward, approaching a boreal climate with longer, colder winters and cooler, wetter summers" (Alberta Environmental Protection 1994:8). The mean annual temperature is 2 °C. The average summer (May – August) temperature is 13 °C (Achuff 1992:15). The mean annual precipitation is 350-450 mm (Achuff 1992:15). The frost-free period averages 95 days per year (Achuff 1992:15).

Flora

As discussed above, Bodo is located in the Central Parkland, but is in a transitional zone between the Central Parkland and the Northern Fescue Grassland (Aldrich et al. 1997:23). This landscape is a patchwork of different vegetation clusters including aspen woodland, lush fescue grassland, shrubs, and wetlands (Aldrich et al. 1997:23). More than 200 native plant species can be found near Bodo (Aldrich et al. 1997:23). In the Parkland area, open grassy areas are intermingled with forests (Wilkinson 1990:12). Two major forest types are recognized including groves of aspen (*Populus tremuloides*) in drier areas and balsam polar (*Populus balsamifera*) forests in wetter areas (Achuff 1992:16). Both forest types are characterized by a lush and species rich understory of woods rose (*Rosa acicularis* and *Rosa woodsii*), low-bush cranberry (*Viburnm edule*), wild red raspberry (*Rubus idaeus*), dewberry (*Rubus pubescens*), twining honeysuckle (*Lonicera dioica*), sarsaparilla (*Aralia nudicaulis*), bearded wheat grass (*Agropyron trachycaulum*), fairy bells (*Disporum trachycarpum*), pink wintergreen (*Pyrola asarifolia*), Lindley's aster (*Aster ciliolayus*), northern bedstraw (*Galium boreale*), fireweed (*Epilobium angustifolium*), cream-coloured peavine (*Lathyrus ochroleucus*), American vetch (*Vicia americana*), and star-flowered Solomon's seal (*Smilacina stellata*) (Achuff 1992:16).

Species that characterize the aspen forests include: snowberry (*Symphoricarpos albus*), saskatoon (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), beaked hazel (*Corylus cornuta*), bunchberry (*Cornus canadensis*), wild lily-of–the-valley (*Maianthemum canadense*), and false melic grass (*Schizachne purpurascens*) (Achuff 1992:16). While species that characterize the wetter balsam poplar forests include red osier dogwood (*Cornus stolonifer*), pussy willow (*Salix discolor*), northern gooseberry (*Ribes oxyacanthoides*), green alder (*Alnus crispa*), bracted honeysuckle (*Lonicera involucrate*), bluebells (*Mertensia paniculata*), palmate-leaved coltsfoot (*Petasites palmatus*), mitrewort (*Mitella nuda*), and baneberry (*Actaea rubra*) (Achuff 1992:16). The grassland vegetation of the Central Parkland includes rough fescue (*Festuca scabrella*) as the dominant grass type, while western porcupine grass (*Stipa curtiseta*) is important in the southern part of the region on south-facing slopes and on solonetzic soils. Other important grasses found in solonetzic soils are June grass (*Koeleria micrantha*) and western wheat grass (*Agropyron smithii*) (Achuff 1992:16).

Fauna

The fauna of the Central Parkland is a mix of animals from the Northern Fescue and Boreal Mixed sub-regions (Achuff 1992:17). Fauna of the Bodo region includes a variety of mammals, birds, and aquatic species. Currently large ungulates in the Central Parkland include mule deer (*Odocoilus virginianus*), white-tailed deer (*Odocoilus heminonus*), and moose (*Alces alces*). Carnivores include coyote (*Canis lantrans*), red fox (*Vulpes vulpes*), porcupine (*Erethizon dorsatum*), badger (*Taxidea taxus)*, black bear (*Ursus americanus)*, and cougar (*Felis concolor*). Small mammals in the Bodo region include the thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), Richardson's Ground Squirrel (*Spermphilus richardsonii*), striped skunk (*Mephitis mephitis*), and white-tailed jackrabbit (*Lepus townsendii*) (Gibson 2001:9; Blaikie 2005:8).

Historically a number of other species occupied the Central Parkland. These species include plains bison (*Bison bison*), elk (*Cervus canadensis*), grizzly bear (*Urus horribilis*), and wolf (*Canis lupus*) (Blaikie 2005:8). As the reader will see below, bison compose essentially 100% of the faunal remains from Area 5 excavation. Historically bison were widespread across North America and were the most critical food resource on the Plains (see DeMallie 2001). Although extinct in the wild today, bison were once the most plentiful large mammal species in the study area:

> It is doubtful that anyone can conjure up the sight, smell, sound, and feel of the Great Plains prior to the coming of the white man. A partial requirement would be to envision an estimated 30 to 60 million bison wandering and feeding over this vast grassland along with four to eight million antelope, and extensive herds of deer, elk, big horn sheep, wolves, cougars, bears, and other wild animals (in Arthur 1975:11).

Various birds occupy the region seasonally and year round (Gibson 2001:9). Numerous migratory waterfowl utilize the area, most notably Canada geese (*Branta canadensis*), snow geese (*Chen hyperborean*), mallards (*Anas platyrhynchos*), and an array of other ducks (*Bucephala* spp., *Aythya* spp., and *Anas* spp.) (Blaikie 2005:9). Sage grouse (*Centrocercus urophasiaanus*), nighthawks (*Chordeilus minor*), meadowlarks (*Sturnella neglecta*), and assorted hawks (*Buteo* spp.) are also found in the Central Parkland (Strong 1992:12).

Numerous lakes and other permanent wetlands are found in the Central Parkland. Many of these aquatic habitats are slightly or strongly saline (Alberta Environmental Protection 1994:8). Lakes in the vicinity the Bodo Archaeological Locality include Sounding, Dillberry, and Fleeing Horse lakes (Gibson 2001:3). These lakes may contain a variety of fish including burbot (*Lota lota*), white sucker (*Catostomus commersoni*), longnose sucker (*Catostomus catostomus*), lake herring (*Coregonus artedii*), shorthead redhorse (*Moxostoma macrolepidotim*), northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), and yellow perch (*Perca flavescens*) (Scott and Crossman 1973). Some of these fish are valued for their high fat content and are captured easily when they congregate in groups in shallow water during spawning runs (Gibson 2001:3). Beyond fish, the presence of these permanent and seasonal bodies of water also allows for a variety of aquatic mammals to live in the area, including muskrat (*Ondatra zibethicus*) and beaver (*Castor canadensis*) (Blaikie 2005:9).

2.2 Cultural-Historical Setting

The Bodo Archaeological Locality is considered to be multi-component. Since their initial discovery, FaOm-1 and FaOm-22 have demonstrated clear evidence of Late Precontact occupation and limited evidence of earlier occupations. By the end of the 2006 field season, diagnostic projectile points recovered from the site included Oxbow (approx. 4500-3000 BP), Hanna (approx. 4000-3000 BP), Pelican Lake (approx. 3500-

2000 BP), Avonlea (approx. 1800-1200 BP), and Old Women's Phase (approx. 1200-200 BP) (date from Mirau et al. 1999). This thesis focuses on the Old Women's Phase occupation as revealed in Area 5.

The Late Precontact (or Late Prehistoric) Period on the northern Plains is most commonly defined as lasting from approximately 1800 BP to 200 BP (Dyck 1983:110; Reeves 1983:16; Vickers 1986:88). In Alberta, the most common way of dividing the Late Precontact Period is to refer to the period from approximately 1800 to 1200 BP as representing the Avonlea Phase and the later phase from 1200 BP to 200 BP as representing the Old Women's Phase (Vickers 1986:88-95). This two-phase division is based on diagnostic projectile points and ceramic types. The Old Women's Phase is often broken into two sub-divisions including the Prairie Side-Notched Sub-Phase (1200 BP to 700 BP) and the Plains Side-Notched Sub-Phase (700 BP to 200 BP) (Kehoe 1966:830-33). Brumley and Dau (1988:50-51) define the Old Woman's Phase as containing Prairie and Plains side-notched projectile points (as defined by Kehoe 1966:830-834) in association with Saskatchewan Basin Complex: Late Variant pottery (as defined by Byrne 1973: 331-356). Area 5 contains side-notched projectile points and Saskatchewan Basin Complex: Late Variant pottery. As such, Area 5 is here considered a representation of the Old Women's Phase.

Recently Peck (1996) and Peck and Ives (2001) developed a new system to divide the late side-notched points found in Alberta and Saskatchewan. They argue that, "Kehoe's (1966) classification of Prairie and Plains side-notched points masks the continuity in projectile point stylistic change through time on the Alberta and Saskatchewan Plains" (Peck and Hudecek-Cuffe 2003:85). Their new system includes the Early Cayley series (1250 years BP to 650 years BP) and Late Cayley (after 650 years BP in Alberta) or Mortlach (after 650 BP in Saskatchewan) projectile point styles. According to Peck (1996) and Peck and Ives (2001), Cayley Series projectile points are consistently in association with Saskatchewan Basin Complex: Late Variant pottery and define the Old Women's Phase in Alberta. Peck (2004:83) visually inspected a subset of the projectile points from Area 5 and classified them as Cayley Series.

Overall Area 5 clearly falls within the Old Woman's Phase based on the typology of the recovered material culture. Reeves (1983:20) considers the Old Women's Phase to be directly ancestral to the historic Blackfoot people. As well, Peck (1996) asserts that geographic distribution of Cayley projectile points and ethnographic records suggest that Old Women's Phase people are ancestral to the Blackfoot.

CHAPTER THREE: ARCHAEOLOGY OF AREA 5

3.1 Site Discovery and Excavation

Terry Gibson of Western Heritage Services Inc. discovered the Bodo Archaeological Locality in 1995. The first archaeological discovery consisted of two complete bison skulls that were recovered from an oil/gas industry-related backhoe trench in the fall of 1995 (Gibson et al. 1998). The initial discovery led to the assignment of the name FaOm-1 to the original site. By 2000 a considerable amount of archaeological work was being undertaken at the site due to increased oilfield industry activity and the site boundary of FaOm-1 was expanded to cover several hectares. A second site, FaOm-22, was discovered in 2003. Together FaOm-1 and FaOm-22 make up the Bodo Archaeological Locality. The Department of Anthropology at the University of Alberta has used the Bodo Archaeological Locality as the setting of an archaeology field school since the summer of 2002.

In the spring of 2000 Alberta Western Heritage Inc., under the direction of Terry Gibson, was commissioned by Murphy Oil Company Ltd. to undertake an archaeological assessment of four well pad localities in the Bodo Archaeological Locality. These four well pads were randomly sampled and tested for archaeological material. This testing lead to the detailed assessment and mitigation of the well pad #10-32. Based on initial shovel tests and surface survey, it was determined that the proposed well pad area contained reasonably uniform and rich archaeological deposits (Gibson 2006). Detailed excavation of ten separate excavation blocks throughout the well pad followed this discovery (Figure 4). Cultural remains were uncovered and collected from six of these excavation blocks. Three of the six blocks (Areas 3, 5, and 7) produced abundant quantities of cultural materials in good stratigraphic context (Gibson 2006). Analysis of Area 7 has been conducted by Blaikie (2005), Area 5 is the focus of this thesis, and limited analysis of Area 3 has been undertaken thus far. The Area 5 excavation of a 2 x 2 m square revealed a very dense layer of bone and organic matter less than 10 cm beneath the ground surface (Gibson 2004:10) (Figure 5). This bone layer is approximately 20 cm thick and rests on a thin black paleosol. The bone bed was removed as a single level, revealing complete and fragmented bison bone and preserved bison hair mixed in with a dense organic matrix that resembled hardened compost (Gibson 2004:10). Gibson (2006:15) believes that this organic matrix is a mixture of hide, hair, and viscera from butchered animals. In addition, a large number of complete projectile points, some pottery, and other tools were recovered within the bone bed.

Prior to this thesis, very little of the material recovered from Area 5 had been analyzed in detail. Past analyses include Peck's (2004) classification of a portion of the projectile point assemblage and the dental cementum increment analysis of five bison molars recovered from the 2 x 2 m unit. As well, the staff of Alberta Western Heritage under the direction of Terry Gibson undertook additional laboratory work on this collection. Gibson's work culminated in the final report for the mitigative archaeological work undertaken at this site submitted to Albert Community Development in 2006 (see Gibson 2006).

Figure 4: Well pad #10-32 excavation areas undertaken in the summer of 2000. Excavations yielding artifacts (positive) are indicated in black while those that did not produce cultural material (negative) are indicated in white. Figure courtesy of Terry Gibson.

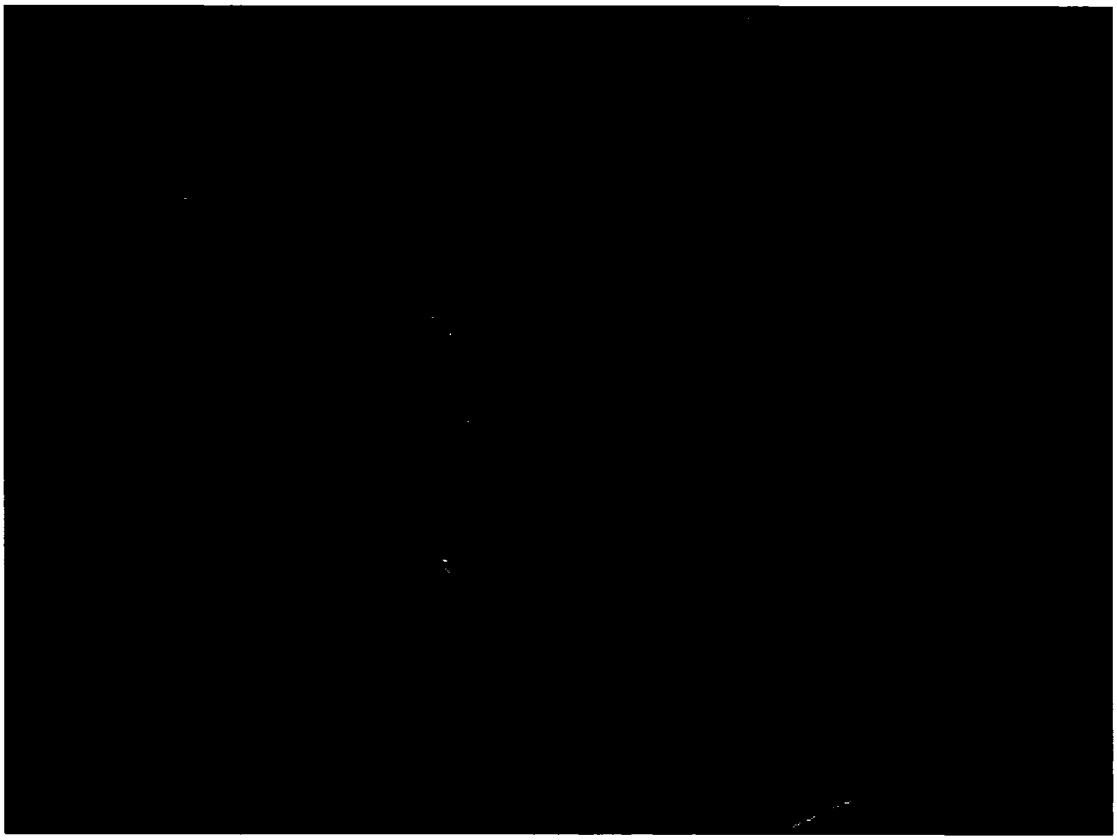


Figure 5: Area 5 under excavation. Photo courtesy of Terry Gibson.

3.2 Field Methodology

In the summer of 2000, a field crew from Alberta Western Heritage Inc. (of which I was not a member) excavated four 1 x 1 m square units resulting in the four-meter square excavation area known as Area 5 (Units 1 through 4). Three levels were excavated to a basal depth of approximately 50 cm below the ground surface. Matrix collected during excavation was screened over six-millimeter mesh sieves. The cultural materials recovered were bagged by quadrant or 50 x 50 cm provenience unit. Figure 6 illustrates a map of the excavation grid from Area 5.

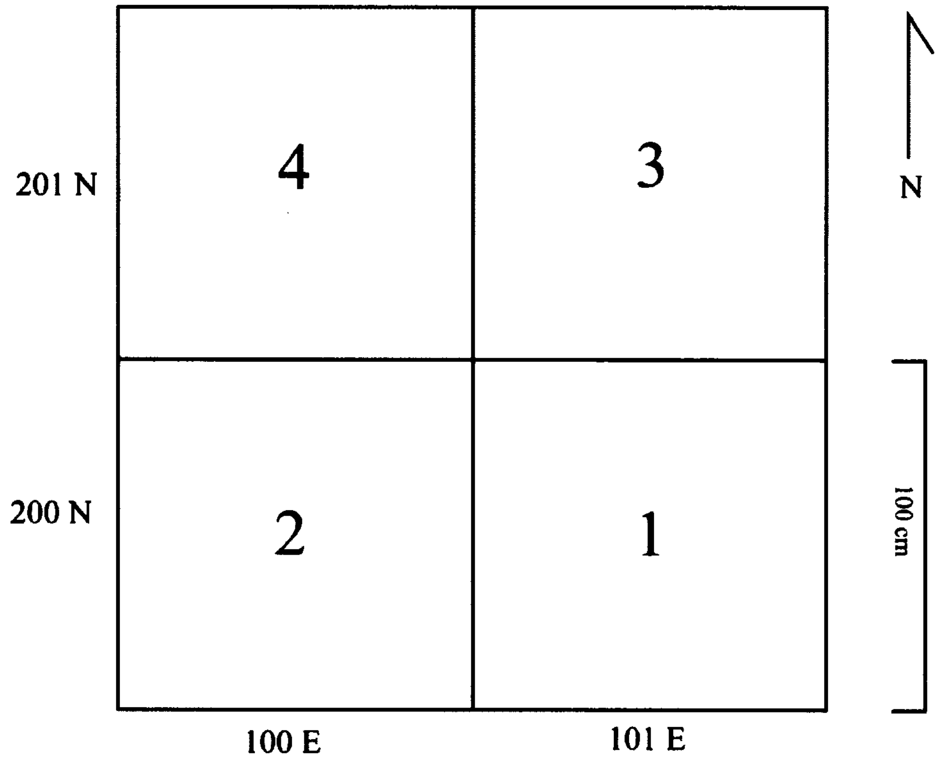
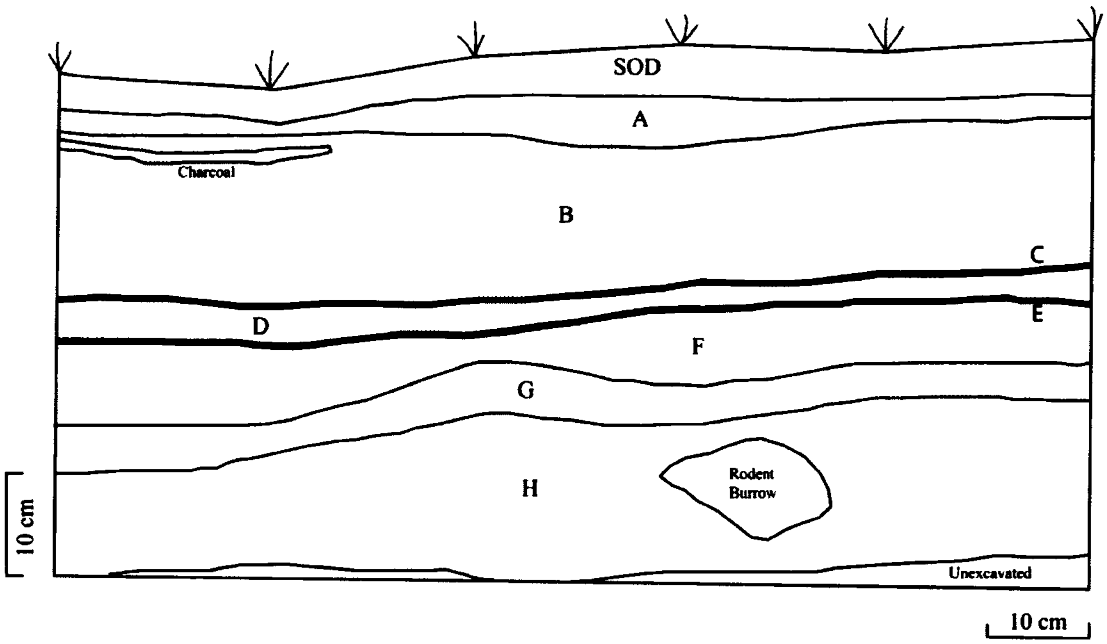


Figure 6: Map of excavation grid including unit coordinates from Area 5.

3.3 Stratigraphy:

Three levels were excavated during investigations of Area 5. Level 1 (approx. 0-10 cm depth below ground surface) consisted of sod on top of mostly sterile sand. Level 2 (approx. 10-25 cm depth below ground surface) was the bone bed and was excavated as a single cultural level. Level 3 (approx. 25-50 cm depth below ground surface) consisted of a multiple thin black paleosols overlying mostly sterile sand. Figure 7 is a profile of the stratigraphy of the excavation area.

The stratigraphy of Area 5 is complicated. Thin black paleosols were observed above the bone bed in a few locations along the excavation profile. A more prominent paleosol was present about five centimeters below the base of the bone bed deposit (Gibson 2004:10). Detailed excavation with a focus on the stratigraphy and the erosional and depositional history of the Area 5 is needed to understand the processes that created the site. At this time, preliminary assessment of the bone bed stratigraphy indicates that the bone bed was a single discrete depositional event and was not interrupted by periods of erosion or deposition.



Legend	
A	SAND (medium brown)
B	BISON BONE BED with orange/brown organic substance and bison hair
C	PALEOSOL
D	SAND (light brown)
E	PALEOSOL
F	SAND (orange/brown)
G	PALEOSOL that is faint and discontinuous
H	SAND (light brown)

Figure 7: Stratigraphy of the south wall of Unit 1 (200 N 101 E) (Drawn to scale).

3.4 Radiocarbon Dates

The vast amount of relatively well-preserved faunal remains from Area 5 provided a sizeable selection of potential specimens for radiocarbon dating. Funding (from Alberta Western Heritage Inc.) was made available to obtain four conventional radiocarbon dates. The chosen faunal specimens were sent to Brock University Earth Sciences Radiocarbon Lab. Since no detailed vertical or horizontal provenience information was recorded for bone specimens during the excavation of Area 5, I chose four specimens to radiocarbon date based on their fulfillment of the minimum mass requirement (approx. 200 grams of well preserved bone), and which appeared to have little organic contamination (free of sediment, soil, rootlets, etc.). One specimen from each of the four 1 x 1 m units was submitted for dating. All bones submitted were from the bone bed deposit.

Sample BGS 2654 (artifact 98004) was a bison left proximal radius from excavation Unit 4 (201.00 N 100.50 E). The sample had no indications of any natural or cultural modifications. The proximal shaft exhibited a spiral fracture, but the bone was not heavily weathered. Sample BGS 2655 (artifact 91581) was a bison left distal tibia from Unit 1 (200.00 N 101.50 E). The sample had some minor root damage on the shaft and visible cut marks (associated with butchering) on the lateral margin of the shaft. The cranial surface of the bone was slightly more weathered than the caudal surface especially near the distal end. The distal shaft exhibited a spiral fracture, but overall the bone was not heavily weathered. Sample BGS 2656 (artifact 97638) was a bison right distal scapula from Unit 3 (201.50 N 101.50 E). This sample had evidence of carnivore tooth marks on the medial face of the bone, as well as a few cut marks on the medial surface. The blade of the scapula was cracked, broken, warped, and slightly more weathered on the medial surface than the lateral surface. However, overall the structural integrity of the bone was good and the bone was not otherwise heavily weathered. The final sample, BGS 2657 (artifact 92279), was recovered from Unit 2 (200.00 N 100.50 E). This sample was a left humerus shaft and partial distal end. The proximal end of the shaft was modified by carnivore gnawing, and tooth puncture marks were observed on the distal end. In addition, numerous scratches covered the entire shaft of the bone and crisscross each other. Obvious cut marks were also present on the cranial surface of the bone near the proximal end. Slight root damage was also visible on the medial surface of the bone near the distal end of the shaft.

A summary of the results of the radiocarbon dating, including the corrected and calibrated ages provided by the Brock Laboratory, is presented in Table 1. The maximum and minimum calibrated age ranges and intercepts (including the one-sigma and two sigma data range) are provided in Table 2. All of the dated samples have over thirteen percent collagen yield and therefore are considered to have more than enough collagen to allow for accurate dates (see Weber et al. 2005). The results of the radiocarbon dates suggest the possibility of two distinct periods of site formation. BGS 2655 and BGS 2657 appear to represent site occupation during the early AD 1400's. Samples BGS 2654 and BGS 2656 appear to represent a later occupation period, possibly sometime during the late 1500's or early 1600's. When a chi-square test is performed on the four dating results, the samples are shown to be significantly different at a 95% confidence level, suggesting multiple occupation events. However when a chi-square test is performed on BGS 2655 and BGS 2657, the samples are shown to be statistically the same at a 95% confidence interval. When BGS 2654 and BGS 2656 are tested against each other, they are shown to be statistically the same at a 95% confidence level also. Even though the four dates are statistically different, when the calibration curves for the four dates are viewed (see Figure 8) there is a slight overlap (~ AD 1450) in the dates, suggesting the possibility that all four dates represent the same period of site occupation.

The physical evidence from the site also appears to indicate that the deposit is a single, discrete site occupation. This is apparent for several reasons. Some bones crosscut the entire bone bed deposit suggesting that the whole deposit is the product of a single depositional event. In addition, the stratigraphy provides no evidence for a period of erosion or deposition at the site that would separate two periods of occupation. Furthermore, the quality of bone preservation throughout the bone bed is relatively uniform, suggesting rapid burial. Finally, the fact that the ~ 20 cm thick bed of bone at Area 5 included decomposed viscera and hair throughout the deposit suggests rapid burial resulting in anoxic and anaerobic conditions that allowed for preservation of soft tissue and hair.

At this time, the apparent discrepancy between the dates and the stratigraphy cannot be completely resolved with out further excavation and dating that would focus on a detailed assessment of site formation processes. However, for the purposes of this thesis, the faunal remains from Area 5 will be analyzed as a single occupation because of the overlap of the radiocarbon dates and the lack of physical evidence to support the multiple depositional events taking place at Area 5.

Brock Lab Number Catalogue Number	BGS 2654 98004	BGS 2655 91581	BGS 2656 97638	BGS 2657 92279
Calculated Age (years BP)	190±40	283±40	245±40	422±40
Corrected Age (years BP)	290±40	460±40	330±40	500±40
Calibrated Age (years BP)	310±40	510±40	380±40	520±40

Table 1: Summary of radiocarbon dating results from FaOm-1, Area 5. Calibrated ages after Stuiver et al. 1998.

Brock Lab Number Catalogue Number	BGS 2654 98004	BGS 2655 91581	BGS 2656 97638	BGS 2657 92279
1 sigma	1520 (1640) 1650	1430 (1440) 1450	1480 (1520, 1570, 1630) 1640	1410 (1430) 1440
2 sigma	1480 (1640) 1790	1410 (1440) 1480	1450 (1520, 1570, 1630) 1650	1330 (1430) 1450

Table 2: Maximum and minimum calibrated age ranges and intercepts, years AD. After Stuiver et al. 1998.

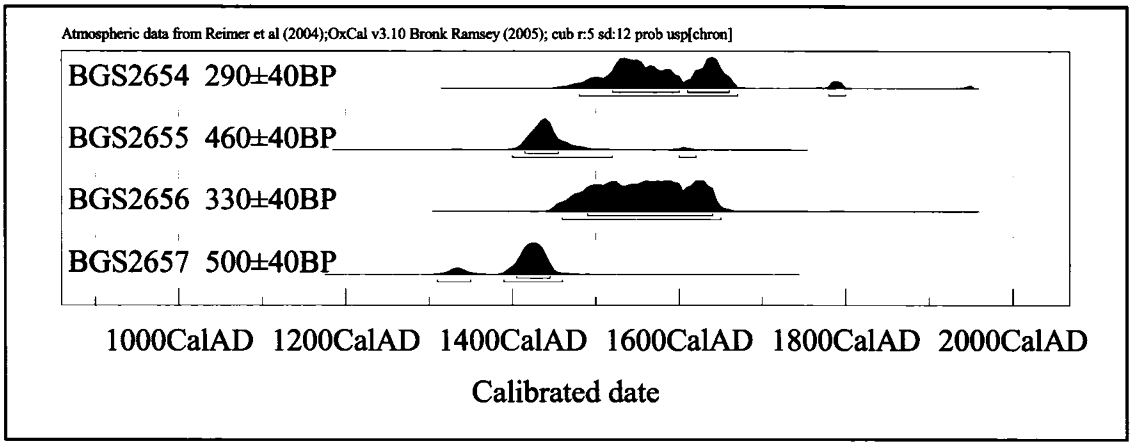


Figure 8: Calibration curves for the four samples dated from Area 5. Calibration curves generated by OxCal v 3.10 (see Bronk Ramsey 1995 and 2001). Atmospheric data from Reimer et al. (2004).

