To the Graduate Council:

I am submitting herewith a thesis written by Jennifer A. Borresen entitled "A Faunal Analysis of the Frazier Site, an Agate Basin-Age Bison Kill-Butchery Site in Northeastern Colorado." I have examined the final paper copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

Walter E. Klippel, Major Professor

We have read this thesis and
recommend its acceptance:

Gerald F. Schroedl, Professor

Paul W. Parmalee, Professor Emeritus

Acceptance for the Council:

Vice Provost and Dean of
Graduate Studies

A FAUNAL ANALYSIS OF THE FRAZIER SITE, AN AGATE BASIN-AGE BISON KILL-BUTCHERY SITE IN NORTHEASTERN COLORADO

A Thesis
Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

Jennifer A. Borresen
May 2002

Thesis
2002
.B67

Copyright © 2002 by Jennifer A. Borresen
All rights reserved.

ACKNOWLEDGMENTS

This thesis would not have been possible without the support of a number of people. I thank my committee chair, Dr. Walter Klippel, for introducing me to the world of zooarchaeology beyond the Plains! Your support and confidence in my ability means a lot. Thank you Drs. Parmalee and Schroedl for providing support and assistance throughout this project. In particular, Dr. Schroedl, thank you for making your library available, and, Dr. Parmalee, thank you for generously donating a portion of your library to me.

I owe a deep debt of gratitude to Dr. James Dixon for facilitating access to the Frazier site faunal collection. I thank you for having such faith in me and remaining an enthusiastic supporter over the past few years. Numerous individuals at the Denver Museum of Nature and Science also deserve recognition for the help they have provided. Thank you Ryntha Johnson, Jude Southward, Steve Holen, Kris Haglund, and Liz Clancy. In addition, I appreciate the help and insight provided by Matt Hill, Scott Slessman, Larry Todd, Dave Byers, Bill Manley, Weber Greiser and Robert Burton. I am grateful to the University of Tennessee for providing funding to transport the materials from Denver to Knoxville.

On a more personal level, I thank Drs. Jack Fisher and Tom Roll for instilling in me a desire to do archaeology. It was with the both of you that I first realized the wonders of digging in the dirt and I count myself lucky to have been one of your students.

This thesis would never have been completed without the loving support of my family and friends. Thank you Mom, Dad, and Annie for being so wonderful. Your seemingly infinite confidence and love is what enables me. Thank you Susan for showing such an interest in my work. Thank you Shelly for your innate ability to put

things in perspective and always make me feel better…even from across the country. Friends just don't get any better than you. Thank you Sarah Hughes, Corey Sparks, Jacquel Arismendi, Judy Patterson, Jodi Jacobson and Dan Weinand for making my stay in Knoxville a little more comfortable. Also, my life is more complete because of the companionship of my four-legged family: Dolci (against who all others will always be compared), Gabby, Cleo, Kermit, and Tashi. I miss you D.

And finally, to my best friend, Craig Lee…I dedicate this thesis. You truly are my inspiration.

ABSTRACT

The Frazier site (5WL268) was excavated in the late 1960s under the direction of Dr. H. Marie Wormington and represents the only known Agate Basin-age (ca. 10,000 years B.P.) bison kill-butchery site in Colorado. As such, it provides important information about Late Paleoindian subsistence on the High Plains. Left astragali indicate that a minimum of forty-four bison (*B. antiquus*) was killed at the site and measurements taken on the calcanea and metacarpals suggest the archaeofauna is largely comprised of females and immature animals. While Wormington interpreted the site as a secondary processing area, bison skeletal part frequencies, bone breakage patterns and butchery evidence provide a refined picture of the site's function, suggesting instead that it represents a kill locale. This interpretation is strengthened by a comparison with other Agate Basin-age archaeological sites, particularly the Agate Basin site. However, while the Agate Basin site appears to reflect the selective removal of high-utility upper limb elements only, the skeletal element profile from the Frazier site suggests a scenario in which both high-utility upper limb elements and low-utility metapodials were transported from the site. Such behavior may be indicative of seasonal differences in bison carcass utility related to the Frazier site's occupation late in the cold season (late winter-early spring).

TABLE OF CONTENTS

Chapter		Page
1.	Introduction	1
2.	Bison and Paleoindian Subsistence on the High Plains	5
	Bison Behavior and Physiology	5
	Paleoindian Subsistence	8
	The Agate Basin Cultural Complex	11
	The Hell Gap Site	13
	The Agate Basin Site	16
	Summary	17
3.	The Frazier Site	19
	Site Setting and History of Investigations	19
	Excavation Areas and Recovery Methods	20
	Wormington's Interpretation of the Site	22
	Lithic Materials	24
	Geology	25
	Radiocarbon Dates	26
	History of Faunal Studies	27
	G. Edward Lewis (1966, 1968)	27
	D. Eidlen (1993)	29
	Todd, Hofman and Wormington (1990)	30
	Other Studies	30
4.	Zooarchaeological Methods	32
	Specimen Identification	32
	Bone Modification	33
	Carnivore and Rodent Modification	34
	Burning	34
	Subaerial Weathering and Root Etching	34
	Bone Breakage and Other Evidence for Butchery	35
	Quantification	36
	Number of Identified Specimens (NISP)	36
	Minimum Number of Elements (MNE)	36
	Minimum Number of Animal Units (MAU)	37
	Minimum Number of Individuals (MNI)	37
	Sex and Age Determination	37
5.	Results	40
	Taxonomy	40
	Herd Structure	42

TABLE OF CONTENTS, CONTINUED

Chapter Page

Seasonality Assessment 44
Articulated Segments 48
Skeletal Element Abundance 48
Density-Mediated Attrition 55
Bison Carcass Utility 60
Modifications 66
Rodent and Carnivore Modification 66
Bone Breakage and Other Evidence for Butchery 70
Burning 72
Bone Tools 72

6. Summary and Conclusions 75

Interpreting the Frazier Site Bison Archaeofauna 75
The Frazier Site versus the Agate Basin Site 81
Conclusions 84

List of References 88

Appendices 105

Appendix 1. Curation of the Frazier Site Archaeofauna 106
Appendix 2. Faunal Analysis Coding Format 110
Appendix 3. Frazier Site Bison Calcanea Measurements 114
Appendix 4. Frazier Site Bison Metacarpal Measurements 115
Appendix 5. Criteria for Determining the Minimum Number of Elements (MNE) in the Frazier Site Bison Archaeofauna 117
Appendix 6. Frazier Site Faunal Data (CD-ROM) 118

Vita 119

LIST OF TABLES

Table		Page
2.1	High Plains Paleoindian chronological chart	12
5.1	Bison skeletal element abundance, Frazier site	49
5.2	Tooth frequency in the bison archaeofauna, Frazier site	51
5.3	Frazier site bison skeletal element abundances and corresponding volume density values	58
5.4	Bison skeletal element abundances, bison carcass utility values And value ranks, Frazier site	64
5.5	Spearman rank-order correlations between bison %MAU and utility, Frazier site	65
5.6	Incidence of modification in the Frazier site bison archaeofauna	67

LIST OF FIGURES

Figure		Page
2.1	Agate Basin projectile points from the Frazier site	14
2.2	High Plains archaeological sites containing Agate Basin components	15
3.1	Topographic map of the Frazier site showing excavation localities	21
3.2	"Pit" feature encompassing units F34, F35, G34, G35, Frazier site	23
5.1	Distribution of bison bone specimens, Localities 1 and 3, Frazier site	41
5.2	Mean bison metacarpal length from selected High Plains archaeological sites	43
5.3	Male (a), female (b), and immature (c) bison calcanea from the Frazier site	45
5.4	Selected crossplots of bison metacarpal measurements (mm); (a) distal breadth vs. lateral condyle breadth, (b) lateral condyle breadth vs. lateral trochlea depth, (c) lateral condyle breadth vs. depth of medial sagittal ridge, and (d) medial condyle breadth vs. lateral condyle breadth	46
5.5	Bison skeletal element abundance profile, axial elements, Agate Basin (AB) level of the Agate Basin site and Frazier site	52
5.6	Bison skeletal element abundance profile, Frazier site	54
5.7	Bison skeletal element profiles for forelimb (a) and hind limb (b) elements, Frazier site	56
5.8	Scatterplot of %MAU of bison skeletal parts against bone mineral density values (Kreutzer 1992), Frazier site	59
5.9	Scatterplots of %MAU of bison skeletal elements against (a) (S)AVGTP, (b) (S)AVGPRO, and (c) (S)AVGMAR	61
5.10	Patterned breakage of bison metacarpals (a) and tibiae (b), Frazier site	71
5.11	Possible bone tools, Frazier site	73

LIST OF FIGURES, CONTINUED

Figure		Page
6.1	Equability of bison remains, Frazier site	77
6.2	Bison skeletal element profiles for Frazier site and Agate Basin site, Agate Basin (AB) level	82
6.3	Bison forelimb (a) and hind limb (b) skeletal element profiles for the Frazier site and the Agate Basin site, Agate Basin (AB) level	83
6.4	Bison skeletal element profiles for the Frazier site and the Hell Gap Locality II Agate Basin level	86
A.1	Examples of bag labels	108

LIST OF PLATES

Plate		Page
1	Frazier site faunal data	In pocket

-CHAPTER ONE-

INTRODUCTION

The frequent recovery of bison remains at archaeological sites attests to the fact that bison figured prominently in the subsistence strategies employed by prehistoric peoples on the High Plains of North America. Consequently, archaeologists have long been interested in bison bonebeds as a means of understanding the relationship between prehistoric peoples and the bison they hunted.

During the late 1960s, archaeologists working under the direction of the late Dr. H. Marie Wormington uncovered the remains of approximately 50 bison at an archaeological site in northeastern Colorado. Wormington, a preeminent authority in Paleoindian studies and one of the first women in the United States to pursue a career (and earn a Ph.D.) in archaeology, named the site after its discoverer, Frank Frazier. Preliminary analysis of the Frazier site assemblage led her to interpret it as an Agate Basin-age (ca. 10,000 year old), secondary bison processing location (Wormington 1984, 1988). However, shortly after completing excavations at the site, Wormington resigned as Curator of Archaeology at the Denver Museum of Natural History (now the Denver Museum of Nature and Science but hereafter referred to as DMNH) and a thorough analysis of the assemblage was never completed. Only cursory references to the site exist in print (Brunswig 1992; Cassells 1983:60, 1997:81; Frison 1991:26, 40; Gilmore et al. 1999:72; Stanford 1999; Wormington 1984, 1988).

Current understanding of High Plains Paleoindian subsistence behavior relies heavily on sites similar to the Frazier site, i.e., sites excavated decades ago. In the

face of new and increasingly refined methodologies a number of these sites are receiving renewed attention (e.g., Byers 2001; Hill 2001). However, analysis of already-existing archaeological collections presents a unique set of obstacles including (1) an inability to develop research questions prior to field excavations, (2) difficulty in determining the research objectives of the original project and how those may have influenced collection procedures, and (3) missing documentation and materials. Each of these obstacles influences the types of questions that can be asked of an archaeological collection but the latter two are particularly important to interpreting the Frazier site. Over the past several years, field techniques have steadily become more rigorous. At most archaeological sites today it is not uncommon for archaeologists to utilize a number of high-tech instruments to obtain precise information about the provenience of artifacts. In contrast, 30 years ago at the Frazier site, excavators infrequently recorded vertical provenience on recovered artifacts, and horizontal provenience can often only be established to excavation unit. In addition, sediments were rarely screened, which surely had a direct affect on the recovery of certain skeletal elements.

As might be expected, information documenting the excavation of the Frazier site is incomplete. Included in the DMNH archives are the crew chiefs' field notes (David Acton in 1966, Robert Bradley in 1967), a list of surface finds collected in 1965, a handful of photographs (n = 9), unit plan maps, copies of National Science Foundation proposals and/or reports for each year of excavation, and miscellaneous records that are difficult to interpret; however, there exist no notes authored by Wormington and, based on existing documentation (Wormington 1967:3), a significant number of photos are unaccounted for. Of note is that a large number of slides from the Frazier site excavations were acquired in 2001 from Frank Frazier,

the site's discoverer. The slides have subsequently been scanned to compact disc and a copy will be placed in the DMNH archives.

The following thesis provides a thorough analysis of the Frazier site archaeofauna, which is largely comprised of bison. In Chapter 2, modern bison behavior and physiology is discussed in terms of (1) its applicability to extinct bison forms, and (2) its possible influence on prehistoric human utilization of bison. In addition, numerous models of High Plains Paleoindian subsistence are discussed. A brief description of the Agate Basin Cultural Complex is provided, along with an overview of sites bearing Agate Basin components.

Chapter 3 summarizes the history of investigations at the Frazier site and includes a short description of the recovered lithic materials, site geology, and radiocarbon dates. Past studies with the Frazier site faunal remains are also discussed.

Chapter 4 presents the zooarchaeological methods employed in the identification and analysis of the Frazier site archaeofauna. Quantification methods, such as number of identified specimens, minimum number of elements, minimum animal units, and minimum number of individuals are outlined, as are the types of modifications noted in the present study. Useful methods for determining herd composition, i.e., sex and age of the bison remains, are also addressed.

Results of the current analysis are presented in Chapter 5. The taxonomy and herd structure of the Frazier bison is established and issues surrounding site seasonality are discussed. Skeletal element abundance information is provided along with skeletal element profiles. The taphonomic history of the Frazier site archaeofauna is discussed in terms of bison carcass utility, density-mediated

attrition, rodent and carnivore modification, burning and butchery evidence (e.g., cut marks, impact scars, bone breakage).

Chapter 6 provides an interpretation of the Frazier site bison remains. In contrast to Wormington (1984, 1988), the site is interpreted as a kill location from which complete forelimb and upper hind limb units were removed for further processing elsewhere. A comparison of the Frazier site bison archaeofauna with the bison remains from the Agate Basin level of the Agate Basin site (Hill 2001) reveals a striking similarity between the two faunal assemblages, suggesting that similar activities occurred at both sites. However, discrepancies in the frequency of certain skeletal elements suggests the Frazier Paleoindians may have been more nutritionally stressed than the Agate Basin Paleoindians, perhaps as a result of the Frazier site's occupation relatively late in the cold season. The chapter concludes with a brief discussion concerning how the Frazier site fits into the current understanding of High Plains Paleoindian subsistence.

-CHAPTER TWO-

BISON AND PALEOINDIAN SUBSISTENCE ON THE HIGH PLAINS

The elevated, western portion of the Great Plains, or High Plains, contains a large number of Paleoindian (ca. 11,500 to 8,000 B.P.) archaeological sites. The scientific excavation of many of these sites suggests they were probably occupied by highly mobile, specialized big-game hunters (Bamforth 1988; Hill 2001; Kelly and Todd 1988; Todd and Hofman 2001). In particular, the prevalence of bison kill-butchery sites on the High Plains (e.g., Frison 1970, 1973, 1974, 1978, 1984, 1991, 1996; Frison and Stanford 1982; Frison and Todd 1987; Jodry and Stanford 1992; Reher and Frison 1980; Wheat 1972, 1979) indicates that bison were an integral component of Paleoindian subsistence.

Bison Behavior and Physiology

Although presently there exists only one species of bison (*Bison bison*) in North America, at least one other bison species (*Bison antiquus*) was hunted on the High Plains during the prehistoric period (McDonald 1981). In contrast to present-day bison, this now-extinct taxon was considerably larger and had longer, broader horns (McDonald 1981). Climatic change (Guthrie 1984) and/or human hunting pressure (Martin 1967, 1984) eventually led to a reduction in overall body size and by approximately 5,000 years ago the larger form had been replaced by *Bison bison* (Hughes 1978; McDonald 1981; Wilson 1974a).

North American bison taxonomy has undergone extensive modification since Linnaeus (1758) first described the present-day form (e.g., Allen 1876; Cuvier 1825; Frick 1937; Knight 1849; Leidy 1852; Lucas 1899; Schultz and Frankforter 1946; Skinner and Kaisen 1947). Particularly germane to the present study is the

taxonomic classification of *B. antiquus* and the two subspecies associated with it (*B. a. antiquus* and *B. a. occidentalis*). While the present study follows the idea that "antiquus" and "occidentalis" represent two subspecies of *B. antiquus* (McDonald 1981), others suggest they are two subspecies of *B. bison*, i.e., *Bison bison antiquus* and *Bison bison occidentalis* (Wilson 1974a). Regardless of their taxonomy, it is widely accepted that the two forms were contemporaneous, with the subspecies *antiquus* perhaps representing a "southern" form and *occidentalis* a "northern" form (Wilson 1974:93). The north/south distinction is poorly defined, however, as the geographic range of each subspecies overlapped considerably (McDonald 1981:83, 92).

In order to make meaningful interpretations about Paleoindian (and other prehistoric) bison kill-butchery sites, modern bison behavior is often used to model prehistoric bison behavior. Obviously, doing so assumes that prehistoric and modern bison behaved in similar ways, which may or may not have been the case. However, based on morphological similarities between modern bison and their extinct counterparts and in the absence of alternatives such a practice seems justified.

Throughout much of the year modern adult male and female bison live in sexually segregated groups (McHugh 1958:15-16; Berger and Cunningham 1994:25). Cow groups typically include adult females and juveniles (3 years old and younger) and are generally larger than bull groups (McHugh 1958:14; Berger and Cunningham 1994:75). Intermingling of the two groups is largely restricted to the fall rut (McHugh 1958:15-16). Whereas female bison tend to favor open spaces, males frequent both open and fractured landscapes (Berger and Cunningham 1994:84). These behavioral patterns, if applicable to prehistoric bison, likely

influenced the composition of bison kills, and the resulting faunal assemblages should reflect the general time of year during which kills occurred.

Intra-skeletal differences in body-part utility may have resulted in selective procurement and utilization of bison by prehistoric humans (Binford 1978; Emerson 1990; Speth 1983). Utility indices (Binford 1978) have proven useful in interpreting prehistoric processing decisions and information concerning skeletal part utility is available for a growing number of species, including sheep (Binford 1978), caribou (Binford 1978; Jones and Metcalfe 1988), musk ox (Will 1985), red kangaroo (O'Connell and Marshall 1989), horse (Outram and Rowley-Conwy 1998), guanaco (Borrero 1990), llama (Gonalons 1991; Tomka 1994), phocid seals (Lymen et al. 1992b), otarrid seals (Savelle et al. 1996), harbour porpoise (Savelle and Friesen 1996), some East African ungulates (Blumenschine and Madrigal 1993), white-tailed deer (Jacobson 2000; Madrigal 1999; Madrigal and Capaldo 1999) and, most importantly for the present study, bison (Emerson 1990). Such studies predict that the remains of low utility skeletal parts will dominate kill localities, whereas processing sites may yield greater frequencies of high utility elements.

In addition to general utility considerations, between-sex seasonal variation in skeletal part utility also may have influenced processing decisions (Emerson 1990; Speth 1983).

> Both sexes are in poorest shape in the spring, but males reach their lowest point earlier than females and are improving at the time when females reach their lowest point. Similarly, although both sexes improve during early summer, males improve more rapidly. In mid- to late summer...males decline sharply while females continue to improve gradually throughout the summer, fall, and even early winter. Both sexes decline in late winter, but males often enter this period with less fat reserve and are therefore more vulnerable to undernutrition if conditions are severe. Males, however, rebound much faster and sooner in the spring than pregnant or lactating females (Speth 1983:163).

Deviations from the expected pattern of bison utilization based on skeletal part utility may therefore be explained through consideration of seasonal variations in the fat content of male and female skeletal parts, particularly appendicular elements.

Clearly, considerations of modern bison behavior, including aggregation patterns, body-part utility, and the timing of cow and bull nutritional stress, can contribute to the development of models of prehistoric subsistence adaptations on the High Plains.

Paleoindian Subsistence

The archaeological record suggests that many aspects of bison utilization remained unchanged throughout prehistory (Bamforth 1988:155). Both the Paleoindian and Late Prehistoric periods are dominated by large mammal kill sites, few campsites, and generally similar lithic tool kits. In spite of these similarities, however, there are fundamental differences between Paleoindian and Late Prehistoric subsistence behavior (Bamforth 1988; Frison 1982b; Hill 2001; Todd 1991; Todd et al. 1990) and, consequently, models of Late Prehistoric adaptation are not applicable to Paleoindians. For example, Paleoindians appear to have hunted small groups of bison (≤ 50) throughout the year (although with greater intensity during the late fall and early winter), while hunting by later groups was largely restricted to the early fall. Furthermore, Paleoindians relied heavily on natural topographic features as a means of trapping bison, while their Late Prehistoric counterparts often constructed corrals, pounds, and drive lanes to trap and kill large numbers of animals. Lastly, in contrast to sites of later age, the paucity of hearth features found at Paleoindian sites, together with the low frequency of butchery evidence on recovered bones, suggests that bison were not as extensively processed at Paleoindian kills.

Proposed models of Paleoindian adaptation on the High Plains attempt to explain diachronic change in High Plains hunter-gatherer subsistence behavior (Bamforth 1988; Frison 1982b; Greiser 1985; Hill 2001; Kelly and Todd 1988; McCartney 1983, 1990, Todd 1991). These models often focus on seasonal use of bison. Given that modern observations indicate the physiological condition of bison is relatively poor during the latter months of the year (Emerson 1990; Speth 1983; Speth and Spielmann 1983), the tendency for Paleoindian bison kill-butchery sites to represent cold-season kills is of particular interest. Largely as a result of excavations at the Agate Basin site, Frison (1982b, 1988) proposes that cold-season hunting of bison allowed Paleoindians to establish frozen meat caches that could be utilized throughout the winter months.

In contrast, McCartney (1983, 1990) argues there is little evidence suggesting that storage was a main component of winter subsistence strategies during the Paleoindian Period. Seasonality data instead suggest Paleoindians hunted bison throughout the winter months with no obvious clustering of kills during the early part of the cold season. Depending on the season, Paleoindians utilized different bison hunting strategies in an effort to procure those animals in prime nutritional condition (see Speth 1983, 1987; Speth and Spielmann 1983). Thus, bulls were pursued in the winter and spring, while cows and calves were a nutritionally better (and easier) target during the summer and fall.

Using environmental data and knowledge of resource composition and distribution, Greiser (1985) suggests that climate (and its effects on plant and animal resources) played a major role in the subsistence strategies employed by hunter-gatherer groups on the High Plains. During the early Paleoindian period (ca. 8,500-11,000 B.C.), less marked seasonal extremes and cooler temperatures supported a

diverse and abundant flora and fauna that was available throughout much of the year. Early Paleoindians predominantly utilized small mammal and plant resources during the spring, summer, and early fall, and large mammals during the late fall and early winter (Greiser 1985:30). As a result of decreased seasonal variation in resource availability, the caching of food resources was unnecessary. Later in the Paleoindian Period, climates became more seasonal and arid, resulting in a decrease in flora species and the extinction of a number of animals. Increasingly cooler winters led to a greater reliance on large herbivores and an emphasis on stored food.

Todd (1991) integrates paleoclimatic information into his proposed model for Paleoindian subsistence by hypothesizing that climatic circumstances explain observed differences between Paleoindian and Late Prehistoric subsistence strategies. Reduced seasonal variation during the late Pleistocene/early Holocene may have resulted in longer growing seasons for plant resources (Guthrie 1984) and, as a result, different seasonal cycles of bison nutrition. In other words, "seasonal fluctuations in bison body fat condition may not have been as extreme as they were by the middle and late Holocene" (Todd 1991:232). Contrary to McCartney (1983, 1990), Todd argues it is unlikely that Paleoindians altered their hunting strategies from season to season. Instead, they may have utilized within-bone nutrients (marrow and bone grease) and carbohydrate-rich rumen (stomach contents) during the colder months as fat and carbohydrate supplements to an otherwise largely lean-meat diet.

Most recently, Hill (2001) suggests that as climate shifted from equable to more continental conditions, seasonal differences in resource abundance became more marked and Paleoindians adapted accordingly (Hill 2001:16). Specifically, his

reanalysis of the Folsom, Agate Basin, and Hell Gap components of the Agate Basin site, along with his analysis of the terminal Paleoindian Clary Ranch faunal remains, indicates increased carcass utilization through time. Prior to the onset of more continental climates, early Paleoindians were able to obtain bison in good nutritional condition during much of the year. Consequently, at cold-season kill-butchery sites there is little evidence suggesting the processing of bones for their within-bone nutrients; the meat and intramuscular fat alone supplied adequate nutrition. However, as seasonal climates became more extreme so too did the nutritional status of bison. Late Paleoindians countered this nutritional dilemma by systematically processing bison bone for marrow during the winter months. Significant increases in carnivore ravaging, coupled with evidence suggesting heavier processing of bison remains at Late Paleoindian cold-season sites, suggests that neither people nor carnivores were obtaining enough nutrition from meat and intramuscular fat. Hill (2001:257) proposes that caching during the cold weather months was periodically used; however, it was likely not a regular part of Late Paleoindian subsistence behavior. Instead, caching was "used situationally as a backup food supply during periods of subsistence stress, rather than as a regular source of sustenance until depleted."

Of main import to the present study is how the Agate Basin-age Frazier site fits into proposed models of Paleoindian subsistence. To set the stage, attributes of the Agate Basin Cultural Complex are discussed below, followed by a brief description of previously excavated archaeological sites containing Agate Basin components.

The Agate Basin Cultural Complex

The Agate Basin cultural complex is one of many important complexes recognized on the High Plains (Table 2.1). Distinctions between complexes are

Table 2.1. High Plains Paleoindian chronological chart (adapted from Frison 1991:Figure 2.4).

Years Before Present	Projectile Point Types and Cultural Complexes
12,000	
	Pre-Clovis
11,500	
	Clovis
11,000	Goshen
	Folsom
10,500	Midland
	Agate Basin
10,000	Hell Gap
9,500	Alberta
9,000	Cody
8,500	Angostura?
	Fredrick
8,000	James Allen
	Lusk

largely based on morphological differences of projectile points. However, as discussed above, the analysis of faunal remains recovered from archaeological sites illustrates important changes in subsistence behavior within the Paleoindian Period.

Dating to approximately 10,500 to 10,000 years ago, the Agate Basin complex is defined by long, slender, horizontally-flaked projectile points with parallel or slightly convex sides, straight or convex bases, and thick, lenticular cross-sections (Figure 2.1; Frison 1991:57; Wormington 1957:141). While Agate Basin components are generally situated stratigraphically above Folsom components, radiocarbon dates suggest the two may have overlapped in time (Frison 1988:95, 1991:57, 59).

Agate Basin projectile points enjoy an extensive distribution. Although most common on the Great Plains of Canada and the United States, they have also been discovered in Idaho, Iowa, Wisconsin, New York, New Jersey and Mexico (Fishel 1988; Hill et al. 1998; Justice 1987; Wormington 1957:141). In spite of the point's wide distribution, only a handful of Agate Basin sites have been excavated. The Carter/Kerr-McGee site in northeastern Wyoming contains a mixed Agate Basin-Hell Gap level (Frison 1984, 1991:57) but most of what is known about the complex comes from two sites in eastern Wyoming: the Hell Gap site and the Agate Basin site (Figure 2.2).

The Hell Gap Site

The Hell Gap site (Irwin-Williams et al. 1973) is a multi-component campsite consisting of five localities. The site was excavated in the early 1960s by Harvard University and the University of Wyoming and revealed a near complete sequence of Paleoindian cultural remains, including materials from the Goshen, Folsom, Midland, Agate Basin, and Hell Gap complexes. Agate Basin was the best-represented complex at the site (Irwin-Williams et al. 1973:47). Artifacts from the

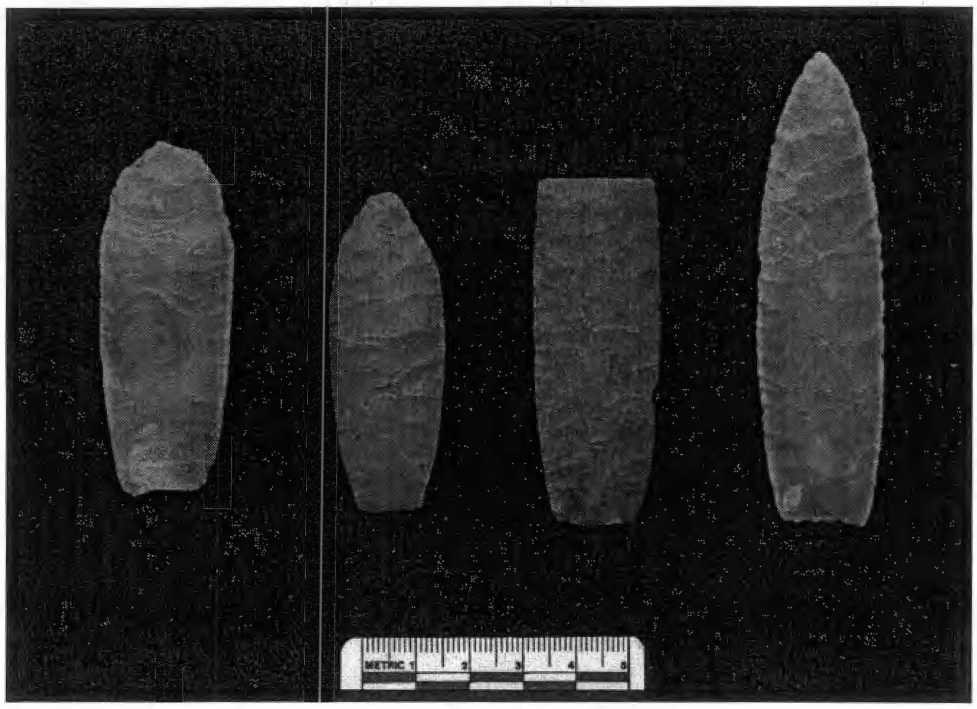


Figure 2.1. Agate Basin projectile points from the Frazier site. Photo courtesy of Scott Slessman.