3.5 Cultural Materials Overview

Features

The excavators did not identify any features during the excavation of Area 5 other than the bone bed itself. A minor charcoal deposit was recorded in the stratigraphy drawings in the original field notes. This possible feature was in the SW quadrant of Unit 1 (200 N 101 E) at a depth of about 8-10 cm below the ground surface (within the bone bed deposit) (see Figure 7). Future controlled excavation of the remaining portion of Area 5 may reveal the presence of other features.

Lithics

In total 97 chipped stone artifacts (total weight 609.5 g) and two ground stone ones (total weight 1245.2 g) were recovered from Area 5. This lithic assemblage includes projectile points, broken tools, retouched flakes, flakes, shatter, a stone chopper, a hammer stone, and a grooved maul. Table 3 illustrates the quantity of lithic tool and debitage types recovered from Area 5.

Artifact Type	Number	Mass (g)
Projectile Point	62	60.60
Shatter	17	19.90
Flake	11	2.80
Retouched Flake	4	2.50
Broken Tool	2	1.80
Chopper	1	522.80
Grooved Maul	1	187.00
Hammer Stone	1	1058.20
Total	**99**	**1855.60**

Table 3: Lithic artifact types and their quantity at Area 5.

The lithic raw material types from Area 5 were determined by using visible macroscopic properties of the raw materials. Raw materials in the assemblage include Swan River chert, silicified peat, siltstone, indeterminate chert, quartzite, obsidian, chalcedony, quartz, mudstone, limestone, silicified wood, granite and unidentified igneous material. Table 4 provides the lithic raw material frequency. Note that this table does not include the chopper, hammer stone, and grooved maul, all of which are granite, because their heavy weights would distort the results. All of these materials are locally available as cobbles in glacial deposits except for obsidian, which is exotic to the site area. The most common raw material is Swan River chert (37% of lithic assemblage by number and 39% by weight).

No patterns were observed in spatial distribution of lithic artifacts within the excavation area; the lithics materials scattered randomly through the four excavated units. This is expected, given that the excavation area is small and it would be very difficult to identify patterns of distribution within this area.

Material	**Number**	**% Total Number**	**Mass (g)**	**% Total Mass**
Swan River Chert	36	37%	33.80	39%
Silicified Peat	19	20%	17.50	20%
Siltstone	12	13%	11.30	13%
Ind. Chert	11	11%	9.60	11%
Quartzite	5	5%	3.50	4%
Obsidian	4	4%	0.50	<1%
Chalcedony	3	3%	1.70	2%
Quartz	2	2%	0.50	<1%
Mudstone	1	1%	0.20	<1%
Limestone	1	1%	0.40	<1%
Unidentified Igneous	1	1%	6.70	8%
Silicified Wood	1	1%	1.00	1%
Total	**96**	**100%**	**86.70**	**100%**

Table 4: Lithic artifact raw material frequency from Area 5.

Projectile Points

Sixty-two projectile points (including fragments) were recovered from Area 5. Figure 9 shows some of the point styles recovered from the excavation area. Table 5 lists the frequency of lithic raw materials for projectile points. This variety of raw materials is common for Late Precontact sites on the Plains in Alberta. All of the projectile points recovered from Area 5 are identified as Late Side-Notched projectile points (see 'Cultural-Historical Setting' for a discussion of Late Side-Notched projectile points). Based on a visual inspection by the author, forty projectile points from Area 5 are Plains Side-Notched specimens. Four of the projectile points appear to more closely resemble Prairie Side-Notched points, but could represent a variant of a Plains Side-Notched point. Peck (2004:83) classifies a sample of the projectile points from Area 5 as representing Cayley Series projectile points, which essentially includes both Plains and Prairie Side-Notched variants. For the purposes of this thesis the projectile points are referred to in a general sense and considered to be Late Precontact Side-Notched projectile points.

The most unusual feature of the projectile point assemblage is its size; the number of projectile points per volume excavated is very high, even for kill sites on the Plains (pers. com. Gibson 2006). The abundance of projectile points suggests to me that Area 5 is an area of primary killing. The points may have been discarded along with the bison remains recovered from the excavation block, perhaps because the animals were killed nearby and the points were located in unused portions of the carcasses. The lack of other stone tools suggests that perhaps only initial butchering and processing was occurring at this site, with more intensive processing occurring elsewhere.

Given the time period of occupation, nearly all of these points likely were from arrows used by hunters on foot (the occupation of Area 5 predates the introduction of horses in this area of the Plains). It seems likely that multiple arrows were often needed to dispatch a single bison. At least 16 bison are represented by the bones recovered from Area 5 (see Chapter 4); this would translate to over three projectile points per animal. While it is beyond the scope of this thesis, it would be interesting to compare the number of points per animal recovered in other northern Plains sites. Especially interesting would be to compare these ratios at sites where bows and arrows were used versus sites where atlatl and darts were employed, as these technologies likely varied significantly in terms of the effectiveness at killing. Equally interesting would be to compare these ratios between locations where different bison hunting strategies were employed (jumps, pounds, ambushes, etc.). These studies might ultimately provide some insight into the hunting strategies employed at Area 5.

Material	Number	% Total Number	Mass (g)	% Total Mass (g)
Swan River Chert	25	40%	23.00	39%
Silicified Peat	12	19%	14.70	25%
Siltstone	11	18%	10.00	17%
Ind. Chert	9	15%	7.60	13%
Chalcedony	3	5%	1.70	3%
Silicified Wood	1	2%	1.00	2%
Quartzite	1	2%	0.80	1%
Total	**62**	**101%**	**58.80**	**100%**

Table 5: Frequency of the lithic raw materials of the projectile points from Area 5.

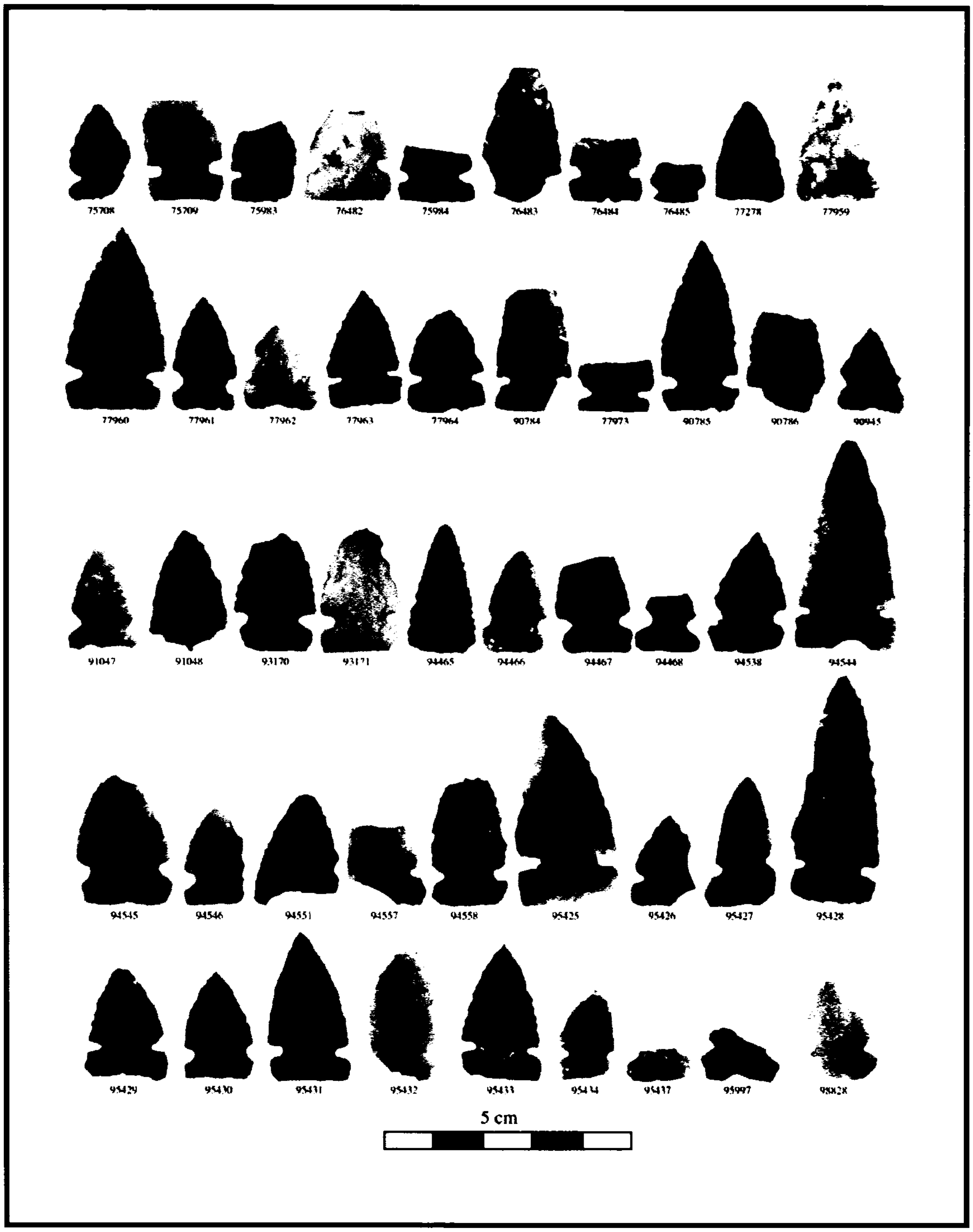


Figure 9: A selection of projectile points recovered from Area 5. Photo courtesy of Terry Gibson.

Thermally Altered Stone

The Area 5 excavation assemblage includes 49 pieces of thermally altered stone (often referred to as fire broken rock or fire cracked rock) of a variety of sizes. The total mass of the thermally altered stone exceeds 19 kg. The dominant lithic raw material is granite (88% by number). Both sandstone and quartzite (12% by number) are minor components of the assemblage. A summary of the composition and frequency of the thermally altered stone in the assemblage is presented in Table 6. Granite, quartzite, and sandstone are available as bedrock, outcrops, or glacial debris in the Bodo area. However, the Bodo Sand Hills themselves are devoid of any of these rocks, other than those introduced by human activity. The thermally altered stone may have been transported from the surrounding prairie and the Eyehill Creek Valley.

The presence of thermally altered stone suggests that domestic activities (such as heating and cooking) were taking place at the site. Depending on the total number of bison killed in this area it may have been necessary for the hunters to remain in the area of the kill for a few days to butcher all of the animals. Occupation of an area even for a very short time (less than a day) would produce some habitation debris from food preparation and cooking. The presence of thermally altered stone at Area 5 suggests to me that the people who used this site may have spent a day or more at the site, butchering the bison carcasses and preparing them for transportation to the base camp. Additionally, the thermally altered stone at this site, due to a lack of other large stones, may have been used as crude hammer stones to break and smash bones with (Pers. Comm. Gibson 2006). Further excavation of Area 5 would assist in the determining activates that were taking place at the site (beyond butchering) and the length of time the site was occupied.

Material	Number	% Total Number	Mass (g)	% Total Mass (g)
Granite	43	88%	14718.80	77%
Sandstone	2	4%	1142.30	6%
Quartzite	4	8%	3219.30	17%
Total	**49**	**100%**	**19080.40**	**100%**

Table 6: Summary of the composition and frequency of thermally altered stone from Area 5.

Pottery

Fourteen pottery specimens were recovered from the Area 5 assemblage. All of these pottery sherds are smaller than 2.5 cm in diameter and weigh less then six grams. The pottery sherds have granite grit temper; this was the standard during the Late Precontact period on the northwest Plains (Walde and Meyer 2003:134). Six of the twelve sherds have some exterior decoration. Three of the decorated sherds (artifact 94462, 95438, and 982318) appear to have a cord-wrapped exterior. The other three decorated sherds (artifact 96784, 97503, and 97846) share a series of three decoration types and appear to be from the same pot, but could not refitted. Two rim sherds (artifact 96784 and 97503) have angular incisions on both the internal and external surface. Directly below the incisions on what would presumably be the external surface of the pot is evidence of a dentate stamping pattern. Below this are small appliqué balls of clay. The final decorated pottery sherd (artifact 97846) also has appliqué clay balls on its exterior surface, and the clay type and amount of firing matches that of artifacts 96784 and 97503. The final eight pottery sherds are so small that no discernable decoration could be attributed to them. The sparse sample of pottery available from Area 5 makes a typological assessment difficult. However I feel that the available pottery samples represent Saskatchewan Basin Complex: Late Variant pottery. This pottery has been described as having relatively thick walls and a globular shape (Meyer 1988:56). As seen from the specimens from Area 5, most Saskatchewan Basin Complex: Late Variant pottery vessels also have some sort of surface treatment. Meyer (1988:56) states that: "...punctuates are common, and impressions made with coarse, cord wrapped tools and incisions with pointed tools also occur." Since the pottery is minimally represented at the site and is a minor component of this thesis, no further analyses were attempted.

The presence of pottery, like the presence of thermally altered stone, suggests that some domestic activates (such as heating and cooking) were occurring at the site. Twelve small fragments of pottery do not imply that intense habitation was taking place. Therefore, it is likely that this human occupation of the area was limited to the time it would have taken to butcher the animals and prepare them for transport.

Bone Tools

The lack of stone tools other than projectile points at the site, may suggest that expedient bone tools were utilized for on-site carcass butchering. However weathering and surface exfoliation of the bone made identifying and assessing bone tool remains difficult because any polish and surface modification was often rendered invisible. Polish or wear that may have been present likely has been worn away or distorted by a variety of taphonomic factors (see Chapter 4 for a discussion of the taphonomic agents present at Area 5). However, at least three bone specimens interpreted as bone tools were identified.

Artifact 90569 was identified as a radius shaft fragment. This bone is smoothed at one end and shaped into a scoop form while the opposite end of the tool has been formed into the shape of an awl. Artifact 96616 was identified as a rib shaft fragment. This rib specimen is the inferior face of a rib shaft that was split longitudinally. The distal end of this rib fragment is notched (or serrated) and the exterior bone surface is polished and the interior surface is smoothed on the distal end. Artifact 94540 was also identified as a rib shaft fragment. This specimen has been smoothed intensively on both its interior and exterior surfaces, and is heavily polished. The ends of this bone are rounded and spatulate in shape. Blaikie (2005:123) reports that ten modified rib body fragments similar to artifact 94540 were recovered from Area 7, a possible secondary processing site less than 100 m southeast of Area 5 (see Figure 4). Blaikie describes this tool type as an "expedient butchering and processing implement...believed to have served in the stripping of flesh from bones, the separation of muscles, and the extraction of marrow from long bone cavities" (Blaikie 2005:123). Artifact 96616 also may have been used to perform a similar function.

CHAPTER 4: FAUNAL ASSEMBLAGE

The following chapter includes a discussion on the laboratory methods and procedures taken during the cataloguing and analysis of the faunal remains from Area 5. As well, a detailed examination and quantification of the faunal remains from Area 5 is undertaken in this chapter, including an extensive discussion of each bison skeletal element with a focus on interpreting butchering patterns and element portion presence and absence. These analyses were undertaken with the purpose of determining if Area 5 is a bison kill site. In addition, a discussion of Area 5 taphonomy and bone density is included in this chapter.

4.1 Questions Posed

There are numerous ways that bison kill sites can be identified by archaeologists. They can be recognized by their distinctive location on the landscape, their tool assemblages, and their faunal assemblages. In this chapter I attempt to demonstrate that Area 5 was part of a bison kill site through analyses of the faunal remains. I examine butchering patterns, element representaion, and transportation decisions visible through the faunal remains of Area 5. The patterns seen in the faunal assemblage at Area 5 are compared to other kill sites on the northwest Plains. In addition, ethnographic and historic patterns of bison butchering and transport are used for comparison.

Late Precontact bison kill sites are common on the Plains, and some such sites that have been examined in detail include Frison (1970, 1974), Kehoe (1973), Reher (1970), Reher and Frison (1980), Brink and Dawe (1989), Shortt (1993), and Tischer (2000). Similar patterns of butchery and transport have been observed at these sites.

Generally, at these kill sites, certain portions of the bison are removed and other portions are often left behind. For example, the removal of the upper limb, hump, side, breast, and marrow bones (all high food value portions of a bison) away from the kill site for further processing is common. As well, the discard of lower limb bones (low food value portions of a bison) is also observed. Secondary processing sites (often representing habitation sites) are locations where the desirable cuts of meat were transported after they were removed from kill sites. At secondary processing sites extensive butchering and processing activities are undertaken, including meat cutting and preservation, marrow removal from bones, and rendering bones for bone grease. These activities result in a more intensely fragmented faunal assemblage than can be expected at kill sites. A detailed examination of the faunal remains recovered from Area 5 in this chapter will allow me to determine if the patterns of faunal representation observed resemble those at kill sites or are more similar to those at secondary processing sites on the northwest Plains.

4.2 Laboratory Methods

The faunal remains from Area 5 were washed, dried, and catalogued by the staff of Alberta Western Heritage Inc. in St. Albert, Alberta. In 2004 the artifacts were brought to the University of Alberta where the identifiable faunal remains were separated from the unidentifiable ones and further analysis and cataloguing was undertaken on the identifiable specimens. During the analysis none of the specimens required special handling to ensure their preservation. The faunal material varied only slightly in terms of overall bone structural integrity and most bone remained in a stable state throughout excavation, transportation, storage, and analysis.

During the analysis identifiable elements were catalogued by recording the catalogue number, provenience information (unit number, northing, easting, quadrant, level, depth of level), taxon, element, element portion, size class (mm), weight (g), side, fracture type, modifications, modification location, percentage of root alteration, weathering stage, and stage of fusion. The presence or absence of the density scan sites defined by Kreutzer (1992) were also recorded during the laboratory analysis. 'Identifiable' specimens include those specimens that are identifiable to element, as well as undifferentiated skull fragments, undifferentiated tooth fragments, and undifferentiated long bone fragments. Unidentifiable fragments only include specimens that are too fragmented or weathered to be identified (but are assumed to be bison). These fragments were catalogued by recording the provenience information, size class (mm), weight (g), and modification types. Comparative osteological material used for identifying the archaeological faunal remains from Area 5 was provided by the Department of Anthropology Zooarchaeological Reference Collection at the University of Alberta (see Table 7 for list of bison specimens used as a reference). Hesse and Wapnish (1985), McCuaig Balkwill and Cumbaa (1992), Hillson (1996), and Todd (2001) were also used in the identification of bison faunal remains from Area 5.

Acc. No.	Sub-species	Sex	Age	Location
981.3.1	*Bison bison bison*	Male	Adult	Elk Island National Park
980.12.1	*Bison bison bison*	Female	Adult	Alberta Game Farm
982.1.1	*Bison bison bison*	Female	7+ years	Elk Island National Park
983.4.1	*Bison bison athabascae*	Male	2 years	Elk Island National Park
983.2.1	*Bison bison bison*	Female	6 months	Elk Island National Park
980.39.1	*Bison bison athabascae*	Male	Immature	Calgary Zoo

Table 7: Bison specimens in the zooarchaeological reference collection at the University of Alberta.

4.3 Non-Bison Faunal Remains

Since only four specimens were identified as being non-bison, they are treated separately here. Two of the non-bison specimens from Area 5 are coyote (*Canis latrans*). One of these is a portion of the palatine and vomer bones, while the other is the proximal end of a phalanx. Two other specimens, both small and essentially complete elements (but very weathered), are clearly not bison, but could not be identified.

4.4 Quantification of Bison Remains

Basic quantitative zooarchaeological measurements were defined and determined for each specimen from Area 5. The quantification techniques used are standard measurements that allow researchers the means of discussing the quantity of material from a site as well as comparing one faunal assemblage to another. The measurements used to quantify the faunal remains from Area 5 include the number of identified specimens (NISP), minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal unit (MAU). These quantifications will be discussed in more detail in the next sections.

Archaeological investigations of Area 5 resulted in the recovery of 10,787 pieces of faunal material weighing 104 kg. As discussed above, bison (*Bison bison bison*) dominates the assemblage, representing over 99.9% of the total assemblage by weight and count. Bison remains total 3228 (91.4 kg) specimens and 7559 (12.1 kg) unidentifiable specimens (unidentifiable but assumed to mostly be bison). See Table 8 for a breakdown of all specimens recovered from Area 5.

Bone Specimens	**Number of Specimens**	**Weight (kg)**
Non-Bison	4	0.005
Identifiable Bison Fragments	2235	86.4
Undifferentiated (Bison) Tooth Fragments	771	0.9
Undifferentiated (Bison) Skull Fragments	77	0.6
Undifferentiated (Bison) Long Bone Fragments	145	3.5
Unidentified (Mammal)	7559	12.1
TOTAL	10791	104.0

Table 8: NISP and weight of specimens recovered from Area 5

Table 9 is a summary of the quantification measures (NISP, MNI, MNE, MAU, and MAU%) for each element recovered from Area 5. Table 10 and 11 represent the elements ranked from highest MNI values to lowest and the highest %MAU value to the lowest in order to give an indication of the relative abundance of elements. When interpreting this quantification information and considering element representation patterns and butchery, one must bear in mind that the material being analyzed is only a sample of the material from the site. The total size of the Area 5 site is unknown and the sample for this thesis comes from a 2 x 2 m excavation area.

Table 9: NISP, MNI, MNE, MAU, and %MAU for the bison assemblage.

Element	NISP	MNI	MNE	MAU	% MAU
Cranium	151	7	14	7.0	58%
Mandible	104	14	24	12.0	100%
Incisor	59	-	-	-	-
Maxillary Premolar	40	-	-	-	-
Mandibular Premolar	51	-	-	-	-
Maxilla Molar	65	-	-	-	-
Mandible Molar	61	-	-	-	-
Hyoid	11	-	-	-	-
Sternum	0	0	0	0.0	0%
Atlas	16	7	7	7.0	58%
Axis	10	3	3	3.0	25%
Cervical Vertebra	54	5	24	4.8	40%
Thoracic Vertebra	154	5	59	4.2	35%
Lumbar Vertebra	46	5	24	4.8	40%
Sacrum	23	9	9	9.0	75%
Caudal Vertebra	8	1	-	-	-
Ribs	538	3	51	3.9	33%
Scapula	75	12	18	9.0	75%
Humerus	29	10	19	9.5	79%
Radius	41	14	22	11.0	92%
Ulna	24	6	12	6.0	50%
Metacarpal	17	8	15	7.5	63%
Fifth Metacarpal	2	1	1	0.5	4%
Innominate	58	6	12	6.0	50%
Femur	13	4	6	3.0	25%
Patella	2	2	2	1.0	8%
Tibia	39	16	18	9.0	75%
Talus	12	7	12	6.0	50%
Calcaneus	10	6	9	4.5	38%
Fused Central and 4th Tarsal	12	7	12	6.0	50%

Table 9 continued: NISP, MNI, MNE, MAU, and %MAU for the bison assemblage.

Element	NISP	MNI	MNE	MAU	% MAU
Fused 2nd and 3rd Tarsal	6	2	6	3.0	25%
Lateral Malleolus	6	3	6	3.0	25%
First Tarsal	0	0	0	0.0	0%
Metatarsal	19	10	17	8.5	71%
Second Metatarsal	0	0	0	0.0	0%
Proximal Phalanx (1st)	56	7	56	7.0	58%
Middle Phalanx (2nd)	45	6	43	5.4	45%
Distal Phalanx (3rd)	36	4	33	4.1	34%
Proximal Sesamoid	22	2	22	1.4	12%
Distal Sesamoid	6	1	6	0.8	7%
Radial Carpal	9	6	9	4.5	38%
Intermediate Carpal	15	9	15	7.5	63%
Ulnar Carpal	9	7	9	4.5	38%
4th carpal	14	11	14	7.0	58%
Fused 2nd and 3rd Carpal	13	7	13	6.5	54%
Accessory Carpal	6	3	6	3.0	25%

Table 10: Elements ranked by MNI.

Element	MNI	Element	MNI
Tibia	16	Middle Phalanx (2nd)	6
Radius	14	Radial Carpal	6
Mandible	14	Cervical Vertebra	5
Scapula	12	Thoracic Vertebra	5
4th carpal	11	Lumbar Vertebra	5
Humerus	10	Femur	4
Metatarsal	10	Distal Phalanx (3rd)	4
Intermediate Carpal	9	Accessory Carpal	3
Sacrum	9	Lateral Malleolus	3
Metacarpal	8	Axis	3
Skull	7	Ribs	3
Atlas	7	Patella	2
Talus	7	Fused 2nd and 3rd Tarsal	2
Fused Central and 4th Tarsal	7	Proximal Sesamoid	2
Proximal Phalanx (1st)	7	Fifth Metacarpal	1
Ulnar Carpal	7	Caudal Vertebra	1
Fused 2nd and 3rd Carpal	7	Distal Sesamoid	1
Innominate	6	First Tarsal	0
Ulna	6	Second Metatarsal	0
Calcaneus	6	Sternum	0

Table 11: Elements ranked by %MAU.

Element	MAU	% MAU	Element	MAU	% MAU
Mandible	12.0	100%	Lumbar Vertebra	4.8	40%
Radius	11.0	92%	Radial Carpal	4.5	38%
Humerus	9.5	79%	Calcaneus	4.5	38%
Tibia	9.0	75%	Ulnar Carpal	4.5	38%
Sacrum	9.0	75%	Thoracic Vertebra	4.2	35%
Scapula	9.0	75%	Distal Phalanx (3rd)	4.1	34%
Metatarsal	8.5	71%	Ribs	3.9	33%
Intermediate Carpal	7.5	63%	Lateral Malleolus	3.0	25%
Metacarpal	7.5	63%	Femur	3.0	25%
Crania	7.0	58%	Fused 2nd and 3rd Tarsal	3.0	25%
Atlas	7.0	58%	Accessory Carpal	3.0	25%
Proximal Phalanx (1st)	7.0	58%	Axis	3.0	25%
4th carpal	7.0	58%	Proximal Sesamoid	1.4	12%
Fused 2nd and 3rd Carpal	6.5	54%	Patella	1.0	8%
Talus	6.0	50%	Distal Sesamoid	0.8	7%
Fused Central and 4th Tarsal	6.0	50%	Fifth Metacarpal	0.5	4%
Innominate	6.0	50%	Sternum	0.0	0%
Ulna	6.0	50%	First Tarsal	0.0	0%
Middle Phalanx (2nd)	5.4	45%	Second Metatarsal	0.0	0%
Cervical Vertebra	4.8	40%			

Number of Identified Specimens Present (NISP)

NISP is the least derived measure used in faunal analysis and is the simplest way of quantifying faunal remains. It is defined by Klein and Cruz-Uribe as "the number of identified bones (specimens) per species…" (1984:24-25). The NISP for the Area 5 assemblage is 10,787. NISP is a standard measurement, but is problematic when it used to compare different species diversity within a site or comparing the same species representation at different sites (see Grayson 1984). NISP is extremely sensitive to bone fragmentation because fragmentation will not affect all species or all elements at a site equally (Klein and Cruz-Uribe 1984:25).

Minimum Number of Individuals (MNI)

MNI is "the number of individuals necessary to account for all the identified bones" (Klein and Cruz-Uribe 1984:26). It is important to remember that MNI is the smallest total of individuals based on skeletal specimens represented. Therefore MNI is simply a minimum value and the actual count of individuals may be much higher than this value. MNI has been calculated numerous ways (see Reitz and Wing 1999:194-199). For the purposes of this study, bone landmarks were entered into the faunal analysis database during the preliminary analysis. This allowed for the relatively simple quantification of the most abundant portion of a bone present in the assemblage. After the initial analysis of all the specimens, like elements were laid out and compared in order to confidently determine if a landmark was completely present. Although this method is laborious, I feel that this is the most accurate way to establish MNI, especially when dealing with a relatively small assemblage. Element fusion was also taken into account when calculating MNI.

Minimum Number of Elements (MNE)

MNE is a quantification method defined by Lyman (1994a:42) as the "minimum number if individual elements necessary to account for the whole and fragmentary specimens observed." In other words, MNE is the minimum number of elements that account for the sample regardless of the element side (Tischer 2000:58). For example, if there are five right humeri and seven left humeri in an assemblage, the MNE is twelve whereas the MNI would be seven. At sites with poor preservation, Shortt (1993:75) notes that MNE counts provide good information because even un-sided elements can be accounted for in this measure.

Minimum Animal Unit (MAU) and % MAU

MAU is calculated by dividing the MNE for each element by the number of times that element if found in the skeleton of an individual taxon (Lyman 1994a:42). After MAU is derived for each element, the largest MAU value is used as a standard. The other MAUs are then divided by the standard and multiplied by 100 to produce a normed scale designated % MAU (Ritz and Wing 1999:216). In other words, "...% MAU is the ratio of each element's MAU standardized as a percentage of the highest MAU value in the collection" (Ritz and Wing 1999:216). Therefore, the most abundant element(s) in an assemblage always has a %MAU of 100%, with all less abundant elements having %MAU values of less than 100%.

4.5 Taphonomy

Defined in 1940 by the Russian paleontologist I.A. Efremov, taphonomy is "the science of the laws of embedding" (Efremov 1940:93). In useful archaeological terms, "taphonomy is the study of the range of processes that affect the remains of an animal between its death and its recovery from a paleontological or archaeological site" (Todd 1983:38). Since 1940, taphonomy has become an important concept not only for paleontologists, but also for archaeologists, especially paleoethnobotanists and zooarchaeologists (Lyman 1994b:1). After an animal has perished, numerous natural taphonomic agents alter and even eliminate bone that can potentially be recovered from archaeological sites. As a result, it is critical that any interpretation of human behavior based on faunal remains from archaeological sites include a discussion of taphonomy.

Taphonomic agents such as subaerial weathering, fluvial transport, carnivore and rodent activity, hot/cold cycles, wet/dry cycles, ungulate and human trampling, burning, and root etching affect faunal remains pre- and post-deposition. Taphonomic agents of destruction and disturbance play a major role in information loss at archaeological sites. To understand the taphonomic agents at work, archaeologists examine faunal remains in detail for evidence of modification. The identified taphonomic agents that affected the faunal material at Area 5 are discussed in detail below.

Weathering of the bone from Area 5 was recorded in terms of weathering stages defined by Behrensmeyer (1978). Behrensmeyer (1978:151) defines six (0 through 5) weathering stages, with stage 0 representing no weathering and stage 5 representing bone that is falling apart in situ. All of the bones from Area 5 fall within weathering stage 1 to weathering stage 4. About 40% of the identifiable bones (excluding teeth) by NISP were assessed to have stage 1 weathering, indicating that they have slight cracking of the exterior cortical bone surface. Another 40% were assigned to weathering stage 2. These bones exhibit a cracked cortical bone surface as well as a bone surface that is starting to flake. Twenty percent of the specimens are in stage 3 weathering, which is characterized by cortical bone that is rough and fiberous in texture, but weathering does not penetrate deeper than 1.5 mm in this stage. Finally, less than 1% of the identifiable bones are considered to be in stage 4 weathering, which is indicated by a very rough and fiberous texture with bone splinters that are falling off the bone. Overall, the weathering patterns on at least 80% of the bone are not extensive. Generally the faunal remains show cortex weathering that includes cracking, splitting, and exfoliation of the outer surface of the bone in varying degrees of intensity, but otherwise are stable and intact. Few specimens demonstrate weathering that goes beyond the outer cortex of the bone.

It is assumed that most weathering of archaeological bone takes place in a sub-aerial environment and that the amount of weathering is an indication of the time that elapsed before burial of archaeological specimens (Dyck and Morlan 1995:149). However at Area 5, I suggest that some of the weathering seen on the bones may have occurred post-excavation. When excavated, the bones were very dry and mixed in with a material thought to be desiccated hide and viscera. During excavation, the field archaeologists considered the whole mixture of bone and organic material as being in a hard packed mummified state (pers. comm. Gibson 2006). Uncovering of the faunal elements during excavation exposed the bones to moist and dry cycles, probably resulting in some of the observed cracking and flaking. Brink et al. (1985:166) noted that during the 1983 field season of excavation at Head-Smashed-In Buffalo Jump, "freshly exposed bone in good condition would acquire cracks and splits within days of exposure." The Area 5 excavation took place in two phases over one month apart, and even though the exposed artifacts were covered with tarps during this duration, the prolonged exposure to the environment likely would have resulted in moisture fluctuations that could have increased the pre-existing bone weathering. Not all the weathering present on the bones can be attributed to post excavation exposure, but I do suggest that the pre-excavation weathering stages may be slightly lower than those assigned in the analysis.

Another important point to take into consideration is that the bones were recovered from shallow, dry, and sandy sediment that may have been unstable in the past. This instability could have resulted in multiple cycles of exposure and reburial of the bones with time. Wind and sunlight exposure will cause increased weathering of bone; therefore, cycles of exposure may have affected the current condition of the bone. As well, being that the bones were deposited close to the surface, freeze and thaw cycles, frost heaving, and wetting and drying cycles may have also had an effect on this deposit. According to Miller (1975:218) experiments with freezing, thawing, wetting, and drying "have produced breaks parallel and transverse to the longitudinal axis of long bones." Similar patterns are seen on some specimens from Area 5 assemblage. Since the deposit was buried less than 10 cm below the surface, it can be assumed that it would be more affected by freeze and thaw cycles than a more deeply buried deposit. As such, it cannot definitively be determined that the weathering of the bones is all due to sub-aerial weathering occurring before the bones were initially buried. Regardless, the observed weathering may have erased evidence of other taphonomic agents.

Root etching is another taphonomic agent potentially contributing to bone modification at the site, but appears relatively infrequently. The procedure used to record the amount of root damage on each bone was based on Tischer's (2000:47) method used for analysis of faunal material at the EgPn-440, a bison kill site in southern Alberta. Root etching was recorded as being absent (affecting less than 5% of the bone), minor (affecting between 5% and 30% of the bone), or major (affecting over 30% of the bone). Over 99% of the bone specimens recovered from Area 5 were assessed as being absent of root etching. Of the identifiable specimens, 87 specimens (<1%) have minor root etching, and 16 specimens (<1%) have major root damage. The sandy environment the bones were recovered from is currently lacking abundant vegetation other than sparse grasses. As such, the paucity of root etching may be a function of the sparse vegetation at the site.

Animal activities at an archaeological site can also modify, destroy, and move bones within a site. Scavenger and rodent gnawing were seen infrequently on the bone specimens recovered from Area 5. Eighty-one identifiable specimens (<1%) exhibited evidence of gnaw marks and tooth drag from scavengers and 66 specimens (<1%) showed evidence of rodent gnawing. No specimens could be identified confidently as being digested and reintroduced to the assemblage by scavengers. The minimal affects of scavengers and rodents on the bone may be indicative of rapid burial after deposition. Rapid burial is also suggested by the fact that organics, such as desiccated soft tissue, hair, and guts, were preserved.

Burning (blackening) and calcining (whitening) of bone are also considered taphonomic agents at archaeological sites. However at Area 5, only eight specimens are burnt and six specimens are calcined (<1%). All specimens affected by heat are small fragments of unidentifiable bone. As such, fire is not considered a significant taphonomic factor at the site.

In summary, the limited amount of scavenger gnawing, rodent gnawing, root etching, and weathering is consistent with an assemblage that has minimal taphonomic biases. When these data are combined with evidence of spiral fractures, cut marks, and hammer impact marks, and association with tools, it suggests that majority of the faunal assemblage from Area 5 is the product of human activity. As such, I therefore assume for the remainder of my analyses that the general patterns of element representation and element portion patterning are primarily the result of human behavior.

Bone Density

A final factor that should be taken into consideration when assessing the effects of taphonomic processes on a faunal assemblage is bone density and its relationships to the relative abundance of skeletal parts. Bone density is the commonly used proxy measure of a bone's ability to withstand destructive forces (Lam and Pearson 2004:100). However, measuring bone density has proven problematic. Commonly bone density is measured using a photon densitometer at a particular scan site on a bone (see Lyman 1994b, Kreutzer 1992, and Lam 1998). Researchers can then assign representative scan sites to the skeletal parts from an archaeological site and calculate the % MAU for each scan site. Then one can statistically compare the volume densities for the same scan sites to the % MAU for the scan site (Kreutzer 1992:289). This methodology allows a researcher to assess if there is a relationship between density and element portion abundance in an assemblage, and thus if there is reason to believe that the patterns observed are solely the result of taphonomic factors, and not human decision making (only dense elements are being recovered simply because they tend to more readily survive). For example, Kreutzer (1992) measured the bone density of numerous bison elements at various locations on an element and applied her volume density results to two Great Plains archaeofaunal assemblages to see if bone density correlated with element representation. Such bone density studies are often coupled with carcass utility models in order to interpret archaeological faunal assemblages (e.g. Lyman 1992).

For many archeologists, bone density measurements have been an essential tool to assess differential destruction of bone. In the early stages of investigation of the material from Area 5 I was also prepared to use bone density measurements as a way to assess the influence of destructive natural processes to elements or element portions present at the site. I recorded all the scan sites (following Kreutzer 1992) present on every identifiable faunal specimen. However, Lam and Pearson (2004 and 2005) recently questioned the reliability of bone density measurement techniques, suggesting that much of the published data are inaccurate due to an incomplete understanding of what is actually being measured at a density scan site. Lam and Pearson (2004:103) state that Kreutzer's (1992) bone density analysis of bison skeletal remains utilizes geometric shapes to approximate the scan site outline and her results will vary depending on how well the cross-sectional area was defined, thus providing better estimates of density for some scan sites than for others. As well, Kreutzer's (1992) scan sites do not exclude the volume density of the internal medullary cavity; therefore her density results for long bones with large internal cavities could be underestimated (Lam and Pearson 2004). Lam and Pearson (2004:110-11) emphasize that, "the most effective way of incorporating bone density data into taphonomic analyses remains unclear," and "density is only one of the many factors that affect the resilience of a bone to destructive processes…variables such as size, shape, strength, cortical thickness, and hardness, are required for taphonomic studies." It is also difficult to apply bone density analyses of this sort without sampling substantial portions of a site; 'missing' elements and element portions may not be truly missing but rather may simply be deposited in an area of the site not yet excavated. Given that only 2 x 2 m was excavated at Area 5, the possibility for such a bias is strong.

I have not chosen to carry out density/element abundance correlation analyses, as these analyses are likely to produce highly questionable results. However, in Appendix 2 I have included a table listing the relative abundance of scan sites for the Area 5 assemblage for the purposes of future density studies with improved methodologies.

4.6 Description of Elements Identified

Axial Skeleton

Cranium

Bone fragments identified as belonging to the bison cranium numbered 151. The specific area of origin for many cranial fragments could not be determined. However, due to the general lack of other species at Area 5, it can safely be assumed that these unidentified specimens belong to bison and not any other species. Seventy-three cranial elements were recovered from Area 5 that could be identified to specific origin on the crania. The most frequent elements identified as crania include portions of the maxilla (22) and the petrous bone (internal auditory meatus) (12). Other fragments identified included portions of the horn core (1), horn sheath (3), orbit (3), incisive (6), occipital condyles (3), premaxilla (1), nasal (3), jugular process (1), portions of the temporal and/or zygomatic process (5), and fragments from the alveolar ridge of either the mandible or maxilla (13).

The MNI of seven for the skull is based on the presence of seven right maxilla fragments with the maxillary first molar, as well as seven left maxilla fragments with the second molar. In general, cranial elements were relatively infrequently recovered from Area 5 with the exception of the maxilla and the petrous bone. Even these portions have low representation compared to other portions of the bison. For example, the petrous portion of the skull is very dense and has a better chance of surviving over many other parts of the bison. However the MNI for the petrous bone is only five based on the presence of five left petrous bones. This low frequency suggests the petrous portion of the cranium (and perhaps the rest of the cranium) is underrepresented in the Area 5 assemblage.

Bison skulls historically have had considerable importance among Plains peoples. Branch (1929:30-31) states that historically in Mandan Villages in North Dakota, bison heads and horns were used in the 'buffalo dance,' a dance used to call the bison in which re-enactment of bison hunting and butchering takes place. This historic account suggests that bison skulls would not have been discarded haphazardly. Instead, they may have been maintained for ceremonial purposes. In addition to skulls being valued, Ewers (1958:75) states that the long hair on the head, beard, and shoulders of a bison was used to decorate lodges, war clubs, and headdresses, and was used as stuffing for balls used in games. Access to hair would be accommodated by the removal of the skull from a kill site so the hair could be removed at the processing site. In addition, during the ethnographic period, Plains peoples commonly used the brain for food or for tanning hides (Head 1986:73). Therefore, the general lack of cranial elements may be result of the removal of entire crania from the site to be processed elsewhere for brain removal. Such varied use of the bison skulls would likely translate into distinct discard patterns of bison skulls. Such distinct treatment of skulls could play a role in their scarcity in the Area 5 sample.

On the other hand, the fragile and delicate nature of most of the crania bones makes them more susceptible to destruction than more robust bones. For example, Binford (1981:60) attributes the fragmentation and lack of caribou cranial portions at sites to be the result of scavenger activity. According to Binford (1981:60) scavengers gnaw from the nose inward, "removing the face and finally collapsing the cranium, leaving the pallet and occiput in two parts. Rarely do the latter two parts exhibit further gnawing. When the skull is eaten in the manner described, few skull fragments remain at the location of consumption; they appear to have been ingested." Scavenging combined with the fragile nature of the skull also may have resulted in the under representation of this skeletal portion at Area 5. However, given the small area of the site sample, it is equally possible that most bison skulls were simply deposited in the unexcavated portions of Area 5.

Mandible

There were 104 mandible specimens identified. There were 37 specimens that consisted of bone and tooth fragments, and 67 specimens that were bone fragments only. Forty-eight specimens are from the right mandible, 26 are from the left mandible, and 33 are indeterminate to side. The MNI is 14 based on the presence of the right third molar alveolus. The MNI for the mandible is double that of the cranium. This discrepancy suggests that the skull and mandible were treated differently during the butchering process.

Fifteen mandibular specimens with a complete or nearly complete symphyseal surfaces were recovered. Eleven specimens are complete coronoid processes only and two specimens include the coronoid process and a potion of the body of the ascending ramus. Twenty-six specimens are fragments of the horizontal ramus with no teeth present. Sixteen specimens consist of the horizontal ramus with teeth. Nine specimens include portions of the ascending and horizontal ramus with no teeth. Twelve specimens include portions of the ascending and horizontal ramus with teeth (six of these are nearly complete mandibles). Nine specimens are only complete condylar processes (one specimen has a portion of the ascending ramus attached). Five specimens are fragments of the ascending ramus and two specimens are nearly complete ascending ramus. A single specimen of only the mandible angle was identified. As well, a single specimen of the most anterior mandible portion with a complete incisor that was not fully erupted was also identified. Only one mandible specimen had a full post-canine tooth row of three molars and three premolars present.

Forty-five mandible specimens exhibited cut marks. These cut marks were located in various locations but mainly on the buccal face of the horizontal ramus, below and near the mandibular notch on the buccal face, near the anterior portion of the horizontal ramus (near the symphyseal surface), and infrequently on the body of the ascending ramus. The cut marks found on the bodies of the horizontal and ascending ramii may be the result of meat removal from the bone, while the cut marks near the mandibular notch are likely from cutting to detach the mandible from the skull. The cut marks near the symphyseal surface can be attributed to the detachment of the left mandible from the right mandible, probably taking place after the mandible was removed from the skull.

Historically and archaeologically, the mandible was removed from the skull and butchered for two main purposes, this first being to remove the tongue and the second being to access the marrow cavity running along the ventral border of the mandible. The process of removing the mandible from the skull is suggested by the location of cut marks and the fragmentation of the mandible. As mentioned above, there are eleven essentially complete loose coronoid processes. These may be the result of the removal or disarticulation of the mandible from the rest the skull. At the Glenrock Buffalo Jump, Frison (1970:35) attributes the fracturing of the coronoid process by a number of blows with a hammerstone. The coronoid process may have been chopped or cut through in this manner to remove the mandible from the skull. There are also eight mandible specimens that include the coronoid process as well as the condylar process. These fragments suggest that these mandibles may have been detached from the skull by smashing below the mandibular notch, detaching the portion of the mandible including the coronoid and the condylar processes. According to Frison (1970:38) mandibles may have been removed from the skull in order to gain access to the tongue. Historically bison tongues were commonly removed during butchering because they were considered choice cuts of meat and important food source (e.g. Wilson 1924; Roe 1972; Mandelbaum 1979; Verbicky-Todd 1984; Wheat 1972).

Marrow removal from the horizontal ramus of the mandible is also commonly seen at archaeological sites (e.g. Head 1986:73-74; Shortt 1993:100; Tischer 2000:64). The majority of the mandibles from Area 5 do not exhibit damage resulting from marrow removal attempts. However, there are some specimens of the horizontal ramus with and without teeth that are small fragments that may have resulted from smashing the horizontal ramus. As well, there are 16 tooth row fragments that have alveolar processes intact but very little ramus present, suggesting that possibly this part of the ramus was destroyed while attempting marrow removal from the mandible. Given the relative abundance of intact mandibles, marrow extraction from the mandible does not seem to have been a regular activity at this site.

Loose Teeth

Loose teeth and teeth fragments from Area 5 number 1053. Forty maxillary premolars, 65 maxillary molars, 51 mandibular premolars, 61 mandibular molars, 59 incisors, six maxillary deciduous premolars, and 771 unidentified tooth fragments were found. Evidence of butchering was not observed on teeth. Mammal teeth are generally are very durable and preserve well; however they flake apart with time. Flaking apart of teeth is regularly seen at Area 5.

Hyoid

All of the hyoid specimens recovered from the site are too small and fragmented to accurately identify the exact portion present. Eleven hyoid specimens were recovered and due to their small size it was impossible to determine how many animals were represented. Generally, at a kill site, a small number of hyoids are expected because this element supports the tongue, a highly valued portion of the bison carcass; removal of the tongue would result in the removal of the hyoid bone. Tischer (2000:66) notes that the removal of the tongue often results in the presence of cut marks on the hyoid. No cut marks were identified on the hyoid fragments from Area 5, but they may not have been noticeable due to the small size of the pieces of hyoid recovered. As a result, even without cut hyoids, the lack of these elements is circumstantial evidence suggesting that hyoids were being removed alongside the tongues. The low frequency of hyoid specimens suggests that they were commonly leaving the site area. However, given the size and overall fragility of the hyoid bone, their low representation at the site may simply be a reflection of taphonomic destruction.

Sternum

No sternebrae were recovered from Area 5 during excavation. The sternum is a porous, fragile, and low-density bone and preservation of this element is expected to be rare. In addition, the sternum is associated with an ethnographically important cut of meat, the breast or brisket (Wilson 1924:247). At the Casper Site, Frison (1974:44) suggests that the brisket was a desirable cut of meat and the removal of this meat resulted in the removal of the distal ends of the ribs, the costal cartilage and the sternum from the kill site. The near complete lack of distal rib portions, sternum, and costal cartilage at Area 5 suggests a similar practice may have been taking place.

Atlas

Sixteen atlas fragments were identified from Area 5. None of these were complete, but three were nearly complete. The MNI is seven based on the presence of the left cranial articular cavity. No cut marks, carnivore gnawing, or rodent gnawing were present on the specimens. However, the fragmentary nature of recovered atlases may suggest that they are being broken up during the disarticulation of the skull from the rest of the body. The MNI for the atlas is low, but is consistent with the MNI of the skull, suggesting that the atlas was often transported and deposited with the skull.

Axis

Ten axis fragments were recovered from Area 5. None of these specimens are complete, but one is almost complete (it is missing the spine). The MNI is three based on the presence of the right transverse foramen. Three axis fragments are fragments of the axis dens only. The small fragments of the axis recovered from Area 5 do not allow for in-depth interpretation of the axis butchering practices at the site. However, the specimens that are present are quite small suggesting that the axis is generally more fragmented than the atlas. This may imply that the axis specimens were more damaged during the removal of the skull. The only direct evidence of butchering on the axis specimens is a few faint cut marks on the dens of one specimen.

Tischer (2000:67-69) notes that there are two different skull removal patterns seen on the Plains. One consists of removing the skull by cutting between the atlas and the axis and the other is to cut between the occipital condyles of the skull and the atlas. In the sample from Area 5, relative element representation does not provide a strong argument for either method. The low representation of skulls at the site matches the low representation of atlas and axis elements suggesting that often all three elements were perhaps treated equally (not transported or deposited separately). Perhaps the disarticulation of bison skulls from animals represented at Area 5 often occurred at a point posterior to the axis.

Cervical Vertebrae

Fifty-four specimens from Area 5 were identified as cervical vertebrae C3 through C7. During analysis the post-axis cervical vertebrae were not distinguished from each other. Twenty-four cervical specimens had essentially complete centra; therefore the MNI was calculated by dividing twenty-four by five (# of cervical vertebrae/ bison), resulting in a minimum number of five individuals represented. Ten specimens have unfused centra, four specimens are fused with a line visible, and the rest are completely fused.

Cut marks are seen on four cervical vertebrae specimens. As well, most cervical vertebrae are missing portions of the transverse process, spinous process, and articular processes. According to Shortt (1993:87), cervical vertebrae in this condition are the result of the removal of neck muscles associated with the front leg. However, these portions of the vertebrae are also very fragile and could be affected by taphonomic agents. The fragmented nature and the low MNI suggests that many cervical vertebrae were taken away from the site with the attached portions of meat, while the ones left behind were damaged due to the removal of meat. Some of the cervical vertebrae were probably butchered during the removal of the neck meat and possibly the hump meat.

Thoracic Vertebrae

Thoracic vertebrae TH1 through TH14 were represented by 154 specimens. Fifty-nine of these specimens have essentially complete centra. The minimum number of individuals was calculated by dividing the number of centra in the sample by the number of thoracic vertebrae in one animal; this resulted in a MNI of five. Other thoracic vertebrae specimens recovered consist of fragments of spinous processes, transverse processes, centra, and unfused cranial and caudal epiphyses. Thirty-four specimens are fragments of the thoracic vertebrae spinous processes.

Evidence of butchering was observed on numerous specimens. Thirty-eight specimens have cut marks. Thirty of these specimens have cut marks on the spinous process and eight specimens have cut marks on the centrum. Cut marks were found on both intact and fragmented spinous process specimens. These cut marks do not appear to occur in a patterned way. The marks were observed on all spine margins and faces and on both the distal and proximal ends of the spines. According to Shortt (1993:90) these types of marks on the spinous process suggests that meat removal was attempted by cutting along the spinous process in order to strip the muscle mass away from the hump. Historically, Plains people regarded the bison hump as a choice piece of meat (Wheat 1972). Shortt (1993:90) also suggests that butchering to remove meat around the rib cage may have occurred by cutting the lateral side of the thoracic vertebrae bodies resulting in the removal of transverse processes. These butchering methods would have resulted in the fragmentation and possibly removal of the spinous processes from the site with the associated meat. However, vertebral processes are very fragile and taphonomic processes could result in their low frequency as well.

Three thoracic vertebrae specimens are unusual because they have been damaged by puncturing, perhaps for removal of 'bone grease' from the centrum. It is difficult to determine if this puncturing was the result of the cultural activity of marrow extraction or the work of scavengers. Eight vertebrae specimens have evidence of scavenger gnawing and five specimens show evidence of rodent gnawing.

Lumbar Vertebrae

Forty-six specimens were identified as lumbar vertebrae LM1 through LM5. Twenty-four of these specimens had essentially complete centra. The minimum number of individuals was calculated by dividing the number of centra specimens in the sample by the number of lumbar vertebrae in one animal; this resulted in a MNI of five. Other lumbar vertebrae specimens include fragments of articular processes, transverse processes, centrum fragments, and unfused cranial and caudal epiphyses. Nine specimens have unfused centrum, three specimens are fused with a line visible, and the rest are completely fused.

One specimen has cut marks on its centrum. Another specimen has hack marks on the transverse process. As well, one specimen has rodent gnawing on the centrum. Damage to the lumbar vertebrae seems to be the result of the removal of the transverse processes or the spinous processes. Only three specimens with complete centra have large portions of the transverse process present and six specimens have intact individual transverse process portions. One specimen has a complete spinous process present, and all other specimens have partial spinous processes or no processes whatsoever. According to Shortt (1993:93) the removal of the spinous and transverse processes is related to the removal of a muscle mass from the side of the animal. Therefore the fragmented nature of the lumbar vertebrae remains may likely be the result of the removal of side meat from the animal. The MNI for the lumbar vertebrae is not very high, suggesting that many were removed from the site with the attached portions of back and side meat, while the ones left behind at the site are damaged due to the removal of meat.

Sacrum

Twenty-three sacral specimens were identified from Area 5. The MNI is nine based on the presence of the first sacral vertebrae centrum. The sacral specimens consist of three specimens that are almost complete, one caudal fragment (the fifth sacral vertebrae) including part of the medial crest, one medial crest fragment (near caudal end), three ala fragments with part of auricular portion visible, seven fragments of the first sacral vertebrae with portions of the ala attached, and eight fragments of sacral vertebral bodies two, three, or four. Six sacral specimens are fused completely and three specimens are unfused.

Some butchering marks are evident on the sacrum. Cut marks are present on three sacral specimens. In addition, frequently the ala of the first vertebrae is damaged or missing. According to Shortt (1993:95) this type of damage results from the chopping of ligaments in order to separate the pelvis from the sacrum. All of the specimens with the first sacral vertebrae present are damaged. There are no hack marks associated with any of these breaks. However, one specimen exhibits some cut marks on the cranial portion of the ala. Scavenger gnawing was only observed on one specimen.

The low frequency of sacral vertebral bodies two through five may be the result of the removal of these portions from Area 5. Shortt (1993:95) suggests that sacral vertebrae may have been removed from kill sites with muscle masses from the pelvic area or hindquarters due to their more caudal position within the bison skeleton. In addition, removing the tail from the carcass could result in the posterior sacral vertebrae being destroyed and transported elsewhere (Shortt 1993:95). Frison (1970:11) also notes that the fourth or fifth sacral vertebrae were most likely chopped off when the tail was being removed with the hide.

Caudal Vertebrae

Eight specimens were identified as caudal vertebrae. Five of these specimens were complete and three were fragments. Given that there are twenty caudal vertebrae in a bison, the MNI for Area 5 is one. No evidence of butchering or cut marks were observed on the caudal vertebrae specimens, but one specimen had evidence of scavenger gnawing. Two specimens were unfused.

The lack of caudal vertebrae is likely the result of tail removal with the hide. Brink and Dawe (1989:147) suggest that this is the case at Head-Smashed-In Buffalo Jump, and Frison (1971:83) suggests that same pattern at the Ruby Site in Wyoming. In addition, Verbicky-Todd (1984:194) points out that bison tails were historically recorded as being used as lodge ornaments. According to McHugh (1972:98), a bison tail on a handle was a 'standard accessory' in Plains sweat lodges. It was used to sprinkle water on heated rocks and as a tool for massaging the body. As well, numerous people have recorded that bison tails were attached to the end of sticks and used as fly switches (Ewers 1955:51; Ewers 1958:75; Grinnell 1892:228; Mandelbaum 1979:60). Tixier reports that in 1840 the Osage cut off the tail of a bison during butchering and kept it as a trophy of their conquest (in McDermott 1940:195). The various uses for a bison tail suggest that it was a valued commodity with numerous purposes and therefore would infrequently be abandoned at the kill site. There appears to be little evidence for the deposition of tails at Area 5.

Ribs

Area 5 produced 538 rib specimens. Complete ribs are poorly represented; only six specimens are nearly complete, missing only their distal ends. There are 418 medial shaft portions of the ribs with no proximal or distal ends. Rib specimens with proximal portions intact are less prevalent with 120 specimens identified. The MNI was determined by using the landmark of intact rib heads. MNI was calculated by dividing 31 left rib heads by 13, the number of left ribs present in a bison; the resulting MNI is three. Two rib body fragments are bone tools. Sixteen rib specimens have evidence of rodent gnawing and 22 specimens have evidence of scavenger gnawing.

Cut marks occurred on almost half of the rib specimens; 244 rib specimens had cut marks on the rib body or less frequently on the rib neck. Cut marks were located on all portions of the rib bodies, including the interior, exterior, anterior and posterior surfaces. As such, the ribs show a high frequency of breakage and cut marks. This suggests that they were heavily butchered elements of the skeleton. Fragmentation of the ribs occurs in a patterned way at Area 5. Proximal ends are common, distal ends are very uncommon, and the majority of the specimens are medial shaft fragments. Ninety-eight (82%) rib specimens with a portion of the head present are less than 20 cm in length. According to Head's (1986:78) work with the bison faunal remains at the Balzac Site in southwest Alberta, an abundance of small proximal sections of rib suggests that the segmentation of the ribs usually occur at around 10 to 20 cm from the axial skeleton. According to Tischer (2000:75) the breakage of ribs in this pattern is due to the breakage and removal of the tubercle and head to aid in the removal of side meat. In comparison to proximal ribs, distal rib sections are very rare in the Area 5 sample. Head (1986:78) proposes that the lack of distal rib portions at kill sites suggests that these portions were being removed from the kill site with the costal cartilage and the sternum as part of the breast meat. The patterns of rib breakage seen at Area 5 are consistent with these suggestions.

Costal Cartilage

Four specimens of costal cartilage were identified. Generally, costal cartilage does not preserve in abundance at archaeological sites because it is not a well-mineralized element. However, if preservation circumstances are ideal and costal cartilage is relatively well mineralized, it can survive in open-air archaeological settings. The lack of costal cartilage from Area 5 may be the result of human decision-making, preservation factors, or both. Costal cartilage is associated with the sternum and the distal end of the ribs, and might have been removed from the site with the breast meat, as suggested by the rib fragmentation pattern. In addition, McHugh (1972:105) reports that historically Plains people used costal cartilage as an ingredient in glue. If this was the case, costal cartilage may have been selectively removed and destroyed through production of this adhesive.

Appendicular Skeleton

Scapula

Seventy-five scapula specimens were recovered from the site. The assemblage of scapulae was very fragmentary with no complete specimens present. The scapula MNI is ten based on the presence of the right glenoid cavity. However there are two left scapula specimens (which do not include the right glenoid cavity) that are consistent with the approximate size of a six-month old bison. If these two individuals are included in the MNI calculation (if the apparent age of specimens are taken into account), the MNI becomes 12. Ten specimens have scavenger gnawing on them and rodent gnawing marks six specimens.