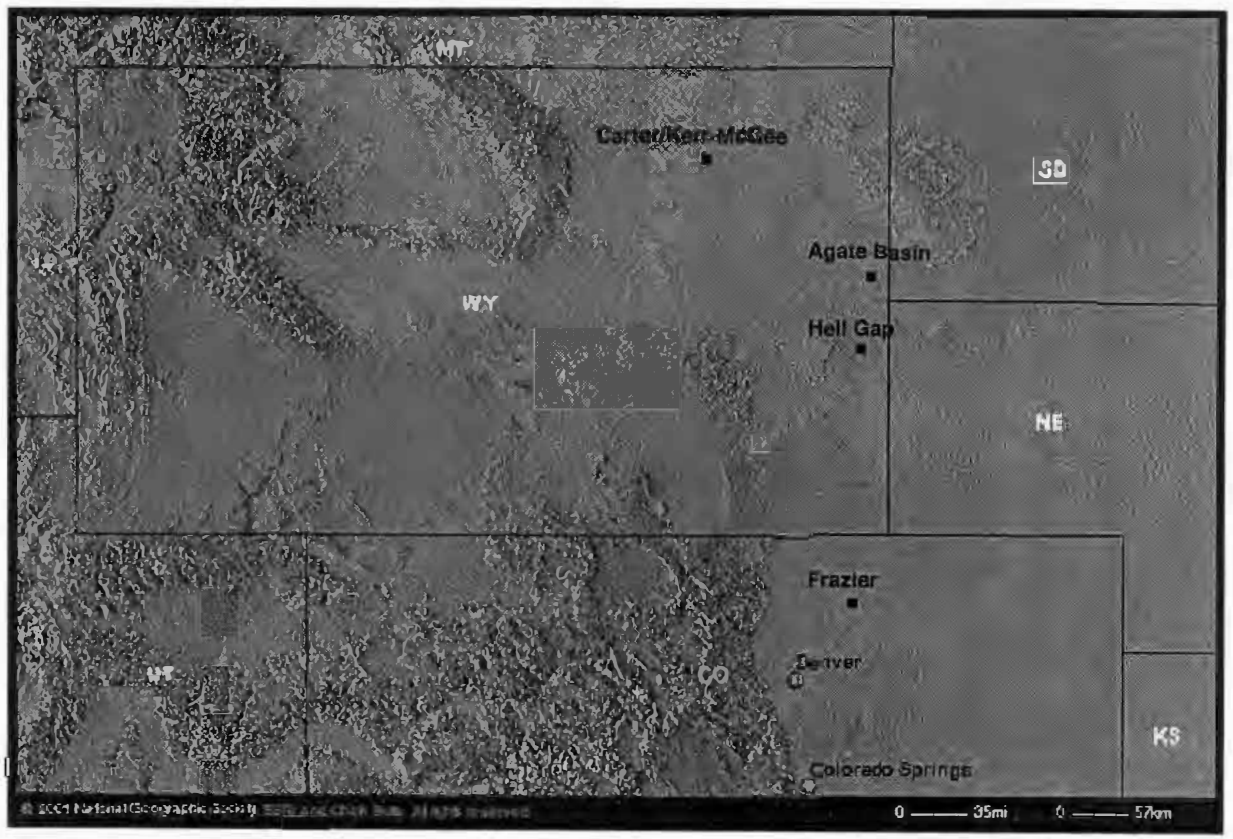


Figure 2.2. High Plains archaeological sites containing Agate Basin components (map adapted from http://www.nationalgeographic.com/mapmachine).

complex were recovered from four of the five localities and included projectile points, scrapers, a bifacial knife, and a bone needle. In addition, the Agate Basin level of Locality II contained the remains of three small structures.

A recent reanalysis of the Locality II Agate Basin faunal remains (Byers 2001) revealed that site occupants utilized bison (MNI = 14) and, to a lesser degree, deer and antelope. Evidence suggesting intensive processing of fat-rich skeletal parts indicates that Agate Basin Paleoindians at the Hell Gap site may have been utilizing a "fat-seeking strategy" as a means of adapting to environmental changes during the Late Pleistocene.

The Agate Basin Site

Similar to the Hell Gap site, the Agate Basin site contains multiple Paleoindian occupations, including Folsom, Agate Basin, and Hell Gap. The site is comprised of eleven localities (or areas) and has received considerable attention since its discovery by a local livestock owner in 1916 (Frison and Stanford 1982). Frank H. H. Roberts of the Smithsonian Institution conducted minimal testing in 1942 (Roberts 1943) and is responsible for assigning the Agate Basin points their formal name (Roberts 1961). Although a small excavation was carried out in 1959 (Agogino and Frankforter 1960), the first major excavation took place in 1961 and was directed by William M. Bass and Frank H. H. Roberts (Bass 1970). In the late 1970s it was discovered that a significant amount of the site still lay undisturbed and was regularly being looted. From 1975 to 1980, George Frison (University of Wyoming) and Dennis Stanford (Smithsonian Institution) jointly directed major excavations at the site. Their work resulted in a monograph that remains a primary source of information about Paleoindian subsistence behavior (Frison and Stanford 1982). Excavations at the site (and surrounding area) not only documented a series

of Paleoindian occupations, but also revealed that cold-season bison hunting was practiced throughout the Paleoindian Period (Frison 1988:96).

The Agate Basin component of Area 2 produced the largest bison kill-butchery archaeofauna from the site (Hill 2001:107). This component, dated to 10,430 ± 570 B.P. (RL-557), contained the remains of at least 53 bison that had been killed during late fall/early winter to late winter/early spring (Frison and Stanford 1982). Subsequent reanalysis of the mandibular dentition suggests the bison died in early to mid-winter (Hill 2001:109), a slight refinement of the earlier assessment. Frison and Stanford (1982:365) believe the site was "not an actual kill location, but was probably close to one." In his recent reanalysis, however, Hill (2001:110) uses skeletal part frequencies, bone breakage patterns, and an examination of the lithic assemblage to argue that the bison were killed "at the location of the bonebed itself." Butchery was aimed at total nutrition, i.e., the acquisition of both meat and fat resources (Emerson 1990:585), and involved selective recovery and transport of high-utility upper limb units (Hill 2001:139). Lower limb elements appear to have been discarded, presumably in an effort to reduce transport costs. Assuming procurement of fat was a main objective of the Agate Basin Paleoindians, selection of scapulae and upper limbs suggests carcasses were not fat-depleted at the time of the kill (Hill 2001:142-143), maybe as a result of less extreme seasonal climate variability during the late Pleistocene-early Holocene (as compared to later in the Holocene).

Summary

In short, many models suggest that climatic change during the late Pleistocene-early Holocene played a central role in Paleoindian subsistence strategies. The emergence of more continental climates altered the distribution of food resources

and also affected the location of non-food necessities such as water and wood (Greiser 1985). In particular, the archaeological record suggests that bison carcass utilization became more intense toward the end of the Paleoindian period (Hill 2001). Unfortunately, the low number of sites that have been excavated, particularly from the Late Paleoindian Agate Basin complex, restricts the application of Paleo-indian subsistence models. Though Agate Basin projectile points are widely distributed, Agate Basin components are rare at archaeological sites and the bulk of information concerning the complex comes from two sites containing multiple occupations. The Frazier site represents the only single-component Agate Basin site excavated to date and, consequently, analysis of the site's faunal remains not only provides an important source of new information about the cultural complex, but also about Paleoindian subsistence on the High Plains.

-CHAPTER THREE-

THE FRAZIER SITE

Site Setting & History of Investigations

The Frazier site is situated on the Kersey Terrace (McFaul et al. 1994) of northeastern Colorado and lies approximately one mile south of the South Platte River. The site is one of several Paleoindian archaeological sites on the terrace, including the Clovis-age Dent site, the Folsom-age Powars site, and the Cody-age Jurgens site, but represents the only known Agate Basin-age site in Colorado and is one of only a few such sites known to exist.

While attempting to locate the Powars Folsom site in July 1965, Frank Frazier, a surveyor from Greeley, Colorado, discovered bison bone and lithic artifacts eroding out of two gullies approximately two miles north and one mile west of the town of Kersey, Colorado (Wormington 1966a:4). Frazier contacted the DMNH, and the Curator of Archaeology, Dr. H. Marie Wormington, decided to investigate the area. Testing took place throughout the months of August and October 1965 and resulted in the recovery of numerous bison bones. Wormington (1966a:4) believed the site contained a single component, noting that "[the bones] lay on the same level and it seemed clear that only one bone bearing layer was represented." Few *in situ* lithics were recovered during the testing period; however, on October 10, 1965, a near complete Agate Basin projectile point was discovered in context with bison bone.

Upon completion of the 1965 testing of the Frazier site a proposal was submitted to the National Science Foundation (NSF) requesting $5,869.20 to support the 1966 season of excavations at the site (Wormington 1966a). The proposal was successful (NSF GS Grant 1252) and work that year resulted in the excavation of 39

five-by-five foot units (Wormington 1966b). In addition, 189 auger holes were dug in an attempt to better understand the site's boundaries. Numerous stone artifacts and bison bones were recovered and bones from the hindquarters appeared to be particularly common.

Additional funds were requested from the NSF for continued excavation of the site in 1967 (Wormington 1967a). During that year, 85 additional units were excavated, producing a combined total of 124 excavated units (Wormington 1967b). Wormington (1967b:2) noted upon completion of the 1967 season that the most productive portion of the site had been cleared in its entirety and that further excavation was unnecessary. The recovery of a total of 50 left astragali (43 recovered during excavations and 7 found on the surface) during investigations at the site provided the minimum number of bison present (Wormington 1967b:3).

Excavation Areas and Recovery Methods

Four main areas were investigated at the Frazier site and were designated Localities 1, 2 3 and 1 East (Figure 3.1). A grid was established based on an as-yet-undetermined datum point(s). Five-by-five foot units were given letter-number designations (e.g., F28 and H21), with letters indicating a unit's north-south provenience and numbers specifying its east-west provenience.

Of particular note is Locality 2, which includes the following units: G'55, H'55, I'55. The reason for using an apostrophe in the unit designations is unknown. One possible explanation is offered by a unit plan view that places H'55 north of G'55. According to the way the grid was established, H units should be located south of G units. Excluding artist error, perhaps a mistake in assigning unit designations led to the use of an apostrophe in the Locality 2 unit designations.

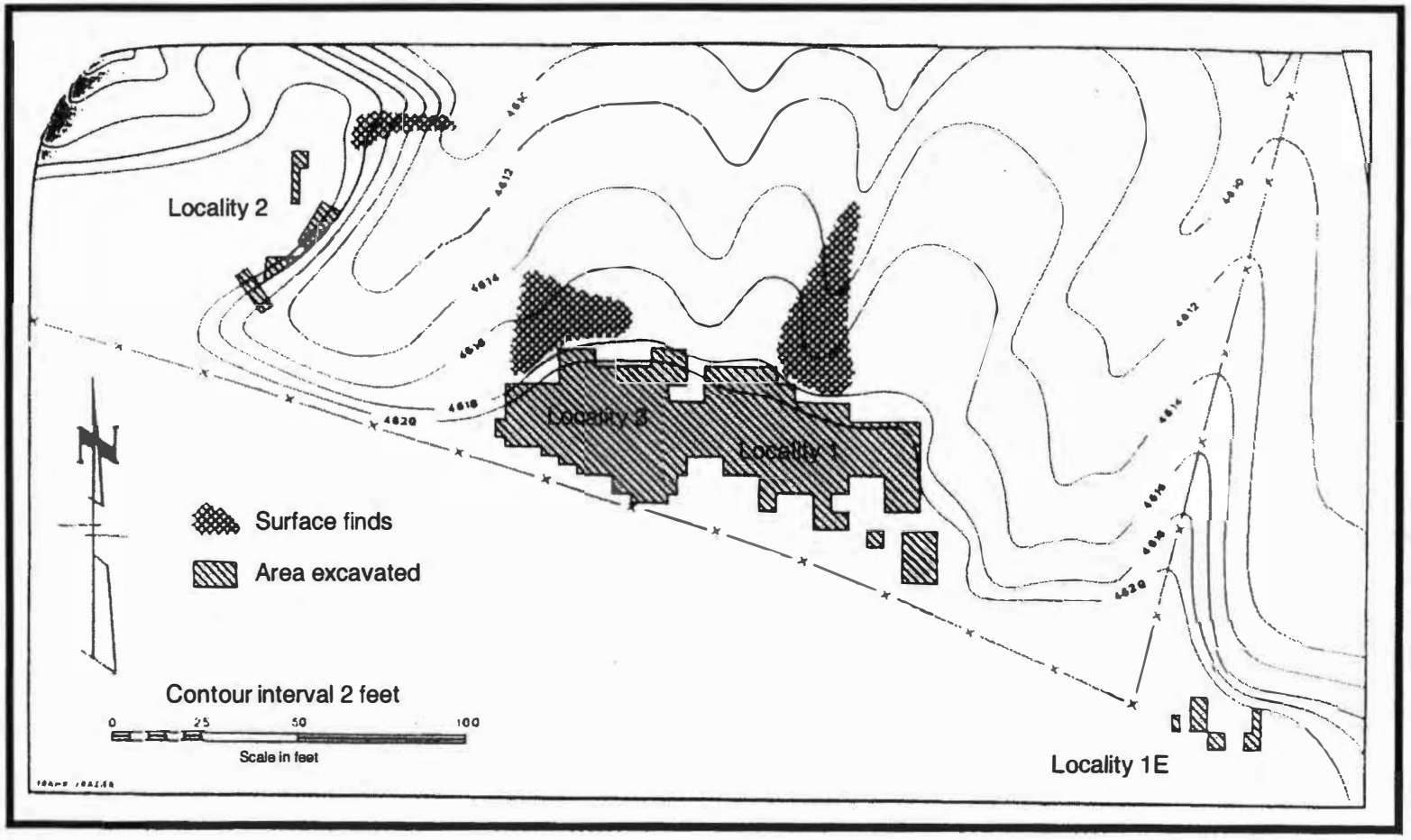


Figure 3.1. Topographic map of the Frazier site showing excavation localities (adapted from Wormington 1984:Figure 1).

Plan views for units F35 and G35 show a "pit feature." A photo of this large, basin-shaped soil stain is included in the slides obtained from Frank Frazier (Figure 3.2). Although not reflected on unit plan views, the photo reveals that the feature also extended into units F34 and G34. The function of the feature is unknown and, although field notes (July 16, 1967) indicate a soil sample was removed, no samples of the pit's contents are currently in the collection. Slessman (2001b) suggests the feature is a hearth. His interpretation relies on field documentation that suggests the presence of burned bone within approximately 5 to 6 meters of the feature. However, an entry in the field foreman's notes (Robert Bradley, July 18, 1967) states, "The evidence that it [the feature] is rodent activity is growing by the minute." Unfortunately, Bradley offers no further explanation, and the function of the stain remains uncertain.

As far as can be determined from existing documentation, soil was not screened at the Frazier site. Robert Burton (personal communication 2001), an excavator at the site during the 1967 field season, remembers only one time when dirt was sieved. Further, vertical provenience information for each specimen was infrequently recorded and horizontal provenience can often only be established to unit. Wormington (1967b:3) notes, "After bones and stones were exposed a Polaroid picture was taken of each square before specimens were removed." These photos would provide useful information pertaining to the vertical and horizontal location of bone specimens but, unfortunately, they are not present in the DMNH archives.

Wormington's Interpretation of the Frazier site

Based on the recovered material, Wormington concluded that the Frazier site represented a single component, secondary butchering and processing area

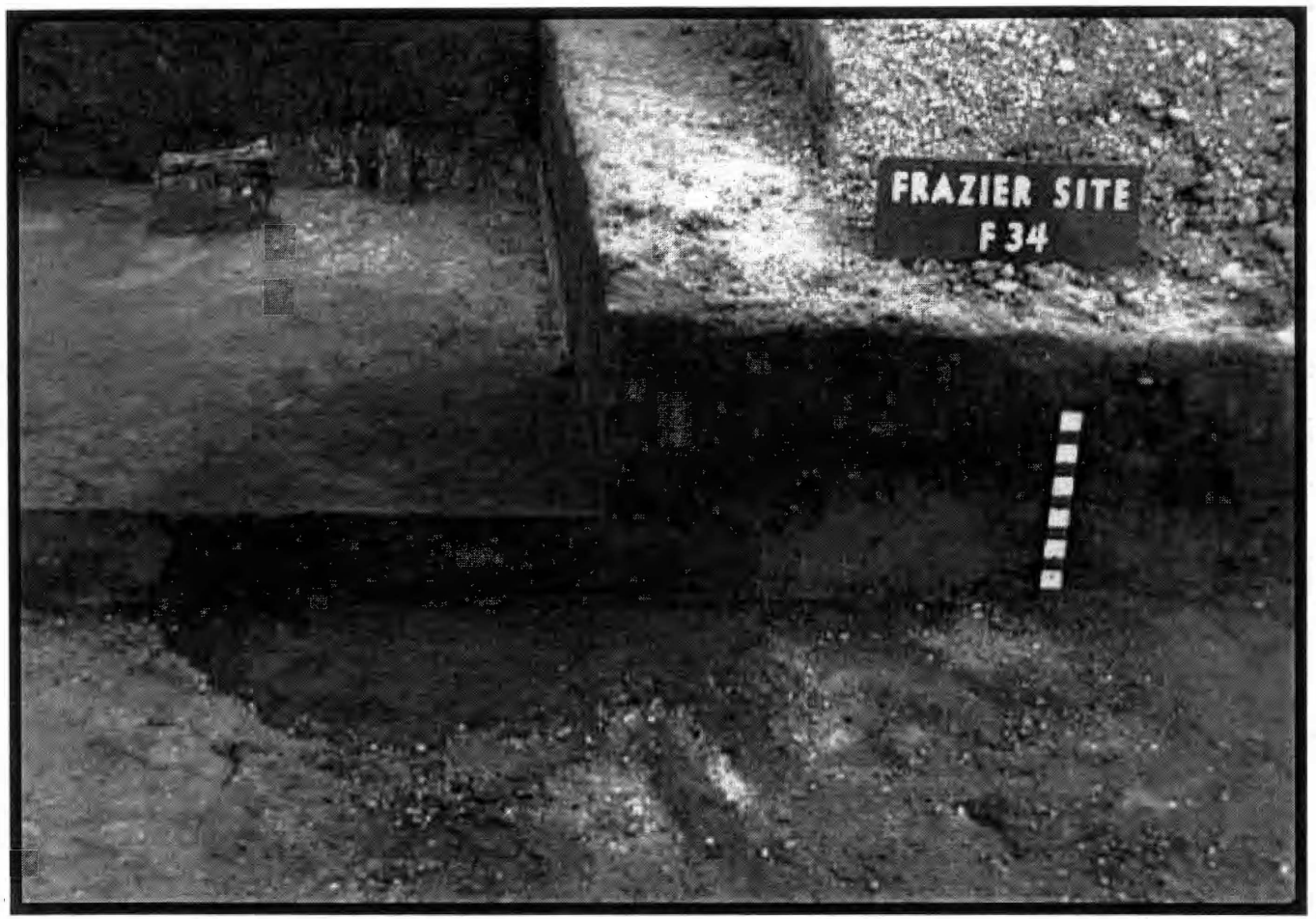


Figure 3.2. "Pit" feature encompassing units F34, F35, G34, G35, Frazier site (photo courtesy of Frank Frazier).

(Wormington 1984, 1988). The site was largely comprised of the remains of approximately 43 bison (*Bison occidentalis* or *Bison antiquus*) and the tools used to butcher them.

> The nature of the bones recovered confirms the impression gained from the previous years excavations, that only portions of the animals were brought into camp and that the kill was made elsewhere. There are no cliffs in the area that would have provided a suitable location for a bison jump, so it is probable that the animals were driven into a blind arroyo, as they were at the Olsen-Chubbuck site (Wormington 1967b:3).

Although not located, she believed the kill locality was not far from the site, as it was "unlikely that heavy bison quarters would be carried any great distance" (Wormington 1984:12; see also Wormington 1967b:3).

Lithic Materials

Wormington's interpretation of the Frazier site as a secondary processing area was not only based on the recovered bones but also on the types of lithic artifacts present at the site. While a more in-depth analysis of the Frazier lithic assemblage is forthcoming (Slessman 2002b; see also Slessman 2000, 2001a, 2001b, 2002a), a brief summary of the lithic artifacts, as interpreted by Wormington, is provided here. The lithic assemblage contains few projectile points (n = 10) but many scrapers, including 14 end scrapers, 20 side scrapers, and 5 scraping tools worked on all edges. Other artifacts include two broken bifaces (interpreted as knives), one flake with two graver tips, one side scraper with a well-marked beak on one edge, one side scraper with a deeply concave edge (possibly used for smoothing spear shafts), a few utilized flakes, and debitage (Wormington 1984:13). Also recovered was an "unusual implement [resembling] an angle-edge end scraper, but in the center of the working end was a very sharp graver tip" (Wormington 1984:13). Three of the projectile point fragments appear to have been reworked after being

broken and one has a narrow flute on one side (Wormington 1984:13). In addition, a wide range of raw materials is represented in the Frazier lithic assemblage, including Flattop chalcedony (northeastern Colorado), Hartville Uplift chert (Wyoming), Alibates (Texas), petrified wood, and Morrison Formation quartzite (Slessman 2000, 2001a).

Interestingly, over the course of investigations at the site, only three projectile points were found in context. The bulk of lithic artifacts recovered were tools of other types, including scrapers and gravers. At the time, little was known about the Agate Basin non-projectile point tool assemblage, therefore, the Frazier site provided a unique and valuable source of information (Wormington 1966b). By the end of the 1967 field season, a pattern in the distribution of lithic artifacts was discernable. The three *in situ* projectile points had all been uncovered close to one another (the eastern portion of the site), while other lithic tools (e.g., scrapers, knives, and gravers) were most often found on the western side (Wormington 1967b). Further, concentrated areas of particular tool types around the site suggested specialized activity areas (Wormington 1966b).

Geology

A brief outline of the geology of the Frazier site was included in the report of investigations submitted to the NSF after the 1966 field season (Malde 1966; see also Malde 1984). Written by Harold E. Malde, a geologist with the U.S. Geological Survey, it explained the geologic context in which the Frazier site materials were found. The artifacts and bones were recovered from the lower part of a prismatic clay layer, which was described as "a sandy loam, probably of eolian origin and subsequently altered by soil development to its present prismatic appearance" (Malde 1966:5).

> Judging from the stratigraphic position of the artifacts, the site was presumably occupied shortly after the gley horizon developed, when terrain along the ancient South Platte River had begun to be dissected and was no longer poorly drained. The site was surely occupied before most of the prismatic layer had accumulated and before this layer had developed its prismatic structure by weathering. Stone artifacts in this layer commonly have crusts of carbonate on the underside and "patina" on the upper sides, which can be attributed to hydration during soil development. If so, the patina is a feature that formed after the artifacts were buried. However, the origin of the patina is still problematical and must be investigated (Malde 1966:5).

Malde's remarks regarding the formation of "crusts of carbonate on the underside" of many stone artifacts perhaps helps to explain the presence of a carbonate layer on many of the bone specimens. In a subsequent article, Malde (1984:15) reports,

> ...the carbonate crusts and patina developed concurrently on the artifacts when the relict soil profile was formed in the sand layer. That is, the patina is a feature of the soil and does not reflect subaerial exposure of the artifacts. The stratigraphy, in fact, fails to indicate any hiatus during accumulation of the sand.

Geologic information thus suggests that the Frazier site remains did not lay exposed on the surface for a great length of time.

Radiocarbon Dates

An attempt was made to radiocarbon date the Frazier site using a bone sample recovered from the 1966 field season (Wormington 1967b:4). However, the resulting date of 5050 ± 150 (Isotopes, Inc. I-2563) years was much too young for an Agate Basin-age component. At the University of Arizona's Geochronology Laboratory, C. Vance Haynes, also encountered difficulties with a bone sample. As Wormington (1967b:4) notes,

> He subjected the sample to extensive pretreatment and tried by every means possible to isolate collagen for dating, but he was unsuccessful. The bone was strongly impregnated with hydrated iron and manganese oxides and partially replaced by calcium carbonate.

Fortunately, a soil sample collected by Haynes at the Frazier site in 1966 produced two dates much more consistent with what is expected from Agate Basin-age sites (Haynes and Haas 1974:373): 9,550 ± 130 years B. P. (SMU-32) years and 9,650 ± 130 years B.P. (SMU-31). Because the collected soil came from an organic soil horizon overlying the Frazier bison bonebed, the dates likely provide only a *minimum* age for the site.

Notably, over the past several years multiple authors have misunderstood and, consequently, incorrectly reported the Frazier site radiocarbon dates. Wheat (1979:152) appears to have averaged the two dates when he wrote, "Both samples gave dates of 9600 + 130 B.P." Cassells (1983:60, 1997:81) incorrectly reports the dates as 9550 ± 130 B.P. and 9000 ± 130 B.P. Brunswig (1992:16) provides the correct dates but incorrectly states that the dated soil samples came from "a dark organic soil immediately *underlying*" the bonebed and "probably *pre-date* the Agate Basin component by no more than one to three centuries" (emphases added).

History of Faunal Studies

G. Edward Lewis (1966, 1968)

Included in the 1966 Report of Investigations for the NSF was a report submitted by G. Edward Lewis, a paleontologist with the U.S. Geological Survey, pertaining to the bones recovered from that season's fieldwork (Lewis 1966:3). Based on the "random, unassociated fashion" of the bison bone, he concluded (1966:3) that the site was not a kill locale, rather "selected cuts must have been taken to the Quarry site from the place where killing and butchering took place." He noted (1966:3-4) the fragmentary nature of the bones, their similarity in size to *Bison bison occidentalis*, and that a minimum of 13 animals were present at the site based on the recovery of 25 astragali.

An additional report by Lewis dated August 14, 1968 and by the same author is also present in the DMNS archives (Lewis 1968). Presumably, the document represents a final report on his analysis of the Frazier bone. It reports the number of bones and bone fragments studied and identified (n=6000) and also comments on the presence of non-bison bone in the assemblage, i.e., a *Canis lupus nubilis* Say radius and an *Odocoileus* sp. calcaneum. Curiously, Lewis (1968:1) suggests that a minimum of 28 bison were present at the site (based on left astragali), a number that is problematic given the date of the report (1968) and the fact that Wormington (1967b:3) had previously reported a minimum of 50 bison (based on the same element).

For a lack of diagnostic skull fragments, Lewis (1968) compared the size of metacarpals and astragali recovered from the Frazier site with both modern bison and *Bison antiquus occidentalis* specimens (recovered from the Olsen-Chubbuck site assemblage; see Wheat 1972 for more information on this site) as a means of determining the species of the Frazier bison. Numerous measurements taken on both elements suggested that the Frazier bison likely represented an extinct species.

> Bison remains from the Frazier site may represent *Bison occidentalis*? Lucas, although another extinct species such as *Bison antiquus* Leidy cannot be ruled out on present osteological evidence (Lewis 1968:3).

Lewis (1968:3) also again speculated that the Frazier site was not a kill location.

> The aboriginal population butchered little but bison meat at the Frazier site. Having made the bison kills elsewhere, they usually separated the front legs and hind legs from the rest of each carcase [sic] and then carried the legs to the site, there to separate the meat from the bones. They usually separated other cuts of meat from the carcase [sic] where it was killed, and carried very few axial skeletal bones with the meat to the Frazier Site.

D. Eidlen (1993)

In May 1993, Denise Eidlen, a graduate student in Anthropology/Archaeology at the University of Colorado at Denver, completed an internship at the DMNH. While there, she began a project which consisted of "inventorying and rehousing the faunal collection from the Frazier site, assessing its potential for use in a Bison exhibit, and analyzing the bones for signs of butchering" (Eidlen 1993:1). Eidlen's analysis involved going through boxes containing the Frazier site faunal remains and properly curating the specimens. Bone specimens were placed in "an appropriate size polyethylene zip lock bag" with the site number (DMNH 15), specimen number (unit and/or field ID number), bone identification (skeletal element) and the genus and species (*Bison occidentalis*) written on the outside (1993:4). In addition, Inventory Record forms were completed for each specimen (1993:3). She did not complete the reboxing aspect of her project and her work resulted in only partial analysis of the Frazier archaeofauna. Based on a Frazier site bone count list presumably authored by G. Edward Lewis and stating that a total of 998 bones were originally identified to element, Eidlen (1993:7) calculated that she analyzed approximately 38% of the assemblage.

Eidlen's (1993) research included examination of the Frazier bones for evidence of butchery. Of the bones she studied, 14 had cut marks, 71 had tooth marks, 22 had either cut marks or tooth marks, and 8 showed "evidence of wear or being split to obtain marrow," resulting in a grand total of 115 specimens (30% of those studied) with evidence of human or carnivore modification (1993:7-8)

While the incompleteness of her study made conclusions difficult to draw, Eidlen (1993:12-13) offered some interpretive suggestions based on the available documentation and her results. Like Wormington, she suggested the site was a

secondary butchering station rather than a kill. The high frequency of foot and appendicular bones indicated transport of the fore- and hindquarters to the site for butchering. She noted a similarity in cutmark frequency between the Frazier and Olsen-Chubbuck sites (Wheat 1972) and believed that the large number of unidentifiable bone fragments indicated an extensive effort to recover marrow. The discovery of only five projectile points but many sidescarpers suggested the Frazier occupants were processing hides, and patterning in the distribution of lithic material types was believed "indicative of specialized activity areas, or preference of lithic material for processing certain skeletal elements" (Eidlen 1993:13).

Todd, Hofman and Wormington (1990)

Todd, Hofman and Wormington (1990) conducted a partial study of the Frazier site bison humeri and mandibular third molars (M_3s) in an attempt to ascertain the site's season of occupation as well as the sex ratio of the Frazier bison population and their size relative to other Paleoindian sites. A study of 23 loose M_3s tentatively suggested a late winter to early spring occupation. Measurements taken on eight fragmentary humeri indicated a 1:1 sex ratio and suggested that the Frazier bison were "comparable in size to those from the Lipscomb and Jones-Miller sites and slightly larger than bison associated with Cody Complex artifacts at the Horner, Frasca, and Lamb Springs sites" (1990.:2).