Scapula specimens recovered from Area 5 generally consist of the glenoid cavity, neck, and/or cranial and caudal borders of the scapula with very little of the blade present. The blades of most scapula specimens are absent or very fragmented. This fragmentation can be attributed to the fragile nature of the scapulae blade. The thin bone that makes up the scapula blade (high surface area to volume ratio) makes the blade more susceptible to weathering and mechanical attrition. The scapula blade is also less dense (see Kreutzer 1992:281) than the rest of the scapula. The part of the blade that is most commonly recovered is the caudal ridge. Nine specimens are fragments of the caudal ridge on the medial face of the scapula. Eleven specimens have intact glenoid fossae and necks with fractures below the neck or partially down the blade. According to Tischer (2000:76) this breakage pattern may suggest that these scapulae were broken to remove the forelimb from the rest of the carcass. However, at Area 5, these fractures often do not appear to have formed when the bone was fresh and may be the result of post depositional fracturing. Also ethnographic records indicate that breaking the scapula is not necessary for removing the element from the body. For example, Mandelbaum (1979:58) notes that among the Plains Cree bison limbs were cut off, with the scapula being separated at the joint rather than by cutting or smashing through the bone.

Thirty-eight scapula specimens display cut marks. These are found in various locations on the scapula blade, including the lateral face, the scapula spine, the cranial border, the caudal border, and the neck. These marks could be the result of the removal of meat from the scapula by stripping and/or cutting the meat away from the bone (Shortt 1993:104). According to Frison (1970:14) this type of process would result in longitudinal cut marks on the infraspinous and supraspinous fossae. Unfortunately, only one specimen from Area 5 is complete enough to have significant portions of the infraspinous and supraspinous fossae present. This specimen does have longitudinal scrape (cut) marks on the infraspinous fossa suggesting that meat removal was occurring in the manner specified by Frison. However, many of the other cut marks found on specimens are likely the result of element disarticulation from the body and not meat removal. Six specimens have cut marks on the neck or just below the neck on the medial face of the scapula, likely the result of disarticulating the humerus from the scapula.

At Area 5 the scapula generally appears to have been modified on site, and does not appear to be an element that was regularly left intact or removed offsite. It cannot be said conclusively if the fragmentation of the scapulae at the butchering site is a result of cultural modification or taphonomic post depositional processes, but both frequent cut marks as well as some specimens with scavenger gnawing suggests that both cultural and natural processes were at work shaping the assemblage.

Humerus

Thirty specimens represent the humerus in this assemblage. The MNI is ten based on the presence of ten left specimens with an intact radial fossa. None of the humerus specimens are complete and distal fragments outnumber proximal fragments. One is nearly complete, missing only small portions of the proximal end of the bone and part of the distal medial condyle. Four specimens exhibit portions of the proximal end, including the complete specimen, a shaft with a fragment of a humerus head attached, and two loose fragments of humeri heads. Twenty specimens include all or part of the distal portion of the humerus. Eight specimens are shaft fragments from various locations. All of the humeri examined that have visible proximal or distal ends have fused epiphysis.

Sixteen specimens have cut marks present mostly on the distal portion of shaft, mainly perpendicular to the length of the bone. Thirteen specimens have spiral fractures, nine of which are spiral fractures immediately above the distal metaphysis. This pattern of humeri alteration indicates purposeful element breakage for food procurement. Shortt (1993:106) discusses this type of breakage pattern at the Happy Valley Kill Site in Calgary, Alberta as, "element smashing or breaking to facilitate the removal of marrow after the meat was removed." Although many of the humeri at Area 5 have evidence of this type of butchering, much of the condition of the humeri is likely the result of scavenger activity. Nine specimens have missing proximal ends and obvious crenulated edges created by scavengers. The proximal end of the humerus is less dense than the rest of the humerus (Kreutzer 1992:279) and as such is likely more susceptible to butchering and to scavenger destruction. Overall, the proximal portion of the humerus is under-represented at the site and this absence can be attributed to both human butchering as well as taphonomic processes such as scavenger activity. Brink and Dawe (1989:84-95) also report an under-representation of proximal humeri at Head-Smashed-In Buffalo

Jump, but the poor state of preservation at this site presents difficulties for interpreting this pattern.

Unusual modifications were also found on one humerus. The only nearly complete humerus has a round puncture mark mid shaft on the lateral face. This puncture is slightly oblong and has a diameter of 2.5-3 cm. The same specimen has a smaller round puncture (about 0.5 cm diameter) on the caudal face of the olecranon fossa. Both of these alterations are unusual. The shape and size of the larger puncture appears to be the result of human modification, but the purpose of such modification is unclear. One possible explanation can be found in the observations of Turney-High (1941:37), who observed the Kutenai butchering bison and found that, "holes were punched in the hind quarters just above the knee to receive the thongs by which they were packed. These holes were higher up on the front legs." It is unclear if these holes were through the bone and flesh, or only the flesh. Perhaps the punctures on the Area 5 humerus resulted from similar efforts to attach lines for the purposes of transport.

Radius

A total of 42 radius specimens were recovered from Area 5. The MNI is 14 based on the presence of the left proximal medial rugose area immediately below the glenoid cavity. Ten radius specimens are complete or nearly complete. Eight specimens are distal ends with portions of the shaft and four specimens are loose distal epiphyses. Ten specimens are portions on the proximal end and shaft, and nine specimens are shaft fragments only. Seventeen radius specimens have a portion of the ulna fused to them, either the styloid process or a fragment of the ulna shaft. Complete radio-ulna specimens were not recovered. Four radial specimens have scavenger gnawing present and two specimens appear to be gnawed on by rodents. The proximal end of the radius, when present, was completely fused, but four unfused distal epiphyses and three specimens with no distal epiphyses were also present.

Twenty radial shafts have cut marks on them and 12 others have spiral fractures. This fracture pattern suggests that marrow was being extracted from radii at the site. However, numerous radii also have no evidence of spiral fracturing and are nearly complete suggesting that marrow extraction was not practiced consistently on radii during the butchering process. It seems that the lower forelimb was generally abandoned at Area 5. Fletcher and La Flesche (1911:307) report that historically among the Omaha, "the fore quarters, being tough, was the least desirable part of the animal for food, and was frequently thrown away." The presence of many nearly complete radii at Area 5 attests to the notion that they were generally not heavily processed. However, the presence of cut marks and spiral fractures on some specimens suggest that meat removal and marrow extraction was undertaken, but neither were a regular activity.

Ulna

A total of 24 ulna specimens were recovered from Area 5. All of the ulnae discussed in this section were not attached to the radii discussed above. The MNI for the ulna is six based on the presence of the right trochlear notch. Only one ulna is nearly complete, missing only the styloid process. Two other ulnae are nearly complete, missing only their styloid process and portions of their proximal ends. Fourteen specimens exhibit portions of the proximal end and the shaft, three specimens are styloid process fragments, and seven specimens are fragments of the ulna shaft. One loose proximal epiphysis is present, and one proximal ulna head has a visible fusion surface.

Many of the ulnae exhibit damaged on their proximal ends. Nine proximal ends have damage and four are without damage. The damaged specimens are missing the olecranon tuber and part of the olecranon. It is not clear if the absence of this portion is the result of butchering or scavenger activity. None of these breaks are considered to be spiral fractures; instead they are jagged and crushed in appearance. Two of the specimens may have crenulated edges created by the activity of scavengers, but the others have no evidence of scavenging. Tischer (2000:82) describes a similar pattern of olecranon crushing without the evidence of scavenger tooth marks at EgPn-440. In addition, Shortt (1993:111) suggests that this pattern is the byproduct of separating the radio-ulna from the humerus. Perhaps this crushing results from a heavy, blunt tool being used for disarticulation. Cut marks are rare compared to the evident proximal end crushing of the olecranon. Two specimens have faint cut marks on the ulna shaft, one specimen has faint cut marks on the proximal end, and one specimen has faint cut marks near the neck of the ulna.

Carpals

All six carpal bones were found at Area 5. The one with the highest MNI value is the fourth carpal, with an MNI of 11. Nine radial carpal specimens were recovered. The MNI is six based on the presence of the left radial carpal. Seven of the radial carpals are complete and two are fragmented. Fifteen intermediate carpals were recovered at Area 5. Twelve specimens are complete and three specimens are fragmented. The MNI for the intermediate carpal is nine. Nine ulnar carpal specimens were identified. Seven of these are complete and two are broken. One specimen has cut marks. The MNI for the ulnar carpal is seven. Fourteen fourth carpals were recovered from Area 5. Eleven specimens are complete and three are fragmented. One specimen has cut marks. As mentioned, the MNI for the fourth carpal is eleven. There are 13 fused second and third carpal specimens. Of these 12 are complete and one is fragmented. The fragmentation is likely the result of scavenger gnawing. The MNI for the fused second and third carpal is seven. There are six complete accessory carpal specimens. The accessory carpal MNI is three.

Generally no butchering marks are present on the carpals except in two cases (fourth carpal and ulnar carpal) where faint cut marks are visible. Frison (1974:38) suggests that cut marks on the radial or ulnar carpals are evidence of removing the foot by cutting the ligaments that attach it to the radius. Generally the cortical bone surface of the carpals from Area 5 is weathered, making it impossible to detect clear evidence of cut marks on such small elements. As a result, even though there are few cut marks on the carpals from Area 5, it is still possible that the front foot was being detached in the way described by Frison. However numerous distal radii are present, which may suggest the distal front foot was being detached by breaking the radius instead of cutting the joint at the carpals. The MNI values of the carpals are similar to that of the metacarpal, suggesting that these distal forelimb bones were being treated as a butchering unit.

Metacarpal

A total of 17 metacarpal specimens were recovered from Area 5. Thirteen specimens are complete or nearly complete. Three specimens are the proximal diaphysis fragments, and one is the distal end with a portion of the diaphysis present. The MNI is eight based on the identification of eight right specimens with the large proximal central nutrient foramen present. Fifteen specimens include all or part of the proximal portion of the metacarpal and ten specimens include all or part of the distal portion of the metacarpal. Three of the metacarpal specimens examined are unfused and without a distal epiphyses. As well, one specimen has a visible fusion line on the distal end.

Eleven metacarpal specimens have cut marks present. These cut marks are very fine and generally found on all faces of the bone except the distal and proximal ends. These cut marks are generally perpendicular to the shaft of the bone, but one specimen does exhibit cut marks running parallel on the shaft. The location of these cut marks are indicative of skin and flesh removal from the front leg. One specimen exhibits a spiral fracture, which may indicate the smashing of this element for marrow. However, it is clear that the metacarpals were not subject to intense butchering and cultural modification. Two specimens have evidence of scavenger gnawing on the distal end of the element. The presence of thirteen complete and nearly complete elements indicates that they were being abandoned at the site as whole elements. This is perhaps due to the low meat, marrow, and bone grease yield of the metacarpal (see Brink 2001) and its anatomical association with other relatively poor meat yielding sections of the skeleton (distal radius, carpals, and phalanges).

Fifth Metacarpal

The fifth metacarpal is a vestigial metacarpal located laterally and caudally of the metacarpal (Tischer 2000:84). Two fifth metacarpals were recovered from Area 5, one being complete, the other represented by only the distal tip. Side was not determined for these bones. There are two fifth metacarpals in a single animal, so the MNI based on this element is one. No evidence of butchering or cut marks is present. The low representation of the fifth metacarpal is likely a reflection of its small size and apparent fragility, which likely makes it more vulnerable to scavengers and other taphonomic agents.

Innominate

Innominates are represented by 58 specimens. The MNI is six based on the presence of six right acetabulum notches and six left acetabulums. All specimens that have intact acetabulums are fused without a line. Four specimens display carnivore gnawing and three specimens exhibit some rodent gnawing. None of the innominate specimens recovered are complete. The two largest innominate specimens are most of a right illium and a left portion of a partial illium, ischium, and pubis. In total there are five innominate specimens present that have portions of the illium, ischium, and pubis present. Three specimens are portions of the pubic symphysis. Six specimens are fragments of the pubis bone, and the remainder are small portions of the either the illium or ischium.

The morphological complexity of the innominate makes breakage and butchering patterns difficult to determine. Eleven innominate specimens exhibit cut marks. Five specimens have cuts marks on or near the acetabulum. These are probably the result of the disarticulation of the hind limb from the innominate. Nineteen specimens included portions of the acetabular area. Shortt (1993:118) argues that broken and fragmented pieces of the acetabular area are suggestive of butchering involving purposeful breakage of the bone to facilitate the removal of the femora; such may have occurred at Area 5. In addition, few illium and ischium specimens have intact borders. According to Tischer (2000:85) the borders of the illium and ischium are less dense and tend not to preserve at archaeological sites. Also these borders are points of muscle attachment and therefore may undergo damage during the butchering process.

Six ilium specimens have faint scrape marks, possibly the result of meat removal. Frison (1970:19) notes that there are two main regions of the innominate that are affected by the removal of meat – the ischial tuberosity and the coxal tuberosity. These portions of the innominate are rare at Area 5. Only one specimen has in intact coxal tuberosity and two specimens that are the ischial tuberosity only, but both of these portions are lacking on all other specimens. Therefore it seems likely that meat was being removed from the illium at Area 5.

Femur

Thirteen specimens from Area 5 were identified as femora. The MNI is four based on the presence of the right minor trochanter. This is the lowest MNI of all the long bones. No complete specimens were recovered and no specimens had a complete proximal or distal end. Fragments of the proximal end accounted for four specimens and fragments of distal end accounted for four specimens. The remaining five specimens are shaft fragments. All shaft fragments include at least a portion of the minor trochanter or the supracondyloid fossa. One specimen had a visible fusion line between the proximal epiphysis and the diaphysis. Another specimen consisted of a femoral neck that had a visible fusion surface without a proximal epiphysis. Two specimens exhibited scavenger gnawing.

Generally femora are underrepresented at kill sites (e.g. Tischer 2000; Shortt 1993). The lack of femora at a kill site would suggest that they were being removed to a habitation site for further processing. However, identifiable femur fragments are also rare at many habitation sites in Alberta. For example, at the Balzac Site, a stratified habitation site in southwestern Alberta, Head (1985:86) reports that the femur is generally poorly represented at the site and suggests that the element is highly fragmented due to muscle stripping, bone marrow removal, or bone grease production. The under-representation of the femur at kill sites and processing sites suggests that femora were generally heavily processed for marrow and bone grease, rendering their fragments difficult to identify. The femur was not only associated with a large meat portion but it has high marrow and bone grease utility as well (see Brink 2001). These factors likely contribute to the paucity of femora remains recovered on the northwest Plains. Only two femur specimens from Area 5 exhibited cut marks. These cut marks were found below the neck on the proximal shaft of two femora.

<u>Patella</u>

Two patellae were identified from Area 5. Both were from the left hind limb and thus the MNI for patellae is two. There is no evidence of butchering on these specimens. The patellae representation is similar to that of the femur; both are underrepresented compared to more distal elements of the hind limbs. The low frequency of the patella suggests that they were being removed from Area 5 with the femur. This lack of patellae can be explained by the concept of 'riders.' Binford (1978, 1981) discusses 'riders' as low food value elements that will be removed from the kill site because they are securely attached to more desirable elements. The position of the patella between the distal femur and the proximal tibia, both choice element portions that are found in very limited numbers at Area 5, suggests that the patella was a rider with these elements out of the site. Additionally, Shortt (1993:120-21) suggests that at the Happy Valley Bison Kill Site, patellae were conveniently used as "hand-holds for stripping and transporting large rear-leg muscles." This behavior also suggests that the patella would be transported away from the kill site.

Notably, the under-representation of the patella at kill sites is not consistent. At the Wardell Buffalo Trap, Frison (1973:42) reports that several patellae were recovered from the kill and many have chop markings on them, suggesting butchery to release the major trochanter of the femur. Although it does seem that the major trochanter was at least sometimes being chopped off at Area 5, the associated patellae were either not left at the site, deposited elsewhere at the site, or did not preserve.

Tibia

Thirty-eight specimens represent the tibiae in this assemblage. The MNI is 16 based on the presence of the left distal medial articular groove. None of the tibia specimens are complete. One is nearly complete, missing small portions of the proximal end due to weathering. Five specimens exhibit complete proximal ends or portions of proximal ends and 18 specimens exhibit complete portions of the distal end. Fifteen specimens are shaft fragments from various locations on the diaphysis. Tibia shaft fragments may be over-represented compared to other long bone shafts because they are more easily identified than other long bone shaft fragments due to their square shape and prominent muscle attachment ridges (Brink and Dawe 1989:104). All distal epiphysis are completely fused. One loose proximal epiphysis is present; one nearly complete specimen has a visible line of fusion.

In general, distal ends of the tibia are more common than the proximal ends. The over-representation of the distal tibia does not appear to be a product of differential destruction due to bone density because the density of the proximal tibia appears to be very similar to that of the distal end (Kreutzer 1992:281). However, according to Brink (2001:282) the distal tibia has significantly less bone grease than the proximal end. As a result, the overrepresentation of the distal tibia suggests that the distal tibia has less food value than the proximal portion. Therefore, the distal shaft of the tibia may have been where the foot was detached from the rest of the hind limb, with the rest of the tibia was removed from the site for further processing. This is supported by the fact that all 16 left distal tibiae and the three right distal tibiae have evidence of spiral fracturing on the shaft, indicating fracture of the bone while it was fresh. The two proximal tibiae present also have spiral fractures on their shafts. This pattern is commonly reported at bison kill sites. For example, Tischer (2000:89-90) describes a similar pattern of distal tibia predominance at the EgPn-440, where far more distal tibia specimens (38) were recovered than proximal tibia portions (11). Brink and Dawe (1989:88) also state that at Head-Smashed-In Buffalo Jump the proximal tibia is almost non-existent while the distal ends constituted the entire tibia assemblage. Frison (1973:46) too reports this pattern at the Wardell Buffalo Jump in Wyoming. Finally, Shortt (1993:121) suggests that at the

Happy Valley Kill Site, tibiae were broken after the removal of the meat and the proximal portions of the bone were removed from the site and the distal portions left behind. It thus seems likely that the pattern of distal tibia dominance at Area 5 was the result of similar processes.

Three tibia mid-shafts fragments from Area 5 have cut marks, and one proximal tibia shaft and 12 distal tibia shafts show cut marks. Most of these specimens have cut marks that run perpendicular to the shaft, but three of the 12 also have cut marks that run parallel to the shaft. According to Binford (1981:119), cut marks on the distal portion of the tibia shaft are common at kill sites he examined and are the result of detaching the tibia from the astragalus. The parallel cut marks on the distal portion of the tibia shaft are faint and most likely result from meat removal from the tibia. Minimal amount of scavenger damage is seen on the tibia. One tibia shaft fragment has some evidence of scavenger tooth drag and rodent gnawing is present on four tibia specimens. In addition, one tibia specimen may be an expedient tool. It has a long spiral fracture on the shaft and the remaining shaft forms a spatulate shape near the proximal end. There is little evidence of intentional retouch, polish or wear from use, but it appears smoothed on the interior surface as a result of wear.

Tarsals

Only five of the six tarsals were recovered from Area 5; tarsal 1 was not found at the site. The highest MNI value comes from the talus and the fused central and fourth tarsal. Both of these tarsals include seven complete left specimens. Twelve talus specimens were identified all were complete specimens. Twelve fused central and fourth tarsal specimens were also recovered. Eleven of these specimens are complete, while one is fragmented. Ten specimens were identified as the calcanea. None of these specimens are fragmented or broken. However, three specimens are unfused and missing the proximal epiphysis, while one specimen has a visible fusion line and another is represented by an epiphysis only. The MNI is six based on left calcanea. The fused second and third tarsal and the lateral malleolus are underrepresented compared to the other tarsals. Six complete specimens represent the second and third fused tarsal, and the MNI is two based on rights. There are six lateral malleoli specimens as well; five are complete and one is fragmented. The MNI is three based on rights. The low representation of the fused second and third tarsal and the lateral malleolus, as well as the absence of tarsal 1 may be the result of the small size of these tarsals compared to the size of the other tarsals. These smaller tarsals are more susceptible to being consumed completely by scavengers.

No cut marks were found on the tarsals. This is not unexpected because the lower limb at Area 5 seems to have been removed by smashing the distal shaft of the tibia instead of cutting through the ligaments of the joint between the tarsals and the tibia. Generally the damage and fragmentation seen among the tarsals from Area 5 is attributed to natural taphonomic factors and not cultural activities.

Metatarsal

A total of 19 metatarsal specimens were recovered from Area 5. The MNI is ten based on the presence of the left proximal medial articular surface. Thirteen specimens were complete or nearly complete, four specimens are portions of the proximal end including the shaft, one specimen is the distal end including the shaft, and the final specimen is a proximal articular surface fragment. Seventeen specimens include all or part of the proximal portion of the metatarsal and 11 specimens include all or part of the distal portion of the metatarsal. Two of the metatarsal specimens examined are unfused and do not include a distal epiphysis.

Spiral fractures are recorded on two metatarsal shafts. These spiral fractures may indicate bone breakage for marrow release. However, it is clear that the metatarsals were not subject to intense butchering and cultural modification as were the other elements of the hindlimb, such as the femur and the tibia. This is consistent with the minimal butchery observed on the metacarpals, but it should be kept in mind that a few unidentified fragmented metapodial fragments were present in the assemblage and could represent some intensive butchery of these lower leg elements. The pattern of limited processing of metatarsals is not unusual because the position of this element in the lower limb means it has less meat, less bone grease, and less marrow (see Brink 2001) than more proximal hind limb bones. However, seven specimens show evidence of cut marks. Five specimens have faint cut marks on the proximal diaphysis and two specimens have faint cut marks on the distal diaphysis. These cut marks are found perpendicular to the shaft of the bone and their location is indicative of the skin removal from the hind leg (Tischer 2000:91).

Second Metatarsal

The second metatarsal is a vestigial metatarsal (Tischer 2000:84). This bone is small, round, variable, and difficult to side. No second metatarsals were identified in the

Area 5 assemblage. The small size of this element makes it susceptible to scavengers and other taphonomic agents, such as weathering. The activity of these agents would result in the low frequency of the second metatarsal at Area 5.

Undifferentiated Metapodials

Specimens that could not be identified as either metatarsals or metacarpals are classified as metapodial fragments. Fourteen specimens from Area 5 were identified to be metapodial fragments. Twelve of these specimens are complete portions of the distal metapodial condyles. One is a shaft fragment with a portion of the vascular groove and two fragments are portions of the proximal end of a metapodial. No evidence of butchering is evident on any of these metapodial fragments. Ten of the distal condyle specimens are complete portions of unfused distal epiphysis.

Undifferentiated Long Bone Shafts

Specimens that could not be identified as specific long bones but were a portion of an indeterminate long bone shaft were considered to be undifferentiated long bone shaft fragments. There were 145 of these shaft fragments recovered from Area 5. These specimens had no features that would allow for their identification. According to Lam and Pearson (2005:100) long bones are generally quantified based on the epiphysis counts because they are more identifiable than shaft fragments and the inclusion of shaft fragments would result in higher counts of the high–utility, more dense upper limbs (humerus, radius/ulna, femur, and tibia) in archaeological assemblages. As a result the scarcity of high utility long bones documented at many faunal assemblages may simply be a reflection of the fact that shaft fragments could not be identified and therefore were not quantified (Lam and Pearson 2005:100). This problem is difficult to resolve and it is likely (due to the difficulty of identification) that long bone shafts may be underrepresented in the quantification of long bones at Area 5.

Phalanges

There were 148 phalanx specimens recovered from Area 5. Each limb of a bison has two proximal phalanges, two medial phalanges, and two distal phalanges. Bison phalanx specimens are extremely difficult to assign to side or to front or rear limb, and no such designations were attempted here. There are 56 proximal phalanx specimens, 45 medial phalanx specimens, 36 distal phalanx specimens, and 11 undifferentiated phalanx fragments. Of these unidentified specimens two are proximal epiphysis of a proximal or medial phalanx, one is distal epiphysis of a proximal or medial phalanx, three are unidentifiable phalanx body fragments, two are fused distal portions of a proximal or medial phalanx, and three are fused proximal portions of a proximal or medial phalanx.

Proximal Phalanges

All 56 proximal phalanx fragments have intact distal ends. There are a total of eight proximal phalanges in the body, so the resulting MNI is seven. Fifty-five of the proximal phalanx specimens were complete and one is just the distal portion of the phalanx. Two of the complete specimens were unfused and were missing the proximal epiphysis.

Four phalanx specimens have faint cut marks on the body. As well, there are seven proximal phalanx specimens that have punctured or split bodies. Shortt (1993:133) describes four proximal phalanges from the Happy Valley Bison Kill Site that are split longitudinally and suggests that this may be evidence of preparation for boiling of the element. Blaikie (2005:118) states that a number of bison proximal phalanges recovered from Area 7 of the Bodo Archaeological Locality have been split longitudinally or have a hole punctured into the marrow cavity. Blaikie (2005:118) discusses a comparable fracture pattern seen on antelope phalanges from the Lost Terrace Site in Montana (Davis et al. 2000:62). Davis et al. (2000:64) suggests that this pattern of nutrition extraction is a result of "severe subsistence stress." Davis et al. (2000:62) explains that a group facing food shortages may resort to extensive and unselective use of a bison carcass for food, including intense consumption of phalanges. In addition, Dorsey (1884:239) stresses that historically bison feet and hooves were never considered as food unless it was a time of severe food shortage. However, nutritional stress does not seem to be factor at Area 5, due to the fact that many bones that have higher food value than phalanges were left unbutchered. If phalanges were being selected for marrow extraction at Area 5, it may have been situational and not an activity regularly undertaken at the site. However the lack of a clear pattern of breakage suggests that the split or punctured phalanges from Area 5 could also be the result of scavenger activity.

Medial Phalanges

There are 45 medial phalange specimens and 43 of these fragments have intact distal ends. Eight medial phalanges are found in a bison resulting in a MNI of six. Forty-one specimens are complete, two specimens are distal fragments, one specimen is a proximal fragment, and one specimen is a weathered body fragment. As well, three complete specimens are missing the proximal epiphysis, and one specimen has a visible distal epiphysis fusion line. There is no clear evidence of butchering or gnawing on any of the specimens. One specimen may have cut marks on the body, but they are very faint and hard to identify with certainty.

Distal Phalanges

Thirty-six specimens are identified as the distal phalanx, and 33 of these have intact proximal ends. Again eight distal phalanges are found in the body, so the MNI is four. Twenty-nine specimens are complete, four are fragments of the proximal end, and three specimens are body fragments. The distal phalanx epiphysis is essentially fused at birth and all specimens in this collection are fused. There is no evidence of butchering or gnawing on any of the specimens.

Sesamoids

There are four proximal sesamoids and two distal sesamoids in each foot of a bison. Nineteen (unsided) essentially complete proximal sesamoids and three fragments of proximal sesamoids were identified. A MNI of two is determined for the proximal sesamoid, based on the presence of 16 proximal sesamoids per bison. Six complete distal unsided sesamoids were also identified, and a MNI of one was determined, based on the presence of eight distal sesamoids per bison. Even though the sesamoids articulate within the phalanges, they are generally not recovered in any quantity at archaeology sites.

Their small size makes them susceptible to weathering or scavenger destruction. The chance of sesamoid preservation is very low.

Summary

Element representation, butchering patterns, and transport decisions revealed through the Area 5 faunal material demonstrates that Area 5 shares many of the patterns seen at numerous kill sites on the northwest Plains. Generally, portions of the bison with the largest amounts of meat, marrow, and bone grease, including the back, sides, breast, and upper limbs, are either heavily butchered or lacking from the Area 5 assemblage. This suggests that these parts were being removed from the site for further processing. Other parts of the bison, such as the distal limbs and the mandible that have less food value, show less evidence of intense butchering. The absence of meat on these portions of the body makes them less likely to be butchered or carried away from the kill site for further processing; therefore they are often relatively frequently recovered whole or fragmented at a kill site. Figure 10 is an overview of where evidence of butchering frequently occurred on the bison remains recovered from Area 5. This figure illustrates the common location of cut marks and the portions of bone generally missing or rare at Area 5.

The data presented in this chapter strongly supports the notion that Area 5 is part of a bison kill site. At least 16 bison were killed and butchered and the desired portions removed for further processing, with the less desirable portions abandoned at the site. The effects of taphonomic activities at the site appear to be minimal. As a result, I feel it is safe to suggest that most of the element portion patterns seen at this site are the result of cultural activities.