Other Studies

Loose papers in the DMNH archives along with other evidence suggest the Frazier site faunal remains were used in additional studies. For example, though not documented in museum archives, Sally Thompson Greiser (1985:68) reports that she reviewed the faunal and lithic material from the site. Subsequent personal communication with both her and Weber Greiser has revealed that she analyzed the

lithics and Weber examined the bone. The timing of their work corresponds with newspaper wrappings dating to late 1980 that were found on a number of the faunal specimens during the present analysis. Greiser (1985:68) interprets the Frazier site to be an Agate Basin camp and bison-processing locale.

-CHAPTER FOUR-

ZOOARCHAEOLOGICAL METHODS

The following section outlines the methods used in interpreting the Frazier site archaeofauna. This includes a brief note on terminology and specimen documentation, along with a description of the types of modifications recorded on bone specimens and a definition of the various quantification methods used to describe them. Carnivore and rodent activity are discussed in detail while other non-cultural taphonomic processes such as bone weathering and root etching are only briefly considered.

In the present study, the terms "specimen" and "element" are frequently utilized. Following Lyman (1994:100), a specimen is recognized as "an archaeologically discrete phenomenological unit, such as a complete humerus, a distal half of a tibia, or a mandible with teeth in it," while an element is "a discrete, natural anatomical unit of a skeleton, such as a humerus, a tibia, or a tooth." Simply stated, specimens represent elements in either their complete or incomplete form.

Specimen Identification

The Frazier site faunal remains were identified using the Vertebrate Comparative Collection in the Zooarchaeology Laboratory at the University of Tennessee, Department of Anthropology. Taxonomic designation of non-bison remains was based on Burt and Grossenheider (1980). Analysis of the Frazier site bison remains utilized a tripartite coding system (Appendix 2) of "element, portion, and segment" introduced by Gifford and Crader (1977) and subsequently enhanced by Todd (1987). The system provides a standardized way of describing each bone, including fragments, and leads to a more accurate understanding of faunal collections. A

number of other characteristics of each identifiable specimen were also recorded, including side and fusion. Unidentified specimens were thoroughly described and any observable characteristics, particularly any visible modifications, were noted.

As is the case with many High Plains Paleoindian faunal collections, the Frazier site archaeofauna is extremely fragmentary; few complete specimens exist. While some researchers have previously chosen to exclude long bone shaft (and other) fragments from their analyses (e.g., Stiner 1994:237-238), the inclusion of such fragments is essential, as bone density and economic utility can significantly influence bone survivorship. Articular ends are arguably the most diagnostic part of a long bone; however, their low density (Kreutzer 1992; Lyman 1984) and high nutritional value (Binford 1978) often makes them susceptible to both cultural and non-cultural taphonomic processes (Lyman 1985). Similarly, long bone shafts are frequently targeted by both humans and carnivores for their within-bone nutritive value, but their durability (Kreutzer 1992; Lyman 1984) and minimal nutritional value following marrow removal often results in greater survivability over time (Binford et al. 1988; Blumenschine 1988). With these thoughts in mind long bone shaft fragments in the Frazier site archaeofauna were recorded to element when possible and diagnostic landmarks (e.g., the supracondyloid fossa of the femur) were noted when present.

Bone Modification

In addition to basic specimen identification (element, portion, segment, side and fusion), additional descriptive observations were documented, including butchery evidence, carnivore and rodent modification, and burning. Subaerial weathering and root etching were not systematically recorded although generalizations concerning these two types of damage are briefly discussed.

Carnivore & Rodent Modification

A significant amount of research has been conducted on the impact that non-human scavenger activity can have on faunal assemblages (e.g., Haynes 1980a, 1980b, 1981, 1982, 1983a, 1983b; Johnson 1985; Kent 1981; Marean et al. 1992; Marean and Spencer 1991;Thornton and Fee 2001; Wilson 1983). Many aspects of animal scavenging behavior, particularly by large carnivores, mirror human behavior and sometimes make it difficult to distinguish human carcass utilization from that of other predators (Haynes 1980b:341). Because prey carcasses are attractive to carnivores and humans for similar reasons, both agents often target the same skeletal parts, i.e., those that offer the most meat and/or fat. Fortunately, patterned, predictable behavior on the part of carnivores can aid in distinguishing human from carnivore carcass modifications (Haynes 1980b, 1981, 1982). Therefore, when present in the Frazier archaeofauna, rodent and carnivore modification was noted.

Burning

Though rare, some specimens in the Frazier site archaeofauna display evidence of burning. When observed, the specimen's color, i.e., brown, black, or white, was noted.

Subaerial Weathering and Root Etching

Largely as a result of the fragmentary nature of the assemblage, subaerial weathering and root etching were not systematically recorded. However, the archaeofauna as a whole exhibits evidence of weathering, although it is unclear whether the weathering occurred prior to or after burial (see Chapter 2 for background on the geology of the site). Cortical surface flaking and longitudinal cracks and breaks are not uncommon in the assemblage. In addition, many of the

bones possess a layer of calcium carbonate. Root etching was not frequently observed.

Bone Breakage and Other Evidence for Butchery

As might be expected given their antiquity, most Paleoindian faunal assemblages rarely retain direct evidence of butchery. Post-depositional processes often alter the outer cortical surface of bone specimens, thus destroying any butchery marks. Such is the case with the Frazier site bone. A handful of specimens with cut marks were identified and recorded. However, the majority of bone from the Frazier site has undergone extensive post-depositional alteration, as is evidenced by cortical flaking and the presence of a calcium carbonate build-up on much of the bone.

Because bone breaks in predictable ways depending on its freshness, i.e., the duration of time since death, particular breakage may often be the result of human butchery practices. Spiral fractures are typically associated with bone broken while in a relatively fresh, or "green", state, whereas transverse and longitudinal fractures characterize dry bone breakage (e.g., Bonnichsen 1979; Johnson 1985, 1989; Morlan 1983). Spiral fractures are expected to occur in assemblages where humans were interested in obtaining the fat-rich marrow from within long bone shafts. As such, bones exhibiting green (spiral) fractures in the Frazier site archaeofauna were recorded.

A final butchery attribute that was recorded for all applicable Frazier specimens concerns percussion-generated fracture, which is often a product of human marrow processing. Along with spiral fractures, such processing frequently results in additional modifications to the bone, including hammerstone impact and anvil rebound damage. These two occurrences manifest themselves in a number of ways (Fisher 1995; White 1992), including notches (the specific point where the

hammerstone blow occurred), conchoidal flake scars, incompletely detached impact flakes, crushing, percussion striae, percussion pits, and peeling. Because of poor bone preservation, notches and inner-conchoidal flake scars were the only characteristics identified on the Frazier site bone.

Quantification

A number of quantitative methods were employed in analysis of the Frazier site bison, including number of identified specimens (NISP), minimum number of elements (MNE), minimum number of animal units (MAU), and minimum number of individuals (MNI).

Number of Identified Specimens (NISP)

NISP is the total count of identified specimens, or fragments, per species, as well as per element (Lyman 1994:100). Because the Frazier site faunal assemblage largely consists of only one species (bison) the former use of NISP is not particularly relevant. However, NISP per element is used when discussing the relative frequency of particular modifications (e.g., frequency of cut marks, rodent gnawing, etc.) observed on specimens.

Minimum Number of Elements (MNE)

MNE denotes the minimum number of a particular element that is represented in an archaeofauna and is a method of measuring portions of skeletons of individual species (Lyman 1994:102; Reitz and Wing 1999:215). MNE is based on the presence of overlapping landmarks. In general, the landmark occurring most frequently in the archaeofauna provides the MNE value for that element. In the present study, MNE values are presented both by side (when applicable) and as a comprehensive sum. It is not necessary to use the same landmark when determining MNE per side. For example, the CPS facet provides the MNE for the

left proximal metacarpal whereas the MNE value for the right side is based on the CPF facet. As Hill (2001:31) notes, "When considered by side, these data [MNE by side] are operational as MNI."

Minimum Number of Animal Units (MAU)

MAU refers to the minimum number of animal units necessary to account for the specimens in an assemblage (Lyman 1994:105) and is useful as an indicator of differential transport and processing by humans (Binford 1978:70). To calculate MAU, MNE values are divided by the number of times the element appears in a complete skeleton (Binford 1984:50-51). An MNE of four femurs thus yields an MAU of two. Standardized MAU (%MAU) was then calculated by dividing each element MAU by the highest MAU in the assemblage and multiplying by 100 (Binford 1984:80-81; Binford and Bertram 1977).

Minimum Number of Individuals (MNI)

First introduced by White (1953), MNI is the minimum number of animals necessary to account for all identified specimens and is calculated based on the most frequently occurring element. For paired appendicular elements (and some axial elements), MNI per element can be obtained from MNE per side; the side with the larger MNE provides the MNI for that element. The element bearing the highest MNI provides the MNI for the archaeofauna.

Sex and Age Determination

Various methods have been devised for determining the population dynamics of bison remains recovered from archaeological sites. Metrical differences in the size of selected skeletal elements are often used to suggest the sexual composition of archaeofaunas, while bone fusion rates and tooth eruption and wear provide information about age structure.

Modern bison comparative collections are frequently used to assess sexual variation in extinct bison populations. Implicit is the notion that traits denoting sexual differences in modern populations were similar in extinct taxa and can therefore be used to determine the population dynamics of past bison populations. In general, adult male bison bones tend to be considerably larger than adult female bison bones (Bedord 1978; Duffield 1973; Speth 1983). The skull presents the most obvious differences and a number of sexual comparisons have been made based on craniometrics (Empel 1962; Krysiak and Swiezynski 1967; Shackleton et al. 1975; Skinner and Kaisen 1947; Speth and Parry 1980; Wilson 1974b, 1980). The mandible has also proven useful (Reher 1974). Other researchers have examined the postcranial skeleton, including the limb elements (Smiley 1978; Speth 1983; Todd 1986, 1987; Todd, Hofman, and Schultz 1992; Zeimens 1982), carpals and tarsals (Hill 1996; Kooyman and Sandgathe 2001; Morlan 1991, 1992; Zeimens 1982), and phalanges (Zeimens 1982).

Forelimb elements have received considerable attention (Bedord 1974, 1978; Peterson 1977; Peterson and Hughes 1980; Todd 1986, 1987; Todd, Hofman, and Schultz 1992) and perhaps best reflect size differences in male and female bison. The larger head and horns carried by bull bison likely results in weight variations between the sexes that are mainly restricted to the forelimb region (Hughes 1978:33). With this in mind, and owing to a lack of measurable humerus and radius-ulna specimens, metacarpal specimens were used as a means of determining the sexual composition of the Frazier site bison remains.

Analysis of the Frazier site metacarpals followed methods established by both Bedord (1974, 1978) and Speth (1983). While each follows the same general methodology, i.e., the results of a series of measurements are cross-plotted and

data point clusters are interpreted to represent male and female groups, an advantage of Speth's (1983) system is its applicability to fragmentary remains. Also of note is that both techniques are designed for use on elements that are completely fused. In bison, fusion of the proximal metapodials occurs before birth but distal metapodials do not fuse until the animal's third or fourth year (Bement and Basmajian 1996; Empel and Roskosz 1963; Koch 1935). Consequently, unfused distal metapodial fragments (which are common in the Frazier archaeofauna) cannot be used to assess sex. Due to their notable preservation, calcanea were also examined and serve as a useful comparison to the metacarpal results. Following methods proposed by Hill (1996) and, to some extent, Morlan (1991), a series of measurements were taken on the Frazier calcanea. In addition to being cross-plotted and examined graphically, the results were compared with data available from bison remains recovered at other contemporary Paleoindian sites.

Establishing age profiles for faunal remains recovered from archaeological sites provides archaeologists with useful information pertaining to population structure and site seasonality. Tooth eruption (e.g., Main and Owens 1995; Silver 1970) and wear patterns (Grant 1982; Klein and Cruz-Uribe 1984; Payne 1973, 1987) are frequently studied for this purpose, particularly in the case of bison kill-butchery sites (e.g., Frison and Reher 1970; Frison et al. 1976, 1978; Reher 1970, 1973, 1974; Reher and Frison 1980; Todd and Hofman 1978; Todd, Rapson and Hofman 1996; Wilson 1980). For bison (and other animals), studies pertaining to the timing of bone epiphyseal fusion (Bement and Basmajian 1996; Empel and Roskosz 1963; Koch 1935) are also helpful in achieving an understanding of herd age structure. Due to a lack of mandibular toothrows, the present study relies on bison bone fusion rates to discuss the composition of the Frazier site bison remains.

-CHAPTER FIVE-

RESULTS

The Frazier site archaeofauna is highly fragmentary, consisting of 19,815 specimens. Although the majority of the assemblage is bison (NISP = 19,798), the archaeofauna also contains the remains of deer (*Odocoileus* sp., NISP = 1), dog and/or wolf (*Canis* sp., NISP = 8), Plains pocket gopher (*Geomys bursarius*, NISP = 1), gopher (Geomyidae, NISP = 1), ground squirrel (*Citellus* sp., NISP = 201), unknown medium-sized mammal (NISP = 1), and unknown small-sized mammal (NISP = 1). Of the total number of bison bone fragments, 3,994 (20.2%) bones are identified to specific element and left astragali provide the minimum number of 44 individuals represented in the assemblage.

Bone distribution across the site is fairly homogenous although some areas of higher concentration are apparent (Figure 5.1). While Wormington (1967:2) believed the most productive areas of the site had been excavated in their entirety, areas of relatively heavy bone concentration occurring along the excavated grid margins suggest that perhaps the full extent of the site has not been determined.

The remainder of this chapter presents a faunal analysis of the Frazier site bison archaeofauna. Specific aspects of the assemblage discussed include the taxonomy of the Frazier bison, herd structure, skeletal element abundance, site seasonality, and evidence for both human and non-human modification including the presence of bone tools.

Taxonomy

Analysis of the Frazier site bison suggests they are larger than modern bison (*B. bison)* and similar in size to both *B. antiquus occidentalis* and *B. antiquus antiquus*

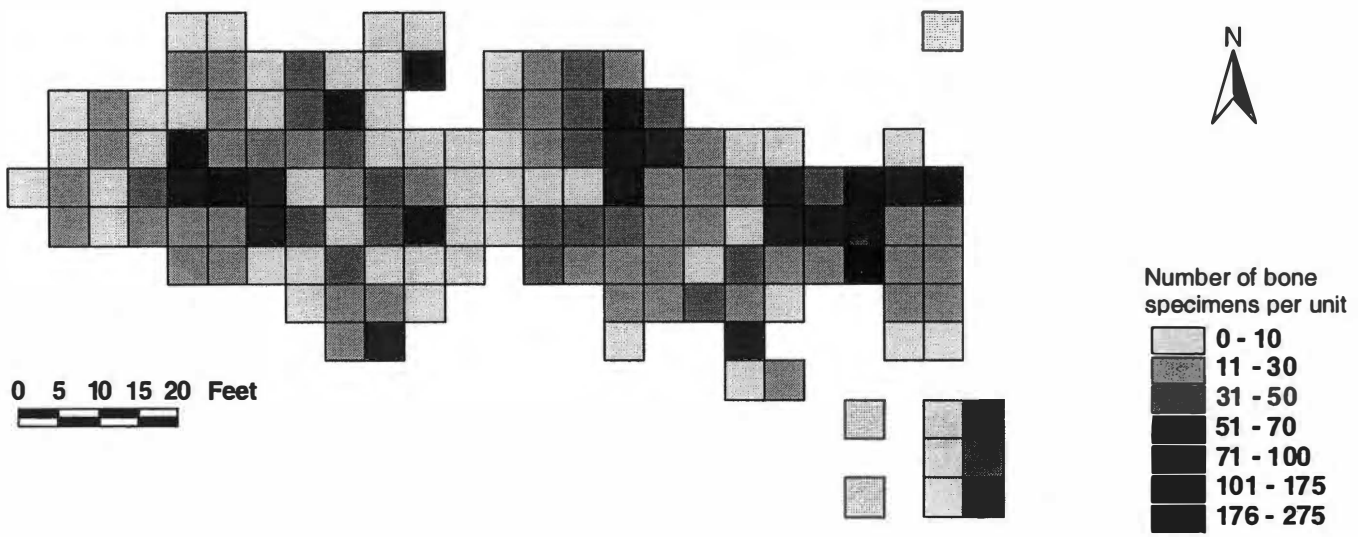


Figure 5.1. Distribution of bison bone specimens, Localities 1 and 3, Frazier site. (Note: does not include unidentified fragments.)

(McDonald 1981). To illustrate this point, Figure 5.2 presents metacarpal data from eleven High Plains archaeological sites, including the Frazier site. Changes in metacarpal size illustrate a significant decrease in bison body size over the past 11,000 years. The Frazier metacarpals are similar in size to those recovered from contemporary Paleoindian sites and considerably larger than metacarpals from the more recent sites.

Herd Structure

The presence of unfused distal metapodial condyles along with unfused metapodial shaft fragments suggests the Frazier bison assemblage represents the remains of a cow-calf herd. Rates of epiphyseal bone fusion for cattle and modern bison (Duffield 1973; Empel and Roskosz 1963; Koch 1935; see also Sisson and Grossman for *Bos* fusion rates) along with fusion rates obtained from articulated *B. b. antiquus* skeletons at the Folsom-age Cooper site in Oklahoma (Bement and Basmajian 1996) demonstrate that the distal epiphysis of metapodials fuses by approximately 3-3½ years of age. Studies of modern bison behavior indicated that cow herds are primarily comprised of females, juveniles three years old and younger and, occasionally, bulls older than four years (McHugh 1958:14). Consequently, metapodials should be fused by approximately the time juvenile males are leaving the cow herds, and bull herds should not contain animals with unfused metapodials.

Selected measurements taken on the calcanea support the premise that the Frazier bison represent a cow-calf herd. Thirty-nine Frazier calcanea, 11 of which were unfused, were examined and measured (Appendix 3). After viewing the results graphically, as well as comparing them with data from other Paleoindian bonebeds (Hill 1996:Table A3.2), the calcanea appear to represent 6 males, 12 females, 11 immature individuals, and 10 specimens of unknown sex. Collectively

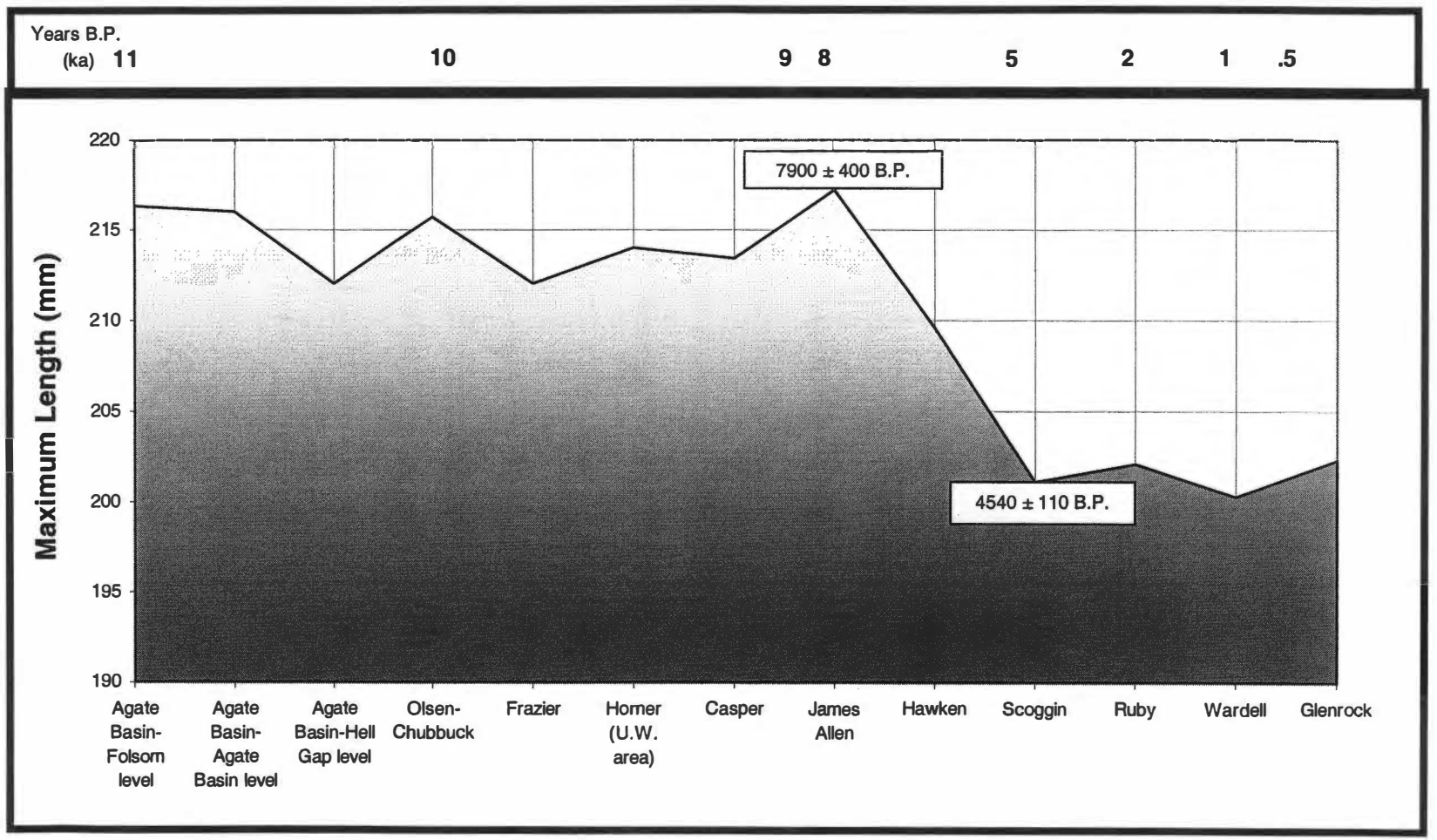


Figure 5.2. Mean bison metacarpal length from selected High Plains archaeological sites (adapted from Hughes 1978: Table 3; data from Hughes 1978:Table 3 and Zeimens 1972:Table 4.5).

then, the calcanea suggest a herd composition of 15.4% males, 30.8% females, 28.2% immature, and 25.6% unknowns. Of note is that the proximal calcaneus does not fuse until approximately five years of age, which is well into a bison's adult life. As a result, the presence of large, unfused calcanea (Figure 5.3c) in the assemblage raise the possibility that more males were present in the herd than is suggested by only considering fused specimens.

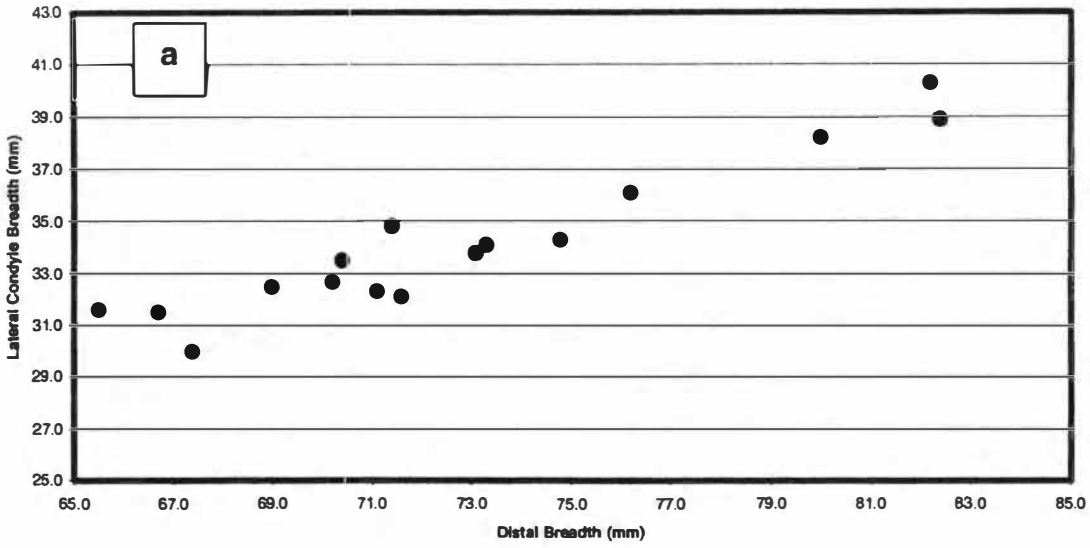
When considering sex ratio, it is important to keep in mind that faunal remains recovered from archaeological sites are often directly associated with site function and human decision-making. As such, they represent those carcasses or carcass portions that were either selected for or against and may not mirror the original herd composition. In the case of bison kill-butchery locations, faunal remains presumably represent what was not selected for transport. It has been argued that seasonal variability in cow and bull bison nutritional condition may have influenced processing decisions (Speth 1983). If this premise is true, comparing the frequency of males and females across multiple elements in an archaeofauna can help determine if differential carcass utilization occurred. Few skeletal elements in the Frazier archaeofauna provide the requisite measurements needed to conduct meaningful sex comparisons; however, cross-plots of selected metacarpal measurements (Speth 1983) suggest few bulls are represented in the assemblage (Figure 5.4a-d; Appendix 4). This evidence corroborates the results obtained from the calcanea and concurrently implies that little sexual selection occurred at the site.

Seasonality Assessment

A definitive assessment of the seasonality of the Frazier site bison archaeofauna was not established in the present study. As discussed in the previous chapter, the



Figure 5.3. Male (a), female (b), and immature (c) bison calcanea from the Frazier site.



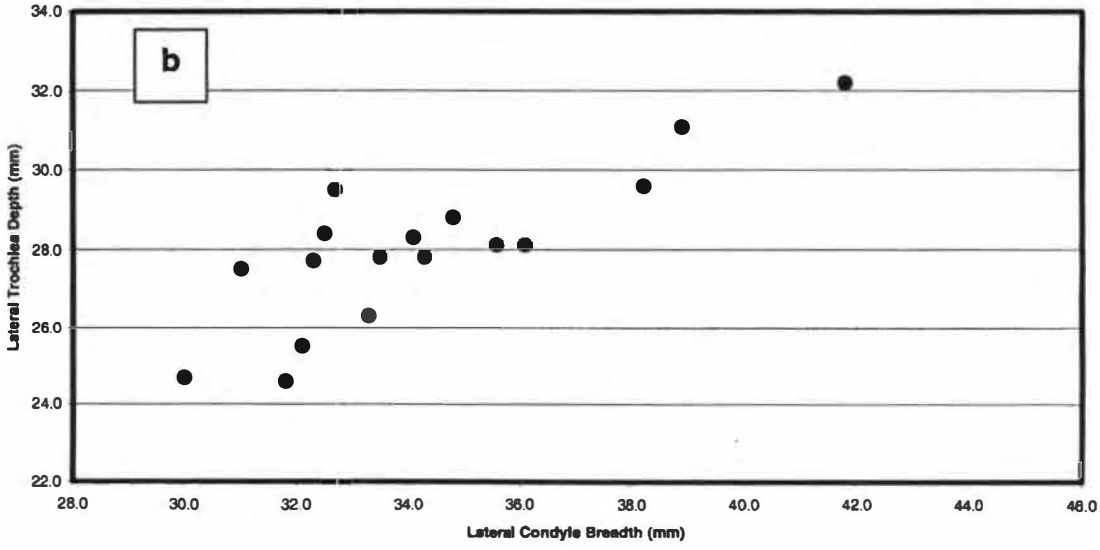
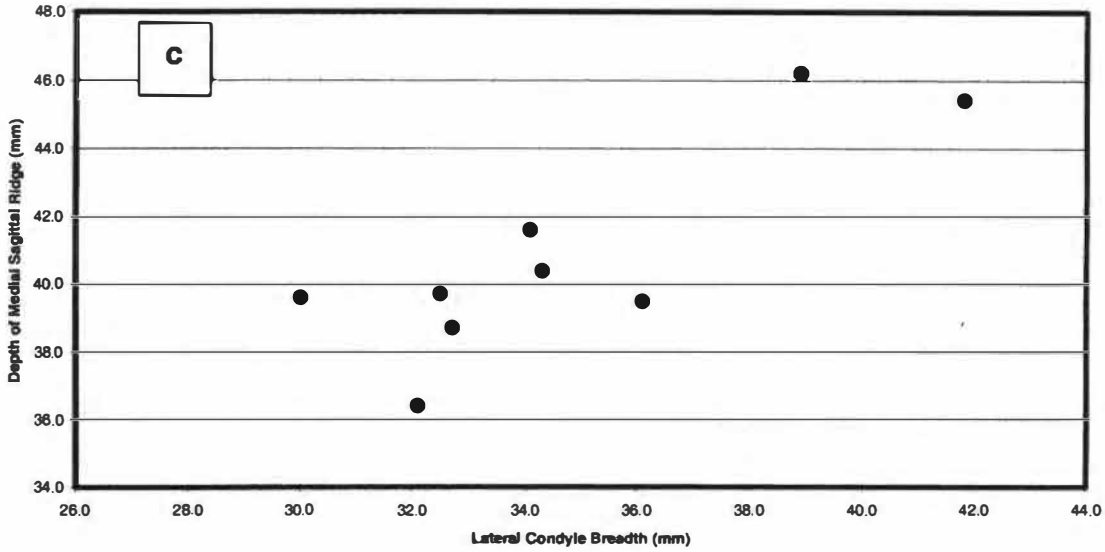


Figure 5.4. Selected crossplots of bison metacarpal measurements (mm); (a) distal breadth versus lateral condyle breadth, (b) lateral condyle breadth vs. lateral trochlea depth, (c) lateral condyle breadth vs. depth of medial sagittal ridge, and (d) medial condyle breadth vs. lateral condyle breadth (measurements taken from Speth 1983: Appendix, Figure 57, Figure 59, Figure 60).



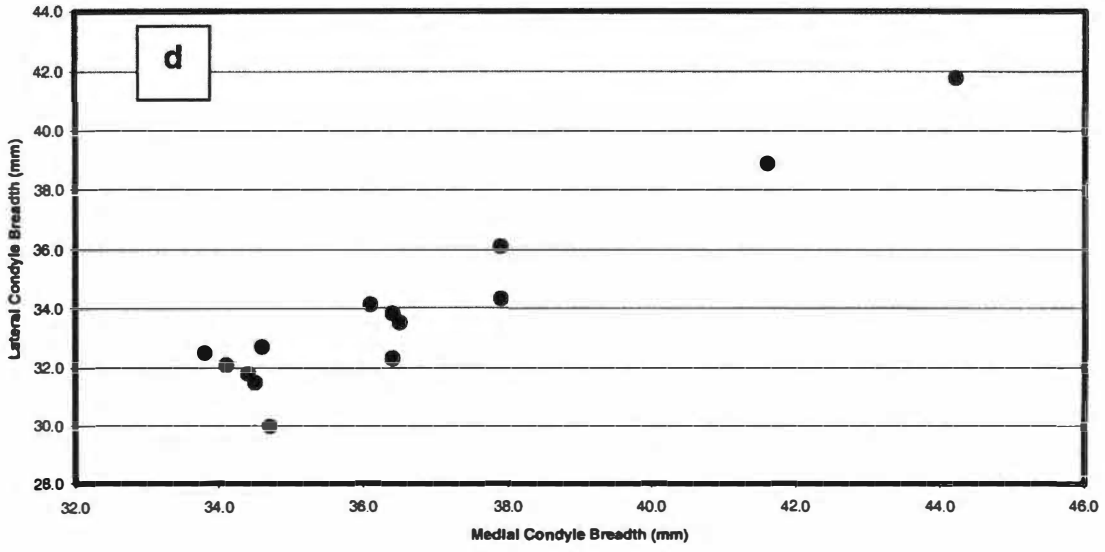


Figure 5.4. Continued.

seasonality of bison kill-butchery sites is often determined through the study of bison mandibular dentition and, occasionally, maxillary dentition (e.g., Frison 1982a; Frison and Reher 1970, Reher 1973, 1974; Reher and Frison 1980; Todd and Hofman 1987; Todd, Rapson and Hofman 1996; Wilson 1980). The majority of published seasonality studies currently rely on the presence of whole or partial toothrows to assess season of death. Because the Frazier site archaeofauna contains a number of loose teeth but few tooth rows, it is unlikely that techniques currently available would allow for a reliable establishment of seasonality. However, experts on bison dentition and seasonality briefly examined the Frazier teeth prior to the present analysis and offer a very tentative and cautious assessment of late winter-early spring based on wear patterns observed on 23 mandibular M_3s (Todd, Hofman, and Wormington 1990). In the absence of other evidence, their assessment is utilized in the present study.

Articulated Segments

The Frazier site bison archaeofauna contains very few articulated elements. The 1967 field notes mention only two articulated carcass segments, including an articulated lower leg in unit G28 and an articulated forelimb (actually a lower hind limb and part of a forelimb) in unit D30. However, unit profiles (drawn by excavators) suggest a greater number of articulations are present in the assemblage. Fragmentation and other post-depositional processes (e.g., carnivore activity) have likely concealed the actual number of articulated segments. No attempt was made in the present study to anatomically refit elements.

Skeletal Element Abundance

Table 5.1 presents skeletal element abundance information for the Frazier site bison archaeofauna. Right petrous portions and right M_3s provide the highest MNE

Table 5.1. Bison skeletal element abundance, Frazier site.

Element	Code	NISP	Left	Right	n	MNE	MAU	%MAU
Crania	CRN	151	(4)	(5)	(1)	5	5.0	12.5%
Mandible	MR	712	22	27	0	27	27.0	67.5%
Atlas	AT	5	-	-	2	2	2.0	5.0%
Axis	AX	7	-	-	3	3	3.0	7.5%
Cervical (3-7) vertebra	CE	103	-	-	19	19	3.8	9.5%
Thoracic (1-14) vertebra	TH	77	-	-	33	33	2.4	5.9%
Rib	RB	844	0	0	16	16	0.6	1.4%
Lumbar (1-5) vertebra	LM	48	-	-	12	12	3.2	8.0%
Sacrum	SA	21	-	-	14	14	14.0	35.0%
Indeterminate Vertebra	VT	155						
Scapula	SC	239	19	20	2	41	20.5	51.3%
Humerus	HM	84	15	11	3	29	14.5	36.3%
Radius	RD	99	16	19	1	36	18.0	45.0%
Ulna	UL	50	10	13	1	24	12.0	30.0%
Radial Carpal	CPR	35	20	14	0	34	17.0	42.5%
Intermediate Carpal	CPI	32	13	19	0	32	16.0	40.0%
Ulnar Carpal	CPU	25	11	14	0	25	12.5	31.3%
Fused 2-3 Carpal	CPS	38	21	14	1	36	18.0	45.0%
Fourth Carpal	CPF	33	20	13	0	33	16.5	41.3%
Accessory Carpal	CPA	9	3	6	0	9	4.5	11.3%
Indeterminate Carpal	CP	7						
Metacarpal	MC	97	20	20	3	43	21.5	53.8%
Metacarpal 5	MC5	2	0	0	2	2	1.0	2.5%
Innominate	IM	32	7	5	1	13	6.5	16.3%
Femur	FM	56	10	4	9	23	11.5	28.8%
Patella	PT	11	3	5	1	9	4.5	11.3%
Tibia	TA	105	19	17	1	37	18.5	46.3%
Astragalus	AS	81	44	36	0	80	40.0	100.0%
Lateral Malleolus	LTM	12	4	8	0	12	6.0	15.0%
Calcaneus	CL	99	29	24	1	54	27.0	67.5%
First Tarsal	TRF	0	0	0	0	0	0.0	0.0%
Fused Central & 4th Tarsal	TRC	65	33	18	0	51	25.5	63.8%
Fused 2nd & 3rd Tarsal	TRS	33	23	9	1	33	16.5	41.3%
Metatarsal	MT	114	21	20	4	45	22.5	56.3%
Metapodial	MP	54						
Phalanx 1	PHF	180	0	0	153	153	19.1	47.8%
Phalanx 2	PHS	157	0	0	146	146	18.3	45.6%
Phalanx 3	PHT	53	0	0	42	42	5.3	13.1%
Indeterminate Phalanx	PH	17						
Proximal Sesamoid	SEP	45	0	0	45	45	2.8	7.0%
Distal Sesamoid	SED	7	0	0	7	7	0.9	2.2%
Total		**3994**						

Note: crania count (in parentheses) from petrous portions

values for the crania (MNE = 5), while mandibular MNE values are derived from the right M_3 (MNE = 27). Given the comparable size and structure of both maxillary and mandibular teeth, their marked difference in frequency is unexpected (Table 5.2). However, a number of Paleoindian kill sites exhibit comparable patterning, including the Folsom site (Meltzer, Todd, and Haynes 2002) and both the Area II Agate Basin component and the Main Hell Gap component (Area III) of the Agate Basin site (Hill 2001). The greater surface area of bison crania in relation to mandibles perhaps best explains this pattern. Mandibles may have been more quickly buried following site occupation whereas the larger, blockier crania perhaps lay exposed on the surface for a greater period of time and, consequently, underwent more extensive weathering damage.

The postcranial axial skeleton is poorly represented, as are a number of small elements. In his recent reanalysis of the Agate Basin level of the Agate Basin site, Hill (2001:122-125) offers a compelling argument for the field discard of selected axial elements at that site. His claim is based on a comparison of the Agate Basin material with material from the Horner site (Todd 1987), which, like the Agate Basin site, was excavated during the same time period (the late 1970s) and by the same institution (the University of Wyoming). Field notes from the excavation of the Horner II bone bed provide a count of the elements collected as well as those discarded in the field. Similar patterning between axial elements from the Horner site and those from the Agate Basin level of the Agate Basin site suggests that comparable field collection strategies took place at both sites (Hill 2001:Figure 3.29). Striking similarities between the Frazier assemblage and the Agate Basin assemblage indicate that selective field discard of these elements may also have occurred at the Frazier site (Figure 5.5). However, the acceptance of such an

Table 5.2. Tooth frequency in the bison archaeofauna, Frazier site.

Maxillary				
Tooth	Left	Right	N	MNE
DP3/4	1	0	0	1
DP3	0	0	0	0
DP4	0	1	0	1
P2	1	2	0	3
P3	0	0	0	0
P4	0	1	0	1
P3/P4	1	1	0	2
M1/M2	8	2	0	10
M1	1	2	0	3
M2	2	3	0	5
M3	2	5	0	7
P3 & P4 combined	1	1	0	2
M1 & M2 combined	11	7	0	18
Mandibular				
Tooth	Left	Right	N	MNE
IC	2	3	1	6
DP3	3	0	0	3
DP4	2	2	0	4
P2	4	0	0	4
P3	7	4	0	11
P4	9	7	0	16
P3/P4	2	1	0	3
M1/M2	28	29	1	58
M1	7	11	0	18
M2	8	8	0	16
M3	22	27	0	49
P3 & P4 combined	18	12	0	30
M1 & M2 combined	43	48	1	92

Note: counts include teeth that are part of toothrows

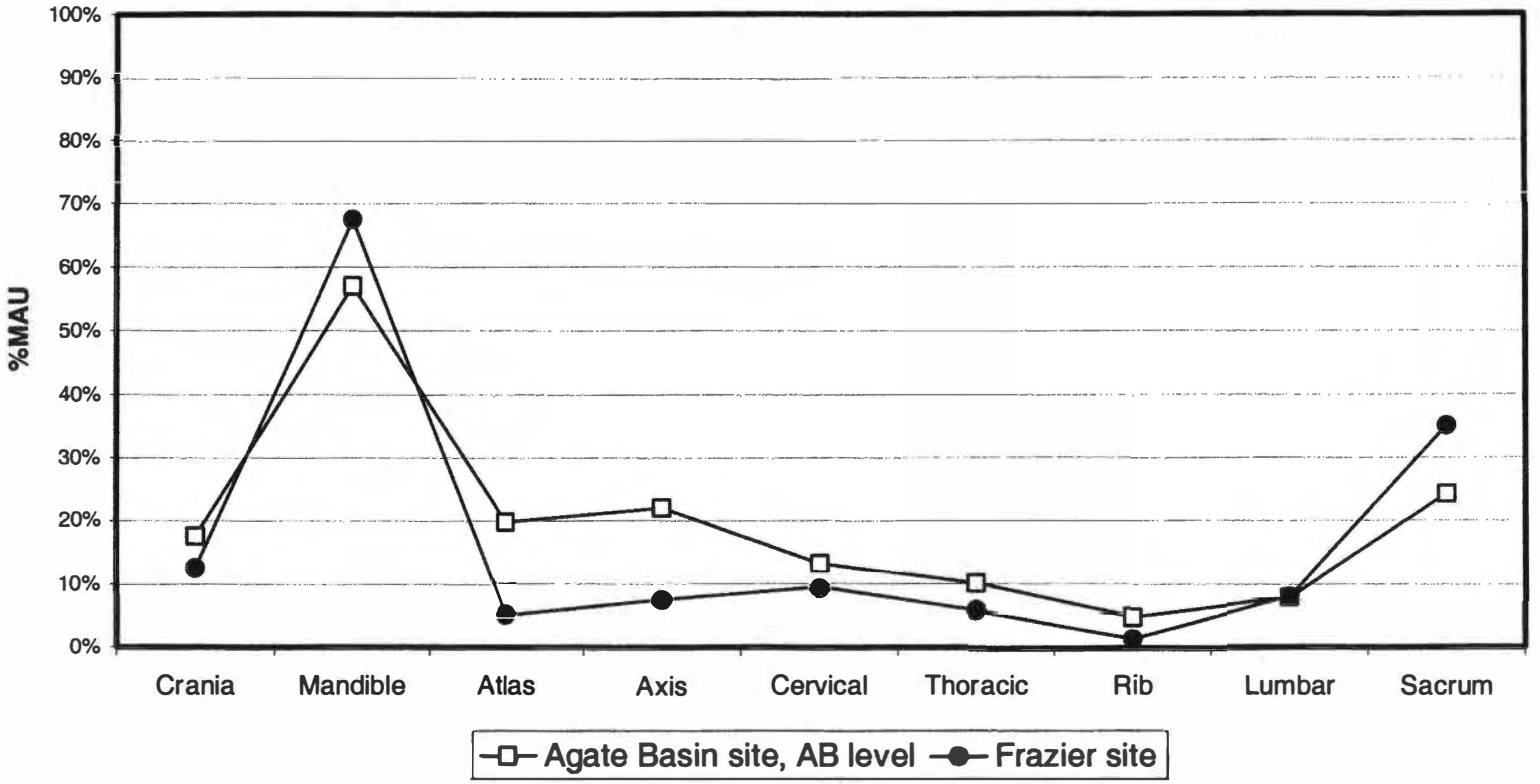


Figure 5.5. Bison skeletal element abundance profile, axial elements, Agate Basin (AB) level of the Agate Basin site (Hill 2001:Table 3.21) and Frazier site.

explanation ignores the improbability that the same elements would be selectively discarded in the field at both the Frazier and Agate Basin sites given that a decade separates each site's excavation and, further, that each site was excavated by different institutions.

In addition to axial elements, small elements such as accessory carpals, fifth metacarpals, lateral malleoli, and first tarsals, are uncommon in the Frazier bison archaeofauna. In fact, no first tarsals were identified in the assemblage. Hill (2001:125) noted a similar phenomenon in the Agate Basin level of the Agate Basin site, which he attributes to field attrition. Although little information on the collection procedures practiced at the Frazier site exists, the absence of soil screening at the site (Robert Burton, personal communication, 2001) suggests that low frequencies of small, compact elements may be a result of field collection practices.

The most abundant forelimb element in the archaeofauna is the radial carpal (MNE = 34), while the least abundant elements are the fifth metacarpal (MNE = 2) and the accessory carpal (MNE = 9). Of the major limb elements, the metacarpal occurs most frequently (MNE = 43) and the ulna occurs least frequently (MNE = 24). The most abundant hind limb skeletal element is the astragalus (MNE = 80). The least abundant hind limb element is the first tarsal (MNE = 0), followed by the patella (MNE = 9). The most frequent major limb element is the metatarsal (MNE = 45), while the least frequent element is the femur (MNE = 23).

Figure 5.6 presents the skeletal element abundance profile for the Frazier site bison remains. Comprehensive MNEs are converted to ratio MAUs based on an MAU of 40 derived from astragali. The profile reveals that the axial skeleton is underrepresented in relation to other skeletal elements while the forelimb and hind limb elements are present in fairly equable numbers. Of particular note is the sharp

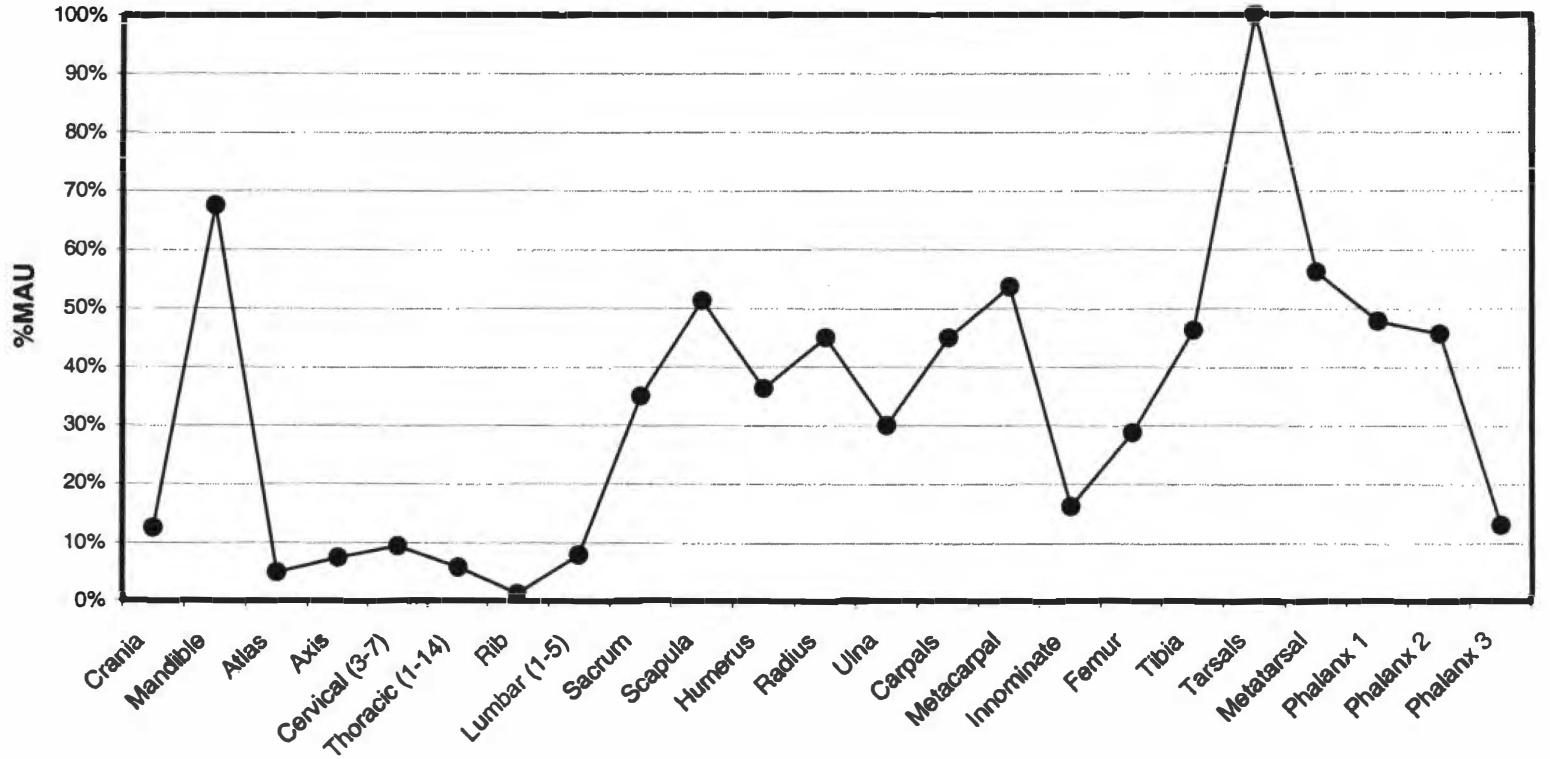


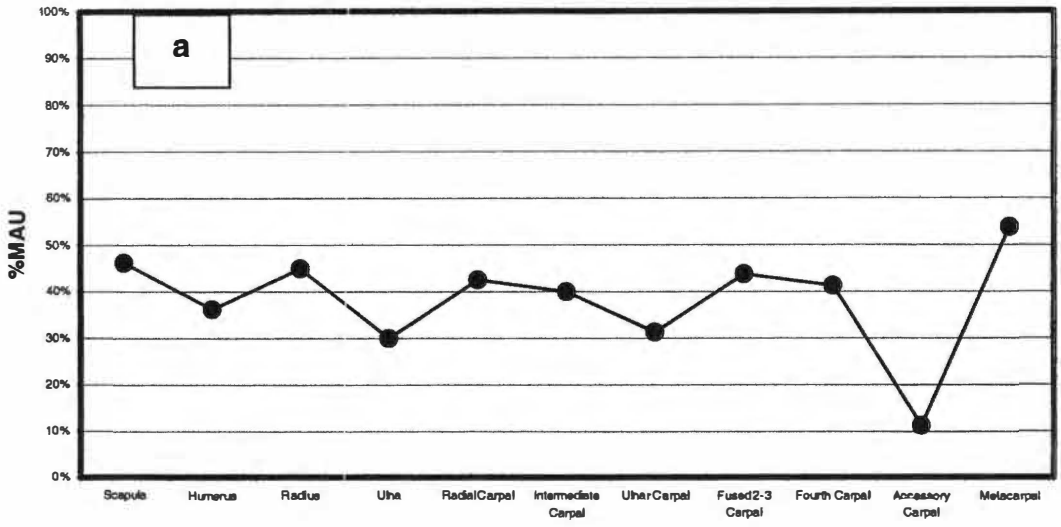
Figure 5.6. Bison skeletal element abundance profile, Frazier site.

increase from tibiae to tarsals that is followed by a drastic drop in metatarsal frequency. A closer look at forelimb and hind limb element profiles is provided in Figure 5.7a-b. The fifth metacarpal, first tarsal, and patella are excluded from the profiles due to potential field collection bias. To reiterate, with the exception of the ulna and the accessory carpal, forelimb element representation is fairly equable. Hind limb representation is more varied. Following Hill's (2001:123-125) argument that selected element frequencies are a result of field discard, the low frequency of the lateral malleolus is expected. The considerably higher ratio MAUs for the larger elements that articulate with the lateral malleolus (e.g., the astragalus and calcaneus) lend support to the notion that this element was overlooked in the field collection process (Hill 2001:125). However, the discrepancy between astragalus frequency and other lower hind limb elements is unexpected. Given the fact that both the calcaneus and fused central and fourth tarsal are large, easily identifiable and articulate with the astragalus, they should occur in similar frequency to the astragalus. Particularly surprising, however, is the low metatarsal frequency in relation to the astragalus.

Observed differences in skeletal part frequency may be the result of either human activity or non-human taphonomic processes. In an effort to determine the extent to which humans and/or other agents shaped the Frazier site bison assemblage, both density-mediated attrition and bison carcass utility are considered.

Density-Mediated Attrition

Because non-cultural taphonomic processes can alter the skeletal element frequencies at archaeological sites, discussions regarding site formation processes



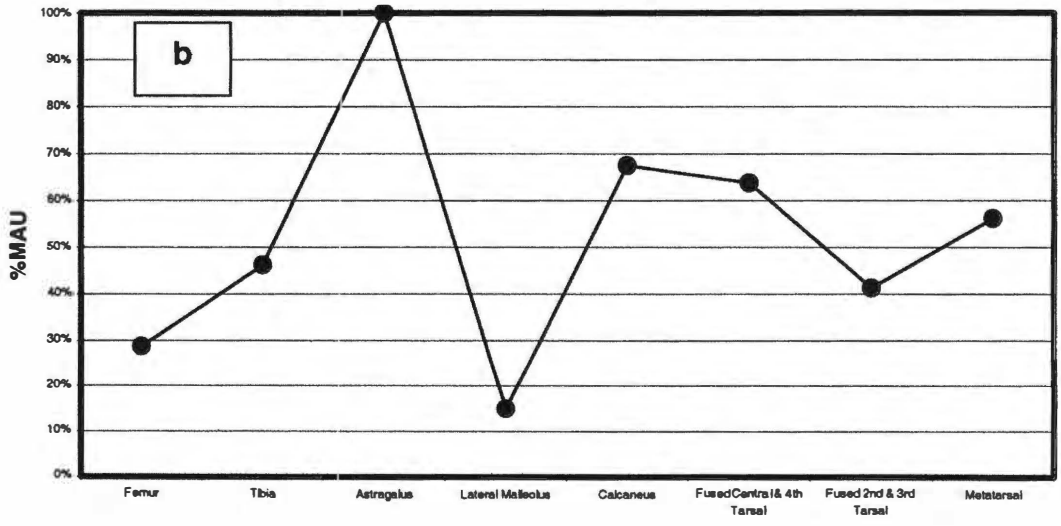


Figure 5.7. Bison skeletal element profiles for forelimb (a) and hind limb (b) elements, Frazier site.

must necessarily include consideration of these agents (e.g., carnivore modification, subaerial weathering). One method of investigating the affect non-human taphonomic processes have had on an archaeological faunal assemblage considers the structural density (g/cm^3) of individual skeletal elements (Lyman 1994:234-258). Bone density values are available for a growing number of species, including domestic goat (Brain 1967, 1969), domestic sheep (Behrensmeyer 1975; Lyman 1982, 1984), deer (Lyman 1982, 1984), pronghorn antelope (Lyman 1982, 1984) marmot (Lyman et al. 1992a), vicuna and guanaco (Elkin and Zanchetta 1991), seal (Chambers 1992), and bison (Kreutzer 1992, 1996). It is expected that low-density elements will be more thoroughly impacted by preservation processes than high-density elements.

In short, the structural density of a given element is obtained by measuring the mineral content at particular locations, or "scan sites," along the bone (Lyman 1994:238). The scan site that most closely corresponds to the portion of the bone used for computing MNE values provides the density value for that bone or bone portion. Table 5.3 presents a list of skeletal elements, corresponding scan sites and bone density values used to determine the relationship between %MAU and bone density in the Frazier bison archaeofauna. A scatterplot of bison bone density values (Kreutzer 1992) against ratio MAUs is provided in Figure 5.8. Because density values can vary drastically between the proximal and distal ends of long bones, both ends were considered when determining the relationship between ratio MAUs and bone density. A Spearman's rank-order correlation reveals a significant, positive correlation ($r_S = 0.543$, $p = 0.005$), indicating that element frequency tends to increase as density increases. Consequently, density-mediated attrition likely contributed to what is currently seen in the Frazier site faunal assemblage.

Table 5.3. Frazier site skeletal element abundances and corresponding volume density values.

Element	MNE	MAU	%MAU	Rank	Volume Density[a]	Scan Site	Rank
Atlas	2	2	5.0%	2	0.34	AT3	8
Axis	3	3	7.5%	7	0.65	AX1	24
Cervical Vertebra	19	3.8	9.5%	8	0.62	CE1	23
Thoracic Vertebra	33	2.4	5.9%	3	0.42	TH1	13
Lumbar Vertebra	12	2.4	6.0%	4	0.21	LU1,2	1
Sacrum-Innominate	14	14.0	35.0%	12	0.27	SC1	3
Rib	16	0.6	1.4%	1	0.31	RI1,2	4.5
Scapula	41	20.5	51.3%	22	0.5	SP1	19
Proximal Humerus	5	2.5	6.3%	5.5	0.24	HU1	2
Distal Humerus	29	14.5	36.3%	13	0.38	HU5	10
Proximal Radius	36	18.0	45.0%	15.5	0.45	RA1	17
Distal Radius	30	15.0	37.5%	14	0.35	RA5	9
Carpals	36	18.0	45.0%	15.5	0.44	UNCIF	15
Proximal Metacarpal	41	20.5	51.3%	22	0.59	MC1	22
Distal Metacarpal	40	20.0	50.0%	20	0.53	MC4,5,6	21
Proximal Femur	23	11.5	28.8%	11	0.33	FE1,2	7
Distal Femur	8	4.0	10.0%	9	0.31	FE5,6	4.5
Proximal Tibia	5	2.5	6.3%	5.5	0.41	TI1	11.5
Distal Tibia	37	18.5	46.3%	18	0.41	TI5	11.5
Tarsals	80	40.0	100.0%	25	0.72	AS1	25
Proximal Metatarsal	41	20.5	51.3%	22	0.52	MR1	20
Distal Metatarsal	44	22.0	55.0%	24	0.44	MR5,6	15
Phalanx 1	153	19.1	47.8%	19	0.47	P1 1,2,3	18
Phalanx 2	146	18.3	45.6%	17	0.44	P2 1,3	15
Phalanx 3	42	5.3	13.1%	10	0.32	P3 1	6

[a] from Kreutzer 1992

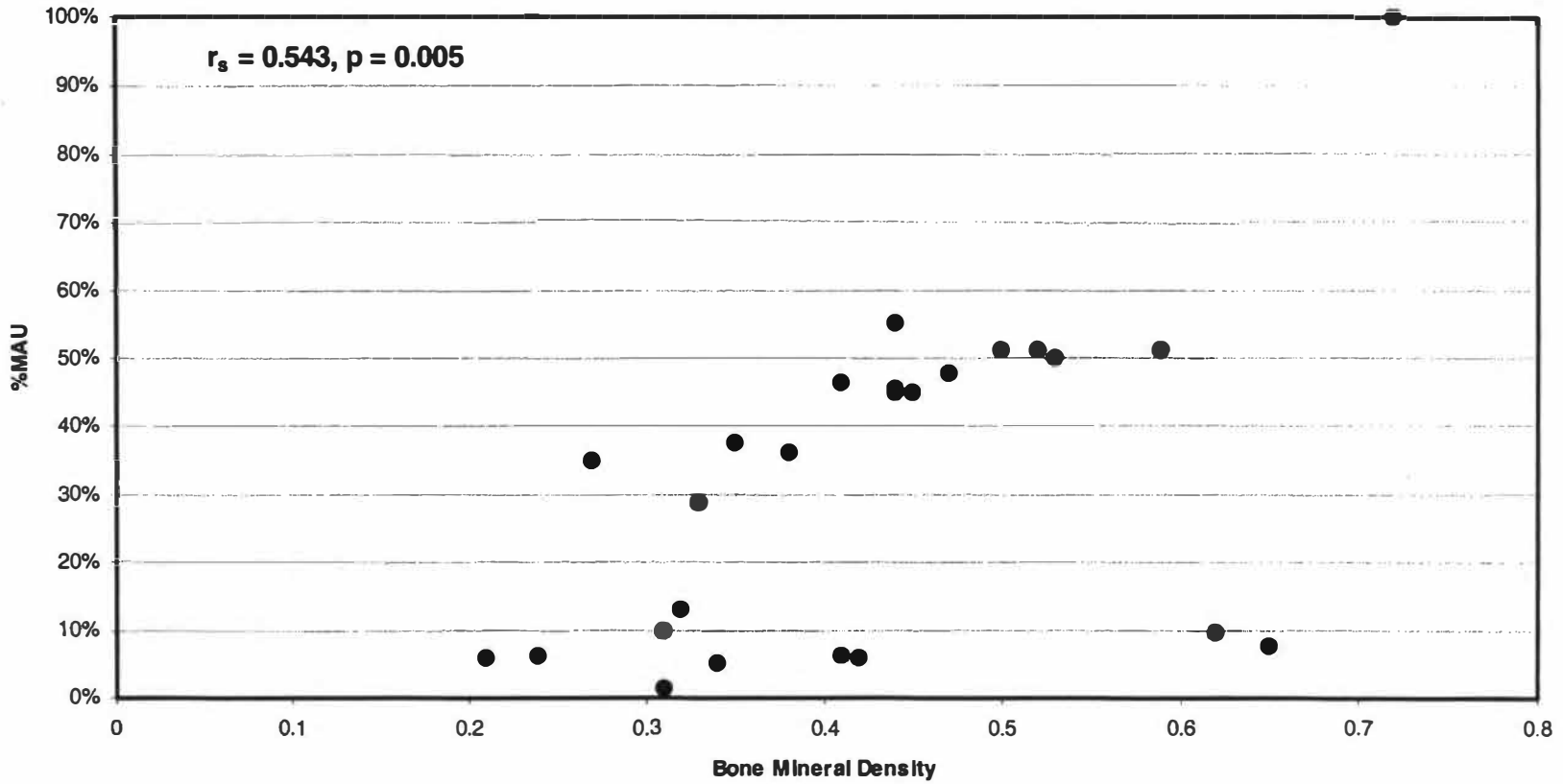


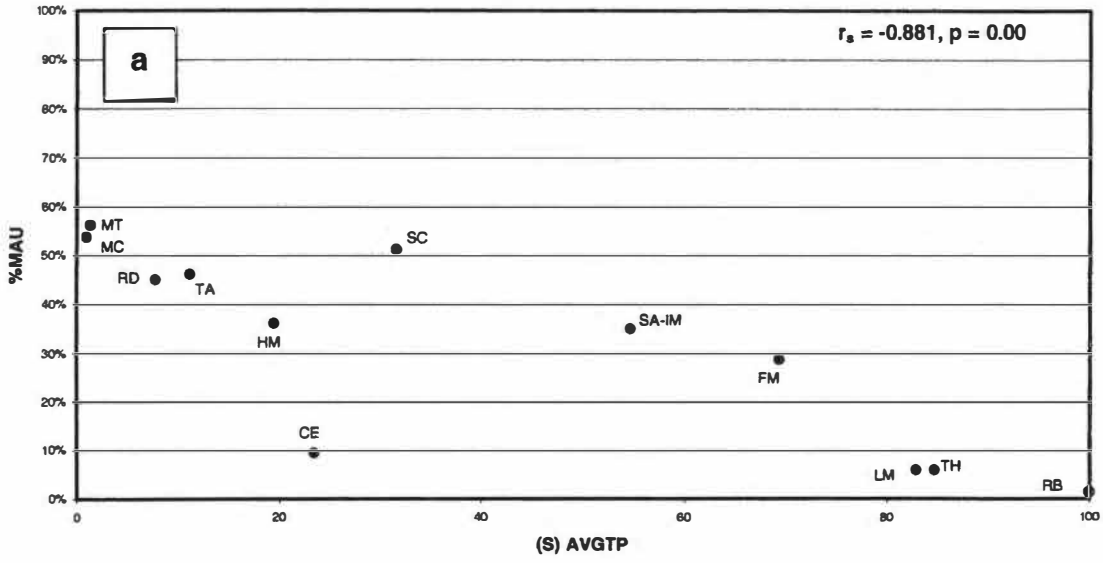
Figure 5.8. Scatterplot of %MAU of bison skeletal parts against bone mineral density values (Kreutzer 1992), Frazier site.