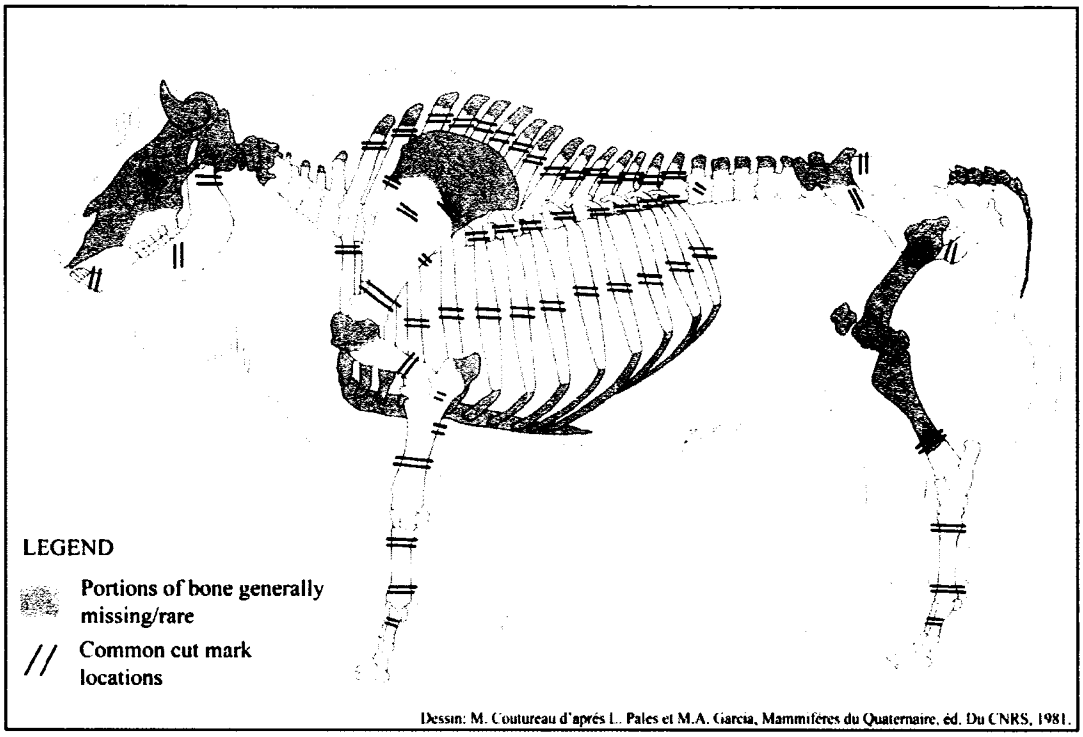


Figure 10: Diagram of bison skeleton showing general butchering patterns for Area 5 (Original skeletal drawing from http://www.archeozoo.org/en-article134.html).

CHAPTER 5: AGING, SEXING, AND SEASONALITY

Determination of the age and sex of the bison faunal remains at a kill site is important for understanding human decision-making. Aging and sexing analysis can provide us with insight on the nature of the kill, prey selection, and the season of site occupation. Assigning ages to bison remains allows for a mortality profile to be established for the sample being analyzed, providing insight on which age group of animals were being hunted and selected for food. Assigning sex to bison remains from a kill site also assists in determining the choices that people made when selecting their prey. The combined age and sex profile of the animals killed at a site potentially allows for a season of site utilization to be inferred based on herd composition.

Bison, being gregarious animals, form different types of groups during different seasons of the year. For example, during the summer and early fall on the northwest Plains is the bison mating season, known as the 'rut', begins in late June or early July and can extend through to the end of September (e.g. Branch 1929:6-7; McHugh 1972:192). During this season smaller cow/calf groups and small bull groups congregate to form large mixed herds of animals. Because the seasonal behavior and grouping of bison is predictable, the age and sex composition of a sample of bison remains from a kill site (if the remains represents a single kill event) can be indicative of the season of site occupation. The determination of site seasonality is used to understand the hunting and processing decisions people were making at different times of the year.

5.1 Aging Bison

Assessing the age of bison is an important element of zooarchaeological studies on the Plains (e.g. Frison and Reher 1970; Reher 1974; Frison et al. 1976; Reher and Frison 1980; Todd et al. 1990; Shortt 1993; Unfreed 2005). Generally, aging bison faunal remains relies on the analyses of tooth eruption and wear, and less commonly the states of epiphyseal fusion of post-cranial bones (Shortt 1993:137). Measurements of the metaconid height of lower molars is also a technique used to assess the age of bison, but a large sample of mandibles is necessary to get reliable periodicity and to separate the specimens into multimodal groups which indicate distinct age categories (e.g. Reher 1970:51-52; Reher and Frison 1980:64); such an assemblage is not available from Area 5 and therefore this analysis was not undertaken. Dental cementum increment analysis has also been used to assess ages of bison in archaeological contexts, including in Area 5 (e.g. Peck 2000; Peck 2004). However, the accuracy of this method is unknown and it is time consuming, destructive, and requires equipment and expertise that are beyond the scope of this thesis.

Epiphyseal fusion analysis relies on the well-established and predictable pattern of the fusion of bison skeletal elements during maturation. The determination of age based on epiphyseal fusion rates is limited because it is only possible to age young individuals whose elements are not completely fused. Another limiting factor is that this method can only result in a general age bracket assignment – precise age estimations are usually not possible. However, when this aging method is combined with patterns of tooth eruption and wear, it can provide useful data for reconstructing mortality profiles for archaeological bison populations. Here I use the post-cranial epiphyseal fusion data of European bison (Koch (1932, 1935); adapted by Duffield (1973:13)) to estimate the time of death for bison. These standards are commonly used in North American bison studies.

Standard archaeological procedures for determining the age of death for bison always include an assessment of tooth eruption and wear. The first basic assumption behind this technique is that bison teeth erupt and wear in a systematic and standard manner (Brumley and Peck 2000:2). However, within a single population, tooth development, eruption, and wear are known to vary depending on the month of birth, nutrition, and growth rate of individuals (Olson 2005:87). A second basic assumption is that tooth wear is consistent between different regions of the Plains. Cleary, some differences in the amount and pattern of wear on teeth can be expected to vary regionally depending on the available food and substrate.

Although problems do exist with these techniques, as long as they are viewed critically they can provide valuable insight on the population structure of an archaeological population. In this section published data will be used to assign ages to bison mandibular dentition from Area 5. In addition, the epiphyseal fusion states of the faunal material from Area 5 will be assessed with the expectation that these two techniques will produce an overall mortality profile for the bison remains recovered from Area 5.

Estimation of Age Based on Tooth Eruption and Wear Stages

In 1970, Frison and Reher (1970) pioneered the use of tooth eruption and wear studies on the Plains. They were the first to acquire an extensive sample of modern bison dentition of known age, allowing them to compile the original aging data that many archaeologists use today. Their samples were obtained from commercial bison herds in Wyoming and 'wild' bison from Yellowstone National Park slaughtered at yearly age increments (Frison and Reher 1970:46-47). Frison and Reher (1970) first applied their dental eruption and wear schedules to specimens at the Glenrock site in order to study population dynamics and site seasonality. Since this time, their dental eruption and wear sequences have been added to and used to assess the age of bison at numerous Precontact archaeological sites on the Plains. Most researchers, lacking an available reference collection of aged dentition, rely on the previously published photographs, illustrations, and detailed descriptions of tooth eruption and wear to assist in their analyses.

Tooth eruption and wear analysis was conducted on fourteen mandibles from Area 5, including seven left specimens and seven right specimens. Each mandible analyzed had two or more post-canine teeth present. Published tooth eruption and wear data on mandibles from the Glenrock (in Colorado) (Frison and Reher 1970), Hawken (in Wyoming) (Frison et. al 1976), and Junction (in Alberta) (Unfreed 2005) sites were used to assign ages to the Area 5 mandibles. The original analysis of the mandibles recovered from the Glenrock and the Hawken sites was undertaken by using a reference collection of know-age mandible samples. Frison and Reher (1970) analyzed 251 mandibles from the Glenrock Site and Frison et al. (1976) analyzed 95 mandibles from the Hawken site. Unfreed (2005) analyzed 387 mandibles from the Junction site using numerous published descriptions of eruption and wear of mandibular teeth from archaeological sites on the Plains (including Reher and Frison 1980; Reher 1974; Frison et al. 1976; Frison 1982; Head 1986; Todd and Hoffman 1987; Wilson 1988; Landals 1990). Unfreed (2005) provides very detailed descriptions of dental eruption and wear patterns she established for each age category at the Junction site.

For my purposes, age categories presented in the studies above were applied to the Area 5 assemblage. I was interested in developing general age groupings in order to establish a population mortality profile. Therefore it was only necessary to establish the age of an individual to the year. For example, if a mandible specimen from Area 5 was similar to those described by Unfreed (2005) as being 5.8±0.1 years old, the assigned age for my purposes would be 5 to 6 years of age. I feel that determining the age of a mandible more precisely than this cannot be carried out without the employment of a complete reference collection of numerous modern locally derived specimens representing the stages of change in bison dentition within a single year. At the same time, I am confident that mandibular dentition descriptions from other archaeological sites can be used to assign ages to the Area 5 specimens when the goal is to assign the specimens to the broad age categories used here.

Visual inspection of the mandibles from Area 5 allowed for the placement of the specimens into six age groups. Table 12 provides complete descriptions of each mandible assessed. Five mandible specimens represent individuals between 3 and 4 years; two specimens represent individuals between 4 and 5 years; one represents an individual between 5 and 6 years; three represent individuals between 6 and 7 years; two represent individuals between 7 and 8 years; and one represents an individual between 8 and 9 years. These results suggest that the sample population of bison from Area 5 primarily represents a population composed of young adults (4-6 years old) and adults (7-

9 years old) (terminology from Fuller (1959)), with few very old individuals being present.

Specimen #		1 (94816)	2 (91566)	3 (91564)
Dentition		M1, M2, M3, P2, P3, P4, and I3	M1, M2, M3, P2, P3, P4	M1 and M2
Side		Right	Left	Right
Assigned Age Group	**Frison & Reher (1970)**	IV (3.5 years)	IV (3.5 years)	IV (3.5 years)
	Frison et al. (1976)	4 (3.7 years)	4 (3.7 years)	4 (3.7 years)
	Unfreed (2005)	EE (3.8±0.1 years)	EE (3.8±0.1 years)	EE (3.8±0.1 years)
Description of Eruption and Wear	**Frison & Reher (1970)**	P4 partly erupted and unworn. M1 and M2 in regular use. 3rd cusp of M3 erupted above alveolus, but is not worn. Slight wear on the first two cusps of M3.	P4 mostly erupted with little to no wear. M1 and M2 in regular use. 3rd cusp of M3 erupted above alveolus, but is not worn. Slight wear on the first two cusps of M3.	M1 and M2 in regular use.
	Frison et al. (1976)	P4 just coming into wear. M1 and M2 in full wear. M3 in light wear. Hypoconulid is erupted above the alveolus, but not yet in wear.	P4 erupted and coming into wear. M1 and M2 in full wear. M3 is in wear but wear is light on VII and VIII. Hypoconulid erupted above alveolus but not in wear.	M1 and M2 in full wear.
	Unfreed (2005)	P4 is erupting. M1 and M2 fully erupted. M1 is moderately worn. M2 is lightly to moderately worn. M3 is lightly worn on anterior and medial cusp. M3 3rd cusp not completely erupted and unworn. Exostylid of M1 is a teardrop. Exostylids of M2 and M3 are erupting. M1 pre and post fossette are hourglasses. M2 prefossette is an hourglass and postfossette is linear. M3 pre and post fossette are linear.	P2 and P3 erupted; P4 erupting. M1, M2, M3 erupted. P2 light wear; P3 moderate wear; P4 light wear. M1 and M2 Moderate wear. M3 light wear on anterior and medial cusp. Hypoconulid unworn.	M1 and M2 fully erupted and in wear. M2 has moderate wear on anterior cusp and light wear on posterior cusp. Exostylid of M1 is a loop. Exostylid of M2 is erupted but unworn. M1 and M2 pre and post fossettes are hourglasses.

Table 12: Ages and descriptions of mandibles from Area 5.

Specimen #		4 (98326)	5 (90329)	6 (97618)
Dentition		M1, M2, M3, and P4	M1 and M2	M1, P3, and P4
Side		Left	Left	Right
Assigned Age Group	**Frison & Reher (1970)**	IV (3.5 years)	IV (3.5 years)	Not enough information available
	Frison et al. (1976)	4 (3.7 years)	4 (3.7 years)	Not enough information available
	Unfreed (2005)	EE (3.8±0.1 years)	EE (3.8±0.1 years)	FF (4.8±0.1 years)
Description of Eruption and Wear	**Frison & Reher (1970)**	P4 partly erupted and unworn. M1 and M2 in regular use. 3rd cusp of M3 erupted above alveolus, but is not worn. Slight wear on the first two cusps of M3.	M1 and M2 in regular use.	Not enough information available.
	Frison et al. (1976)	P4 just coming into wear. M1 and M2 in full wear. M3 in light wear. Hypoconulid is erupted above the alveolus, but not yet in wear.	M1 and M2 in full wear.	Not enough information available.
	Unfreed (2005)	P4 erupted with very light wear. M1, M2 moderately worn. M3 light wear on anterior and medial cusp; Hypoconulid unworn. Exostylid of M1 unworn. Exostylid of M2 erupted and unworn. Exostylid of M3 just erupted and unworn. M1 and M2 pre and post fossette are hourglasses. M3 pre and post fossette are linear.	M1 and M2 fully erupted. M2 has moderate wear on anterior cusp and light wear on posterior cusp. Exostylid of M1 is a teardrop. Exostylid of M2 is erupted but unworn. M1 pre and post fossette are hourglasses. M2 pre and post fossette are an hourglass.	P3 enamel line is at alveolus. P4 is fully erupted. P3 and P4 in moderate wear. Exostylid of M1 is a loop. M1 pre and post fossette are hourglasses.

Table 12 continued: Ages and descriptions of mandibles from Area 5.

Specimen #		7 (75811)	8 (95554)	9 (90763)
Dentition		M1, M2, M3, and P4	M1, M2, M3, and P4	M1 and M2
Side		Left	Right	Left
Assigned Age Group	Frison & Reher (1970)	V (4.5 years)	VI (5.5-9.5 years)	VI (5.5-9.5 years)
	Frison et al. (1976)	5 (4.7 years)	6 (5.7 years)	7 (6.7 years)
	Unfreed (2005)	FF (4.8±0.1 years)	GG (5.8±0.1 years)	HH (6.8±0.1 years)
Description of Eruption and Wear	Frison & Reher (1970)	M1 and M2 in regular use. 3rd cusp of M3 slightly worn. M3 Posterior style unworn.	All permanent teeth in place and in regular wear.	All permanent teeth in place and in regular wear.
	Frison et al. (1976)	Exostylid of M2 not in wear (almost). Hypoconulid in wear but still remains isolated from the rest of the M3. P4 is in moderate wear.	Enamel line at base of M1 metaconid is close to the level of the alveolus.	M1 enamel line is above alveolus. M2 enamel is below alveolus. Exostylid of M3 is in wear.
	Unfreed (2005)	P4 is fully erupted and in moderate wear. M1 and M2 are moderately worn with dentine cupping. M3 moderately worn on the anterior and medial cusp with dentine cupping; hypoconulid is lightly worn. Exostylid of M1, M2, and M3 are erupted but unworn. M1 prefossette is an arc and postfossette is an hourglass. M2 pre and postfossette are hourglasses. M3 pre and postfossette are linear.	P4 enamel line is above alveolus. M1 enamel line is at or just under the alveolus. M1, M2, and M3 are moderately worn with dentine cupping. Exostylid of M1 is a loop. Exostylid of M2 is a circle. Exostylid of M3 is unworn. M1 prefossette is a arc and postfossette is a hourglass. M2 pre and post fossette are hourglasses. M3 prefossette is an hourglass and postfossette is linear.	P4 and M1 enamel lines is above alveolus. M2 enamel line is below alveolus. M1, M2, and M3 are heavily worn with dentine cupping. Exostylid of M1 is a loop. Exostylid of M2 is a teardrop. M1 prefossette is an arch and postfossette is an hourglass. M2 and M3 pre and post fossette are hourglasses.

Table 12 continued: Ages and descriptions of mandibles from Area 5.

Specimen #		10 (77487)	11 (95555)	12 (91608)
Dentition		M1, M2, and M3	M1, M2, M3, P3, and P4	M1, M2, and M3
Side		Left	Right	Right
Assigned Age Group	**Frison & Reher (1970)**	VI (5.5-9.5 years)	VI (5.5-9.5 years)	VI (5.5-9.5 years)
	Frison et al. (1976)	7 (6.7 years)	7 (6.7 years)	8 (7.7 years)
	Unfreed (2005)	HH (6.8±0.1 years)	HH (6.8±0.1 years)	II (7.8±0.1 years)
Description of Eruption and Wear	**Frison & Reher (1970)**	All permanent teeth in place and in regular wear.	All permanent teeth in place and in regular wear.	All permanent teeth in place and in regular wear.
	Frison et al. (1976)	M1 enamel line is above alveolus. M2 enamel is below alveolus. Exostylid of M3 is in wear. Prefossette of M1 is narrow.	M1 enamel line is above alveolus. M2 enamel is below alveolus. Exostylid of M3 is in wear. Prefossette of M1 is narrow.	Deterioration of M1 is quite evident. Prefossette is gone or nearly gone and deep cupping is evident. M2 still in good condition and the base of the metaconid enamel is close to alveolus level.
	Unfreed (2005)	M1 enamel line is above alveolus. M2 enamel line is below alveolus. M1, M2, and M3 are heavily worn with dentine cupping. Exostylid of M1 and M2 are loops. Exostylid of M3 is a teardrop. M1 prefossette is an arch and postfossette is an hourglass. M2 and M3 pre and post fossettes are hourglasses.	P3, P4, and M1 enamel lines is above alveolus. M2 enamel line is below alveolus. P3 and P4 are heavily worn. M1, M2, and M3 are heavily worn with dentine cupping. Exostylid of M1 and M2 are loops. Exostylid of M3 is a teardrop. M1 prefossette is an arch and postfossette is an hourglass. M2 and M3 pre and post fossettes are hourglass shaped.	M1 enamel line is well above alveolus. M2 enamel line is at alveolus. M3 enamel line under alveolus. M1, M2, and M3 heavily worn with dentine cupping. Exostylid of M1 is eroded. Exostylid of M2 is a loop. Exostylid of M3 is a teardrop. M1, M2, and M3 pre and post fossettes are all arcs.

Table 12 continued: Ages and descriptions of mandibles from Area 5.

Specimen #		13 (91565)	14 (90446)
Dentition		M2 and M3	M2 and M3
Side		Left	Right
Assigned Age Group	**Frison & Reher (1970)**	VI (5.5-9.5years)	VI (5.5-9.5 years)
	Frison et al. (1976)	8 (7.7 years)	9 (8.7 years)
	Unfreed (2005)	II (7.8±0.1 years)	JJ (8.8±0.1 years)
Description of Eruption and Wear	**Frison & Reher (1970)**	All permanent teeth in place and in regular wear.	All permanent teeth in place and in regular wear.
	Frison et al. (1976)	Deterioration of M1 is quite evident. Prefossette is gone or nearly gone and deep cupping is evident. M2 still in good condition and the base of the metaconid enamel is close to alveolus level.	M2 deteriorating with evident cusp cupping. Enamel base of M2 is above the level of alveolus.
	Unfreed (2005)	M1 enamel line is well above alveolus. M2 enamel line is at alveolus. M3 enamel line under alveolus. M1, M2, and M3 heavily worn with dentine cupping. Exostylid of M1 is eroded. Exostylid of M2 is a loop. Exostylid of M3 is a teardrop. M1, M2, and M3 pre and post fossettes are all arcs.	M2 enamel line is above the alveolus. M2 is worn heavily with dentine cupping. M3 enamel line is below the alveolus. M3 is worn heavily with dentine cupping. Exostylid of M2 and M3 are loops. M2 and M3 pre and post fossettes are arcs.

Table 12 continued: Ages and descriptions of mandibles from Area 5.

Estimation of Age Based on Epiphysis Fusion

The epiphyseal fusion rates and associated ages of closure used for this study were compiled by Duffield (1973) based on extensive studies of European bison (*Bison bonasus*) undertaken by Koch (1932, 1935). There is no extensive published data on the epiphyseal fusion rates of Plains bison (*Bison bison*). However, Duffield (1973:132) argues that since Plains bison and European bison are sub-specific and capable of interbreeding and producing fertile offspring, data collected on the European bison should be applicable to North American Plains bison. Note too that age estimates based on epiphyseal fusion are limiting because a bone specimen cannot always be assessed due to fragmentation.

Epiphyseal fusion stages were evaluated for the Area 5 humeral, radial, metacarpal, femoral, tibial, metatarsal, and phalange specimens. The humerus specimens all represent animals that are in at least their fourth year of life. Two radius specimens represent animals between four and six years of age, and all other specimens represent animals over six years old. Two ulna specimens represent animals less than five years old and all other specimens are five years or older. Three metacarpal specimens represent animals in their fourth year or younger, one specimen in the fourth or fifth year, and the rest are older than five years of age. All femur specimens represent animals over five years old except for one that represents an individual less than five years of age. One tibia specimen represents an animal in its fifth year, one specimen in its fifth or sixth year, and all other specimens suggest animals over five years of age. Two metatarsal specimens represent animals in their fourth year or younger, while the rest of the specimens represent individuals that are older than four years of age. Two proximal phalanges have unfused epiphysis and represent individuals less than four and a half years old. Three medial phalanges have unfused proximal epiphysis, and perhaps (the fusion phalanges is not well constrained) represent bison in their second or third year of life.

Although the assessment of the epiphyseal fusion of bones from Area 5 only allows for a general age groupings to be assigned, it can be concluded that many specimens seem to represent individuals around 4 to 5 years of age and older. Other than the three unfused medial phalanges, most specimens likely represent animals older than four years of age (however two ulnae, three metacarpals, one femur, and two metatarsal specimens may represent animals under the age of four). On the other hand, none of the specimens likely representing younger animals appear to be calf-sized, so it seems likely that they represent animals very close to the age of fusion. In other words, animals under four years of age do not frequently appear in the sample from Area 5. On the other hand, the previously mentioned presence of two left scapulae that are the same size as a six-month-old individual suggests that younger individuals are present in the assemblage. The lack of representation of these individuals in the dental and other skeletal remains may suggest that these animals were removed from the site as nearly complete individuals with little butchering undertaken on them at the kill site. There is also little evidence of elderly animals. Such animals would be visible by the presence of completely ossified sacra, completely fused pelvic and scapulae epiphysis, and general bone thickening (Duffield 1973:133). There is no evidence for such traits in the Area 5 sample.

Aging Conclusion

Based on tooth eruption and wear and epiphysis fusion analyses, most of the animals recovered in Area 5 were at least in their fourth year of life, with a few younger individuals also being present. Tooth eruption and wear analyses suggest that numerous animals at the site are young adults between the ages of four and six. As such, the population from Area 5 appears to be composed of young adults and adults between the ages of four and nine, with at least two calves less than a year old also present. This age profile suggests that people who occupied Area 5 were hunting a herd of mostly breeding aged animals (females become sexually mature around two to three years of age and males reach sexual maturity in their third year (Olson 2005:61-64)). Sexing analysis of the long bones, carpals, and tarsals from the site will further help clarify the composition of the animals taken in this site.

5.2 Sexing Bison

The determination of sex composition of an archaeological population is potentially informative about seasonal hunting patterns and prey selection. According to Speth (1983:3), population sex structure information "provides important insights into procurement strategies; and in conjunction with other data such as presence of fetuses and stage of dental eruption and wear, it has proved a useful indicator of the season when the hunt took place."

Sexual dimorphism is a normal characteristic of sexually reproducing organisms (McDonald 1981:149), and is especially pronounced in modern bison. The average weight of a modern mature bull is estimated between 1600-1800 pounds, while the average weight of a mature cow is only 800-900 pounds (Wheat 1972:107). This weight difference is very pronounced in bison bones (Todd 1987:157). It is assumed that precontact bison populations also exhibited a similar degree of sexual dimorphism.

Recent archaeological studies of bison skeletal remains have examined the extent of sexual dimorphism in various bison post-cranial elements. Researchers have measured a variety of modern bison bones of known sex in order to develop methods for assigning sex to archaeological bison remains. Sex determination at archaeological sites on the Plains has been attempted on a variety skeletal elements, including: skulls (Wilson 1974), mandibles (Reher 1970; Reher 1973; Reher 1974; Reher and Frison 1980; Brumley 1995), metapodials (Duffield 1973; Bedord 1974, 1978; Peterson and Hughes 1980); phalanges (Duffield 1973; Roberts 1982), long bones (Speth 1983; Walde 1985; Todd 1986), and carpals and tarsals (Morlan 1991).

Methods for sexing bison faunal remains essentially involve comparing the size of archaeological bison elements with the size of known-sex specimens. This is undertaken through visual inspection of scatter plots of paired bone measurements or through discriminant function analysis. For the purposes of this study, one scatter plot technique and one discriminant function technique were attempted. The first method involved taking measurements of carpals and tarsals as described by Morlan (1991) and plotting the measurements against each other. These points were then visually compared to those of known-sex specimens. The second method involved taking various measurements of long bones (described by Speth 1983) and applying Walde's (1985) discriminate function analysis. Both of these methods are described in more detail below.

Finally, it is important to remember that the age of animals needs to be controlled when assessing the sex distribution of an archaeological bison population (Bedord 1978: 41). For example, a young bison bull can be similar in size to a mature bison cow, and without taking this into consideration, sexing errors would regularly occur. A way of coping with this issue is to utilize only mature bone specimens for sexing purposes. Here maturity was defined by the presence of completely fused epiphyses (following Bedord 1978: 41) on the elements being measured. To keep the sample as large as possible, both right and left specimens were measured in this study; this is a common practice in bison sexing studies (e.g. Tischer 2001; Short 1993).

Sexing using Carpals and Tarsals

The first method of sexing bison was described by Morlan (1991). He took an assortment of measurements on bison carpals and tarsals from the Sjovold site in Saskatchewan and plotted them against each other to demonstrate sex-based distribution patterns. Morlan's (1991) research demonstrates that various measurements of the carpal and tarsal bones from the Sjovold site are bimodal in distribution when plotted with respect to sex. Morlan (1991) includes pictures and descriptions of measurements taken, as well as scatter plots of measurements that demonstrate bimodal distributions that are assumed to reflect the sex differences of his archaeological specimens. He includes a single individual of known sex (male) from Elk Island Park for comparison. Morlan's paper has been criticized because it employed only a single known sex specimen; however, according to Kooyman and Sandgathe (2001), Morlan's more recent work has significantly expanded the known sex sample size and a good separation of sexes is seen between the modern bull and cow/calf specimens (personal communication with Morlan 1998 cited in Kooyman and Sandgathe 2001:70). Jack Brink has also measured additional known sex individuals and is convinced that Morlan's measurements work well for separating adult male bulls from adult cows and calves (personal communication with Jack Brink cited in Kooyman and Sandgathe 2001:70). Both Morlan and Brink have found that some of the carpal/tarsal measurements provide better separation between the sexes.

Due to fragmentation not all carpal and tarsal specimens from Area 5 could provide all measurements described by Morlan (1991). Carpal and tarsal measurements were taken with dial calipers based on Morlan's diagrams and descriptions (see Appendix 2 for lists of all measurements taken). Plots of Area 5 specimens were made using the same variables presented graphically by Morlan for comparison. In addition, variables not plotted by Morlan are explored below. Results of the Area 5 analyses based on carpals and tarsals are presented in Figures 11 through 20. A modern adult bull and adult cow from the University of Alberta, Department of Anthropology Zooarchaeology Collection were measured and included in the plots in order to provide a broader comparative set. Morlan (1991) did not provide the measurements for his modern bull specimen or his archaeological specimens. As such, it was not possible for me to include his specimens into my graphs for comparison.

Radial Carpal

Morlan took three measurements on the radial carpals from the Sjovold site: length, width, and depth. He presented a scatter plot of length versus width for four specimens from Sjovold and demonstrated that the specimens cluster into two modes; the mode near his modern bull specimen was assumed to be bulls and the other mode, representing smaller individuals, was assumed to represent cows and calves.

Eight radial carpals were recovered from Area 5, four of them complete, the others fragmented. Length versus width was plotted for the Area 5 archaeological specimens (as well as for the modern cow and bull) in Figure 11. Two of the four Area 5 specimens appear to belong to the adult bull group (plotting near the modern bull specimen); one specimen appears to be from a cow (plotting near the modern cow specimen). The single outlier is significantly smaller than the other three and probably represents a calf. A similar pattern results from plotting length versus depth and width versus depth for the Area 5 specimens. Morlan (1991:218) states that according to his data from the Sjovold Site all three measurements of the radial carpal depth provide good sex separation of bison. This is also appears to be the case at Area 5.