Bison Carcass Utility

A consideration of bison carcass utility provides a means of investigating the role humans may have played in the formation of the Frazier site archaeofauna (Binford 1978; Emerson 1990; Metcalfe and Jones 1988). Utility refers to the economic value of a given skeletal element and is most often measured in terms of nutritional yield, i.e., protein, fat and grease returns. The relative utility of each skeletal element or element portion is used as an interpretive tool and assumes that the nutritional utility of different skeletal parts will influence processing and transport decisions. Given this, kill sites should contain a higher frequency of low utility elements, whereas processing sites are predicted to contain a greater number of high utility parts.

Following Hill's (2001:73) suggestion that "analytical priority [should be] placed on those elements or element groupings most likely to reflect the primary reasons why a carcass unit was transported or ignored," the analysis of the Frazier bison archaeofauna is restricted to 12 skeletal elements including each vertebral group (cervical, thoracic, and lumbar) and each major limb bone. Utility values are not modified for riders, i.e., those bones that do not contribute significantly to nutrition (for a description of "riders" see Emerson 1990:603). In order to obtain complete element utility estimates for long bones, proximal and distal end values are averaged and, to maintain consistency with other analyses (e.g., Hill 2001), the utility values for the atlas, axis, and cervical 3-7 vertebrae are averaged.

Ratio MAUs are plotted against three modern bison utility models (Figure 5.9a-c; Emerson 1990, 1993): standardized average total food products [(S) AVGTP], standardized average protein [(S) AVGPRO], and standardized marrow fat [(S)



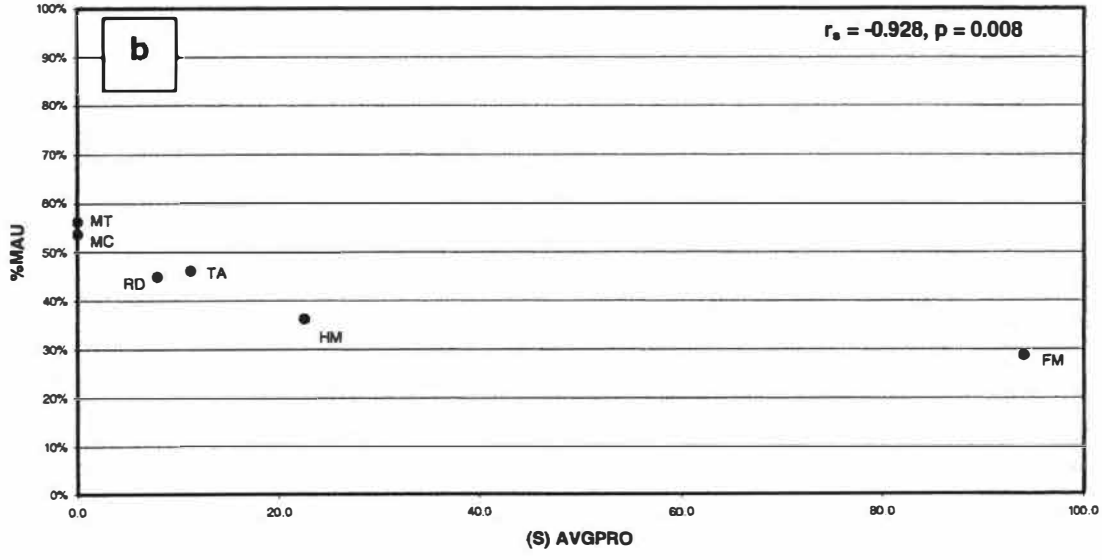


Figure 5.9. Scatterplots of %MAU of bison skeletal elements against (a) (S)AVGTP (Emerson 1990:Table 8.6), (b) (S)AVGPRO (Emerson 1990:Appendix C, Table 11), and (c) (S)AVGMAR (Emerson 1993:Figure 8-5b).

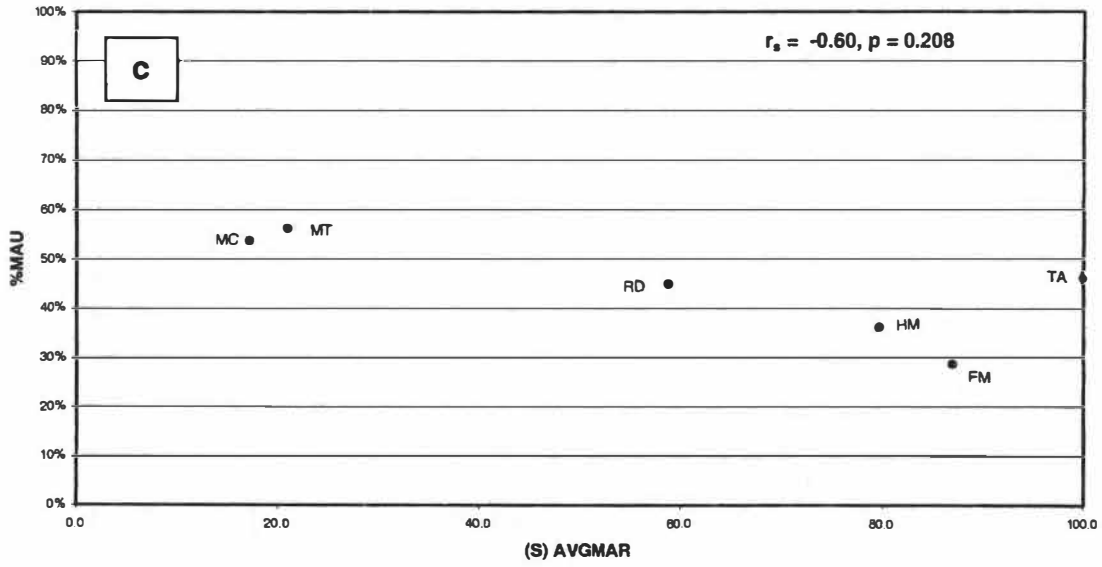


Figure 5.9. Continued.

AVGMAR]. The average total food products (Emerson 1990:Table 8.6) model considers the total caloric yield of meat protein and all fat per element. The marrow index is restricted to major appendicular elements and is a reflection of the amount of marrow available from each element (Emerson 1993:Figure 8-5b). The protein index (Emerson 1990:Appendix C, Table 11) measures the utility of each skeletal element in terms of the caloric yield of muscle protein and intramuscular fat. The latter two models are included in order to determine if a specific nutritional goal (e.g., marrow procurement) was the driving force behind carcass utilization. Utility values for each utility model are presented in Table 5.4.

Table 5.5 provides Spearman rank-order correlation values between ratio MAUs and total food utility, meat utility and marrow utility respectively. The strong, inverse correlation (r_s = -0.881, p = 0.00) between ratio MAUs and total food products suggests there is a tendency for high utility elements to occur in low frequency at the Frazier site. Such a pattern is similar to Binford's (1978) reverse utility strategy, which is expected at kill-butchery locations where relatively low-utility parts would have been discarded or left behind while higher-utility elements were selectively removed for consumption at another locale (Thomas and Mayer 1983:370). Because routine field discard of axial elements could result in misleading correlations between utility and ratio MAU and, quite possibly, spurious interpretations of this aspect of the assemblage, correlations between ratio MAU and utility excluding vertebrae were also calculated. When total products utility is replaced with the meat utility index for long bone elements, the correlation remains strong and inverse (r_s = -0.928, p = 0.008). Elements containing the largest amount of meat are infrequent in the archaeofauna. The correlation between long bone

Table 5.4. Bison skeletal element abundances, bison carcass utility values (Emerson 1990, 1993) and value ranks, Frazier site.

Element	MNE	MAU	%MAU	Rank	(S)AVGTP[ab]	Rank	(S)AVGPRO[ad]	Rank	(S)AVGMAR[c]	Rank
Cervical (all averaged)	19	3.8	9.5%	4	23.4	6	24.6	6	-	-
Thoracic	33	2.4	5.9%	2	84.7	11	62.9	10	-	-
Lumbar	12	2.4	6.0%	3	82.9	10	60.0	9	-	-
Sacrum-Innominate	14	14.0	35.0%	6	54.7	8	51.3	8	3.9	2
Rib	16	0.6	1.4%	1	100.0	12	100.0	12	-	-
Scapula	41	20.5	51.3%	10	31.6	7	43.7	7	1.3	1
Humerus	29	14.5	36.3%	7 (2)	19.5	5 (5)	22.5	5 (5)	79.8	6 (4)
Radius	36	18.0	45.0%	8 (3)	7.8	3 (3)	8.0	3 (3)	58.9	5 (3)
Metacarpal	43	21.5	53.8%	11 (5)	1.0	1 (1)	0.0	1.5 (1.5)	17.3	3 (1)
Femur	23	11.5	28.8%	5 (1)	69.3	9 (6)	94.1	11 (6)	87.0	7 (5)
Tibia	37	18.5	46.3%	9 (4)	11.2	4 (4)	11.3	4 (4)	100.0	8 (6)
Metatarsal	45	22.5	56.3%	12 (6)	1.4	2 (2)	0.0	1.5 (1.5)	21.1	4 (2)

Note: numbers in parentheses represent ranks for correlations involving only long bones

[a] proximal and distal values averaged

[b] from Emerson 1990:Table 8.6

[c] from Emerson 1993:Figure 8-5b

[d] from Emerson 1990:Appendix C, Table 11; average of four carcasses

Table 5.5. Spearman rank-order correlations between bison %MAU and utility (Emerson 1990, 1996), Frazier site.

Correlation	n ranks	r_s	p
%MAU vs. Total Products Utility	12	-0.881	0.000
%MAU vs. Marrow Fat Model[a]	6	-0.600	0.208
%MAU vs. Marrow Fat Model[b]	8	-0.333	0.420
%MAU vs. Averaged Protein Model[c]	12	-0.851	0.000
%MAU vs. Averaged Protein Model[a]	6	-0.928	0.008

[a] only major limb elements

[b] includes scapula and sacrum-innominate

[c] post-cranial axial and major limb elements

marrow utility and ratio MAU is only slightly weaker, although not significant (r_s = -0.600, p = 0.208).

Modifications

Evidence of bone modification by both cultural and non-cultural agents provides important insight about the formation of faunal assemblages. A number of modification types are evident on the Frazier bison remains, including rodent and carnivore damage, green bone breakage, butchery evidence, and burning (Table 5.6). In addition, three possible bone tools were identified. At first glance it appears that the bison remains demonstrate only minimal modification; however, the poor overall condition of the bone assemblage may conceal evidence of modification. The assemblage is highly fragmentary and roughly 75% (n = 14,956) of the bone specimens are unidentifiable to skeletal element. In addition, many specimens exhibit extensive post-depositional weathering damage, e.g., cortical flaking, longitudinal cracking, and calcium carbonate build-up.

Rodent and Carnivore Modification

Rodent modification is infrequent in the Frazier bison archaeofauna (n = 50). It is most common on unidentified long bone fragments (n = 10), first phalanges (n = 7), and tibiae and metacarpals (n = 3). The presence of gopher remains (Geomyidae) and a nearly complete ground squirrel (*Citellus* sp.) skeleton in the Frazier faunal assemblage, along with krotevena, or rodent burrows, observed in some of the units (e.g., E39, F31, and possibly the pit feature in F/G34-35), suggests rodents have occupied the site over the past 10,000 years. It is likely that the rodent damage observed on the Frazier bison remains occurred considerably after human occupation of the site, as many rodent species only gnaw dry bone (Haynes 1981:106).

Table 5.6. Incidence of modification in the Frazier site bison archaeofauna.

Element	NISP	Green	%Green	Cut or Cut/Chop	%Cut	Impact	%Impact	Rodent	%Rodent	Canid	%Canid	Burn	%Burn
AS	81	-	0.0%	7	8.6%	-	0.0%	3	3.7%	10	12.3%	-	0.0%
CE	103	-	0.0%	3	2.9%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
CL	99	-	0.0%	5	3.1%	-	0.0%	2	2.0%	1	1.0%	-	0.0%
CPF	33	-	0.0%	-	0.0%	-	0.0%	1	3.0%	2	6.1%	-	0.0%
CPI	32	-	0.0%	1	3.1%	-	0.0%	-	0.0%	1	3.1%	-	0.0%
CPR	35	-	0.0%	-	0.0%	-	0.0%	-	0.0%	1	2.9%	-	0.0%
CPS	38	-	0.0%	-	0.0%	-	0.0%	-	0.0%	2	5.3%	-	0.0%
CRN	78	-	0.0%	-	0.0%	-	0.0%	1	1.3%	-	0.0%	-	0.0%
FM	56	6	10.7%	-	0.0%	1	1.8%	-	0.0%	1	1.8%	-	0.0%
HM	84	23	27.4%	-	0.0%	1	1.2%	-	0.0%	-	0.0%	-	0.0%
IM	32	-	0.0%	-	0.0%	-	0.0%	1	3.1%	-	0.0%	-	0.0%
LB	2017	280	13.9%	3	0.1%	14	0.7%	10	0.5%	2	0.1%	11	0.5%
LM	48	-	0.0%	1	2.1%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
MC	98	3	3.1%	-	0.0%	-	0.0%	5	5.1%	3	3.1%	-	0.0%
MP	54	-	0.0%	1	1.9%	-	0.0%	1	1.9%	1	1.9%	-	0.0%
MR	523	1	0.2%	2	0.4%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
MT	114	7	6.1%	2	1.8%	1	0.9%	2	1.8%	5	4.4%	-	0.0%
PH	17	-	0.0%	-	0.0%	-	0.0%	1	5.9%	-	0.0%	-	0.0%
PHF	180	-	0.0%	15	8.3%	-	0.0%	9	5.0%	7	3.9%	-	0.0%
PHS	157	-	0.0%	11	7.0%	-	0.0%	2	1.3%	6	3.8%	-	0.0%
PHT	53	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
RB	844	8	0.9%	1	0.1%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
RD	99	8	8.1%	-	0.0%	-	0.0%	2	2.0%	-	0.0%	-	0.0%

Table 5.6. Continued.

Element	NISP	Green	%Green	Cut or Cut/Chop	%Cut	Impact	%Impact	Rodent	%Rodent	Canid	%Canid	Burn	%Burn
SA	21	-	0.0%	-	0.0%	-	0.0%	1	4.8%	-	0.0%	-	0.0%
SC	239	13	5.4%	2	0.8%	-	0.0%	2	0.8%	3	1.3%	-	0.0%
TA	105	31	29.5%	-	0.0%	2	1.9%	5	4.8%	-	0.0%	-	0.0%
TFR	768	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	5	0.7%
TH	77	-	0.0%	2	2.6%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
TRC	65	-	0.0%	-	0.0%	-	0.0%	2	3.1%	2	3.1%	-	0.0%
UL	50	1	2.0%	1	2.0%	-	0.0%	-	0.0%	1	2.0%	-	0.0%
UN	11700	2	0.0%	4	0.0%	1	0.0%	-	0.0%	2	0.0%	79	0.7%
VT	155	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	1	0.6%
TOTAL	**19798**	**383**	**1.9%**	**61**	**0.3%**	**20**	**0.1%**	**50**	**0.3%**	**50**	**0.3%**	**96**	**0.5%**

Note: NISP values for CRN and MR do not include teeth

In addition to the presence of canid remains (n = 8) in the Frazier faunal assemblage, a limited number of bison bone specimens (n = 50) also display direct evidence of canid modification. The most affected elements include the astragalus (n = 10), first and second phalanges (n = 7 and 6, respectively), and the metatarsal (n = 5). Of note, however, is the absence of certain high-fat element portions, including proximal humeri, proximal and distal femora, and proximal tibiae. The low frequency of these portions within the Frazier archaeofauna suggests the possibility of more extensive carnivore modification, and perhaps argues against rapid burial of the bones. As noted by Haynes (1980b:343) and others (Blumenschine and Marean 1993), modern carnivore gnawing does not always produce identifiable tooth marks on bones. In the absence of obvious indicators of carnivore modification (e.g., tooth pitting and scoring) on the Frazier bison remains, Haynes' (1982: Table 1, Table 2) stages of carcass utilization by wolves may be useful as a tool for interpreting the extent to which the archaeofauna has been impacted by scavenging activity. Obviously, there are numerous problems inherent in drawing conclusions based on the absence of certain element portions. However, doing so may aid in understanding the variability in selected skeletal part frequencies observed in the Frazier bison remains. Specifically, Haynes (1980b:346) proposes that the degree of damage to bison femora can be used as a reliable index of bison carcass utilization by modern wolves. The femur undergoes a predictable sequence of carnivore damage, beginning with the proximal end, i.e., removal of the greater trochanter, and proceeding to the trochlear rims, distal condyles and, finally, removal of the femoral head. In light of this, carnivore scavenging might best explain the low frequency of both proximal and distal ends of the femur in the Frazier bison

archaeofauna and provides a possible explanation for the poor representation of proximal tibia and proximal humeri.

Canid activity may also explain the low frequency of metatarsals in relation to astragali. Wolves rarely target lower limb elements in the initial stages of carcass utilization (Haynes 1980b:348). Haynes (1980b:348) notes that, "Even on very well utilized wolf (and other carnivore) kills, metapodials are seldom gnawed distal to the proximal epiphysis." If revisited later in time, however, metapodials are sometimes dragged away from the rest of the carcass, "since these elements are protected longest by uneaten, unpeeled hide, and remain greasy and fetid" (Haynes 1982:276). In fact, "the bones most commonly found hundreds of meters from known carcasses or skeletal sites have been vertebrae, scapulae, and metapodials" (Haynes 1982:276). Consequently, the low frequency of metatarsals in the Frazier bison archaeofauna may be a result of their removal by canids. In addition, canid activity offers an alternative explanation to field discard for the low representation of the axial skeleton in the Frazier bison archaeofauna.

Bone Breakage and Other Evidence for Butchery

A limited amount of human butchery evidence is present on the Frazier bison remains. Green bone breaks and conchoidal flake scars, while not always the result of human activity (Agenbroad 1989; Fisher 1995, Haynes 1983b, Hill 1989), support the claim that humans utilized the Frazier bison. The presence of cut marks on bone specimens offers additional support in establishing a human presence at the site.

On-site marrow extraction appears minimal although patterned breakage of metapodials and tibiae suggests some marrow "snacking" may have occurred during carcass processing (Figure 5.10a-b). Approximately 1.9% (n =383) of the

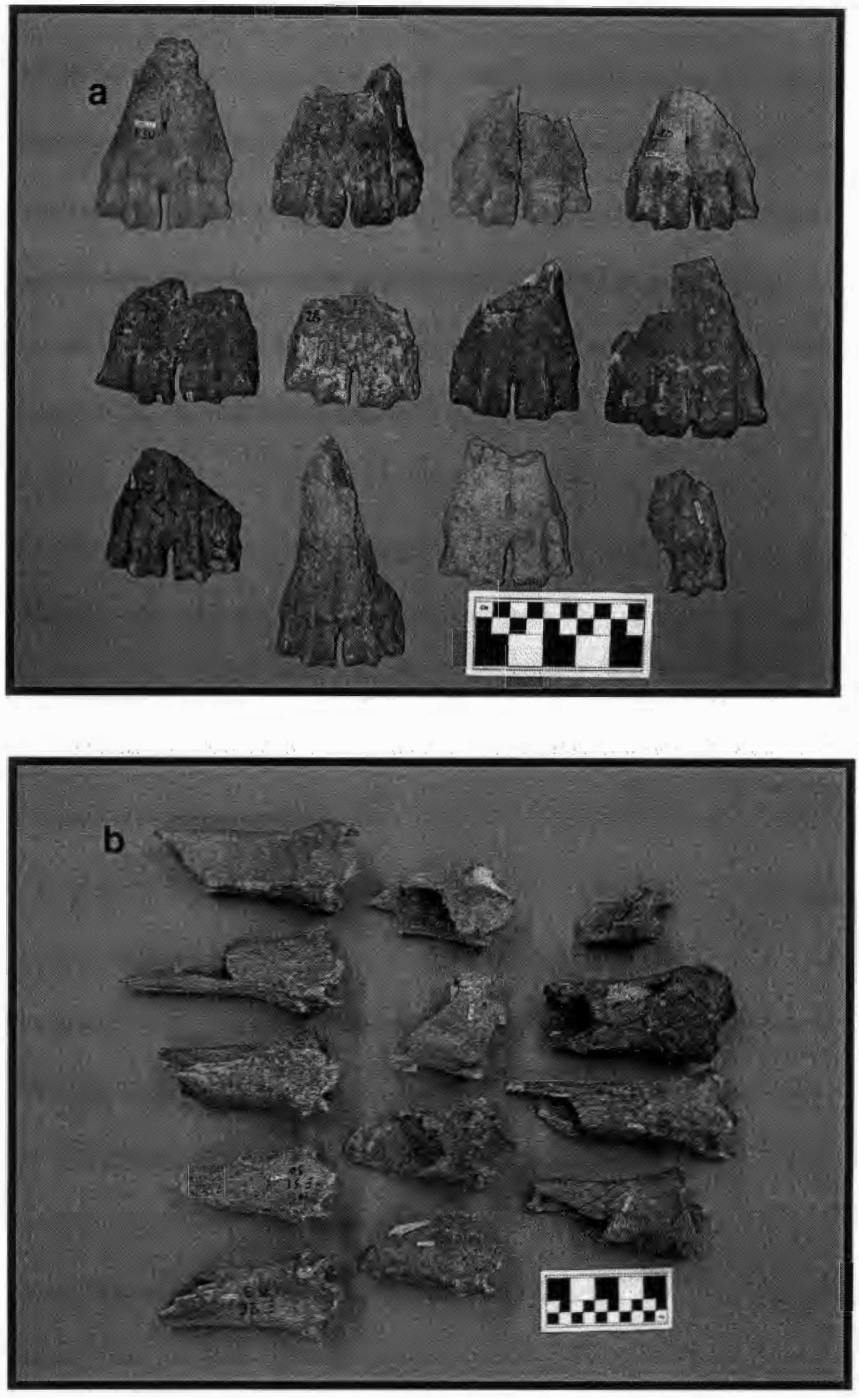


Figure 5.10. Patterned breakage of bison metacarpals (a) and tibiae (b), Frazier site.

Frazier bison archaeofauna exhibits green bone breakage, with the majority of green breaks occurring on long bone fragments (n = 280), humeri (n = 23), and tibiae (n = 31). Only 20 specimens show conchoidal flake scars and the majority of this modification is located on unidentified long bone fragments (n = 14).

The presence and location of cut marks on skeletal elements provides important information about butchery behavior at the Frazier site. Cut marks (n = 61) occur most frequently on phalanges (PHF n = 15, PHS n = 11) and, more importantly, tarsals (AS n = 7, CL n = 5), suggesting that disarticulation of the lower hind limb may have occurred on-site.

Burning

Burning is infrequent on the Frazier bison remains and is restricted to small fragments of long bone shafts (n = 11), vertebrae (n = 1), teeth (n = 5) and unidentifiable specimens (n = 79). Of particular note is that no burned bone specimens are directly related to the pit feature excavated in units F/G34-35 (discussed in Chapter 2).

Bone Tools

Three bone specimens in the Frazier bison archaeofauna exhibit evidence of use. Two are tibia fragments and one is an unidentified long bone fragment. Each is described in detail below. The criteria used for identifying bone tools can be found in Johnson (1985).

Artifact number A1922.29 (Figure 5.11a): Unidentified long bone fragment from the 1966 surface collections (length: 130mm; width: 40mm). The specimen displays a green break as well as a small area of cortical flaking with a cut mark. The green break edge exhibits polish, as does the majority of the outer cortical

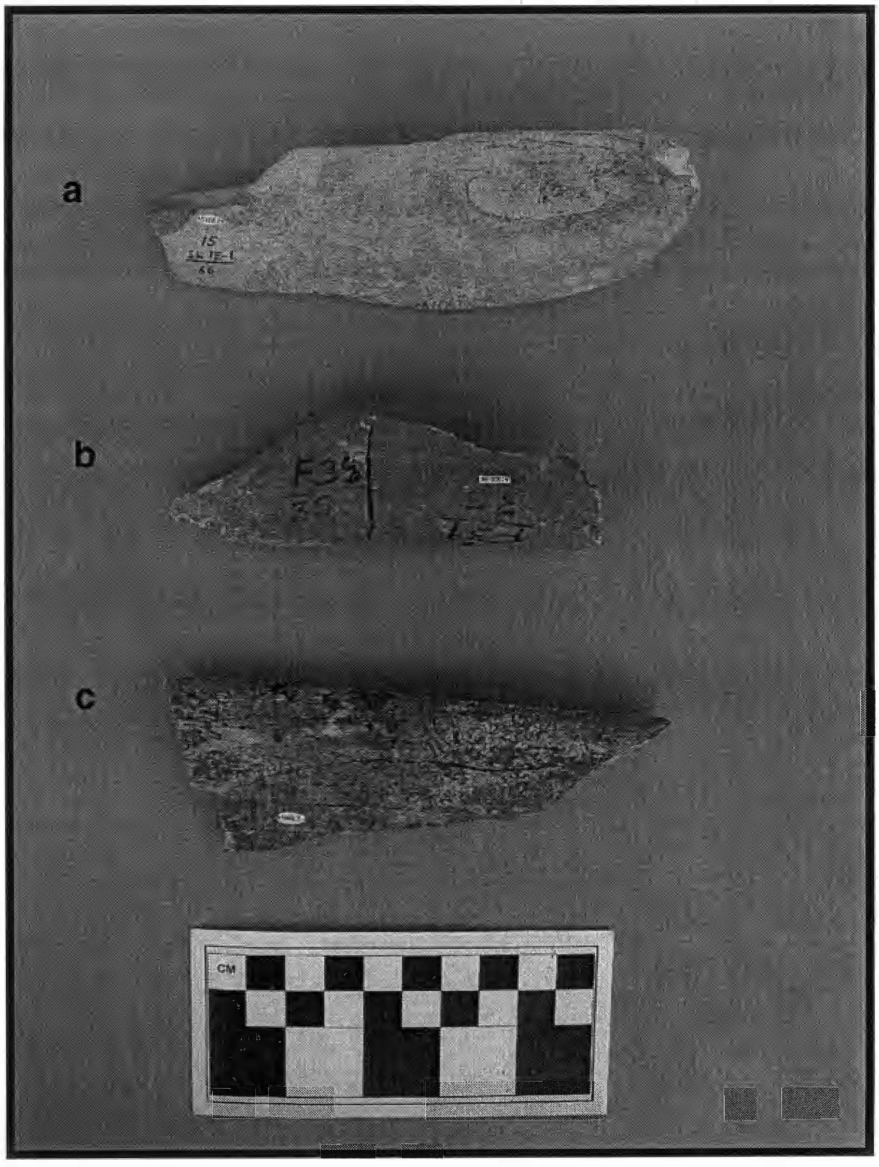


Figure 5.11. Possible bone tools, Frazier site.

surface. A series of small, parallel indentations along the green break edge may be cut marks, although they may also be rodent gnawing.

Artifact number A1922.85 (Figure 5.11b): Posterior-medial tibia shaft fragment from unit F39 (length: 100mm; width:30mm). This specimen is broken into two pieces along a previously glued break. The specimen displays a green break at the proximal end and a fresh break along the distal, posterior edge. The proximal end comes to a point that exhibits evidence of use in the form of both flake scars and polish along the working edge.

Artifact number A1922.7 (Figure 5.11c): Tibia shaft fragment with no provenience (length: 125mm; width: 40mm). The specimen is a posterior shaft fragment with a green break along the distal edge. The break exhibits polish but it is difficult to determine if it is a result of human use or other taphonomic processes.

-CHAPTER SIX-

SUMMARY AND CONCLUSIONS

Interpreting the Frazier Site Bison Archaeofauna

The bison remains recovered from the Frazier site are consistent in size with *Bison antiquus* (McDonald 1981). The present analysis revealed that a minimum of 44 individuals are represented, which differs from Wormington's 1967 report of 50 individuals, as well as from her later report of 43 individuals (Wormington 1984, 1988). Sex ratio and tentative seasonality data suggest the remains are largely those of cows and immature animals who were killed sometime during the late winter or early spring.

Formation of the Frazier site faunal assemblage was likely shaped by both bone density and utility, which is not surprising given that a strong correlation exists between density and utility (Kreutzer 1996:116; Lyman 1985, 1992); the least dense elements tend to be of highest utility, therefore increasing the difficulty of distinguishing between human and non-human activity. The low frequency of vertebrae and ribs, as well as certain long bones, in the Frazier archaeofauna is assumed to be a result of density-mediated attrition and/or field discard. While these elements, particularly the ribs, represent some of the highest utility parts of a bison, they are also some of the least dense. Conversely, patterning observed in the skeletal element profiles suggests human selection is responsible for much of what is seen in the Frazier bison archaeofauna. Strong correlations between ratio MAU and total products utility, meat utility, and marrow utility suggest the Frazier site Paleoindians were targeting both meat (including intramuscular fat) and within-bone nutrient.

Interpreting the function of the Frazier site is complicated by the fact that, with the exception of the axial skeleton and tarsals, major skeletal elements (i.e., limb elements) exhibit approximately a 50% survivorship (Figure 6.1). This makes it difficult to ascertain whether the site represents an area *from which* limbs were removed, i.e., a kill site, or an area *to which* limbs were taken, i.e., a secondary-processing or habitation site. In general, if the Frazier site is a kill locale, it should contain a prevalence of low-utility elements and, consequently, exhibit a reverse utility curve and a significant, inverse rank-ordinal correlation between skeletal frequencies and utility values (Kreutzer 1996:112). In contrast, if the Frazier site is a secondary-processing locale, it should consist largely of high utility elements which, when plotted, produce a gourmet or bulk utility curve and a positive rank-ordinal correlation between utility and ratio MAU.

Skeletal part frequencies, bone modifications, and carcass utility suggest the Frazier site bison archaeofauna most closely resembles a kill locale. Several lines of evidence support this assertion. A strong inverse correlation between ratio MAUs and utility, along with the skeletal element profile, implies that selected, high-utility elements were removed from the site. Also, the presence of dense, non-nutritious skull fragments (e.g., petrous portions, an occipital fragment, and horn core fragments) indicates that at least five skulls were once present at the site, a phenomenon unexpected at secondary processing sites (Wheat 1972:102). On the other hand, the poor representation of skull fragments (MNE = 5) in relation to the MNI of 44, the scattered distribution of bone specimens and the low number of articulated carcass segments (which may be a result of post-depositional processes) are characteristics not expected at a kill locale. Nonetheless, the results of the

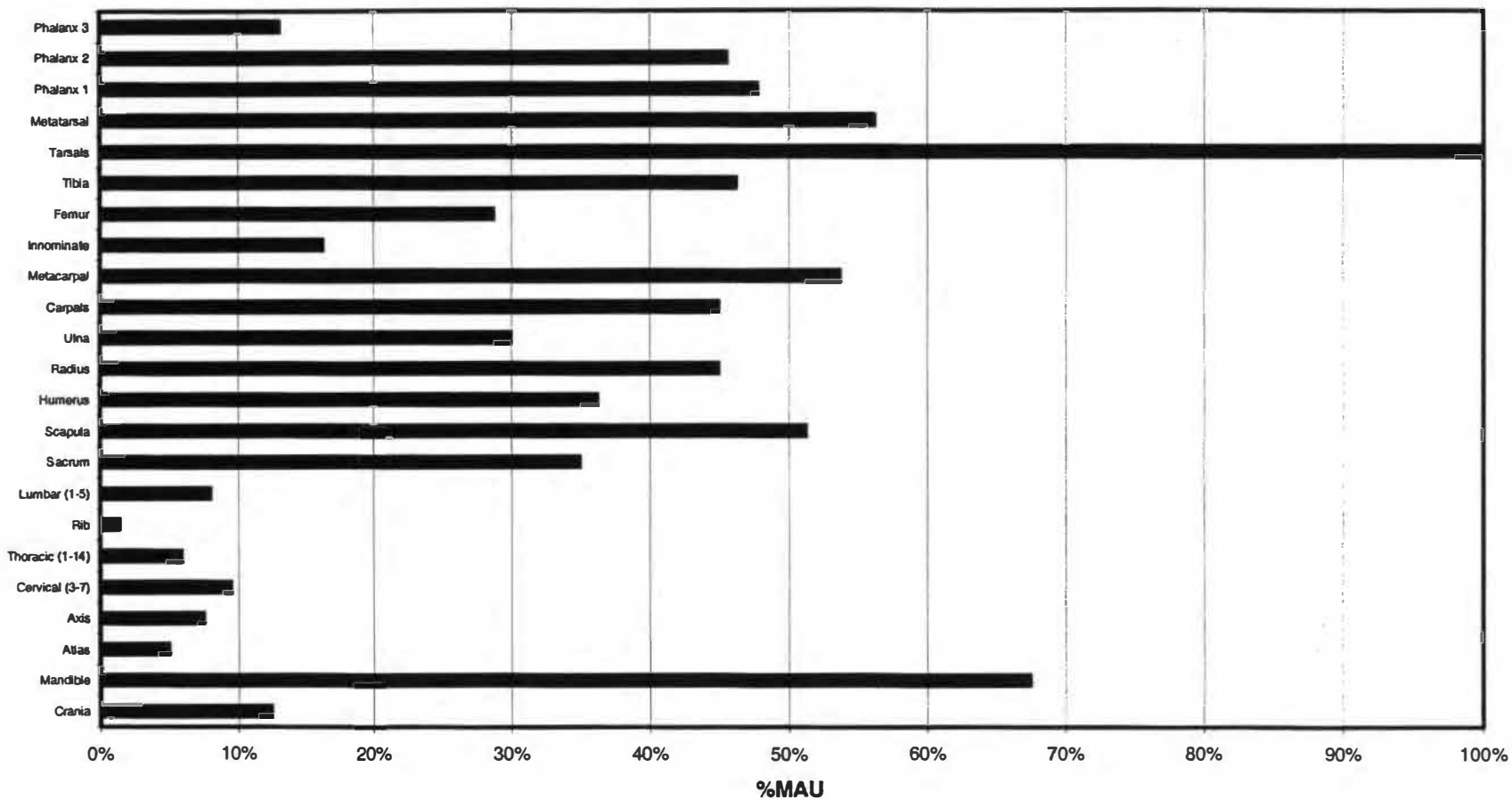


Figure 6.1. Equability of bison remains, Frazier site.

present study indicate that the Frazier site is most likely a processing area at or very near a kill locale.

Skeletal element profiles indicate forelimbs were transported as single units, which is not unexpected. Todd (1987b:259; 1991:224) notes that Paleoindian bison kill sites often reflect removal of complete or near-complete limb units rather than segmented parts. However, the inclusion of low-utility metacarpals contrasts with what is seen at other contemporary sites (e.g., the Agate Basin site), where the distal limbs appear to have been selectively discarded to presumably reduce transport costs (Hill 2001). At the Frazier site, the inclusion of metacarpals in transported limb units may be related to a number of things, including proximity to camp, non-food utility, or seasonal variation in carcass utility. Although no evidence of a campsite associated with the kill has been located, transport costs may not have been a main concern if the Frazier Paleoindians were camped nearby.

Metacarpals also may have been selectively removed from the site for reasons other than direct consumption. Historic and ethnographic accounts suggest that bison were sometimes hunted for specific, non-food reasons like hide procurement (Hornaday 1887; Roe 1972), and the industrial use of bone (e.g., the manufacture of bone tools) is well documented for prehistoric and historic times (Wheat 1972:102-103; Frison 1991; Frison and Craig 1982; Johnson 1982). In addition, Binford (1978:24) notes that the Nunamiut use caribou metapodial marrow as both a waterproofing agent and as a means of creating flexible bowstrings (Binford 1978:24). Obviously, if the Frazier Paleoindians removed metacarpals and other bones from the site for similar, non-food reasons, correlations between ratio MAUs and utility indices will not accurately reflect dietary contributions of specific skeletal elements.

Perhaps the strongest argument for the inclusion of metacarpals in forelimb transport packages relates to the tentative late winter-early spring seasonality assessment proposed by Todd, Hofman, and Wormington (1990). Research on carcass utility suggests that in times of nutritional stress, such as were likely faced by bison (as well as humans) during the late winter-early spring, bison undergo a systematic and predictable fat mobilization process (Emerson 1990; Speth 1983:103-106). As the final fat resource to be depleted, marrow may have provided Paleoindians with a much-needed fat supplement at a nutritionally stressful time of year. Important to the present argument is that marrow is exhausted from the top of the animal down, meaning that marrow in upper limb elements is mobilized before lower limb elements. Consequently, metapodials are among the last elements to be mobilized in the fat depletion sequence and would therefore supply an important source of fat during the late winter-early spring. Moreover, ethnographic accounts suggest that metapodial marrow may be more palatable than other limb bone marrow (Binford 1978:23-24). Binford (1978:23) notes that the Nunamiut Eskimo regard good marrow as that which "melts in your mouth." This characteristic is present in metapodial marrow, where a high oleic acid content results in an oily, runny consistency, as opposed to the solid consistency of other limb bone marrow.

In contrast to the forelimb, the hind limb skeletal profile is more difficult to explain. While the upper elements, i.e., the femur, tibia, and patella, appear to have been selectively removed from the Frazier site, interpretation of the lower elements is somewhat problematic. Survivorship of the lower hind limb elements is highly variable. The high representation of astragali and the fact that they represent one of the most common elements with butchery evidence suggests that lower hind limbs were disarticulated from tibiae at the site. This being the case, the low frequency of

metatarsals in relation to tarsals, especially the astragali, is difficult to interpret. Carnivore activity offers one explanation but the similar frequencies of the metacarpal and metatarsal indicate this is not a strong possibility. Instead, the bones suggest that the Frazier Paleoindians disarticulated the lower hind limb, discarded the tarsals and transported the metatarsals off-site, likely for the same reasons the metacarpals were selectively removed. Why the hind limb was treated differently from the forelimb, i.e., partially disarticulated prior to transport, is a question that cannot currently be answered. For example, while the forelimb is fairly easy to disarticulate, personal experience with cow (*Bos taurus*) carcasses has shown that tight articulations coupled with thick tendons inhibit easy separation of the bones and make disarticulating the tibia-tarsal-metatarsal area very frustrating.

On the other hand, the high frequency of astragali may be the result of selective field collection. Records indicate that the astragali provided the minimum number of individuals for both the 1966 and 1967 field seasons (Wormington 1966b, 1967b). Their noted importance during the 1966 excavations as an indicator of the number of bison present at the site may have resulted in a conscious effort to collect as many astragali as possible during the 1967 season, thus resulting in an inflated MNI number.

In conclusion, it appears the procurement of meat was a main objective of the Frazier Paleoindians. While only a limited amount of bone breakage appears to have occurred on-site (presumably for marrow "snacking"), the removal of roughly half of all limb elements suggests marrow was also an important resource (Brink 2001:257). The consideration of meat and marrow utility alone does not adequately explain the low frequency of metapodials at the Frazier site. In general, metapodials are considered low-utility elements as they provide virtually no meat and very little

marrow. However, as bison undergo nutritional stress and begin utilizing their fat reserves (e.g., during the winter months), the relative utility of individual skeletal parts shifts and metapodials increase in utility (Emerson 1990:Appendix C, Table 3). Consequently, while the transport of upper limb elements suggests they were not completely devoid of within-bone nutrient at the time of site occupation, the selection of metacarpals indicates the bison were not in prime nutritional condition.

The Frazier site versus the Agate Basin site

As discussed in Chapter 2, current understanding of the Agate Basin Cultural Complex relies heavily on information retrieved from two archaeological sites: Hell Gap, a campsite (Irwin-Williams et al. 1973), and Agate Basin, a kill locale (Frison and Stanford 1982; Hill 2001). The addition of the Frazier site faunal analysis therefore represents a major contribution to existing knowledge about the complex and now allows for direct comparison between two Agate Basin-age bison kill-butchery sites.

A comparison of skeletal element profiles from the Frazier site and the Agate Basin (AB) level of the Agate Basin site suggests that similar carcass processing decisions were made at both sites (Figure 6.2). In fact, with the exception of the metacarpal and metatarsal, which occur less frequently in the Frazier site assemblage, the element profiles from each site are virtually identical. Both sites exhibit similar axial element representation (Figure 5.5), which may be a result of field discard. Similarly, closer examination of the forelimb and hind limb profiles from both sites reveals that most elements, including some small carpals and tarsals, are present in near identical frequencies (Figure 6.3a-b). Again, poor representation of selected carpals and tarsals may be the result of field collection procedures.

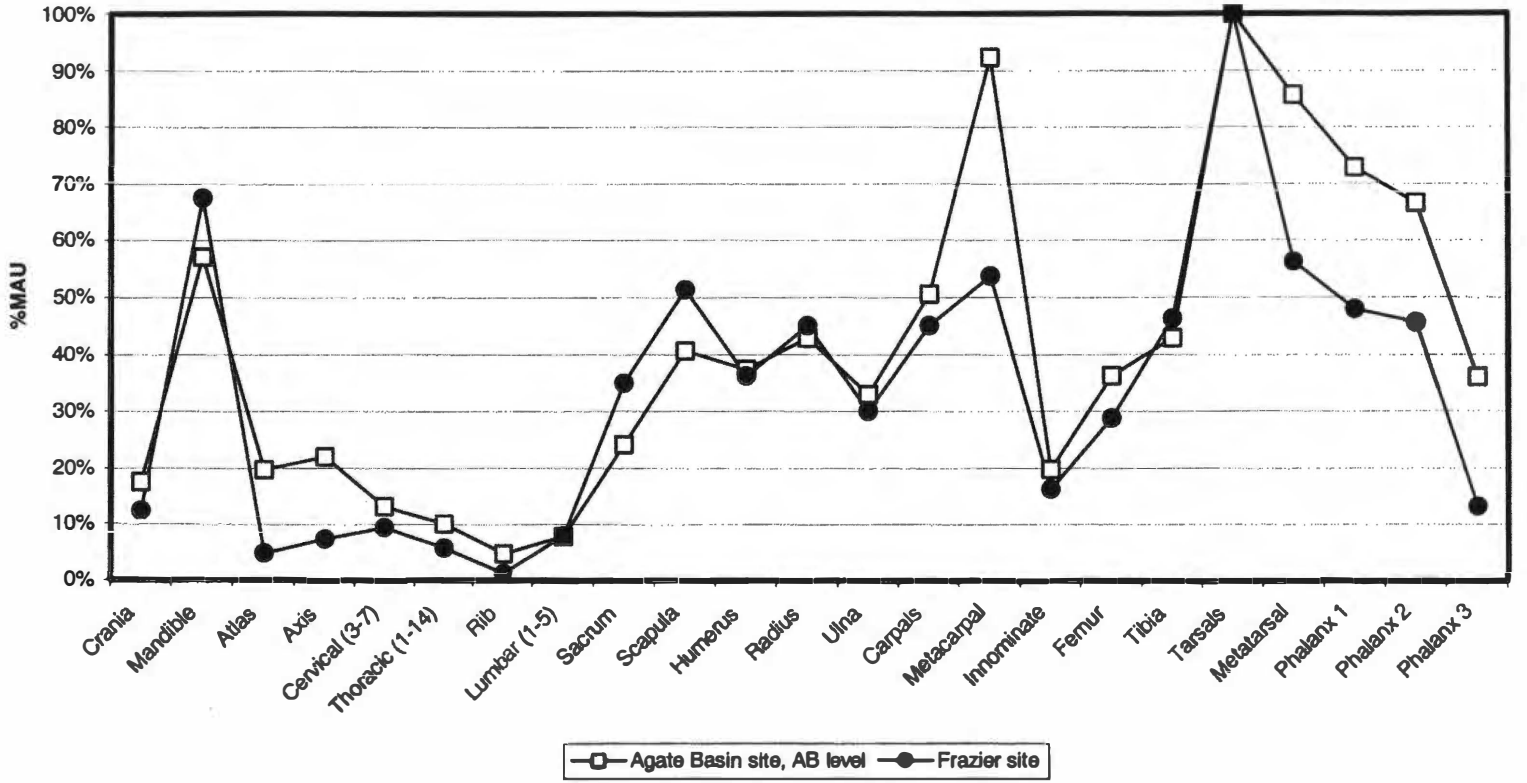
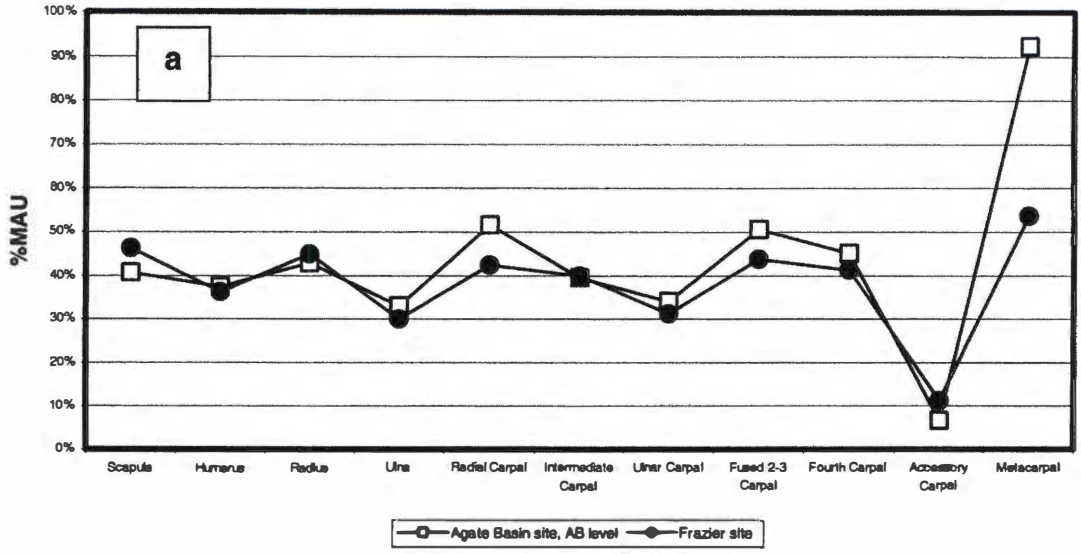


Figure 6.2. Bison skeletal element profiles for Frazier site and Agate Basin site, Agate Basin (AB) level (Hill 2001:Table 3.21).



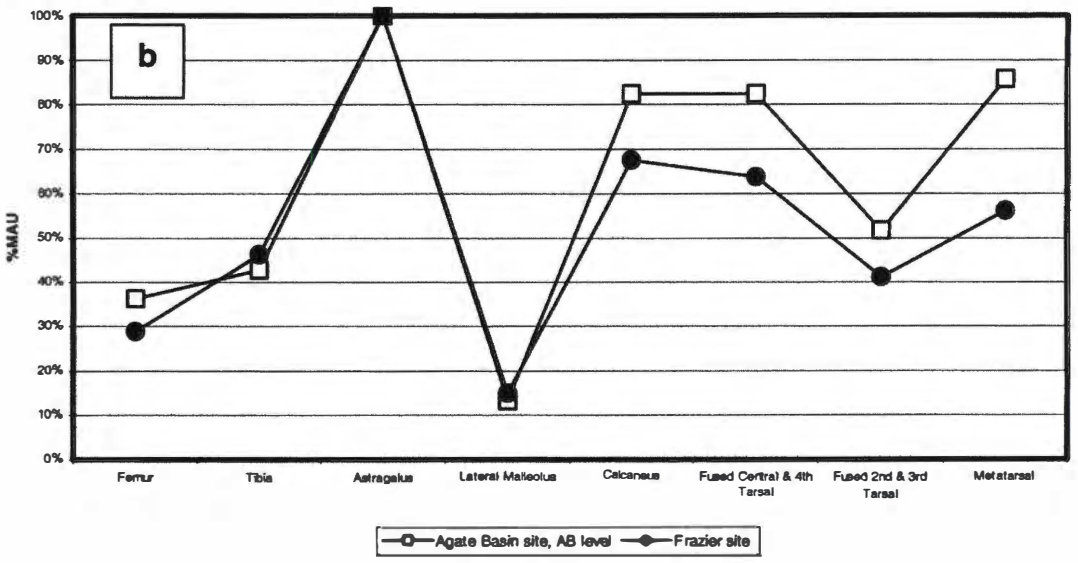


Figure 6.3. Bison forelimb (a) and hind limb (b) skeletal element profiles for the Frazier site and the Agate Basin site, Agate Basin level (Hill 2001:Table 3.21).

While the similarity between skeletal element profiles from the Frazier site and the AB level of the Agate Basin site is striking, differences in metapodial representation indicate that the Frazier Paleoindians were confronted with a different procurement situation, perhaps as a consequence of the season of site occupation.

Conclusions

Current models of Paleoindian subsistence behavior suggest that increasing seasonality during the late Pleistocene-early Holocene resulted in diachronic changes in resource utilization (Greiser 1985; Hill 2001; Todd 1991). High Plains bison kill-butchery sites in particular exhibit evidence of increasing intensity of carcass utilization by both humans and carnivores through the post-Clovis Paleoindian Period (Hill 2001). It is proposed that as climates shifted toward greater seasonal variability, plant productivity (i.e., growing seasons) was reduced and, consequently, bison (and other herbivores) were faced with increasing nutritional stress during the colder months of the year.

Interestingly, seasonality assessments for cold-season Paleoindian bison kill-butchery sites most frequently place site occupation during the late fall-early winter, while late winter-early spring assessments are rare (Todd 1991:Table 11.1). Data from the AB level of the Agate Basin site, a cold-season kill-butchery locale, indicate that bison *were not* nutritionally stressed at the time the site was occupied (late fall-early winter). Conversely, data from the Frazier site, which was occupied during the late winter-early spring, suggests that bison *were* nutritionally stressed and that humans responded to this by selecting elements that might otherwise be considered low utility. Therefore, deviations between skeletal element profiles from the Agate Basin site and the Frazier site, i.e., the inclusion of metacarpals in forelimb transport

packages, may be a result of the Frazier site's occupation later in the cold season. Support for this idea is offered by Todd's (1991:Figure 11.5c) model of bison fat availability, which indicates that even with the relaxed seasonal extremes of the late Pleistocene/early Holocene period bison were the most fat-depleted during the late winter-early spring (February-April).

While the hunting of bison during the Paleoindian Period appears to have occurred throughout the year, data from the Frazier site and the AB level of the Agate Basin site suggest that humans, in an effort to obtain fat resources, adapted their processing behaviors as a result of the season and the extent to which bison were fat-depleted at the time of the kill (Todd 1991). As such, the idea that Paleoindians, and specifically Paleoindians during the Agate Basin Period, practiced a "'fat-indifferent' winter use of animals" (Todd 1991:218) does not appear accurate. While the degree of processing at Paleoindian kill sites is markedly less than at later kill sites, such behavior does not mean Paleoindians were disinterested in bones as a food resource. In fact, the mere inclusion of bones in the transport packages (as opposed to simply stripping the meat and leaving the bones behind) supports the notion that they were interested in exploiting within-bone nutrients. However, it appears that Paleoindians preferred to remove carcass segments from kill sites for more intensive processing elsewhere. Concerning Agate Basin peoples, support for this idea is offered by the Hell Gap Locality II Agate Basin component (Byers 2001). As a campsite, Hell Gap complements both the Frazier site and the AB level of the Agate Basin site. The limited evidence for on-site carcass processing, i.e., marrow removal, at Frazier and Agate Basin may be explained by the patterning in skeletal element abundance at the Hell Gap site, where upper limb packages appear to have been regularly transported for subsequent marrow processing (Figure 6.4).

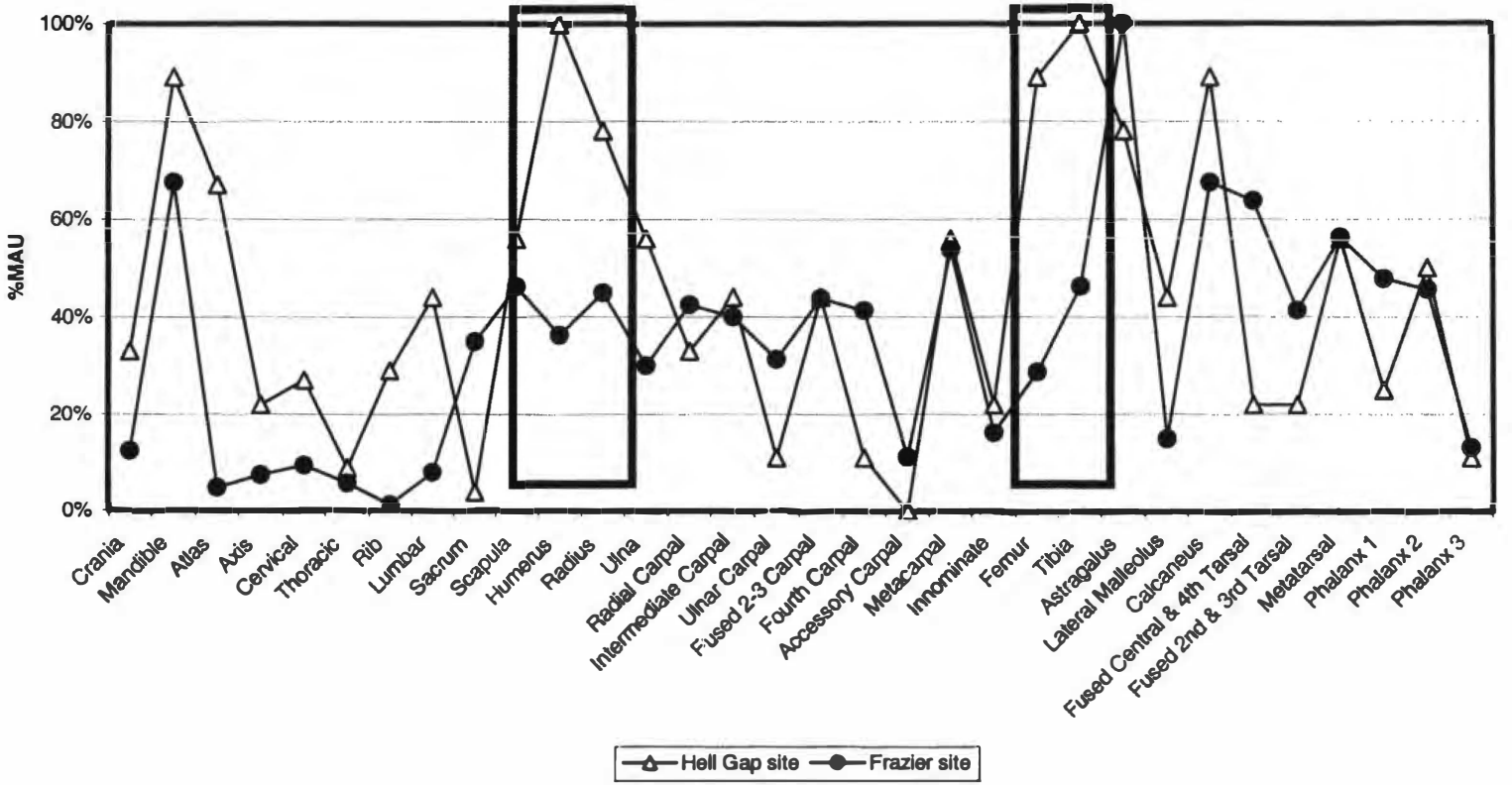


Figure 6.4. Bison skeletal element profiles for the Frazier site and the Hell Gap Locality II Agate Basin level (Byers 2001:Table 3.1). [Note: upper limb element frequencies are highlighted to illustrate differences in skeletal element abundance at a kill site (Frazier) versus a campsite (Hell Gap)].

As is evident from this and other recent faunal analyses, curated collections provide an invaluable source of information about prehistoric human subsistence. This is particularly true on the High Plains, where several important Paleoindian sites were excavated decades ago. While many of these sites were thoroughly analyzed and written up shortly after excavation, the Frazier site never received an in-depth analysis. As the only single-component, Agate Basin-age archaeological site excavated to date, its addition to the Paleoindian literature represents a major contribution and hopefully encourages other researchers to take advantage of the plethora of curated collections available in archaeological repositories. Though not without limitations, such collections will undoubtedly continue to offer important information as methods for extracting information become more refined.

LIST OF REFERENCES

LIST OF REFERENCES

Agenbroad, L.
1989 Spiral Fracured Mammoth Bone from Nonhuman Taphonomic Processes at Hot Springs Mammoth Site. In *Bone Modification*, edited by R. Bonnichsen and M. H. Sorg, pp. 139-147. Center for the Study of the First Americans, Orono, Maine.

Agogino, G. A., and W. D. Frankforter
1960 The Brewster Site: An Agate Basin-Folsom Multiple Component Site in Eastern Wyoming. *National Geographic Society Research Reports, 1961-1962 Projects*:1-6.

Allen, J. A.
1876 *The American Bisons, Living and Extinct*. Memoirs of the Museum of Comparative Zoology, Vol. 4, No. 10. Harvard University Press, Cambridge.

Bamforth, D. B.
1988 *Ecology and Human Organization on the Great Plains*. Plenum Press, New York.

Bass, W. M.
1970 Excavations at the Paleo-Indian Site at Agate Basin, Wyoming. *National Geographic Society Research Reports, 1961-1962 Projects*:21-25.