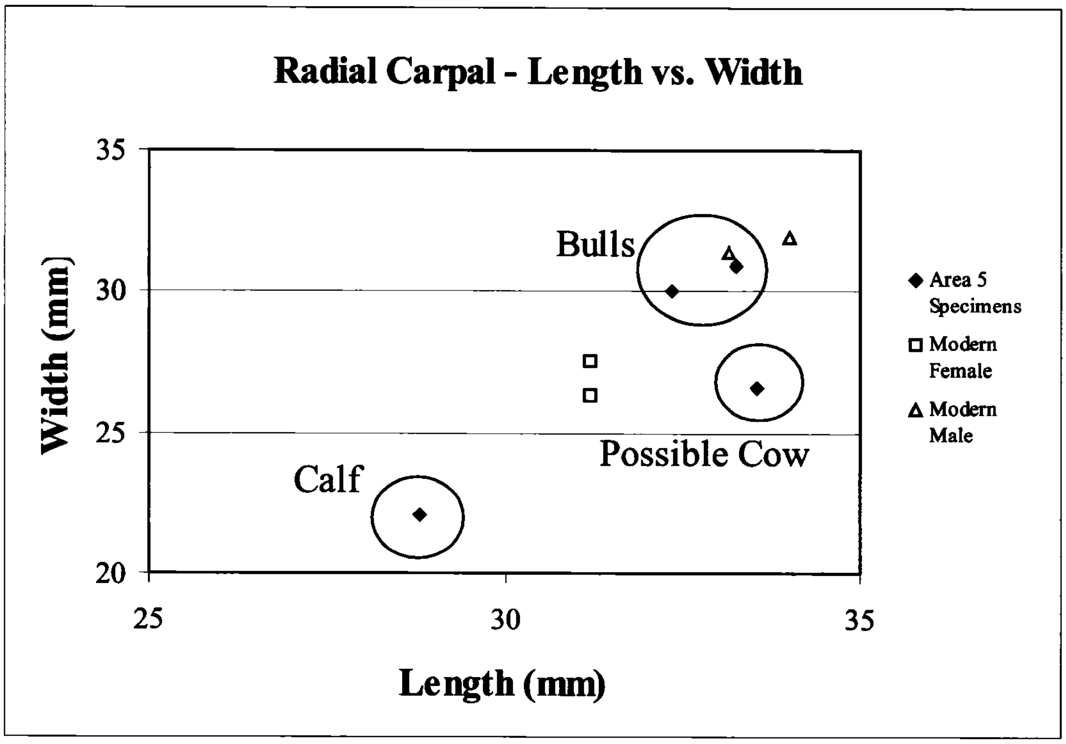


Figure 11: Bivariate plot of length versus width for the radial carpal.

Intermediate Carpal

Morlan took three measurements on the intermediate carpals from the Sjovold site: length, width, and depth. He presents a bivariate plot of width versus depth for eight specimens from the Sjovold site and demonstrates that the specimens cluster into two modes; the mode near his modern bull specimen is assumed to be bulls and the other mode, representing smaller individuals, is assumed to represent cows and calves.

Fifteen intermediate carpals were recovered from Area 5; seven were complete and eight were fragmented. Width versus depth was plotted for the Area 5 archaeological specimens in Figure 12. Five of the Area 5 specimens plotted belong to the cow/calf group, and one specimen is a bull. A final specimen falls outside these two clusters. As a result, this specimen cannot confidently be assigned to a cow/calf or bull group.

Although width and depth measurements of the intermediate carpal provide good a good separation of sex for both the modern and archaeological specimens at Area 5, the length measurement does not. There is little size difference in the length of the modern cow and modern bull intermediate carpals. As a result, when length is plotted against depth or width a separation of sex modes was not observed. This pattern suggests that length of the intermediate carpal is not a good indicator of bison sexual dimorphism; Morlan (1991:221) also states that length is not a good indicator of sexual dimorphism at the Sjovold site.

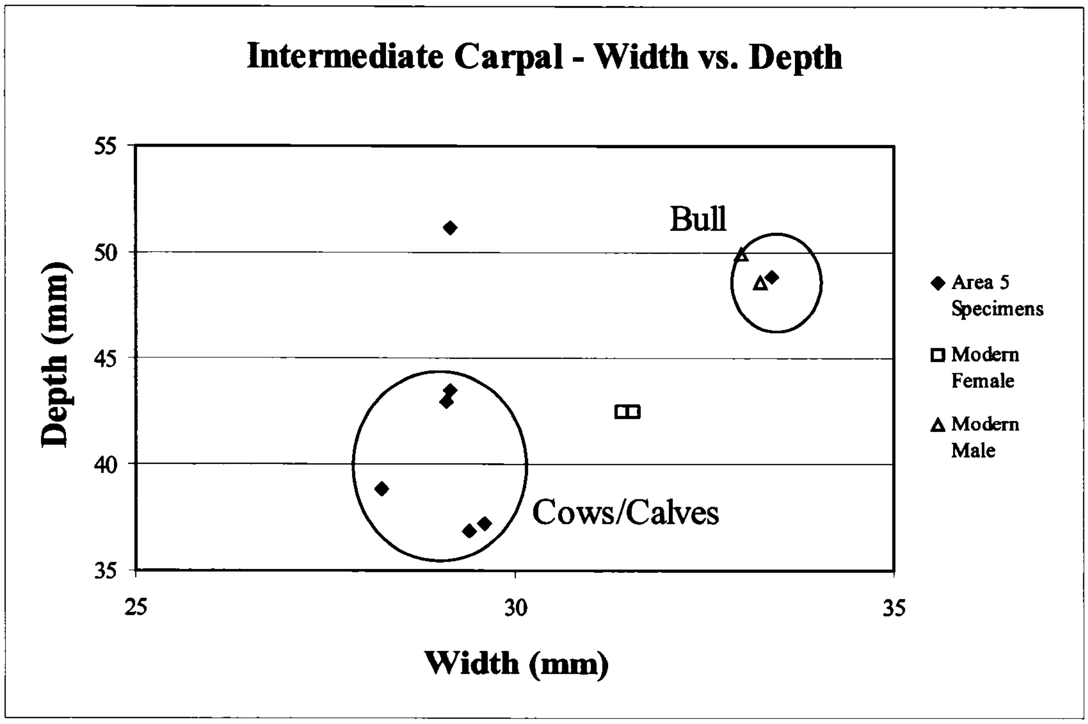


Figure 12: Bivariate plot of width versus depth for the intermediate carpal.

Ulnar Carpal

Morlan took four measurements on the ulnar carpals from the Sjovold site: anterior length, posterior length, width, and depth. He presents a bivariate plot of anterior length versus depth for seven specimens from the Sjovold site and demonstrates that these specimens cluster into two modes. The mode near his modern bull specimen is assumed to be bulls and the other mode, representing smaller individuals, is assumed to represent cows and calves.

Nine ulnar carpals were recovered from Area 5; five were complete and four were fragmented. When anterior length versus depth is plotted for the modern cow and bull ulnar carpals a clear separation is observed. However, the Area 5 ulnar carpal archaeological specimens did not fall into clearly defined clusters when plotted; instead a continuum of specimen points was produced. Therefore, among the archaeological specimens from Area 5 clear sexual dimorphism is not visible using these variables. On the other hand, when anterior length is plotted against posterior length for the archaeological specimens from Area 5, a bimodal pattern was observed (see Figure 13). Four of the Area 5 specimens plotted appear to belong to the cow/calf group and one specimen is clearly a bull.

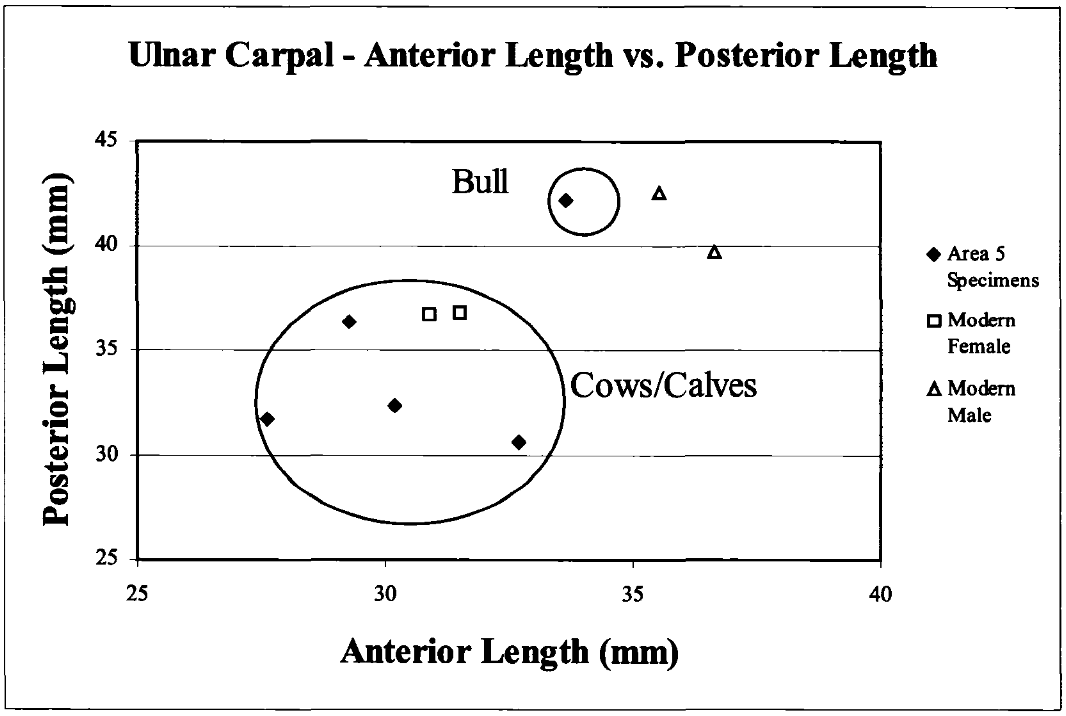


Figure 13: Bivariate plot of anterior length vs. posterior length for the ulnar carpal.

<u>Carpal 2+3</u>

Morlan took three measurements on carpal 2+3 from the Sjovold site: length, width, and depth. He presents a bivariate plot of width versus depth for eight specimens from the Sjovold site and demonstrates that the specimens cluster into two modes. The mode near his modern bull specimen is assumed to be bulls and the other mode, representing smaller individuals, is assumed to represent cows and calves.

Thirteen carpal 2+3 specimens were recovered from Area 5, with nine being complete and four fragmented. Width versus depth was plotted for the Area 5 archaeological specimens in Figure 14. Three of the Area 5 specimens plotted belong to the cow/calf group, and six specimens plotted belong to the bull group. One of the cow/calf group specimens from Area 5 is much smaller than the other two and likely represents a calf.

Length of carpal 2+3 demonstrates a clear separation between the modern cow and bull specimens; however, the Area 5 carpal 4 specimens did not demonstrated separation in the length measurement. Instead the specimens cluster together (and not near either of the modern specimens plotted) because their length measurements are very similar. therefore, among the archaeological specimens from Area 5 clear sexual dimorphism is not visible using this variable. Morlan (1991:221) also suggests that length is not clearly bimodal at the Sjovold site.

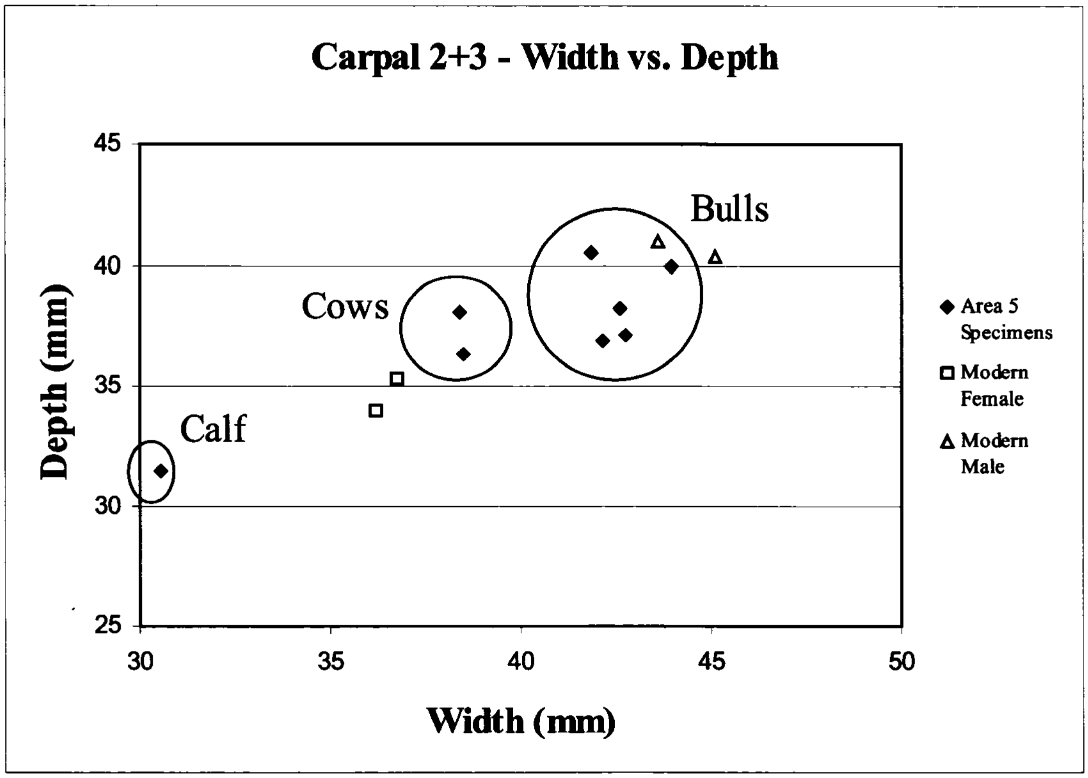


Figure 14: Bivariate plot of width versus depth for carpal 2+3.

Carpal 4

Morlan took three measurements on the carpal 4 from the Sjovold site: length, width, and depth. He presents a bivariate plot of width versus depth for nine specimens from the Sjovold site and demonstrates that the specimens cluster into two modes. The mode near his modern bull specimen is assumed to be bulls and the other mode, representing smaller individuals, is assumed to represent cows and calves.

Fourteen carpal 4 specimens were recovered from Area 5; nine were complete and five were fragmented. Width versus depth was plotted for the Area 5 archaeological specimens in Figure 15. Seven of the Area 5 specimens plotted belong to belong to the cow/calf group, and two specimens plotted belong to the bull group. Two of the cow/calf specimens from Area 5 are smaller than the other five and likely represents calves.

Length of carpal 4 demonstrates a clear separation between the modern cow and bull specimens. However, the Area 5 carpal 4 archaeological specimens do not demonstrated separation in the length measurement, as was seen with the carpal 2+3 measurements. Morlan (1991:221) also suggests that length is not clearly bimodal at the Sjovold site.

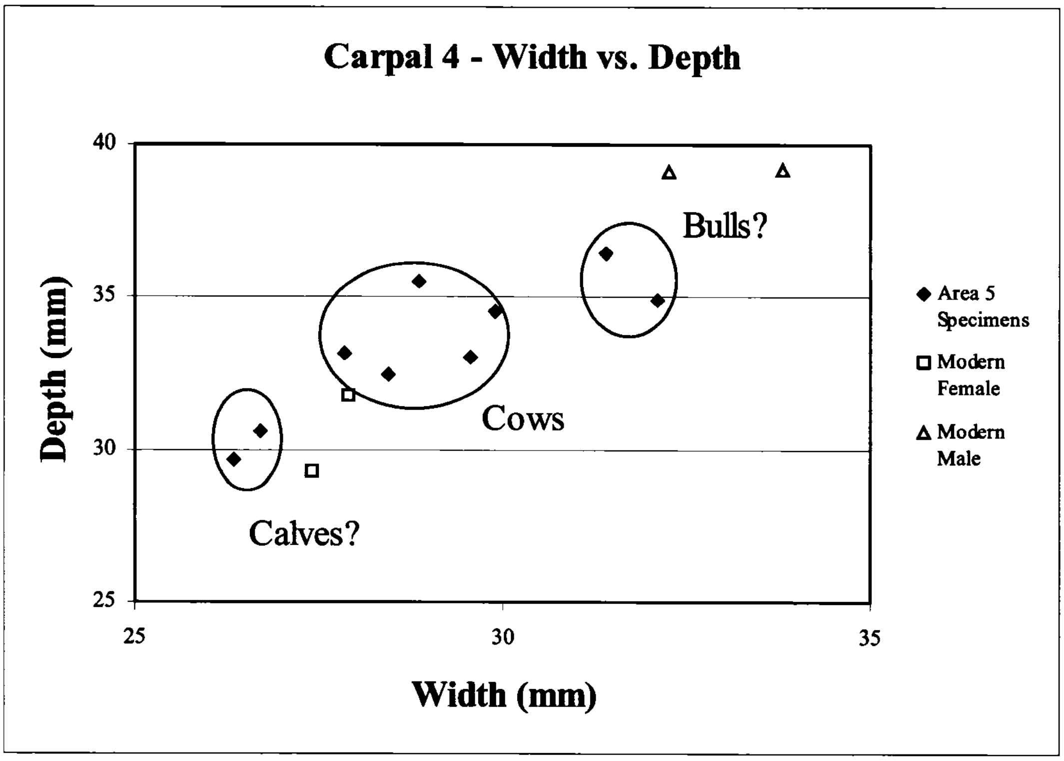


Figure 15: Bivariate plot of width versus depth for carpal 4.

Discussion of Sexing Using Carpals

Morlan did not measure the accessory carpal due to the lack of specimens available for measurement at the Sjovold Site. Similarly, the lack of complete accessory carpals in the Area 5 assemblage prevented sex assessment. In total, thirty-four other carpal specimens were complete enough to be assessed using Morlan's bivariate techniques. Of the thirty-four specimens, 12 are assessed as bulls, 21 are cows/calves (at least four of these specimens are calves), and one specimen cannot be assigned to either group. The carpals from Area 5 show that there are slightly more females than males, but neither sex is over-represented. This suggests that the sample represents a fairly equal mix of mature females and mature male specimens, with a few calves present.

A few problems were encountered during the analysis of the carpals. First, it is difficult to accurately differentiate cows from calves. In some cases a young calf is clearly offset, but it was impossible in many cases to differentiate between possible young males and mature females. The small sample size of carpals also makes the visibility of sexually dimorphic clusters even more difficult to interpret. A larger sample would perhaps produce more distinct clusters in the graphs, making the general structure of the archaeological population more apparent (e.g. Tischer 2001). On the other hand, Shortt (1993:153) argued that in some instances Morlan's bimodality could be attributed to the small samples he examined. Shortt (1993:153-158) plotted larger samples of the same measurements defined by Morlan (1991:223-225), and demonstrated that the clustering phenomenon often disappears and instead a continuum of size ranges is present.

In addition, a problem with the Area 5 sample is the lack of a bimodal distribution occurring with some carpal measurements of the archaeological specimens even when the modern specimens demonstrate a clear separation of size between the cow and the bull using the same measurements. This problem was encountered with the length measurement of both carpal 2+3 and carpal 4. In both of these instances the length is the smallest dimension of the carpal. This pattern may be the result of indistinguishable weathering of the carpal resulting in inaccurate measurements being assessed.

Talus

Morlan took six measurements on the talus from the Sjovold site: medial length, lateral length, distal width, proximal width, medial depth, and lateral depth. He presented a bivariate plot of medial length versus distal depth for eight specimens from the Sjovold site and demonstrate that these specimens cluster into two modes. The mode near his modern bull specimen is assumed to be bulls and the other mode, representing smaller individuals, is assumed to represent cows and calves.

Twelve talus specimens were recovered from Area 5, with eight being complete and four fragmented. Medial length versus distal depth was plotted for the Area 5 archaeological specimens in Figure 16. Seven of the Area 5 specimens plotted belonged to the cow/calf group, and one specimen plotted belonged to the bull group. Four of the cow/calf group specimens from Area 5 are substantially smaller than the other three and likely represent calves. A similar distribution pattern is seen when some of the other variables are plotted (for both the modern and Area 5 archaeological specimens).

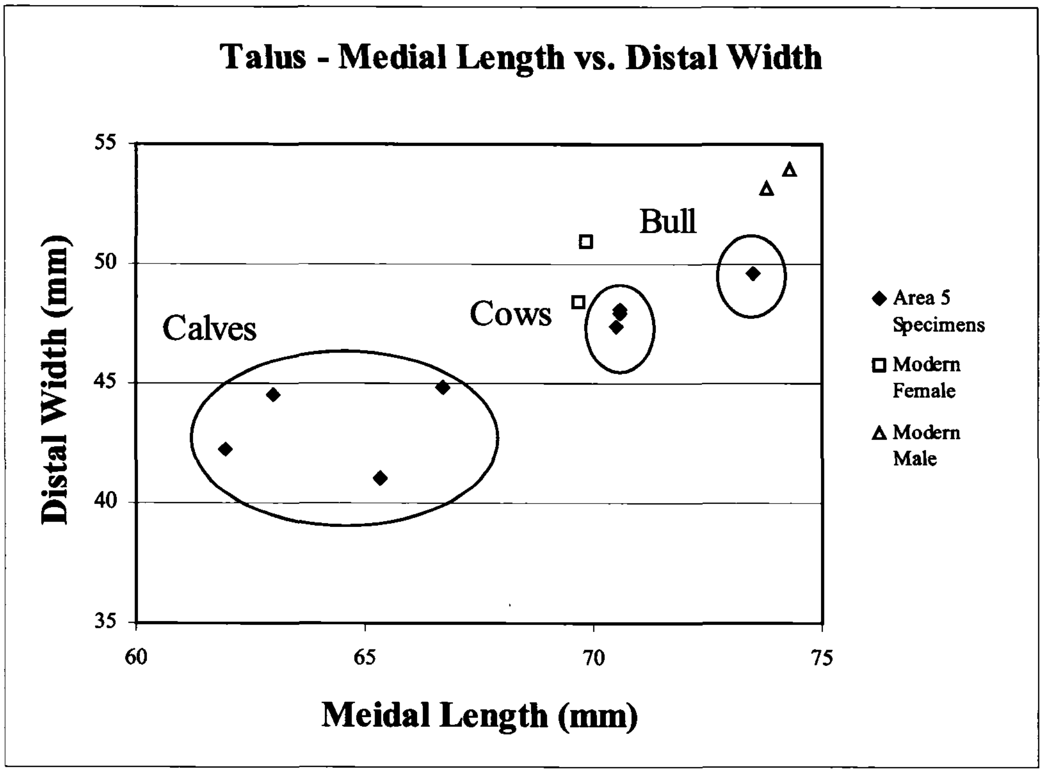


Figure 16: Bivariate plot of medial length versus distal depth for the talus.

Calcaneus

Morlan took seven measurements on the calcaneus from the Sjovold site: length, proximal width, distal width, proximal depth, distal depth, length of the navicular cuboid facet, and length of the calcaneus facet. He presents two bivariate plots, one of distal width versus distal depth, and one of length of the tarsal C+4 facet versus length of the talus facet. The ten specimens from Sjovold he measured demonstrate that the specimens fell into two clusters. The cluster near his modern bull specimen is assumed to be bulls and the other cluster, representing smaller individuals, is assumed to represent cows and calves.

Ten calcaneus specimens were recovered from Area 5. Six were complete and three fragmented, and another was a loose proximal epiphysis. However, of the six complete specimens, three of these had unfused epiphysis and could not be included in the analysis. Distal width versus distal depth and length of the tarsal C+4 facet versus length of the talus facet were plotted for the Area 5 archaeological specimens. Both plots result in a bimodial clustering of specimens based on size difference. Figure 17 demonstrates results when length of the tarsal C+4 facet versus length of the talus facet are plotted. Two of the Area 5 specimens plotted belonged to the cow/calf group, and one specimen plotted belonged to the bull group. A similar distribution pattern was seen when some of the other variables are plotted (for both the modern and archaeological specimens).

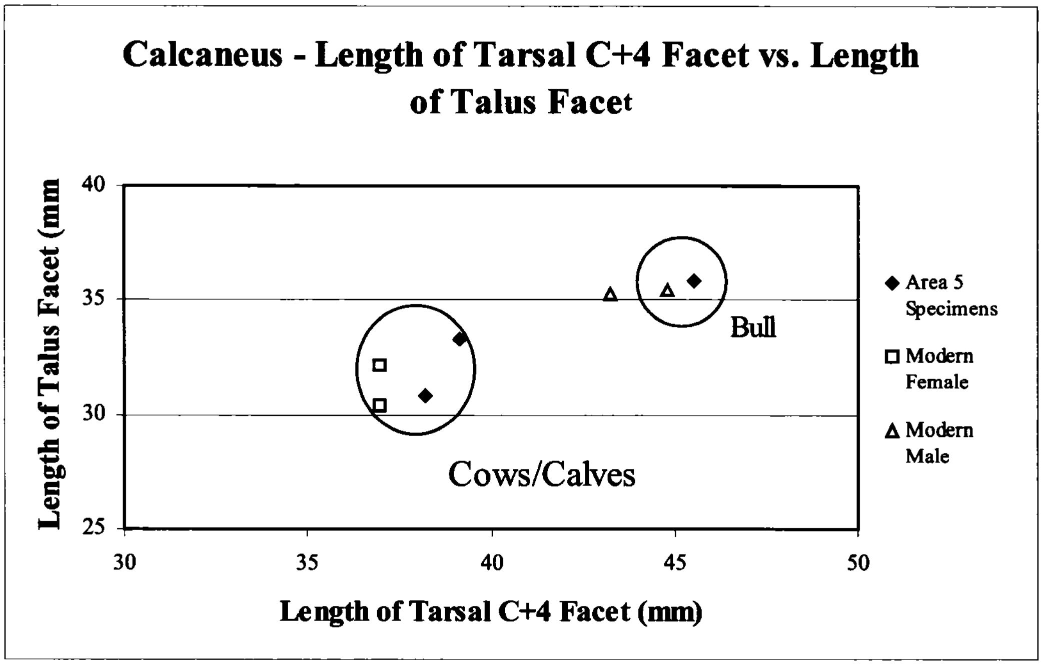


Figure 17: Bivariate plot of length of Tarsal C+4 facet versus length of the talus facet of the calcaneus.

Tarsal C+4

Morlan took three measurements on the tarsal C+4 from the Sjovold site: length, depth, and width. He presents a bivariate plot of width versus depth for eleven specimens from Sjovold and demonstrates that the specimens cluster into two modes. The mode near his modern bull specimen is assumed to be bulls and the other mode, representing smaller individuals, is assumed to represent cows and calves.

Twelve tarsal C+4 specimens were recovered from Area 5, with eight being complete and four fragmented. Width versus depth was plotted for the Area 5 specimens in Figure 18. All eight of the Area 5 specimens plotted belonged to the cow/calf group (plotting near the modern cow specimen). All of these specimens are approximately the same size as the specimens designated as cows/calves by Morlan at the Sjovold Site.

Although width and depth measurements of the tarsal C+4 provide a good separation of sex for both the modern and the archaeological specimens, the length measurement does not. There is little size difference in the length of the modern cow and modern bull tarsal C+4. This pattern suggests that length of the tarsal C+4 is not a good indicator of bison sexual dimorphism.

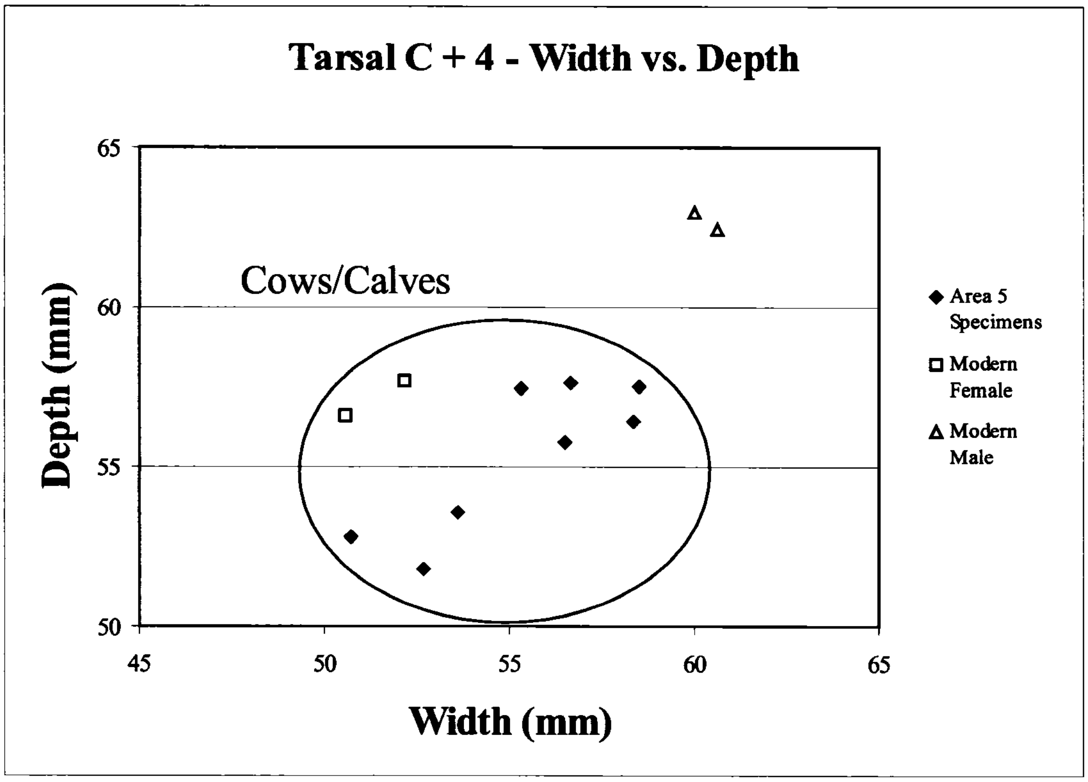


Figure 18: Bivariate plot of width versus depth for tarsal C+4.

Tarsal 2+3

Morlan took three measurements on the Tarsal 2+3 from the Sjovold site: length, depth, and width. He presents a bivariate plot of width versus depth for nine specimens from Sjovold and demonstrates that the specimens cluster into two modes, one assumed to be bulls, the other to be cows and calves.

Six tarsal 2+3 specimens were recovered from Area 5, with three being complete and three fragmented. Width versus depth was plotted for the Area 5 specimens in Figure 19. All three of the Area 5 specimens plotted appear to belong to the cow/calf group. All of these specimens are approximately the same size as the specimens designated as cows/calves by Morlan at the Sjovold Site.

Although width and depth measurements of the tarsal 2+3 provide good separation of sex for both the modern and the archaeological specimens, the length measurement does not. There is little size difference in the length of the modern cow and modern bull tarsal 2+3. This pattern suggests that length of the tarsal 2+3 is not a good indicator of bison sexual dimorphism.

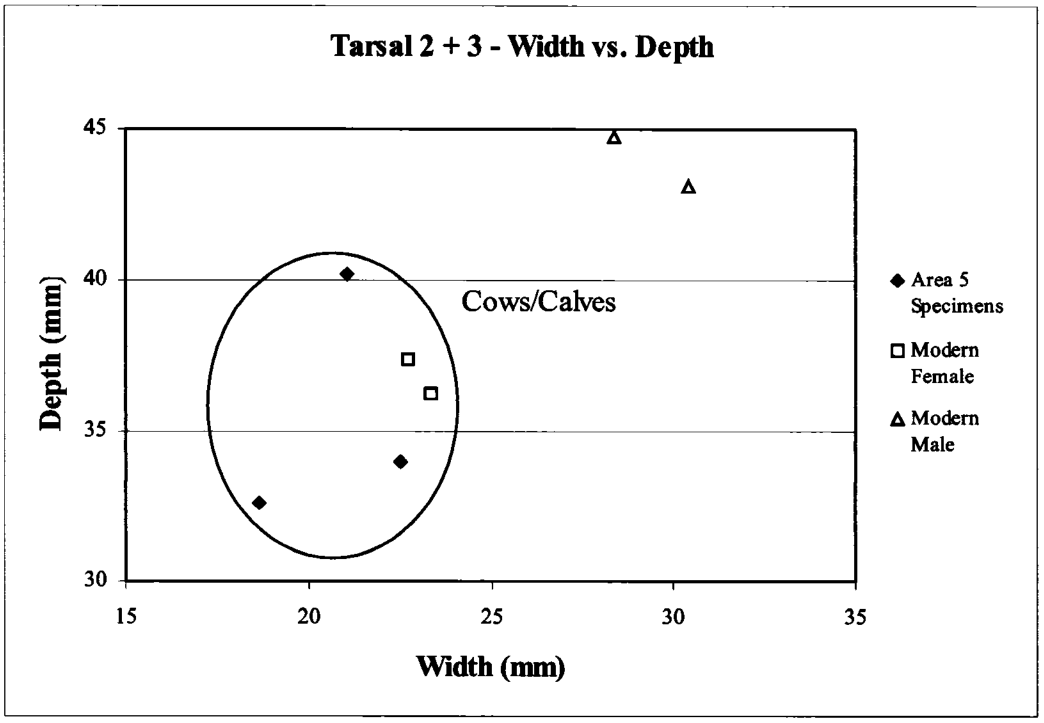


Figure 19: Bivariate plot of width versus depth for tarsal 2+3.

Lateral Malleolus

Morlan took three measurements on the lateral malleolus from the Sjovold site: length, depth, and width. He presents a bivariate plot of depth versus length for eleven specimens from the Sjovold site and demonstrates that the specimens cluster into two modes, one assumed to be bulls, the other cows/calves.

Six lateral malleoli specimens were recovered from Area 5, three being complete and three fragmented. Depth versus length was plotted for the Area 5 specimens in Figure 20. One of the Area 5 specimens plotted belonged to the cow/calf group, and two of the Area 5 specimens plotted belonged to the bull group. Depth versus width also provides a similar bimodal separation. However, a plot of length versus width results in two specimens in the cow/calf group and one bull specimens. Morlan (1991:225) states that the lateral malleolus measurements provide the weakest bimodality of all tarsals. The results from Area 5 also suggest that the lateral malleolus may be problematic for determining sex.

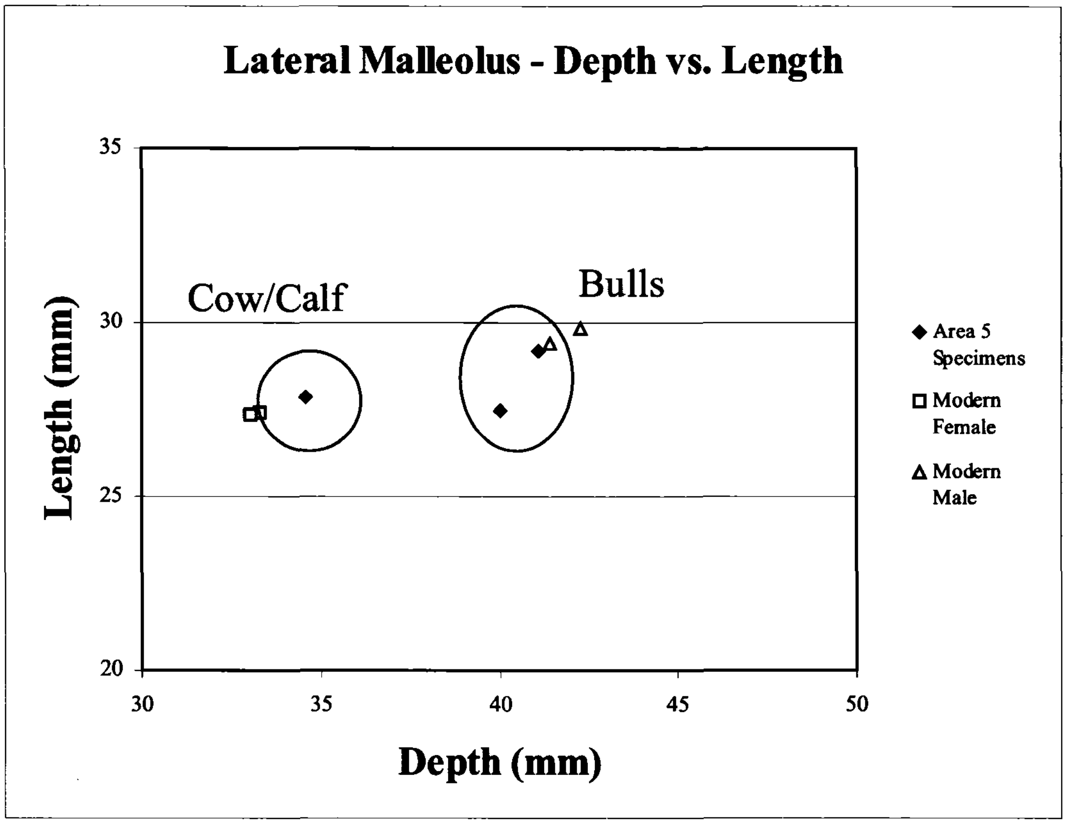


Figure 20: Bivariate plot of depth versus length for the lateral malleolus.

Discussion of Sexing Using Tarsals

Twenty-five tarsal specimens were complete enough to be used in Morlan's bivariate analysis technique. Of the specimens, four are likely bulls and 21 are cows/calves (with at least four of these clearly being calves). In other words, almost 85% of the specimens assessed belong to females and calves. Compared to the carpals, which suggest the population was composed of roughly equal proportions of cows and bulls with a few calves, the tarsals suggest a much higher relative proportion of cows and calves relative to bulls. In my opinion, this inconsistency is most likely the result of differential recovery and the small sample size for both carpals and tarsals from Area 5. If a larger portion of the site was excavated and all the carpals and tarsals were sexed, I suspect the results of the carpal and tarsal analysis would be more consistent with one another. On the other hand, relatively fewer tarsals than carpals may have been assigned as bulls because the lower hind limbs of the bulls being treated differently than those of cows/calves. In other words, bull hind limbs, and thus bull tarsals, were perhaps more often removed from the kill area than those of cow/calves.

In conclusion, I suggest that both the carpal and tarsal assemblage indicate that there are some bulls, calves, and cows in the Area 5 assemblage. The next section presents the results of sexing the long bones from Area 5. These results help clarify the inconsistency demonstrated by sexing the carpals and tarsals.

Sexing Using Long Bones

The second method employed in this study to examine the sex composition of the Area 5 population was the measurement of portions of the proximal and distal ends of long bones and the application of discriminant function analysis. The methodology used was based on that of Walde (1985). Discriminant function analysis is statistical analysis used to determine which variables discriminate between two naturally occurring groups. This analysis allows for "the consideration of similarities and differences between two or more groups using groups of single measurements" (Walde 1985:11). Discriminant function analysis has been applied successfully in both zoological studies (to determine sex) and archaeological studies (to determine sex, distinguish between species, and determine tool typologies) (see Walde 1985:12). According to Walde (1985:9), simple plotting of one variable measurement against another and assigning sex on the basis of resulting clusters (as in Morlan's study) does not provide a statistical test of the sex designations. Walde (1985:10-11) asserts that existing statistical techniques, such as discriminate function analysis, allow for the comparison of primary data as opposed to derived data. In other words, Walde's method has a greater assurance of accuracy because it is proven to be statistically accurate and less open to interpretation as other sexing methods, including Morlan's (1991). As well, Walde's discriminant function analysis does not require preservation of whole elements; instead, it allows for sex determination on partial elements, namely the proximal and distal ends of the humerus, radius, metacarpal, femur, tibia, and metatarsal.

The measurements taken for this analysis are based on those presented by Speth (1983), and these were inserted into discriminant functions derived by Walde (1985) (see Figure 21 for an example of one of these sets of equations and the measurements inserted). In his Master's thesis, Walde (1985) defines one or more sets of equations (there are two equations in a set, one female and one male equation) for each long bone end. When the required measurements are inserted into both equations in a set, the equation resulting in the higher value indicates the sex of the element. For a detailed description of the statistical methods involved in determining the discriminant function equations used in these analyses see Walde (1985:14-21).

Walde (1985) established these equations and tested their accuracy using a collection of modern bison remains of known sex, including Speth's (1983) database and a collection of metapodials from about 120 bison from a single population from Elk Island National Park, Alberta. All of the equations developed by Walde (1985) were tested and found to be accurate for over 90% of the modern specimens sexed. Most equations gave results that were accurate for over 96% of the specimens tested.

All elements measured in Walde's (1985) analyses are from adult animals as defined by the complete fusion of epiphyses. In order to differentiate between large female bison and small male bison, Walde suggests that a numeric difference of at least 1.6 is necessary between the results of a male and female equation in a set in order to positively assign a sex to the specimen. In other words, if the difference between the products of the male and female equations within an equation set is less than 1.6 the sex assigned in that particular case will be considered to be inaccurate. Walde (1985) suggests that sets of equations that result in a difference less than 1.6 should be rejected from the sexing analysis. For the purposes of this study I also used 1.6 as the cutoff value.

The measurements of the Area 5 material were taken with dial calipers based on the diagrams and descriptions from Speth (1983). The measurements were then inserted into Walde's (1985) discriminant function equations in Microsoft Excel. The resulting values were then assessed to determine the sex of the specimen. In numerous cases more than one equation could be used to sex a single specimen and in most cases this resulted in the same sex outcome. However, some specimens showed both a female and male result when multiple equations were applied, producing some doubt as to which sex was truly represented. In these cases, if all but one equation gives a particular sex, the specimen can potentially be assigned that majority sex, but still should be viewed with caution. As well, when only one equation set could be utilized on a specimen (because the specimen was too fragmented for multiple equation sets), the results were taken at face value. However, it is recognized that if additional equation sets could have been used to assess the specimen's sex, different results may have been produced; as such these specimens' sex designations should be viewed with caution. Each element (humerus, radius, metacarpal, tibia, and metatarsal) is discussed in more detail below. Note that no complete femora ends were present in the collection and thus this element was not assessed with these methods.

Proximal Humerus: Equation Set 1

Male = -9.677982 (C) + 331.61367 (D) + 35.38570 (E) – 3.157891 (F) + 30.15858 (G) – 417.0617

Female = -5.40816 (C) + 22.42634 (D) + 26.54183 (E) + 1.530750 (F) + 21.17843 (G) – 272.9888

C = Greatest depth of proximal end.

D = Greatest breadth of proximal end.

E = Depth of head from cranial (anterior) edge of articular surface.

F = Depth of head from cranial (anterior) edge of lesser (medial) tuberosity.

G = Length of cranial (anterior) eminence of greater (lateral) tuberosity from distal edge of rough prominence for attachment of infraspintus tendon.

Figure 21: An example of one of Walde's (1985) equation sets with the explanations of the variables used (see Speth 1983).

Humerus

The assemblage of humeri from Area 5 did not contain specimens complete enough to take measurements of the proximal end. Only the three sets of distal end equations were applicable. Nine distal humerus specimens from Area 5 were complete enough to get sufficient measurements. The results are shown in Table 13 below. Of these specimens, one is assessed as being female (one right) and two as male (one right and one left). Five humeri specimens demonstrate mixed results and sex designations could not be made. In addition, one specimen (#91812) was initially assessed as being female, but the difference between the male and female equation was less than 1.6, so this assessment is not firm. As well, analysis of specimens #94143, 93215, and 98428 all resulted in two of the three equations producing male results, the other equation producing a female result; however, for all three specimens equation 3 produced a difference of less than 1.6, so the sex of these specimens is far from clear. On the other hand, specimens #90987 and 91603 both have two equations that resulted in the same sex designation. In these cases the dominant sex was tentatively assigned to the specimens. It is unclear why mixed results were obtained for some specimens. However, it is apparent from Table 13 that equation 1 consistently produced female results, while equation 2 and 3 differed in their assessments of sex only in one case. Perhaps equation 1 is less reliable than proposed, or some measurement errors were made.

Humerus	Side	Walde (1985) Distal Equation Set Results			Sex Assessment
		1	2	3	
91812	L	-	F	-	INDT
90987	L	F	M	M	INDT (M?)
91603	L	F	F	M	INDT (F?)
94817	L	-	M	-	M
94143	R	F	M	M	INDT
93215	R	F	M	M	INDT
98428	R	F	M	M	INDT
77488	R	F	F	F	F
97621	R	-	M	-	M

Table 13: Sexing results from discriminant function analysis of the humerus.

Radius

Measurements were taken for both the proximal and distal ends of the radius, and thirteen radii specimens from Area 5 were complete enough to be measured. All six proximal radius equations and all three distal radius equations were applied during this analysis. The results are shown in Table 14. Four females and one male were clearly indicated, including three left female specimens, one right female specimen, and one left male specimen. The other eight specimens resulted in mixed results. However, of these eight specimens, six could be classified as most likely being female because the majority of the equations produced the same sex designations.

The radius provided the largest number of specimens that could be measured, but also resulted in the largest number of questionable sex assignments. At EgPn-440 Tischer (2000:142) noted a similarly high proportion of radius specimens that produced inconsistent sex assessments using these formulas. This ambiguity could result from the fact there are more equations for the radius than any other elements, allowing more opportunities for ambiguity. Walde (1985) did not explain why he developed so many radius equations; it is possible that some of these may be problematic. For example, distal equation 1 consistently designated all assessed specimens as males, regardless of the outcomes of the other equations on these specimens. In addition, proximal equation 6 assessed two specimens as male when nearly all other equations on the same specimens indicated they were female. It these two equations were eliminated, only two specimens (#949144 and #93436) would produce ambiguous sex assessments.

Radius	Side	Walde (1985) Proximal Equation Set Results						Walde (1985) Distal Equations Set Results			Sex Assessment
		1	2	3	4	5	6	1	2	3	
94144	L	M	M	M	M	M	M	M	F	F	INDT
93236	L	F	F	F	M	F	M	M	M	M	INDT
94151	L	F	F	F	F	F	F	M	F	F	INDT (F?)
91549	L	F	F	F	F	F	F	-	-	-	F
98425	L	-	-	F	-	-	F	-	-	-	F
77661	L	F	F	F	F	F	F	-	-	-	F
75828	L	-	-	-	-	-	-	M	F	F	INDT (F?)
96877	R	M	M	M	M	M	M	M			M
98560	R	F	F	F	F	F	M	M	F	F	INDT (F?)
90419	R	-	-	-	-	-	-	M	F	F	INDT (F?)
77517	R	-	-	-	-	-	-	M	F	F	INDT (F?)
98003	R	F	F	F	F	F	F	-	-	-	F
94137	R	F	F	F	F	F	M	-	-	-	INDT (F?)

Table 14: Sexing results from discriminant function analysis of the radius.

Metacarpal

Due to the fact that the proximal end of the metacarpal is essentially fused at birth, it is difficult to assess the maturity of specimens when only the proximal end is present. Therefore, for sex assessment, I only measured complete metacarpals. As a result, ten metacarpals were judged complete enough for assessment and the results of the analyses are shown in Table 15. Two specimens were assessed as male and two female, including one left male specimen, one right male specimen, and two right female specimens. Five specimens have mixed results and sex was not be assigned. In addition, one specimen (#91418) gave female results, but the difference between the male and female equation was less than 1.6. Of the five ambiguous specimens, four specimens could be classified as most likely being female because four of the five equations applied resulted in female assessments. All four of these specimens have the proximal metacarpal equation 1 as contradictory to the other four equations, suggesting this equation may be problematic.

Metacarpal	Side	Walde (1985) Proximal Equation Set Results		Walde (1985) Distal Equation Set Results			Sex Assessment
		1	2	1	2	3	
91418	IND	-	-	-	F	-	INDT
75601	L	M	M	-	-	-	M
97637	L	M	F	F	F	F	INDT (F?)
95485	L	M	F	F	F	F	INDT (F?)
94146	L	M	F	F	F	F	INDT (F?)
97583	R	F	F	-	-	-	F
98006	R	-	-	M	M	M	M
94218	R	M	M	F	F	F	INDT
90799	R	-	-	F	F	F	F
97743	R	M	F	F	F	F	INDT (F?)

Table 15: Sexing results from discriminant function analysis of the metacarpal.

Tibia

Only two proximal tibia specimens were complete enough to measure. The single set of proximal tibia equations were applied to these specimens. This resulted in one right male specimen and one right female specimen. Eight other tibia specimens had intact distal ends that allowed for enough measurements to be taken to apply at least one of the two distal tibia equation sets. Application of the equations resulted in seven left female specimens and one mixed results specimen (Table 16).

Based on the results of the distal tibia equations the dominant sex reflected by the tibia is female. This result is significant because the distal tibia is the element that sets the MNI of 16 for the Area 5 assemblage. Based on the seven female-left distal tibiae, at least seven individuals from this site as assessed as being female; this suggests nearly half of the animals potentially are females.

Tibia	**Side**	**Walde (1985) Proximal Equation Set Results**	**Walde (1985) Distal Equation Set Results**		**Sex Assessment**
		1	**1**	**2**	
93211	L	-	F	F	F
91947	L	-	F	-	F
93231	L	-	F	F	F
97881	L	-	F	M	INDT
96300	L	-	F	F	F
96591	L	-	F	F	F
98426	L	-	F	F	F
95564	L	-	F	F	F
92234	R	F	-	-	F
94580	R	M	-	-	M

Table 16: Sexing results from discriminant function analysis of the tibia.

Metatarsal

Due to the fact that the proximal end of the metatarsal, like the metacarpal, is essentially fused at birth, it is difficult to assess the maturity of specimens when only the proximal end is present. Therefore only complete metatarsals were measured, and fourteen such specimens were present in the sample. Of these specimens nine were assessed as being females and three as males, including five left female specimens, four right female specimens, and three left male specimens. Two specimens have mixed results and therefore were not assigned sex (Table 17).

The equations sets for the metatarsals resulted in fewer contradictions than were present in the metacarpal equations. Similar to the tibia, the metatarsal specimens appear to represent more females than males.

Metatarsal	Side	Walde (1985) Proximal Equation Set Results	Walde (1985) Distal Equation Set Results			Sex Assessment
		1	1	2	3	
93233	L	M	-	-	-	M
96669	L	M	M	M	M	M
93232	L	-	F	F	F	F
94567	L	F	-	-	-	F
92280	L	-	F	F	F	F
76743	L	M	-	-	-	M
95540	L	F	-	-	-	F
96592	L	F	F	-	-	F
96610	R	M	F	F	F	INDT
93234	R	F	F	F	F	F
97639	R	F	F	F	F	F
76598	R	F	-	-	-	F
97620	R	-	F	F	F	F
75562	R	-	M	F	F	INDT

Table 17: Sexing results from discriminant function analysis of the metatarsal.

Discussion of Sexing Using Long Bones

The results of the sexing study based on the discriminant function analyses of the proximal and distal ends of long bones from Area 5 suggests the sample population consisted of both males and females. In total 33 long bone specimens were assigned sex with certainty. Twenty-four of these specimens were female while nine specimens were male. These results lead me to believe that the bison population in the sample was a mixed herd, but dominated by females. Viewed another way, when the side of the elements is taken into account, there are at least seven female animals (based on the presence of seven left tibiae assessed as female) and three male animals (based on the presence of three left metatarsals assessed as male). This too suggests a sample population of mixed-sex animals dominated by females.

A few problems with this analysis technique are apparent. The small sample size of measurable long bones from Area 5 is problematic. However, a small sample should not affect the results of discriminant function analysis, as it would with the cluster analyses previously presented. As well, potential problems occur when attempting to assess the sex structure of the entire site population based on the sex assessments of my small sample. Males and females could have been differentially deposited within the site during or following processing, resulting in areas of the site being dominated by one sex or the other. This issue cannot be addressed without additional excavation of the site.

In addition, Shortt (1993:171-72) points out that Walde's data were derived using modern bison and this data may not reflect the size differences present in prehistoric male and female bison. Walde's data were indeed derived from modern bison living in controlled conditions without serious nutritional stress. Due to these enhanced living conditions, these bison are likely to be larger overall than the animals found at Area 5. It seems reasonable to assume that the possible size differences between modern bison and the bison from Area 5 were not significant enough to produce major errors in the equations he developed. In other words, overall animal size might be affected, but there is no reason to believe that the proportion of sexual dimorphism in bison was altered by the modern living conditions of his sample animals.

Aging and Sexing Conclusion

Determining the population structure of an archaeological animal population is difficult and often rendered problematic with contradictory results. Sample size plays a critical role in the level of accuracy achieved in such an analysis, both in terms of the numbers of animals used in constructing reference sets and in the number of specimens from a population available for measurement. In the case of Area 5, the area of the site excavated was relatively small, making inferences about the total site population potentially problematic. At the same time, the generally good preservation of the Area 5 sample allowed for sex and age assessments to be made on a relatively high proportion of the recovered specimens. Relatively speaking, this should result in relatively reliable assessments of age and sex of the recovered population.

Another important limitation of this type of population study is the assumption that the age population structure results are fully representative of the harvested population. Hunters may have selectively removed complete animals from the kill site, especially young calves and fetuses. This could result in a lack of or at least under representation of certain age groups. In addition, the effects of taphonomy, including weathering and scavenger activity, results in removal and fragmentation of specimens from an assemblage, particularly those of very young animals. As a result, it is important to remember that the results obtained here should be considered a rough estimation of the actual population demographics of bison used by the inhabitants of the site.

Overall, the recovered bison sample from Area 5 consists of adult females and adult males, as well as some calves. Based on the sexing analysis, I suggest slightly more females than males are represented. This information can now be applied in conjunction with the aging data to assist in the determination of the season of site occupation.

5.3 Season(s) of Occupation

Season of occupation at Area 5 was previously assessed by Peck (2004), who undertook an analysis of the dental cementum of five molars (M1's) from the site. His analysis resulted in one specimen suggesting a late October to late December kill event and four specimens suggesting a late December to late March kill event (Peck 2004:83). In other words, Peck implied that Area 5 is the result of a late fall and winter occupation. Peck (2004:83) stated that, "it is not unreasonable to interpret these data as kill events starting in late October to late December and continuing into late December to late March Period." However, this interpretation of the season of the kill event(s) does not take into account the lack of fetal bone at the site or the age and sex composition of the sample of bison recovered from Area 5. I have analyzed the entire sample of faunal material from Area 5 and have used the results of this analysis to establish an alternate estimation of season of occupation. I used two commonly applied methods of seasonality determination in order to assess the season of occupation at Area 5: the presence or absence of bison fetal bone and the population structure of the harvested sample of animals.

Interpretations of site seasonality based on the presence or absence of bison fetal bone and the developmental stage of fetuses were originally conducted by Wilson (1974) at the Casper Site and Frison et al. (1978) at the Big Goose Creek Site (Peck 2004:77). According to Head (1986:31), the presence or absence of fetal bones has been cited as the best indicator of site seasonality. The presence of fetal bones at a site suggests use in winter or early spring (Quigg 1978:53-6), and a lack of fetal bone suggests a summer or fall occupation. Fetal bone is lacking completely at Area 5 suggesting that the season of occupation could be summer or fall. However, sometimes the lack of fetal bone at a site can be attributed to processes other than the season of occupation. Driver (1983:141) has suggested that younger animals may by underrepresented in assemblages due to faster deterioration of their bones compared to adult bones. In addition, Morlan (1994:770) suggests that a lack of fetal bone at the Harder Site may be the result of carnivores removing or destroying fetal bone. As well, bones of fetal individuals may also be absent from kill sites due to the preferential selectivity towards these individuals by hunters. For example, at the Ruby Site in Wyoming, Frison (1971:83) notes that fetal bones are almost completely lacking in the butchering area, but several were found in the processing area, suggesting that complete fetal animals were being taking away from the kill site as food items. If fetal individuals were once present at Area 5, evidence of them in this sample is currently not available. It is unlikely that the processes discussed above could erase all evidence of fetal individuals, especially if they were abundant. I suggest that it is more likely that fetal animals (at least with some ossified skeletal elements) were truly not present, and the likely season of occupation was summer or fall.

Bison are gregarious animals and form herds according to age, sex, and season. Therefore, the population structure of a harvested population can also be indicative of the season(s) of site occupation. Bison can be found in small to very large groups depending on season (Meagher 1973:46; McHugh 1972:14-6). Bison herds are constantly splitting and rejoining, picking up new members, and giving up some to other herds (Olson 2005:34). However, there are two main herd compositions that exist in bison 'society.' The first group type is a cow group (also called *matriarchal bands*). This group generally consists of females of all ages, calves, yearlings, most two to three year old males, and often some mature males (Fuller 1960:10-1; Meagher 1973:46; Olson 2005:34). The second group of bison is the bull group (also called *bachelor bands*). This group is composed of almost entirely of mature male bulls and sometimes includes a few cows and their calves (Fuller 1960:10-1; Meagher 1973:46; Olson 2005:34). These separate cow groups and bull groups exist throughout the fall, winter, and spring. However, as summer approaches and the rut begins, breeding congregation occurs and cow groups unite with bull groups. Several authors indicate that bison form the largest herds during the summer rut (Branch 1929:6-7; Soper 1941:389-391; McHugh 1972:191-2; Meagher 1973: 46). These groups are formed by numerous, smaller groups coalescing and melding into vast herds numbering in the tens of thousands (Olson 2005:40). Breeding season may extend from late June or early July through to September (Branch 1929:6-7, McHugh 1972:192). The peak of the breeding season lasts about one month, spanning from the last two weeks of July through the first two weeks of August (Olson 2005:40).

Based on the aging and sexing data discussed, the Area 5 sample population, if it is the remains of a single kill event, may represent a summer season coalesced breeding age cow and bull group with some calves. There are at least seven female animals (based on the distal left tibia) in the sample, and three male animals (based on the left metatarsal) and at least two calves (based on the presence of two left scapulae that are the size of a six month old) present, along with at least four other individuals (based on a MNI of 16). This population structure is consistent with a summer or early fall (July, August, or September) bison population where cows, calves, and bulls were congregated for the rut.

However if the Area 5 deposit represents the outcome of numerous kill events and not a single mass kill, the site season of occupation could be over the course of a single late fall and winter period, as suggested by Peck (2004:83). A late fall/winter occupation could result in a death assemblage similar to that seen in Area 5. Multiple small kills taking place during a single winter could result in the preservation and stratigraphy demonstrated at Area 5 because snow and freezing weather would prevent soil erosion or deposition and would also prevent the decomposition of organic material (such as hide, hair, and viscera found preserved at the site), creating a deposit that appears to be the result of a single depositional event. However, if Area 5 was the result of late winter hunting there should be evidence of fetal bone in the assemblage. The lack of fetal bone combined with the population structure from Area 5 suggests to me that occupation of the site most likely occurred during the summer months, after the calves were born and during the rut.