Bedord, J. N.
1974 Morphological Variation in Bison Metacarpals and Metatarsals. In *The Casper Site: a Hell Gap Bison Kill on the High Plains*, edited by G. C. Frison, pp. 199-240. Academic Press, New York.
1978 A Technique for Determination of Mature Bison Metapodials. In *Bison Procurement and Utilization: A Symposium*, edited by L. B. Davis and M. Wilson, pp. 40-43. Plains Anthropologist Memoir 14. Lincoln, Nebraska.

Behrensmeyer, A. K.
1975 The Taphonomy and Paleoecology of Plio-Pleistocene Vertebrate Assemblages East of Lake Rudolf, Kenya. *Bulletin of the Museum of Comparative Zoology* 146:473-578.

Bement, L. C., and S. Basmajian
1996 Epiphyseal Fusion in *Bison antiquus*. *Current Research in the Pleistocene* 13:95-97.

Berger, J., and C. Cunningham
1994 *Bison: Mating and Conservation in Small Populations*. Columbia University Press, New York.

Binford, L. R.
1978 *Nunamiut Ethnoarchaeology*. Academic Press, New York.
1981 *Bones: Ancient Men and Modern Myths*. Academic Press, New York.

1984 *Faunal Remains from the Klasies River Mouth.* Academic Press, New York.

Binford, L. R., and J. Bertram
1977 Bone Frequencies – And Attritional Processes. In *For Theory Building in Archaeology: Essays on Faunal Remains, Aquatic Resources, Spatial Analysis, and Systemic Modeling*, edited by L. R. Binford, pp. 77-153. Academic Press, New York.

Binford, L. R., M. G. L. Mills, and N. M. Stone
1988 Hyena Scavenging Behavior and Its Implications for the Interpretation of Faunal Assemblages from FLK 22 (the Zinj Floor) at Olduvai Gorge. *Journal of Anthropological Archaeology* 7:99-135.

Blumenschine, R. J.
1988 An Experimental Model of the Timing of Hominid and Carnivore Influence on Archaeological Bone Assemblages. *Journal of Archaeological Science* 15:483-502.

Blumenschine, R. J., and T. C. Madrigal
1993 Variability in Long Bone Marrow Yields of East African Ungulates and Its Zooarchaeological Implications. *Journal of Archaeological Science* 20:555-587.

Blumenschine, R. J., and C. W. Marean
1993 A Carnivore's View of Archaeological Assemblages. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. Hudson, pp. 273-300. Center for Archaeological Investigations, Southern Illinois University, Occasional Paper No. 21. Carbondale.

Bonnichsen, R.
1979 Pleistocene Bone Technology in the Beringian Refugium. National Museum of Man Mercury Series, *Archaeological Survey of Canada Paper* 89:1-280.

Borrero, L.
1990 Fuego-Patagonian Bone Assemblages and the Problem of Communal Guanaco Hunting. In *Hunters of the Recent Past*, edited by L. B. Davis and B. O. K. Reeves, pp. 373-399. Unwin Hyman, London.

Brain, C. K.
1967 Hottentot Food Remains and their Bearing on the Interpretation of Fossil Bone Assemblages. *Scientific Papers of the Namib Desert Research Station* 32:1-7.
1969 The Contribution of Namib Desert Hottentots to an Understanding of Australopithecine Bone Accumulations. *Scientific Papers of the Namib Desert Research Station* 39:13-22.

Brink, J. W.
2001 Carcass Utility Indices and Bison Bones from the Wardell Kill and Butchering Sites. In *People and Wildlife in Northern North America: Essays in Honor of R. Dale Guthrie*, pp.255-274. BAR International Series 944. British Archaeological Reports, Oxford.

Brunswig, R. H., Jr.
1992 Paleoindian Environments and Paleoclimates in the High Plains and Central Rocky Mountains. *Southwestern Lore* 58:5-23.

Burt, W. H., and R. P. Grossenheider
1980 A Field Guide to the Mammals, North America north of Mexico. 3rd ed. The Peterson Field Guide Series 5. Houghton Mifflin, New York.

Byers, D. A.
2001 The Hell Gap Locality II Agate Basin Faunal Assemblage: A Study of Paleoindian Faunal Resource Exploitation. Unpublished Master's thesis, Department of Anthropology, University of Wyoming, Laramie.

Cassells, E. S.
1983 *The Archaeology of Colorado*. Johnson Publishing Company, Boulder, Colorado.
1997 *The Archaeology of Colorado* (revised). Johnson Publishing Company, Boulder, Colorado.

Chambers, A. L.
1992 Seal Bone Mineral Density: Its Effects on Specimen Survival in Archaeological Sites. Unpublished Honors thesis, Department of Anthropology, University of Missouri, Columbia.

Cuvier, G.
1825 *Recherches sur les ossemens fossils*, 3rd edition. Dufouret d'Ocagne, Paris.

Duffield, L. F.
1973 Ageing and Sexing the Post-Cranial Skeleton of Bison. *Plains Anthropologist* 18:132-139.

Eidlen, D.
1993 My Denver Museum of Natural History Archaeology Internship: the Inventory, Examination and Rehousing of the Faunal Material from the Frazier Site. Manuscript on file, Denver Museum of Natural History archives, Denver, Colorado.

Elkin, D. C., and J. R. Zanchetta
1991 Densitometria osea de camélidos – aplicaciones arqueológicas. *Actas del X Congreso Nacional de Arqueologia Argentina* 3:195-204. Catamarca.

Emerson, A. M.
1990 Archaeological Implications of Variability in the Economic Anatomy of *Bison bison*. Ph.D. dissertation, Washington State University, Pullman. University Microfilms, Ann Arbor.

1993 The Role of Body Part Utility in Small-Scale Hunting Under Two Strategies of Carcass Recovery. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. Hudson, pp. 138-155. Center for Archaeological Investigations, Southern Illinois University, Occasional Paper No. 21. Carbondale.

Empel, W.
1962 Morphologie der Schädels von *Bison bonasus* (Linnaeus 1758). *Acta Theriologica* 6:53-110.

Empel, W., and T. Roskosz
1963 Das Skelett der Gliedmassen des Wisents, *Bison bonasus* (Linnaeus, 1758). *Acta Theriologica* 7:259-300.

Fishel, R. L.
1988 Preliminary Observations on the Distribution of Agate Basin Projectile Points East of the Mississippi River. *Wisconsin Archeologist* 70:125-138.

Fisher, J. W.
1995 Bone Surface Modifications in Zooarchaeology. *Journal of Archaeological Method and Theory* 2:7-68.

Frick, C.
1937 Horned Ruminents of North America. *Bulletin of the American Museum of Natural History* 69:1-669.

Frison, G. C.
1970 *The Glenrock Buffalo Jump, 48CO304*. Plains Anthropologist Memoir 7. Lincoln, Nebraska.
1973 *The Wardell Buffalo Trap, 48SU301: Communal Procurement in the Upper Green River Basin, Wyoming*. Anthropological Papers No. 48. Museum of Anthropology, University of Michigan, Ann Arbor.
1974 *The Casper Site: A Hell Gap Bison Kill on the High Plains* (editor). Academic Press, New York.
1978 *Prehistoric Hunters of the High Plains*. Academic Press, San Diego.
1982a Bison Dentition Studies. In *The Agate Basin Site: A Record of the Paleoindian Occupation of the Northwestern High Plains*, edited by G. C. Frison and D. J. Stanford, pp. 240-260. Academic Press, New York.
1982b Paleoindian Winter Subsistence on the High Plains. In *Plains Indian Studies: A Collection of Essays in Honor of John C. Ewers and Waldo R. Wedel*, edited by D. H. Ubelaker and H. J. Viola, pp. 193-201. Smithsonian Contributions to Anthropology Number 30. Smithsonian Institution, Washington, D.C.

1984 The Carter/Kerr-McGee Paleoindian Site: Cultural Resource Management and Archaeological Research. *American Antiquity* 49:288-314.
1988 Paleoindian Subsistence and Settlement During Post-Clovis Times on the Northwestern Plains, the Adjacent Mountain Ranges, and Intermontane Basins. In *Americans Before Columbus: Ice-Age Origins*, edited by R. C. Carlisle, pp. 83-106. Ethnology Monographs 12, Department of Anthropology, University of Pittsburgh, Pennsylvania.
1991 *Prehistoric Hunters of the High Plains*. 2nd ed.. Academic Press, San Diego.
1996 *The Mill Iron Site* (editor). University of New Mexico Press, Albuquerque.

Frison, G. C., and C. Craig
1982 Bone, Antler, and Ivory Artifacts and Manufacture Technology. In *The Agate Basin Site: A Record of the Paleoindian Occupation of the Northwestern High Plains*, edited by G. C. Frison and D. J. Stanford, pp. 157-173. Academic Press, New York.

Frison, G. C., and C. A. Reher
1970 Appendix I: Age Determination of Buffalo by Teeth Eruption and Wear. In *The Glenrock Buffalo Jump, 48CO304: Late Prehistoric Period Buffalo Procurement and Butchering on the Northwestern Plains*, by G. C. Frison, pp. 46-47. Plains Anthropologist Memoir 7. Lincoln, Nebraska.

Frison, G. C., and D. J. Stanford (editors)
1982 *The Agate Basin Site: A Record of the Paleoindian Occupation of the Northwestern High Plains*. Academic Press, New York.

Frison, G. C., and L. C. Todd (editors)
1987 *The Horner Site: The Type Site of the Cody Cultural Complex*. Academic Press, Orlando.

Frison, G. C., M. C. Wilson, and D. N. Walker
1978 *The Big Goose Creek Site: Bison Procurement and Faunal Analysis*. Occasional Papers on Wyoming Archaeology, No. 1. Laramie.

Frison, G. C., M. C. Wilson, and D. J. Wilson
1976 Fossil Bison and Artifacts from an Early Altithermal Period Arroyo Trap in Wyoming. *American Antiquity* 41:28-57.

Gifford, D. P., and D. C. Crader
1977 A Computer Coding System for Archaeological Faunal Remains. *American Antiquity* 42:225-238.

Gilmore, K. P., M. Tate, M. L.. Chenault, B. Clark, T. McBride, and M. Wood
1999 *Colorado Prehistory: A Context for the Platte River Basin*. Colorado Council of Professional Archaeologists, Denver, Colorado.

Gonalons, G. L. M.
1991 La llama y sus productos primaries. *Arqueologia* 1:179-196.

Grant, A.
1982 The Use of Tooth Wear as a Guide to the Age of Domestic Ungulates. In *Ageing and Sexing Animal Bones from Archaeological Sites*, edited by B. Wilson, C. Grigson, and S. Payne, pp. 91-108. BAR British Series Report 109. British Archaeological Reports, Oxford.

Greiser, S. T.
1985 *Predictive Models of Hunter-Gatherer Subsistence and Settlement Strategies on the Central High Plains.* Plains Anthropologist Memoir 20. Lincoln, Nebraska.

Guthrie, R. D.
1984 Mosaics, Allelochemics, and Nutrients: An Ecological Theory of Late Pleistocene Megafaunal Extinctions. In *Quaternary Extinctions*, edited by P. S. Martin and R. G. Klein, pp. 259-298. University of Arizona Press, Tucson.

Haynes, C. V., and H. Haas
1974 Southern Methodist Radiocarbon Date List I. *Radiocarbon* 16:368-380.

Haynes, G. A.
1980a Prey Bones and Predators: Potential Ecologic Information from Analysis of Bone Sites. *Ossa* 7:75-97.
1980b Evidence of Carnivore Gnawing on Pleistocene and Recent Mammalian Bones. *Paleobiology* 6:41-351.
1981 Bone Modifications and Skeletal Disturbances by Natural Agencies: Studies in North America. Ph.D. dissertation, Catholic University of America, Washington, D.C. University Microfilms, Ann Arbor.
1982 Utilization and Skeletal Disturbances of North American Prey Carcasses. *Arctic* 35:266-281.
1983a A Guide for Differentiating Mammalian Carnivore Taxa Responsible for Gnaw Damage to Herbivore Limb Bones. *Paleobiology* 9:164-172.
1983b Frequencies of Spiral and Green-Bone Fractures on Ungulate Limb Bones in Modern Surface Assemblages. *American Antiquity* 48:102-114.

Hill, A.
1989 Bone Modification by Modern Spotted Hyenas. In *Bone Modification*, edited by R. Bonnichsen and M. H. Sorg, pp. 169-178. Center for the Study of the First Americans, Orono, Maine.

Hill, M. G.
1996 Appendix 3: Size Comparison of the Mill Iron Site Bison Calcanea. In *The Mill Iron Site*, edited by G. C. Frison, pp. 231-237. University of New Mexico Press, Albuquerque.
2001 Paleoindian Diet and Subsistence Behavior of the Northwestern Great Plains of North America. Unpublished Ph.D. dissertation, Department of Anthropology, University of Wisconsin, Madison.

Hill, M. G., D. S. Amick, and T. J. Loebel
1998 An Inventory of Wisconsin Paleoindian Projectile Points at the Milwaukee Public Museum. *Current Research in the Pleistocene* 15:18-20.

Hornaday, W. T.
1889 The Extermination of the American Bison, with a Sketch of Its Discovery and Life History. *Annual Report (1887), Smithsonian Institution*:367-548.

Hughes, S. S.
1978 Bison Diminution on the Great Plains. *Wyoming Contributions to Anthropology* 1:18-47.

Irwin-Williams, C., H. Irwin, G. Agogino, and C. V. Haynes
1973 Hell Gap: Paleo-Indian Occupation on the High Plains. *Plains Anthropologist* 18:40-53.

Jacobson, J. A.
2000 White-Tailed Deer Utility Indices: Development and Application of an Analytical Method. Unpublished Master's thesis, Department of Anthropology, University of Tennessee, Knoxville.

Jodry, M. A., and D. J. Stanford
1992 Stewart's Cattle Guard Site: An Analysis of Bison Remains in a Folsom Kill-Butchery Campsite. In *Ice Age Hunters of the Rockies*, edited by D. J. Stanford and J. S. Day, pp. 101-168. University of Colorado Press, Niwot.

Johnson, E.
1978 Paleo-Indian Bison Procurement and Butchering Patterns on the Llano Estacado. In *Bison Procurement and Utilization: A Symposium*, edited by L. B. Davis and M. Wilson, pp. 98-105. Plains Anthropologist Memoir 14. Lincoln, Nebraska.
1982 Paleo-Indian Bone Expediency Tools: Lubbock Lake and Bonfire Shelter. *Canadian Journal of Anthropology* 2:145-157.
1985 Current Developments in Bone Technology. In *Advances in Archaeological Method and Theory*, Vol. 8, edited by M. B. Schiffer, pp. 157-235. Academic Press, Orlando.
1989 Human-Modified Bones from Early Southern Plains Sites. In *Bone Modification*, edited by R. Bonnichsen and M. H. Sorg, pp. 431-471. Center for the Study of the First Americans, Orono, Maine.

Jones, K. T., and D. Metcalfe
1988 Bare Bones Archaeology: Bone Marrow Indices and Efficiency. *Journal of Archaeological Science* 15:415-423.

Justice, N. D.
1987 *Stone Age Spear and Arrow Points of the Midcontinental and Eastern United States*. Indiana University Press, Bloomington.

Kelly, R. L., and L. C. Todd
1988 Coming Into the Country: Early Paleoindian Hunting and Mobility. *American Antiquity* 53:231-244.

Kent, S.
1981 The Dog: An Archaeologist's Best Friend or Worst Enemy – the Spatial Distribution of Faunal Remains. *Journal of Field Archaeology* 8:367-372.

Klein, R. G., and K. Cruz-Uribe
1984 *The Analysis of Animal Bones from Archaeological Sites.* University of Chicago Press, Chicago.

Knight, C.
1849 *Sketches in Natural History: History of the Mammalia*. C. Cox, London.

Koch, W.
1935 The Age Order of Epiphyseal Union in the Skeleton of the European Bison (*Bos bonasus* L.). *The Anatomical Record* 61:371-376.

Kooyman, B, and D. Sandgathe
2001 Sexually Dimorphic Size Variation in Holocene *Bison* as Revealed by Carpals and Tarsals. In *People and Wildlife in Northern North America: Essays in Honor of R. Dale Guthrie*, edited by S. C. Gerlach and M. S. Murray, pp. 67-78. BAR International Series 944. British Archaeological Reports, Oxford.

Kreutzer, L. A.
1992 Bison and Deer Bone Mineral Densities: Comparisons and Implications for the Interpretation of Archaeolgical Faunas. *Journal of Archaeological Science* 19:271-294.
1996 Taphonomy of the Mill Iron Bison Bonebed. In *The Mill Iron Site*, edited by G. C. Frison, pp. 101-143. University of New Mexico Press, Albuquerque.

Krysiak, K., and K. Swiezynski
1967 The Present State of Research on the Morphology of the European Bison. *Acta Theriologica* 12:339-348.

Leidy, J.
1852 *Memoir on the Extinct Species of Ox*. Smithsonian Contributions to Knowledge, Vol. 5, Article 3.

Lewis, G. E.
1966 Report on the Bones at the Frazier Site. In Report on the 1966 Investigations at the Frazier Site, Weld County, Colorado, National Science Foundation Grant GS 1252, by H. M. Wormington, pp. 3-4. Document on file, Denver Museum of Nature and Science archives, Denver, Colorado.
1968 Report on Referred Fossils. Document on file, Denver Museum of Nature and Science archives, Denver, Colorado.

Linnaeus, C.
1758 *Systema Naturae per Regna Tria Naturae, Secundum Classes, Ordines, Genera, Species, cum Characteribus, Differentiis, Synonymis, Locis.* 10th ed. Laurentii Salvii, Stockholm.

Lucas, F. A.
1899 The Fossil Bison of North America. *Proceedings of the United States National Museum* 21:755-771.

Lyman, R. L.
1982 The Taphonomy of Vertebrate Archaeofaunas: Bone Density and Differential Survivorship of Fossil Classes. Unpublished Ph.D. dissertation, University of Washington, Seattle.
1984 Bone Density and Differential Survivorship of Fossil Classes. *Journal of Anthropological Archaeology* 3: 259-299.
1985 Bone Frequencies: Differential Transport, *in situ* Destruction, and the MGUI. *Journal of Archaeological Science* 12:221-236.
1992 Anatomical Considerations of Utility Curves in Zooarchaeology. *Journal of Archaeological Science* 19:7-22.
1994 *Vertebrate Taphonomy.* Cambridge University Press, Cambridge.

Lyman, R. L., L. E. Houghton, and A. L. Chambers
1992a The Effect of Structural Density on Marmot Skeletal Part Representation in Archaeological Sites. *Journal of Archaeological Science* 19:557-573.

Lyman, R. L., J. M. Savelle, and P. Whitridge
1992b Derivation and Application of a Meat Utility Index for Phocid Seals. *Journal of Archaeological Science* 19:531-555.

McCartney, P. H.
1983 An Archaeological Analysis of Bison Remains from the Cody Paleo-Indian Site of Lamb Spring, Colorado. Unpublished Master's thesis, Department of Anthropology, University of Arizona, Tucson.
1990 Alternative Hunting Strategies in Plains Paleoindian Adaptations. In *Hunters of the Recent Past*, edited by L. B. Davis and B. O. K. Reeves, pp. 111-121. Unwin Hyman, London.

McDonald, J. N.
1981 *North American Bison: Their Classification and Evolution.* University of California Press, Berkeley.

McFaul, M., K. L. Traugh, G. D. Smith, W. Doering, C. J. Zier
1994 Geoarchaeological Analysis of South Platte River Terraces: Kersey, Colorado. *Geoarchaeology* 9:345-374.

McHugh, T.
1958 Social Behavior of the American Buffalo (*Bison bison bison*). *Zoologica* 43:1-40.

Madrigal, T. C.
1999 Zooarchaeology and Taphonomy of Late Archaic Hunter-Gatherer Complexity in Central New York. Unpublished Ph.D. dissertation, Department of Anthropology, Rutgers, New Brunswick.

Madrigal, T. C., and S. D. Capaldo
1999 White-tailed Deer Marrow Yields and Late Archaic Hunter-Gatherers. *Journal of Archaeological Science* 26:241-250.

Main, M. B., and R. Owens
1995 Estimating Mule Deer Age from Measurements of Incisor Wear. *Northwestern Naturalist* 76:130-132.

Malde, H. E.
1966 Geology of the Frazier Site. In Report on the 1966 Investigations at the Frazier Site, Weld County, Colorado, National Science Foundation Grant GS 1252, by H. M. Wormington, pp. 4-6. Document in Denver Museum of Nature and Science Archives. Denver, Colorado.
1984 Geology of the Frazier Site, Kersey, Colorado. In *AMQUA Field Trip 2: Paleoindian Sites in the Colorado Piedmont, August 11-12*, pp. 13-16. University of Colorado, Boulder.

Marean, C. W., and L. M. Spencer
1991 Impact of Carnivore Ravaging on Zooarchaeological Measures of Element Abundance. *American Antiquity* 56:645-658.

Marean, C. W., L. M. Spencer, R. J. Blumenschine, and S. D. Capaldo
1992 Captive Hyaena Bone Choice and Destruction, the Schlepp Effect and Olduvai Archaeofaunas. *Journal of Archaeological Science* 19:101-121.

Martin, P. S.
1967 Prehistoric Overkill. In *Pleistocene Extinctions: The Search for a Cause*, edited by P. S. Martin and H. E. Wright, Jr., pp. 75-120. Yale University Press, New Haven.
1984 Prehistoric Overkill: The Global Model. In *Quaternary Extinctions: A Prehistoric Revolution*, edited by P. S. Martin and R. G. Klein, pp. 354-403. University of Arizona Press, Tucson.

Meltzer, D. J., L. C. Todd, and C. V. Haynes
2002 The Folsom (Paleoindian) Type Site: Past Investigations, Current Studies. *American Antiquity* 67:5-36.

Metcalfe, D., and K. T. Jones
1988 A Reconsideration of Animal Body-Part Utility Indices. *American Antiquity* 53:486-504.

Morlan, R. E.
1973 Spiral Fractures on Limb Bones: Which Ones are Artificial? In *Carnivores, Human Scavengers, and Predators: A Question of Bone Technology*, edited by G. M. LeMoine, pp. 241-269. The Archaeological Association of the University of Calgary.
1991 Bison Carpal and Tarsal Measurements: Bulls versus Cows and Calves. *Plains Anthropologist* 36:215-227.
1992 Appendix 2: Bison Size and Gender at the Gowan Sites. In *The Gowan Sites: Cultural Responses to Climatic Warming on the Northern Plains (7500-5000 B.P.)*, edited by E. G. Walker, pp. 203-208. Archaeological Survey of Canada Mercury Series Paper 145. Canadian Museum of Civilization, Ottawa.

O'Connell, J. F., and B. Marshall
1989 Analysis of Kangaroo Body Part Transport Among the Alyawara of Central Australia. *Journal of Archaeological Science* 16:393-405.

Outram, A., and P. Rowley-Conwy
1998 Meat and Marrow Utility Indices for Horse (*Equus*). *Journal of Archaeological Science* 25:839-850.

Payne, S.
1973 Kill-off Patterns in Sheep and Goats: The Mandibles from Asvan Kale. *Anatolian Studies* 23:281-303.
1987 Reference Codes for Wear States in the Mandibular Cheek Teeth of Sheep and Goats. *Journal of Archaeological Science* 14:609-614.

Peterson, R. R.
1977 Sexual and Morphological Characteristics of Bison Populations from Communal Kill Sites in and near Wyoming: Radiographic Analysis of the Metacarpals. Unpublished Master's thesis, Department of Anthropology, University of Wyoming, Laramie.

Peterson, R. R., and S. S. Hughes
1980 Appendix 2: Continuing Research in Bison Morphology and Herd Composition using Chronological Variation in Metapodials. In *The Vore Site, 48CK302: A Stratified Buffalo Jump in the Wyoming Black Hills*, edited by C. A. Reher and G. C. Frison, pp. 170-190. Plains Anthropologist Memoir 16. Lincoln, Nebraska.

Reher, C. E.
1970 Population Dynamics of the Glenrock *Bison bison* Population. In *The Glenrock Buffalo Jump, 48CO304: Late Prehistoric Period Buffalo Procurement and Butchering on the Northwestern Plains*, by G. C. Frison, pp. 51-55. Plains Anthropologist Memoir 7. Lincoln, Nebraska.
1973 Appendix II: The Wardell *Bison bison* Sample: Population Dynamics and Archaeological Interpretation. In *The Wardell Buffalo Trap 48SU301: Communal Procurement in the Upper Green River Basin, Wyoming*, by G. C. Frison, pp. 89-105. Anthropological Papers No. 48, Museum of Anthropology, University of Michigan, Ann Arbor.

1974 Population Study of the Casper Site Bison. In *The Casper Site: A Hell Gap Bison Kill on the High Plains*, edited by G. C. Frison, pp. 113-124. Academic Press, New York.

Reher, C. E., and G. C. Frison
1980 *The Vore Site, 48CK302: A Stratified Buffalo Jump in the Wyoming Black Hills*. Plains Anthropologist Memoir 16. Lincoln, Nebraska.

Reitz, E. J., and E. S. Wing
1999 *Zooarchaeology*. Cambridge University Press, Cambridge.

Roberts, F. H. H.
1943 A New Site. *American Antiquity* 8:100.
1961 1961 Excavations at Agate Basin, Wyoming. *Plains Anthropologist* 7:89-91.

Roe, F. G.
1970 *The North American Buffalo: a Critical Study of the Species in its Wild State*. 2nd ed. University of Toronto Press, Toronto.

Savelle, J. M., and T. M. Friesen
1996 An Odotocete (Cetecea) Meat Utility Index. *Journal of Archaeological Science* 23:713-722.

Savelle, J. M., T. M. Friesen, and R. L. Lyman
1996 Derivation and Application of an Otarrid Utility Index. *Journal of Archaeological Science* 23:705-712.

Schultz, C. B., and W. D. Frankforter
1946 The Geologic History of the Bison in the Great Plains (a preliminary report). *Transcriptions of the Nebraska Academy of Science* 4:103-116.

Shackleton, D. M., L. V. Hills, and D. A. Hutton
1975 Aspects of Variation in Cranial Characters of Plains Bison (*Bison bison bison* Linnaeus) from Elk Island National Park, Alberta. *Journal of Mammalogy* 56:871-887.

Silver, I. A.
1970 The Ageing of Domestic Animals. In *Science in Archaeology: A Comprehensive Survey of Progress and Research* (revised), edited by D. Brothwell and E. Higgs, pp. 283-302. Praeger Publishers, New York.

Sisson, S., and D. Grossman
1953 *The Anatomy of the Domestic Animals*. 4th ed. W. B. Saunders, Philadelphia.

Skinner, M. F., and O. C. Kaisen
1947 The Fossil Bison of Alaska and Preliminary Revision of the Genus. *Bulletin of the American Museum of Natural History* 89:123-256.

Slessman, S.
2000 Lithic Analysis of an Agate Basin Site in Northeastern Colorado: The Frazier Site Revisited. Paper presented at the 58th Annual Plains Anthropological Conference, St. Paul, Minnesota.
2001a The Frazier Revisited: Agate Basin Land-Use on the High Plains. Poster presented at the 66th Annual Society for American Archaeology Conference, New Orleans, Louisiana.
2001b A Picture Says a Thousand Words: New Information Regarding the Frazier Site. Paper presented at the 59th Annual Plains Anthropological Conference, Lincoln, Nebraska.
2002a Late Paleoindian Resource Exploitation at the Frazier site. Paper presented at the 67th Annual Society for American Archaeology Conference, Denver, Colorado.
2002b The Frazier Site: An Agate Basin Occupation and Lithic Assemblage on the Kersey Terrace, Northeastern Colorado. Unpublished Master's thesis, Department of Anthropology, Colorado State University, Fort Collins.

Smiley, F. E.
1978 Changes in the Cursorial Ability of Wyoming Holocene Bison. In Wyoming Contributions to Anthropology Vol. 1. *University of Wyoming Publications* 42:105-126.

Speth, J. D.
1983 *Bison Kills and Bone Counts: Decision Making by Ancient Hunters*. University of Chicago Press, Chicago.
1987 Early Hominid Subsistence Strategies in Seasonal Habitats. *Journal of Archaeological Science* 14:13-29.

Speth, J. D., and W. J. Parry
1980 *Late Prehistoric Bison Procurement in Southeastern New Mexico: The 1978 Season at the Garnsey Site (LA-18399)*. Technical Report No. 12. Museum of Anthropology, University of Michigan, Ann Arbor.

Speth, J. D., and K. A. Spielmann
1983 Energy Source, Protein Metabolism, and Hunter-Gatherer Subsistence Strategies. *Journal of Anthropological Archaeology* 2:1-31.

Stanford, D. J.
1999 Paleoindian Archaeology and Late Pleistocene Environments in the Plains and Southwestern United States. In *Ice Age Peoples of North America: Environments, Origins, and Adaptations*, edited by R. Bonnichsen and K. I. Turnmire, pp. 281-339. Oregon State University Press, Corvallis.

Stiner, M. C.
1994 *Honor Among Thieves: A Zooarchaeological Study of Neanderthal Ecology*. Princeton University Press, Princeton, New Jersey.

Thomas, D. H., and D. Mayer
1983 Behavioral Faunal Analysis of Selected Horizons. In *The Archaeology of Monitor Valley 2: Gatecliff Shelter*, by D. H. Thomas, pp. 353-391. Anthropological Papers Vol. 59, Pt. 1. American Museum of Natural History, New York.

Thornton, M., and J. Fee
2001 Rodent Gnawing as a Taphonomic Agent: Implications for Archaeology. In *People and Wildlife in Northern North America: Essays in Honor of R. Dale Guthrie*, pp. 300-306. BAR International Series 944. British Archaeological Reports, Oxford.

Todd, L. C.
1986 Determination of Sex of *Bison* Upper Forelimb Bones: The Humerus and Radius. *The Wyoming Archaeologist* 29:109-123.
1987 Taphonomy of the Horner II Bone Bed. In *The Horner Site: The Type Site of the Cody Cultural Complex*, edited by G. C. Frison and L. C. Todd, pp. 107-198. Academic Press, Orlando.
1991 Seasonality Studies and Paleoindian Subsistence Strategies. In *Human Predators and Prey Mortality*, edited by M. C. Stiner, pp. 217-238. Westview Press, Boulder, Colorado.