Clearly, the season of site occupation at Area 5 is difficult to determine with certainty. Different approaches to the analysis of site seasonality resulted in various seasons of occupation being suggested. Analysis of dental cementum has provided an indication of the season of site occupation, but should be combined with other lines of evidence in order to confidently assign season of site occupation. As well, a larger sample than that analyzed by Peck (2004) should be used to ensure that the seasonality estimate is replicated on numerous specimens. The presence or absence of fetal bone can provide a general estimation of season of occupation but is difficult to assess due to preservation factors and human decision-making processes that always render complex site formation processes. Finally, herd composition can be a good indicator of site seasonality if it is known that the site is the product of a single kill event. If the bison remains present in this analysis are not the product of a single mass-hunting event, but instead simply the result of hunting individual bison over a broader time range, the assignment of a single season of site occupation could be incorrect. At this time, the season(s) of site occupation cannot be determined with certainty and I feel that further excavation of the site would likely provide some clarification.

CHAPTER 6: DISCUSSION

Faunal analyses at Area 5 were conducted with the intent of gaining a better understanding of the butchering and transport decisions, herd composition, season of site occupation, and hunting strategies employed at the site. This thesis has examined numerous lines of data that indicate Area 5 is a bison kill site. In general, the abundance of projectile points and numerous complete skeletal elements with low food value strongly suggest that Area 5 was a kill site. In addition, the lack of items and features associated with a secondary processing, including abundant pottery, a variety of lithic tools, hearths, boiling pits, and intensively smashed bone, all provide some indication that the main subsistence activities at Area 5 were bison killing and primary butchering. While Late Precontact bison kill sites are common on the northwest Plains, the undertaking of in-depth extensive zooarchaeological examination on such assemblages can still provide a great deal of new information about the variable subsistence practices of Plains peoples, including those practiced in the little-known Parkland region of Alberta.

This chapter discusses the possible hunting strategies employed at Area 5, as well as the butchering and body part transportation decisions made by ancient hunters. The Area 5 bison population structure and possible season of site occupation will also be discussed in this chapter. Finally, the possibility of a secondary processing site associated with Area 5 will be addressed.

6.1 Discussion of Hunting Strategies

At many kill sites the method of bison hunting can be determined based on the location of the kill and the configuration of the landscape. For instance, processed bison located at the base of a steep cliff is indicative of hunting using a jump technique. Unfortunately the bison hunting technique or techniques used by the inhabitants of Area 5 are much less self-evident.

The topography of the landscape surrounding a kill site on the Plains often played a role in the methodologies used to hunt bison. The Bodo sand hill environment is very dynamic and the current configuration of the land may be vastly different than it was centuries ago. Currently these sand hills are partially stabilized by mixed vegetation. Much of the area consists of erosional sand dunes and blowout hollows. The sandy soil and semi-arid environment produces sand dunes with extremely vulnerable vegetative cover. Destabilization in the past may have significantly altered the topography of the landscape around Area 5. Such topographic changes can erase direct evidence of former landscapes, complicating interpretation of hunting methods used at Area 5.

Unlike classic Plains bison jumps such as Head-Smashed-In, Area 5 is not presently associated with any landscape features that could act as a drop-off. No evidence has been found for wood or stone corrals or pounds. However, the parabolic (C-shaped) shape of large sand dunes in this area may have created natural traps that were utilized by hunters. According to Frison (2004:77), in active sand dune fields wind will move the sand that is not stabilized by vegetation and root systems resulting in "long, narrow, and deep parabolic sand dunes with steep sides that can be utilized as animal traps." Not only is the shape of parabolic dunes conducive for trapping prey, but loose sand would also slow the movement of large animals, giving hunters an additional advantage.

An additional aspect of the sand dune environment that may have given hunters an advantage is the existence of a perched water table. A perched water table is a water table near the surface due to an underlying impermeable surface, such as clay. In the sand dunes nearby Area 5, water will often collect in low spots between dunes creating temporary seasonal ponds that were potentially attractive to bison. Frison (1974:21) describes a similar situation at the Casper Site in Wyoming, suggesting that the bison trapping occurred through the use of a parabolic dune. He also notes that in the dune field, "it is not unusual to observe an active dune with a clear pond ringed with lush vegetation a few yards to the windward of the active dune area" (Frison 1974:21). This moist environment would attract bison and the natural topography of the dunes would function as traps, with little need for additional constructed facilities.

Another possible hunting strategy employed at Area 5 is small-scale communal hunting without the use of trapping mechanisms. This would have involved small groups of hunters ambushing groups of bison feeding on the sand hill vegetation or moving through the dunes in search of water. Area 5 apparently predates the arrival of horses in this region of the Plains and no evidence of horses has been found in any of the Bodo area excavations. Binnema (2001:86-94) asserts that horses did not reach this part of northwest Plains until at least the mid 1700's. As such, while the exact hunting strategy employed at Area 5 is hard to directly assess, it is quite clear that hunting was being done by people on foot.

Ultimately, reconstruction of the geomorphological history of the Bodo Sand Hills may help in understanding the local landscape history and may shed light on bison hunting techniques. At this time I can only speculate on the hunting methods employed. In addition, since the entire site has not been excavated and its extent is unknown, it is impossible to determine how many animals were killed and processed at the site. Additional excavation at the site, as well as testing in the vicinity would go far in addressing this basic problem, and might provide insight on the hunting strategies employed. Additional excavation of sites within the Bodo Archaeological Locality may also help better discern the types of hunting strategies employed within this environment.

6.2 Discussion of Butchering and Transportation

There was no standard Precontact method for butchering bison on the Plains. According to Wheat (1972:98):

> Butchering was, in fact, a highly variable process, and the techniques chosen depended on a number of equally variable factors – the time of year, whether meat was for immediate use or for laying in supply, the distance from camp, the use to be made of the hides, if any, and finally, the tribe of Indians involved.

Despite this variability, certain transport patterns and butchering procedures are commonly seen at most large kill sites throughout the Plains. The patterns of element representation and butchering at Area 5 are similar to those seen at kill sites. Area 5 is characterized by relatively poor representation of bison skeletal parts with the largest food value, including the proximal hind limbs, breast (brisket), back (hump), and the sides (ribs), which were likely butchered and removed from kill sites for further processing. In terms of the hind limb, the near absence of femora, proximal tibiae, and tibia shafts suggest that the proximal portion of the hind limb was heavily utilized for meat, marrow, and grease extraction (see Brink 2001). The proximal forelimb, including the humerus and the radius, displays somewhat of the opposite pattern. These elements are more frequently found as whole specimens, suggesting that the proximal forelimb was not as heavily processed for food and not transported away from the kill location as frequently as the proximal hind limb. The proximal humerus is the only part of the upper forelimb that appears to have been heavily utilized. It is essentially absent in the sample, suggesting it may have been utilized for the abundance of bone grease associated with it (see Brink 2001). Fragmented ribs with numerous cut marks, and the paucity of vertebrae, sternal elements, and costal cartilage suggests that these portions were being butchered and sometimes removed, perhaps with meat of the hump, sides, and brisket. In addition to the meat, parts of the back and rib cage were usually valued for their fat content (Brink 2001:256). Marrow was also a common food source on the Plains, but it is difficult to comment on its importance because marrow processing usually took place away from kill sites at secondary processing sites (c.f. Blaikie 2005:139). All long bones are considered marrow bones, but the femur and the tibia were apparently valued by some groups for having the most marrow (Dodge 1959: 273-74). The general lack of the latter two elements at Area 5 makes it difficult to determine if they were processed for marrow, but it is consistent with such a practice. The humerus and the radius, which were more commonly recovered at the site, appear to have been infrequently utilized for marrow extraction. Additionally, the skull was perhaps selectively removed from the site either for food or ceremonial purposes. Both the tongue and brain appear to have been extracted from skulls processed on-site.

The above butchering practices suggest that the bison remains recovered from Area 5 were selectively butchered and utilized. The minimal cut marks and impact fractures on many specimens suggest that only the choice parts of animals were taken while less desirable portions, such as the proximal forelimb, were lightly utilized and often left behind. According to Wheat (1972:101), virtually all historic and ethnographic sources list the most valued parts of bison as the "tongue, hump ribs with meat, marrow bones, and ribs." These cuts, along with the proximal hind limb and the brisket, appear to have been the most valued (if judged by their relative lack of abundance) by the inhabitants of Area 5. Such selective use of bison suggests that food was plentiful during the time when these animals were killed. Ewers (1955:169) asserts that the Blackfoot, during times when game was plentiful only lightly butchered animals and took only the choice parts. Boller (1868:229) also makes a similar observation among the Hidatsa-Mandan stating that, "when there is plenty of meat, the large bones and coarse pieces are always thrown aside, but in times of scarcity there is absolutely nothing left but the head."

The selection of some choice bison parts likely does not leave clear evidence in the archaeological record. For example, historically many internal organs of the bison were consumed, such as the heart, liver, and kidneys, and the blood and milk from these animals also would be consumed (Mandelbaum 1979:58). These parts of the bison were often highly valued, but their use cannot be documented through an analysis of bison skeletal remains alone. It is unclear how or if these portions of bison were utilized at Area 5.

6.3 Discussion of the Bison Population and the Season of Site Occupation

Determining the population structure of an archaeological animal population is difficult. In the case of Area 5, the area of the site excavated is relatively small, making inferences about the total site population potentially problematic. At the same time, the generally good preservation of the Area 5 sample allowed for sex and age assessments to be made on a relatively high proportion of the recovered specimens. Relatively speaking, this should result in relatively reliable assessments of age and sex of the representative population. Aging of the specimens was done by analyzing tooth wear and eruption of mandibular teeth and examining the stages of fusion for numerous bones. The determination of the sex structure of the Area 5 sample population was conducted using a scatter plot distribution technique (Morlan 1991) and a discriminant function technique (Walde 1985). The application of these methods resulted in a profile of the Area 5 sample consisting of more breeding age adult females than breeding age adult males (generally between the ages of 4 and 9 years), as well as some calves. At least seven adult female animals, three adult male animals, and two calves (most likely less than 6 months old) appear to be represented. The remains of very old animals (over 9 years of age) or fetal animals were not recovered at Area 5. Based on the sample of material analyzed from Area 5, these remains represent a mixed-sex group of animals dominated by adult females.

The sample herd structure determined by the aging and sexing analysis from Area 5, along with the absence of fetal bone at the site, was used to assess the season of site occupation. A mixed herd of breeding age males, females, and calves, like that seen at Area 5, is formed in modern bison populations during the summer (July-August) and early fall (September) to facilitate the rut and breeding. The remainder of the year the cows and calves form their own herds, with the bulls forming their own separate groups. If Area 5 is the result of a single mass kill event, it appears that this event would have occurred during the summer or early fall. The complete lack of fetal bone recovered from the site also supports this hypothesis. However, prior to my analysis, Peck (2004) undertook an analysis of the dental cementum of five molars (M1's) from Area 5. This analysis suggested a late October to late December kill and/or a late December to late March kill event (Peck 2004:83). In other words, Peck's data implied that Area 5 was the result of a late fall through winter occupation. However, at least by late winter it would be expected that female bison would be carrying fairly well-developed fetuses and some fetal bone would be present in the assemblage. Such bone has not been found. Assuming the Area 5 assemblage was the product of a single mass kill, it is also somewhat difficult to correlate the inferred sex and age composition of the sample with the seasonality he infers for the site.

At this time, the exact season(s) of site occupation cannot be assigned and I feel that further excavation of the site would assist in enhancing the understanding of the season(s) of site occupation. Excavating more area of the site would perhaps provide additional bone specimens for aging and sexing and may solve the question as to if this site represents a single mass kill or some other depositional sequence.

6.4 Possibility of an Associated Processing Site

Kill sites and processing sites are usually located in areas some distance from one another on the landscape for several reasons. The kill area would often be too contaminated with the discarded remains of dead bison to carry out extensive food processing, and the kill discard would attract scavengers, perhaps making it an unsafe work area. In addition, the prolonged presence and scent of human habitation at the site would deter future prey (bison) from returning to the area (pers. com. Brink 2005). For Area 5, an associated processing site has not been located with certainty.

One processing site initially considered to be associated with Area 5 is Area 7, located approximately 60 meters to the southeast of Area 5. Area 7 was analyzed by Blaikie (2005) as part of his Master's thesis with the goals of understanding who occupied the area, what activities were conducted there, when the site was occupied, where activities were focused, and why this site was utilized. Blaikie (2005:139) concluded that the primary activity undertaken at Area 7 was intensive bison processing and that Area 7 was not a bison kill site. Blaikie (2005:139) suggests that "butchering occurred elsewhere, and portions were selectively transported to Area 7 for more complete secondary butchering and processing." Blaikie (2005) focuses on the analysis of what he refers to as the 'lower occupation' of Area 7. This occupation is rich in faunal remains, lithics, FCR, pottery, and features, and it is stratigraphically beneath the 'upper occupation.' He also briefly discussed that the upper occupation, an occupation with less than 1000 bone fragments, containing mostly unidentifiable fragmented faunal material.

Blaikie (2005) obtained five radiocarbon dates from the lower occupation and one date for the upper occupation. Upon undertaking the analysis of Area 5, I assumed that Area 7 would be the secondary processing site associated with the Area 5 kill. However, the radiocarbon dates indicate that that Area 5 is at least 150-350 years older than the lower occupation of Area 7. The lower occupation of Area 7 was apparently deposited during the late 1700's to the early 1800's, while Area 5 was apparently occupied during the early 1400's to early 1600's. However, a corrected age of 335 ±35 years old was obtained for the upper occupation of Area 7, and this date is in the same time range as the dates from Area 5 (see Chapter 3). However, Blaikie (2005:132) suggests that the upper occupation material is in secondary context - it dates to an earlier time period than the material stratigraphically below it. Blaikie (2005) suggest that the original archaeological material (that makes up the current upper occupation of Area 7) was deposited upslope to the northeast of Area 7. At some point, dune destabilization occurred and material from this episode was deposited on top of the younger material from the lower component of Area 7. However, no potential original source for material has yet been identified. It seems possible that the processing site associated with Area 5 is near Area 7, but may be disturbed. Further excavation and exploratory work needs to be undertaken in the vicinity of Area 7 and Area 5 in order to better establish the relationship between these two sites.

CHAPTER 7: CONCLUSION AND FUTURE DIRECTIONS

This thesis has examined a number of aspects of bison kill sites on the northwest Plains. Area 5 was used as a case study to gain insight on bison hunting and butchering during the Late Precontact period. Although bison kill sites are common on the northwest Plains, few have been analyzed in detail, especially in the Parkland of Alberta. Area 5 is a dense bone bed that proved surprisingly informative considering the small size of the excavated area.

However, Area 5 only represents one of many sites within the Bodo Archaeological Locality, encapsulating the Bodo Sand Hills region. Area 5 is only the second site to be assessed in detail (Area 7 was the first) in the Bodo Sand Hills thus far. Many other sites have been located and excavated, but detailed analyses of these sites have not been completed at this time. Of all of the sites recorded in the Bodo Sand Hills, Area 5 currently appears to represent the only definitive bison kill site. Most of the other sites that have been excavated reveal evidence (such as various hearth and pit features, a variety of stone tools, large collections of pottery, and intensely smashed bone) that appear to be suggestive of secondary processing or habitation sites. The apparent under-representation of kill sites at Bodo may be a factor of sampling strategy, but may also suggest that kill sites were less common in the Bodo Sand Hills than habitation sites. This may suggest that bison killing was infrequently taking place in the sand hills, and instead hunting was occurring on the surrounding prairie, with animal carcasses being brought back to the sand hills for processing. However, the existence of the Area 5 kill site suggests that at least some hunting was taking place in the sand hills themselves. Gibson (pers. com. 2006) believes that more bison kill areas may be located to the south and west of the Area 5, but the infrequent oil field development in this area has limited the opportunity to further explore this area. When surface inspection was conducted adjacent to Area 5 within the sand hills, in areas not affected by oilfield development, complete bones were observed eroding out of the sand south and west of the site, suggesting that the Area 5 bone bed may be much larger, or that other kill sites are present nearby. Clearly additional attempts to locate bison kill sites within the Bodo Sand Hills would be beneficial and their investigation might provide a greater understanding of Late Precontact bison utilization in a sand hill environment. Such types of studies have the potential to contribute to the larger study of bison procurement strategies on the Plains. For example, archaeologists may be able to gain insight as to why indigenous people so heavily utilized this type of area, and what drew people to live and hunt in a sand dune environment, which by today's standards might be considered a marginally productive environment.

As well, before any additional studies of other potential kill sites in the Bodo Archaeological Locality are commenced, it is seems useful to determine the extent of the Area 5 kill site through additional excavation. In addition, a complete analysis of the faunal remains from the nearby sites needs to be conducted in order to better understand the complex hunting and butchering strategies employed. Time and financial constraints did not allow me to further excavate Area 5, but additional study this would go far in addressing the unanswered questions that came out of this thesis. As well, an attempt should be made to find and excavate processing sites associated with Area 5. The excavation and complete analysis of faunal remains from such a site would serve to verify or invalidate the butchering and transport decisions I have suggested here.

Finally, it is my hope that, if anything, my research has created a starting point for future bison utilization research at the Bodo Archaeological Locality. Although many Old Women's Phase bison kill sites have been recorded on the Plains and some have been intensively studied, there is a need to focus future studies on kill sites that represent the time period immediately prior to European influence on the northwest Plains. Numerous sites in the Bodo Site Locality appear to represent the very Late Precontact period, but the majority of these sites remains have not be dated or analyzed (with the exception of Area 5 and Area 7). In my opinion, the Bodo Archaeological Locality is critical to the study of Indigenous bison hunting culture on the northwest Plains immediately prior to the period of European influence and settlement. Further research at bison kill sites from this time period is key in furthering our understanding of many aspects of Indigenous lifeways on the Plains.

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APPENDIX 1: DENSITY SCAN SITE FREQUENCY TABLES

Scan Site (Kruetzer 1991)	Area 5 Frequency
2&3CP	6
AC1	19
AS1	12
AS2	12
AS3	12
AT1	5
AT2	5
AT3	9
AX1	4
AX2	6
AX3	2
CA1	10
CA2	9
CA3	9
CA4	9
CE1	24
CE2	20
CUNEIF	9
DN1	16
DN2	16
DN3	15
DN4	25
DN5	21
DN6	21
DN7	29
DN8	20
FE1	4
FE2	4
FE3	7
FE4	1
FE5	2
FE6	1
FE7	1
5MC	2
HU1	2

Scan Site (Kruetzer 1991)	Area 5 Frequency
HU2	6
HU3	11
HU4	21
HU5	16
HYOID	11
IL1	7
IL2	12
IS1	8
IS2	1
LATMAL	6
LU1	21
LU2	19
LU3	8
LUNAR	15
MC1	13
MC2	13
MC3	13
MC4	15
MC5	13
MC6	12
MR1	15
MR2	17
MR3	16
MR4	13
MR5	13
MR6	10
NC1	12
NC2	11
NC3	11
PATELLA	2
P11	56
P12	54
P13	52
P21	45

Scan Site (Kruetzer 1991)	Area 5 Frequency
P22	40
P31	34
PU1	4
PU2	1
RA1	26
RA2	26
RA3	17
RA4	20
RA5	24
RI1	73
RI2	106
RI3	74
RI4	17
RI5	6
SC1	11
SC2	4
SCAPHOID	9
SP1	17
SP2	22
SP3	6
SP4	25
SP5	3
STERNUM	0
TH1	1
TH2	13
TI1	4
TI2	4
TI3	6
TI4	17
TI5	18
TRAPMAG	13
UL1	7
UL2	11
UNCIF	14

Density Table 1: The relative abundance of scan sites for the Area 5 bison faunal assemblage.

APPENDIX 2: CARPAL AND TARSAL MEASUREMENTS TABLES

RADIAL CARPAL

Artifact #	Side	Length (mm)	Width (mm)	Depth (mm)
90725	L	32.35	30.00	46.80
90416	R	n/a	n/a	47.45
77392	R	35.85	n/a	n/a
92227	L	28.80	22.10	38.25
90338	R	31.65	n/a	48.85
75839	L	33.55	26.60	43.10
98829	L	33.25	30.90	51.35
77525	L	n/a	n/a	n/a
91991	L	n/a	n/a	n/a
Female	L	31.20	27.55	43.55
Female	R	31.20	26.30	43.40
Male	L	33.15	31.40	53.05
Male	R	34.00	31.90	51.90

Carpal Table 1: Measurements of the radial carpal specimens from Area 5 (based on Morlan (1991))

INTERMEDIATE CARPAL

Artifact #	Side	Length (mm)	Width (mm)	Depth (mm)
77398	R	30.80	33.25	n/a
92876	L	27.55	33.40	48.85
94216	L	30.25	29.10	42.95
90216	L	29.50	31.90	n/a
94215	R	25.05	29.60	37.20
96201	R	27.55	29.40	n/a
76982	R	25.00	29.15	43.45
76928	L	26.60	28.50	n/a
77417	L	n/a	n/a	n/a
94772	L	n/a	n/a	n/a
96116	R	n/a	n/a	37.15
98550	R	32.15	29.15	51.15
90339	L	25.40	28.25	38.85
77367	L	28.85	29.40	36.85
90217	L	27.80	n/a	n/a
Female	L	29.20	31.40	42.50
Female	R	28.85	31.55	42.50
Male	L	29.70	33.00	49.90
Male	R	28.60	33.25	48.55

Carpal Table 2: Measurements of the intermediate carpal specimens from Area 5 (based on Morlan (1991))

ULNAR CARPAL

Artifact #	Side	Anterior Length (mm)	Posterior Length (mm)	Width (mm)	Depth (mm)
90341	INDT	n/a	n/a	n/a	n/a
94515	L	n/a	n/a	n/a	n/a
94281	L	30.20	32.40	26.30	39.00
76922	L	27.60	31.70	30.85	34.25
98549	R	33.65	42.20	27.60	38.55
95758	L	n/a	n/a	n/a	n/a
97194	L	29.25	36.35	28.15	39.20
77418	R	n/a	n/a	n/a	n/a
97999	L	32.70	30.65	24.35	36.80
Female	L	31.50	36.85	22.90	29.25
Female	R	30.90	36.75	22.85	34.10
Male	L	35.55	42.55	27.00	41.50
Male	R	36.65	39.70	27.10	41.40

Carpal Table 3: Measurements of the ulnar carpal specimens from Area 5 (based on Morlan (1991))

CARPAL 2+3

Artifact #	Side	Length (mm)	Width (mm)	Depth (mm)
90218	R	n/a	n/a	34.00
91014	L	n/a	n/a	n/a
91095	L	24.40	42.75	37.15
91865	L	23.25	38.40	38.10
77399	L	21.15	35.00	33 .55
91615	R	24.50	41.85	40.55
97049	R	23.85	42.15	36.90
98548	R	21.75	38.50	36.30
77400	R	n/a	36.80	33.90
94553	L	n/a	n/a	n/a
98424	L	21.90	42.60	38.20
98538	L	24.05	43.95	40.00
98830	R	22.65	30.55	31.45
Female	L	20.40	36.75	35.30
Female	R	20.55	36.20	34.00
Male	L	26.20	45.10	40.35
Male	R	26.05	43.60	41.00

Carpal Table 4: Measurements of the carpal 2+3 specimens from Area 5 (based on Morlan (1991))

CARPAL 4

Artifact #	Side	Length (mm)	Width(mm)	Depth (mm)
75660	L	n/a	n/a	n/a
75680	L	23.40	29.55	33.00
90219	L	n/a	n/a	n/a
94136	L	25.45	26.35	29.65
93209	L	22.20	26.70	30.60
94514	L	22.10	28.45	32.45
96200	R	26.15	31.40	36.45
95757	L	23.65	29.90	34.50
77396	L	n/a	n/a	n/a
97126	L	22.90	27.85	33.15
96869	R	25.00	32.10	34.90
96202	L	23.10	n/a	n/a
97998	L	23.80	28.85	35.50
76869	R	n/a	n/a	n/a
Female	L	22.60	27.90	31.80
Female	R	22.60	27.40	29.30
Male	L	30.10	33.80	39.20
Male	R	29.90	32.25	39.15

Carpal Table 5: Measurements of the carpal 4 specimens from Area 5 (based on Morlan (1991))

TALUS

Artifact #	Side	Medial Depth (mm)	Distal Length (mm)	Proximal Width (mm)	Distal Width (mm)	Lateral Length (mm)	Medial Length (mm)
91612	R	n/a	41.45	43.85	n/a	73.30	n/a
91866	R	n/a	36.40	40.00	41.00	66.85	65.35
96458	L	34.00	n/a	n/a	n/a	n/a	66.30
97850	L	n/a	n/a	n/a	48.95	n/a	n/a
97486	L	41.80	43.00	53.80	49.60	77.50	73.50
98304	L	40.60	40.20	47.70	47.90	72.50	70.60
77355	R	38.85	42.60	47.65	n/a	75.00	72.20
76815	L	n/a	41.60	50.85	48.10	76.45	70.60
77380	L	32.90	36.40	45.80	42.25	66.25	61.95
98008	L	35.80	38.55	47.10	44.85	70.35	66.70
76958	R	38.75	41.60	45.85	47.40	72.95	70.50
98799	R	n/a	33.90	40.70	44.50	65.05	63.00
Female	L	43.05	40.60	52.10	50.95	73.90	69.85
Female	R	40.60	40.00	50.35	48.40	73.40	69.65
Male	L	44.70	43.90	54.85	54.00	80.20	74.30
Male	R	44.20	44.45	54.10	53.15	80.40	73.80

Tarsal Table 1: Measurements of the talus specimens from Area 5 (based on Morlan (1991))

CALCANEUS

Artifact	Side	Length of TarsalC+4 Facet (mm)	Length of Talus Facet (mm)	Length (mm)	Proximal Width (mm)	Distal Width (mm)	Distal Depth (mm)	Proximal Depth (mm)
76558	R	38.20	30.80	138.55	33.80	n/a	54.20	34.56
90417	L	36.50	n/a	n/a	36.95	n/a	n/a	n/a
93229	L	45.55	35.85	157.75	42.80	49.65	61.15	41.80
76387	L	39.15	33.25	142.20	40.25	42.55	55.45	39.95
94199	L	n/a	32.60	151.95	37.95	49.40	56.80	42.00
91959	L	40.25	35.45	n/a	n/a	44.80	58.55	n/a
77357	R	n/a	35.35	146.40	n/a	44.50	58.00	n/a
77350	R	36.20	31.55	n/a	n/a	39.95	50.80	n/a
75991	INDT	n/a	n/a	n/a	n/a	n/a	n/a	n/a
98423	L	35.15	32.10	n/a	n/a	n/a	50	n/a
Female	L	36.95	32.10	147.00	37.50	43.10	56.40	36.60
Female	R	36.95	30.40	149.00	36.25	42.45	55.50	37.15
Male	L	43.25	35.30	158.00	40.95	48.90	63.70	47.60
Male	R	44.80	35.45	161.35	41.05	46.85	64.40	48.50

Tarsal Table 2: Measurements of the calcaneus specimens from Area 5 (based on Morlan (1991))

TARSAL C+4

Artifact	Side	Length (mm)	Width (mm)	Depth (mm)
91864	L	49.75	n/a	n/a
94050	R	41.35	56.50	55.80
94150	R	n/a	n/a	n/a
98407	L	n/a	50.70	52.80
77523	R	n/a	58.50	57.50
98305	L	42.85	55.30	57.45
77518	R	n/a	56.65	57.60
92048	L	n/a	n/a	n/a
75607	R	n/a	52.70	51.80
96539	L	39.85	n/a	53.30
95558	L	42.50	53.60	53.55
96538	L	45.90	58.35	56.40
Female	L	51.30	50.55	56.60
Female	R	46.50	52.15	57.70
Male	L	49.90	60.60	62.45
Male	R	48.90	60.00	63.00

Tarsal Table 3: Measurements of the tarsal C+4 specimens from Area 5 (based on Morlan (1991))

TARSAL 2+3

Artifact	Side	Length (mm)	Width (mm)	Depth (mm)
76923	R	11.80	21.05	40.20
75644	INDT	n/a	18.65	32.60
93753	INDT	n/a	n/a	n/a
92228	L	12.25	n/a	41.85
96870	R	11.30	22.50	33.95
75862	INDT	n/a	n/a	n/a
Female	L	9.65	23.35	36.25
Female	R	11.30	22.75	37.40
Male	L	12.60	28.35	44.75
Male	R	13.10	30.40	43.10

Tarsal Table 4: Measurements of the tarsal 2+3 specimens from Area 5 (based on Morlan (1991))

LATERAL MALLEOLUS

Artifact	Side	Length (mm)	Width (mm)	Depth (mm)
91817	L	29.15	20.20	41.10
93210	L	n/a	n/a	n/a
97926	R	n/a	n/a	n/a
77524	R	27.85	17.40	34.60
96209	L	27.50	19.45	40.00
95804	INDT	n/a	n/a	n/a
Female	L	27.40	18.10	33.30
Female	R	27.35	17.45	33.05
Male	L	29.40	20.30	41.40
Male	R	29.80	20.45	42.25

Tarsal Table 5: Measurements of the lateral malleolus specimens from Area 5 (based on Morlan (1991))