Todd, L. C., and J. L. Hofman
1987 Bison Mandibles from the Horner and Finley Sites. In *The Horner Site: The Type Site of the Cody Cultural Complex*, edited by G. C. Frison and L. C. Todd, pp. 493-540. Academic Press, Orlando.
2001 Tyranny in the Archaeological Record of Specialized Hunters. In *People and Wildlife in Northern North America: Essays in Honor of R. Dale Guthrie*, edited by S. C. Gerlach and M. S. Murray, pp. 200-215. BAR International Report 944. British Archaeological Reports, Oxford.

Todd, L. C., J.. L. Hofman, and C. B. Schultz
1990 Seasonality of the Scottsbluff and Lipscomb Bison Bonebeds: Implications for Modeling Paleoindian Subsistence. *American Antiquity* 55:813-827.
1992 Faunal Analysis and Paleoindian Studies: A Reexamination of the Lipscomb Bison Bonebed. *Plains Anthropologist* 37:137-165.

Todd, L. C., J. L. Hofman, and H. M. Wormington
1990 Estimating Season of Death and Population Characteristics of Bison from the Frazier Site, Weld County, Colorado. Manuscript on file, Department of Anthro-pology, Colorado State University, Fort Collins.

Todd, L. C., D. J. Rapson, and J. L. Hofman
1996 Dentition Studies at the Mill Iron and Other Early Paleoindian Bonebed Sites. In *The Mill Iron Site*, edited by G. C. Frison, pp. 145-176. University of New Mexico Press, Albuquerque.

Tomka, S. A.
1994 Quinua and Camelids on the Bolivian Altiplano: An Ethnoarchaeological Approach to Agro-Pastoral Subsistence Production with an Emphasis on Agro-Pastoral Transhumanance. Unpublished Ph.D. dissertation, University of Texas, Austin.

Wheat, J. B.
1972 *The Olsen-Chubbuck Site: A Paleo-Indian Bison Kill.* Memoirs of the Society for American Archaeology No. 26. Washington, D.C.
1979 *The Jurgens Site.* Plains Anthropologist Memoir 15. Lincoln, Nebraska.

White, T. D.
1992 *Prehistoric Cannibalism at Mancos 5MTUMR-2346.* Princeton University Press, Princeton.

White, T. E.
1953 A Method of Calculating the Dietary Percentage of Various Food Animals Utilized by Aboriginal Peoples. *American Antiquity* 19:396-398.

Will, R. T.
1985 Nineteenth Century Cooper Inuit Subsistence Practices on Banks Island, Northwest Territories. Unpublished Ph.D. dissertation, University of Alberta, Edmonton.

Wilson, M. C.
1974a History of the Bison in Wyoming, with Particular Reference to Early Holocene Forms. In *Applied Geology and Archaeology: The Holocene History of Wyoming*, edited by M. Wilson, pp. 91-99. Geological Survey of Wyoming, Laramie.
1974b The Casper Local Fauna and Its Fossil Bison. In *The Casper Site: A Hell Gap Bison Kill on the High Plains*, edited by G. C. Frison, pp. 125-171. Academic Press, New York.
1980 Population Dynamics of the Garnsey Site Bison. In *Late Prehistoric Bison Procurement in Southeastern New Mexico: the 1978 Season at the Garnsey Site (LA-18399)*, by J. D. Speth and W. J. Parry, pp. 88-129. Technical Report No. 12. Museum of Anthropology, University of Michigan, Ann Arbor.
1983 Canid Scavengers and Butchering Patterns: Evidence from a 3600-Year-Old Bison Bone Bed in Alberta. In *Carnivores, Scavengers, & Predators: A Question of Bone Technology*, edited by G. M. LeMoine and A. S. MacEachern, pp. 95-139. Archaeological Association of the University of Calgary, Calgary, Alberta, Canada.

Wormington, H. M.
1957 *Ancient Man in North America.* 4th ed. Denver Museum of Natural History, Popular Series No. 4.

1966a Research proposal submitted to the National Science Foundation. Document on file, Denver Museum of Nature and Science archives. Denver, Colorado.

1966b Report on the 1966 Investigations at the Frazier Site, Weld County, Colorado, National Science Foundation Grant GS 1252. Document on file, Denver Museum of Nature and Science archives. Denver, Colorado.

1967a National Science Foundation Grant GS 1252 Proposal. Document on file, Denver Museum of Nature and Science archives. Denver, Colorado.

1967b Report on the 1967 Investigations at the Frazier Site, Weld County, Colorado. Document on file, Denver Museum of Nature and Science archives. Denver, Colorado.

1984 The Frazier Site, Colorado. In *AMQUA Field Trip 2: Paleoindian Sites in the Colorado Piedmont, August 11-12*, pp. 12-13. University of Colorado, Boulder.

1988 The Frazier Site, Colorado. In *Guidebook to the Archaeological Geology of the Colorado Piedmont and High Plains of Southeast Wyoming*, edited by V. T. Holliday, pp. 82-84. 1988 Centennial Meeting of the Geological Society of America, Department of Geography, University of Wisconsin, Madison.

Zeimens, G. M.

1982 Analysis of the Postcranial Bison Remains. In *The Agate Basin Site: A Record of the Paleoindian Occupation of the Northwestern High Plains*, edited by G. C. Frison and D. J. Stanford, pp. 213-240. Academic Press, New York.

APPENDICES

Appendix 1. Curation of the Frazier site Archaeofauna.

The Frazier site assemblage is permanently housed at the Denver Museum of Nature and Science in Denver, Colorado. Prior to the present study, much of the faunal material was in original field bags, i.e., brown paper bags. In an effort to increase the longevity of the assemblage as well as to facilitate future research with it a major aspect of my analysis involved properly curating the faunal materials. In this way my work completed that begun by Eidlen (1993), albeit in a slightly modified manner. I maintained her methods of boxing the bone specimens, i.e., bones are placed in acid-free trays and stacked three-deep within a box. Small pieces of ethaform are attached to at least two corners of the lower two trays to ensure that the weight of the upper boxes does not crush the bones in the lower trays. In contrast to Eidlen, my method of inventorying the faunal assemblage did not involve the completion of Inventory Records for each specimen. Instead, specimen information was entered directly into Paradox 9, a database program included in the Wordperfect Office 2000 software package. A complete copy of the Frazier site faunal database is provided in Appendix 6.

In its entirety the faunal material from the Frazier site encompasses three accession numbers: A2042, A1922, and A1558. The bulk of the material belongs to accession A2042; Accessions A1922 and A1558 include specimens that were previously in the possession of Dr. Wormington and returned to the museum separate from the main assemblage. Each identifiable bone specimen was assigned a unique number based on a numbering scheme that included the specimen's accession number (e.g., A2042.1, A2042.2, A2042.3, ...). Unidentifiable bone fragments with specific provenience information, i.e. unit and field identification number, also received numbers. With the exception of general unidentified bone

fragments, laser-printed, 6-point font, acid-free paper labels were glued on each numbered specimen using Lascaux Acrylic Adhesive 498, an adhesive that is soluble in acetone. A layer of Lascaux was brushed onto the specimen, the label was affixed, and a topcoat of Lascaux was applied. General unidentifiable fragments were sorted by unit and level (when possible) and each fragment type (e.g., long bone, flat bone, cancellous bone) was counted and given a specimen number. General unidentified fragments were not individually numbered.

Bone specimens were bagged in 2 mil plastic bags of varying size. A number of bags labeled by Eidlen (1993) were retained and can be recognized by their black Sharpie labels. Bag labels were created for all specimens and include the site name and number, specimen number, unit and field identification number (if applicable), and a general description of the specimen (Figure A.1a-c). Labels were printed on acid-free paper and placed in adhesive sleeves on each bag. If a bag was too small to affix an adhesive sleeve the label was placed within the bag.

Prior to beginning the present study, the Frazier site faunal material had been sorted by skeletal element. Specimens not identified to element remained in their original field bags and were placed in boxes labeled "Unidentifiable Bone Fragments." Upon going through the unidentified material, however, it was found that a number of additional specimens were identifiable to element. When an identifiable fragment was pulled from a general, unidentified bone bag, the phrase "w/ general bone" is included on the specimen's bag label (Figure A.1b-c).

Specimen provenience information was obtained from the original field bag in which each specimen was found and all original bags were saved. Most original field bags include the date of discovery, site identification (e.g., Frazier Site (15)), unit number and corresponding locality, and a general description of the contents of

a

5WL268, Frazier Site
Artifact Number: **A2042.633**
Field ID Number/Unit: G21-12
Description: Astragalus
Analyst: J. Borresen, 2001

b

5WL268, Frazier Site
Artifact Number: **A2042.856**
Field ID Number/Unit: I21
Description: Proximal Metatarsal (cut/chop),
w/ general bone, carbonate level
Analyst: J. Borresen, 2001

c

5WL268, Frazier Site
Artifact Number: **A2042.1449**
Field ID Number/Unit: E29
Description: Sacrum,
w/ general bone, Agate Basin level?
Analyst: J. Borresen, 2001

Figure A.1 Examples of bag labels.

the bag. When possible, original bags (e.g., brown paper bags) were curated with the corresponding bone specimen. In cases where this was not possible (e.g., more than one identifiable specimen was found in the same field bag), original bags were retained separate from the specimens. These bags are located with the faunal materials in a box labeled "Frazier Site Original Field Bags."

In general, vertical provenience information for bone specimens is poor; however, in some instances, original bags include information pertaining to the level in which the bone(s) were found (e.g., gley level, general bone level, Agate Basin level, carbonate level) and/or their depth below datum. When present, this information is included on bag labels. Although it may simply be a reference to the age of the site, in instances when original bags read "Agate Basin Complex" (or some similar variation), the bone specimens contained within were tentatively interpreted to be from the Agate Basin level of the site. The presence of a question mark after "Agate Basin level" on bag labels reflects this questionable conclusion (Figure A.1c).

Appendix 2. Faunal Analysis Coding Format
(adapted from Hill 2001: Appendix 1).

ELEMENT CODES

Cranium/Teeth

CRN	cranium	MR	mandible
DPUN	indeterminate deciduous premolar	MUN	indeterminate molar
HS	horn sheath	PUN	indeterminate premolar
HY	stylohyoid	TFR	indeterminate tooth fragment

Axial

AT	atlas vertebra	RB	rib
AX	axis vertebra	SA	sacral vertebra
CA	caudal vertebra	SAC	complete sacrum
CE	cervical vertebra	SN	sternal element
CS	costal cartilage	TH	thoracic vertebra
LM	lumbar vertebra	VT	indeterminate vertebra
MN	manubrium		

Appendicular (Forelimb)

CP	indeterminate carpal	HM	humerus
CPA	accessory carpal	MC	metacarpal
CPF	4th carpal	MCF	5th metacarpal
CPI	intermediate carpal	RD	radius
CPR	radial carpal	RDU	radius-ulna
CPS	fused 2nd and 3rd carpal	SC	scapula
CPU	ulnar carpal	UL	ulna

Appendicular (Hind limb)

AS	astragalus	PT	patella
CL	calcaneus	PV	complete pelvis
FM	femur	TA	tibia
LTM	lateral malleolus	TR	indeterminate tarsal
IM	os coxae	TRC	fused central and 4th tarsal
MT	metatarsal	TRF	1st tarsal
MTS	2nd metatarsal	TRS	fused 2nd and 3rd tarsal

Other Appendicular

DEW	accessory phalanx	PHT	3rd phalanx
MP	indeterminate metapodial	SE	indeterminate sesamoid
PH	indeterminate phalanx	SED	distal sesamoid
PHF	1st phalanx	SEP	proximal sesamoid
PHS	2nd phalanx		

Fragments

CB	indeterminate cancellous bone	LB	indeterminate long bone
FB	indeterminate flat bone	UN	totally unidentified fragment

PORTION CODES

Long Bone

BL	blade of scapula or rib
CDL	condyle
CO	complete
DDS	distal diaphysis
DF	diaphysis
DFD	DS + DSE
DFP	DF + PRE
DPR	proximal diaphysis
DS	distal end
DSE	distal epiphysis
DSH	distal, articular end plus > ½ shaft
DSS	distal, articular end plus < ½ shaft
EP	epiphysis
FK	flake, <½ circumference of shaft
HE	head
IFC	impact cone
IFK	impact flake
PR	proximal end
PRE	proximal epiphysis
PRS	proximal, articular end plus < ½ shaft
PSH	proximal, articular end plus > ½ shaft
SH	long bone shaft
US	unspecified

Cranium

BRC	brain case (FN + OCC)
BSL	basilar
DP2-4	deciduous maxillary premolar
EN	tooth enamel
FN	frontal
HC	horn core
HS	horn sheath
JUG	jugal process
LC	lacrimal
M1-3	maxillary molar #
MUN	indeterminate maxillary molar
MX	maxilla
NSL	nasal
OCC	occipital
PAL	palatine
PAR	parietal
PET	petrous
P2-4	maxillary molar #
PUN	indeterminate maxillary premolar
SKO	other combination
SR	skull roof (FN + HC)
TMP	temporal
TW	tooth row
ZYG	zygomatic

Mandible

ANG	angle
BDR	distal border
CP	condylar process
CRD	coronoid process
DAM	DRM + RAM
DIC	deciduous incisor
DP2-4	deciduous mandibular premolar
DRM	dentary ramus
EN	tooth enamel
HRM	horizontal ramus
IC	incisor
P2-4	mandibular premolar #
M1-3	mandibular molar #
MUN	indeterminate mandibular molar
PUN	indeterminate mandibular premolar
RAM	ascending ramus
SYM	symphysis
TW	tooth row

Stylohyoid

ANG	angle
BOD	body

Vertebra

AEP	anterior epiphysis
AP	articular process
CN	centrum
CNA	CN + AP
CNN	CN + neural arch
CNS	CN + dorsal spine
CNW	atlas, CN + wings
CNT	CN + TSP
DSP	dorsal spinous process
NAS	neural arch + spine
PEP	posterior epiphysis
TSP	transverse spinous process

Scapula

CRB	cranial border
CBD	caudal border
GN	glenoid
GNB	GN + blade fragment
GS	GN + spine

Ulna

ANC	trochlear notch portion
OLC	olecranon portion
SH	shaft

Innominate

AC	acetabulum
ACL	AC + IL
ACP	AC + PB
ACS	AC + IS
IL	ilium
ILC	ilium (cranial)
ILD	ilium (caudal)
IS	ischium
ISC	ischium (cranial)
ISD	ischium (caudal)
PB	pubis
PBS	pubis symphysis
VPT	ventral pubic tubercle

SEGMENT CODES

AL	anterolateral
AM	anteromedial
CD	caudal (posterior)
CDL	condyle
CO	complete
CR	cranial (anterior)
DR	dorsal
DS	distal
EN	tooth enamel
EX	exterior
FO	fore
FR	fragment
HB	split rib blade
HD	hind
HE	head
IN	interior
LT	lateral
ME	medial
PL	posterolateral
PM	posteromedial
PR	proximal
SP	spine
TW	tooth row
VN	ventral
US	unspecified
#	vertebra\rib\tooth

SIDE CODES

A	axial
AB	abaxial
L	left
N	not sided
R	right

EPIPHYSEAL FUSION CODES

PF	proximal fusion	3	complete fusion
DF	distal fusion	4	broken, indeterminate
0	unfused	5	not applicable (e.g., proximal metapodial, tooth, petrous portion)
1	partially fused		
2	fused, line visible		

SEX CODES

F	female	M	male
I	immature female or male	m	immature male

Appendix 3. Frazier Site Bison Calcanea Measurements.

Specimen	Element	Portion	Segment	Side	Fusion	Sex	Measurements				
							LC[a]	LT[b]	CL1[c]	CL4[c]	CL9[c]
A2042.539	CL	PSH	CO	L	3	?	-	36.6	-	-	106.1
A2042.542	CL	CO	CO	L	3	?	38.9	38.3	161.0	-	109.9
A2042.543	CL	CO	CO	L	3	F	39.3	36.0	155.0	53.0	102.3
A2042.551	CL	NCO	PR	L	3	F	-	36.0	-	48.0	107.6
A2042.553	CL	CO	CO	L	3	F	37.8	32.9	154.0	52.0	103.2
A2042.554	CL	CO	CO	L	3	M	44.0	37.6	170.0	63.0	111.7
A2042.557	CL	NCO	PR	L	3	?	-	-	-	-	97.5
A2042.560	CL	PRS	CO	L	3	?	-	35.8	-	-	-
A2042.577	CL	PSH	LT	L	3	?	-	-	-	-	114.5
A2042.592	CL	NCO	PR	L	3	?	-	35.2	-	-	98.3
A2042.593	CL	NCO	PR	L	3	?	-	-	-	-	112.1
A2042.594	CL	CO	CO	L	3	M	44.0	36.3	164.0	60.0	108.5
A2042.610	CL	NCO	PR	L	3	F	-	36.2	-	49.0	103.7
A2042.612	CL	NCO	PR	L	3	M	-	40.2	-	54.0	112.3
A2042.540	CL	CO	CO	R	3	?	38.3	37.3	-	-	104.8
A2042.558	CL	NCO	PR	R	3	?	-	-	-	-	97.1
A2042.562	CL	CO	CO	R	3	F	37.5	35.0	152.0	47.0	101.7
A2042.563	CL	CO	CO	R	3	F	37.6	36.4	154.0	-	101.1
A2042.565	CO	CO	CO	R	3	F	39.1	34.1	154.0	54.0	103.6
A2042.569	CL	CO	CO	R	3	F	39.4	32.3	153.0	51.0	102.2
A2042.575	CL	CO	CO	R	3	?	-	34.1	-	-	100.5
A2042.578	CL	CO	CO	R	3	M	45.1	35.9	184.0	61.0	122.7
A2042.583	CL	CO	CO	R	3	F	37.6	33.8	152.0	-	97.9
A2042.586	CL	NCO	CR	R	3	M	-	35.2	-	60.0	109.3
A2042.601	CL	NCO	NCO	R	3	F	-	38.7	152.0	53.0	108.0
A2042.613	CL	CO	CO	R	3	F	40.2	37.9	160.0	54.0	107.4
A2042.614	CL	CO	CO	R	2	F	37.9	36.7	165.0	-	108.1
A2042.617	CL	NCO	PR	R	3	M	-	41.2	-	56.0	110.9
A2042.606	CL	PSH	CO	L	0	I	-	-	-	-	-
A2042.552	CL	PRS	CO	L	0	I	-	-	-	-	-
A2042.588	CL	CO	CO	L	0	I	36.0[d]	39.5	-	-	-
A2042.582	CL	PSH	CO	L	0	I	-	33.3	-	47.0[d]	-
A2042.576	CL	CO	CO	L	0	I	41.8	35.1	-	53.0	-
A2042.574	CL	PSH	CO	R	0	I	-	-	-	-	-
A2042.608	CL	PSH	CO	R	0	I	-	34.1	-	-	-
A2042.573	CL	CO	CO	R	0	I	40.3	38.1	-	49.0	-
A2042.545	CL	PSH	CO	R	0	I	-	33.2	-	46.0	-
A2042.568	CL	CO	CO	R	0	I	-	35.2	-	-	-
A2042.585	CL	PSH	CO	R	0	I	-	-	-	-	-

[a] Length of Central & 4th Tarsal Facet (Morlan 1991)

[b] Length of Talus Facet (Morlan 1991)

[c] Measurement from Hill 1996; C1=greatest length; C4=greatest breadth; C9=greatest length of shaft

[d] estimated value

Appendix 4. Measurements of Frazier Metacarpals using Speth (1983) and Bedord (1974).

Measurements from Speth 1983

Artifact#	Unit	Field ID#	Element	Portion	Segment	Side	Fusion	Count	SP-A	SP-B	SP-C	SP-D	SP-E	SP-F	SP-G	SP-H	SP-I	SP-J
A2042.71	E30		MC	DS	CO	L	2	1.0	-	-	-	71.4	-	34.8	-	28.8	-	38.9
A2042.73	F28		MC	DS	CO	L	2	1.0	-	-	-	73.1	36.4	33.8	30.3	-	-	-
A2042.72	F28		MC	CO	CO	R	2	1.0	70.0	42.9	42.3	65.5	-	31.6	-	-	-	-
A2042.74	F29		MC	NCO	NCO	R	2	1.0	70.0	42.5	43.0	-	34.0	-	28.7	-	38.9	-
A2042.75	F29?		MC	DS	CO	L	2	1.0	-	-	-	-	44.2	41.8	33.4	32.2	45.4	44.2
A2042.76	F35		MC	NCO	NCO	R	3	1.0	65.0	44.0	41.5	66.8	34.0	32.8	29.4	27.4	39.1	37.4
A2042.77	F40	13	MC	DS	LT	L	3	1.0	-	-	-	82.2	-	40.3	-	-	-	-
A2042.79	F40	17	MC	DS	CO	R	3	1.0	-	-	-	73.3	36.1	34.1	31.6	28.3	41.6	40.3
A2042.80	F42	38	MC	PSH	CO	R	3	1.0	82.0	52.9	48.0	-	-	-	-	-	-	-
A2042.81	G21	1	MC	DS	CO	R	3	1.0	-	-	-	80.0	-	38.2	-	29.6	-	38.9
A2042.82	G21	2	MC	DS	CO	R	3	1.0	-	-	-	74.8	37.9	34.3	31.4	27.8	40.4	38.7
A2042.85	G25	6	MC	NCO	CR	L	3	1.0	-	-	-	80.2	-	40.5	34.8	32.5	44.1	43.3
A2042.892	G25	5	MC	DSE	CO	R	0	1.0	-	-	-	-	34.4	31.8	28.0	24.6	-	34.6
A2042.86	G27		MC	NCO	NCO	R	0	1.0	64.0	37.6	36.8	-	-	-	-	-	-	-
A2042.841	G29		MC	DSS	CO	R	2	1.0	-	-	-	70.2	34.6	32.7	30.9	29.5	38.7	38.6
A2042.87	G31	5	MC	PR	CO	R	3	1.0	73.0	44.5	42.3	-	-	-	-	-	-	-
A2042.88	G38	28	MC	CO	CO	L	3	1.0	82.4	-	46.2	82.4	41.6	38.9	34.1	31.1	46.2	44.1
A2042.89	H24	14	MC	CO	CO	L	2	1.0	75.0	45.1	44.2	76.2	37.9	36.1	30.4	28.1	39.5	38.6
A2042.92	H34		MC	DSS	CO	L	3	1.0	-	-	-	69.0	33.8	32.5	30.5	28.4	39.7	38.7
A2042.909	H35		MC	DSS	ME	L	3	1.0	-	-	-	-	35.9	-	29.4	-	38.4	-
A2042.93	H39	5	MC	CO	CO	R	2	1.0	65.8	46.0	42.8	66.7	34.5	31.5	30.1	-	-	-
A2042.94	H40		MC	NCO	NCO	R	3	1.0	79.0	-	50.0	80.2	40.0	37.9	30.9	28.4	-	39.2
A2042.95	I21		MC	DS	LT	L	3	1.0	-	-	-	-	-	33.3	-	26.3	-	36.3
A2042.922	I23 E1/2		MC	DSE	ME	R	0	1.0	-	-	-	-	35.0	-	26.2	-	-	-
A2042.98	I25	1	MC	PSH	CO	R	3	1.0	69.0	39.0	42.8	-	-	-	-	-	-	-
A2042.99	I26	12	MC	NCO	CR	L	3	1.0	-	-	-	-	-	36.9	-	28.4	-	-
A2042.103	M20		MC	DS	CO	R	3	1.0	-	-	-	71.1	36.4	32.3	30.4	27.7	-	-

Measurements from Speth 1983. Continued.

Artifact#	Unit	Field ID#	Element	Portion	Segment	Side	Fusion	Count	SP-A	SP-B	SP-C	SP-D	SP-E	SP-F	SP-G	SP-H	SP-I	SP-J
A2042.112	none		MC	CO	CO	L	3	1.0	66.0	43.6	41.0	67.4	34.7	30.0	28.7	24.7	39.6	34.2
A2042.104	O20	1	MC	DS	CO	R	3	1.0	-	-	-	71.6	34.1	32.1	29.7	25.5	36.4	35.2
A2042.278	O21		MC	PRS	CO	R	5	1.0	69.1	-	42.6	-	-	-	-	-	-	-
A2042.107	S4		MC	DS	CO	L	2	1.0	-	-	-	70.4	36.5	33.5	31.2	27.8	-	-
A2042.108	S5		MC	DS	LT	R	2	1.0	-	-	-	-	-	35.6	-	28.1	-	37.6
A2042.944	S6		MC	DS	ME	R	3	1.0	-	-	-	-	36.0	-	29.6	-	38.5	-
A2042.106	SI	1	MC	DS	FR	R	3	1.0	-	-	-	-	-	31.0	-	27.5	-	-
A2042.945	X4	19	MC	DSS	US	L	3	1.0	-	-	-	-	40.2	-	31.6	-	-	-

Measurements from Bedord 1974

Artifact#	Unit	Field ID#	Element	Portion	Segment	Side	Fusion	Count	BD-1	BD-3	BD-4	Ratio 6 (BD3/BD1)
A2042.73	F28		MC	DS	CO	L	2	1.0	210.0	42.0	-	20.0
A2042.74	F29		MC	NCO	NCO	R	2	1.0	216.0	38.8	-	18.0
A2042.76	F35		MC	NCO	NCO	R	3	1.0	216.0	-	72.0	0.0
A2042.88	G38	28	MC	CO	CO	L	3	1.0	218.0	51.0	87.0	23.4
A2042.89	H24	14	MC	CO	CO	L	2	1.0	216.0	47.2	80.0	21.9
A2042.93	H39	5	MC	CO	CO	R	2	1.0	198.0	37.0	72.0	18.7
A2042.94	H40		MC	NCO	NCO	R	3	1.0	220.0	-	83.0	0.0
A2042.99	I26	12	MC	NCO	CR	L	3	1.0	216.0	-	-	0.0
A2042.112	none		MC	CO	CO	L	3	1.0	218.0	37.1	72.0	17.0

Appendix 5. Criteria for Determining the Minimum Number of Elements (MNE) in the Frazier Site Bison Archaeofauna.

Element	Left	Right	N	Left Criteria	Right Criteria	N Criteria
Crania	4	5	1	petrous portion	petrous portion	petrous portion
Mandible	22	27	0	M_3	M_3	-
Atlas	-	-	2	-	-	left posterior articular surface
Axis	-	-	3	-	-	dens
Cervical	-	-	19	-	-	anterior articular process
Thoracic	-	-	33	-	-	anterior centrum
Lumbar	-	-	12	-	-	complete centrum
Rib	-	-	16	-	-	head
Sacrum	-	-	14	-	-	anterior portion of segment I
Scapula	19	20	2	posterior lateral glenoid cavity	posterior medial glenoid cavity	posterior glenoid cavity
Proximal Humerus	1	3	1	head	head	head frag
Distal Humerus	15	11	3	medial condyle	medial condyle	medial condyle frag
Proximal Radius	16	19	1	medial glenoid cavity	medial glenoid cavity	medial glenoid cavity fragment
Distal Radius	13	16	1	CPl or CPR facet	CPR facet	complete distal end
Proximal Ulna	10	13	1	anconeal process	anconeal process	shaft presence
Carpals	21	14	1	posterior fused 2-3 carpal	anterior medial fused 2-3 carpal	complete fused 2-3 carpal
Proximal Metacarpal	20	20	1	CPS facet	CPF facet	CPF or CPS facet
Distal Metacarpal	18	18	3	distal anterior foramen	medial condyle	distal anterior foramen
Innominate	7	5	1	ilial muscle depression	ilial muscle depression	presence (acetabulum)
Proximal Femur	10	4	9	fovea capitus	fovea capita/lesser trochanter	fovea capitus
Distal Femur	4	3	1	med. condyle or supracondyloid fossa	supracondyloid fossa	condyle frag
Proximal Tibia	2	2	1	medial condyle	medial condyle	posterolateral foramen
Distal Tibia	19	17	1	posterior medial groove	anterior medial groove	presence
Tarsals	44	36	0	complete astragalus	complete astragalus	-
Proximal Metatarsal	20	20	1	TRS facet	TRS facet	presence
Distal Metatarsal	21	19	4	lateral condyle	medial condyle	distal anterior foramen

Appendix 6. Frazier Site Faunal Database.

See attached CD-ROM (plate 1) for Appendix material. The CD in the appendix contains the Frazier site faunal data. Although originally entered into a Paradox 9 database file, Microsoft Excel is perhaps a more accessible program and, therefore, the Frazier faunal data was exported from Paradox 9 to a read-only Excel file. Excel is a component of the Microsoft Office 2000 Professional software package. The data file is located in the root directory and is named "FrazierFauna.xls." The file contains two worksheets. The first, titled "Frazier Bison," contains all of the data on the Frazier site bison bone specimens and is sorted by element. The second, named "Frazier Non-Bison," includes data on the small number of non-bison bone specimens from the site and is sorted by family.

VITA

Jennifer (Jennie) A. Borresen was born September 21, 1975 in Pocatello, Idaho and spent her early years in Blackfoot, Idaho. At the age of 12, she and her family moved 30 miles north to Idaho Falls, Idaho. She graduated from Idaho Falls High School in 1993.

In the fall of 1993, Jennie began her undergraduate career at Montana State University in Bozeman. Jennie earned a Bachelor of Arts degree in Sociology (Anthropology emphasis) with a minor in History. She graduated with honors in December 1997 and was a member of the Golden Key National Honors Society, Lambda Alpha (Anthropology honors society), and Alpha Kappa Delta (Sociology honors society). She was also an active member of the undergraduate Anthropology club.

Jennie entered the Anthropology graduate program at the University of Tennessee in Knoxville in the fall of 1999, where she focused her studies on zooarchaeology. She was awarded a graduate research assistantship during the 2000-2001 academic year and a graduate assistantship for the 2001-2002 academic year. Additionally, she represented the Anthropology department in the Graduate Student Association in 2000. Jennie was awarded a Master's of Arts degree in Anthropology in May 2002.