The Paleoindian Bison Assemblage from Charlie Lake Cave

by

Claudine Vallières
Bachelor of Arts, McGill University, 2000

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

In the
Department of Archaeology

SIMON FRASER UNIVERSITY

July 2004

APPROVAL

NAME: Claudine Vallières

DEGREE: M.A.

TITLE OF THESIS: The Paleoindian Bison Assemblage from Charlie Lake Cave

EXAMINING COMMITTEE:

Chair: Dr. E. Yellowhorn
Assistant Professor

Dr. J.C. Driver, Professor
Senior Supervisor

Dr. M.C. Wilson, Adjunct Professor

Dr. A.C. D'Andrea, Associate Professor
Examiner

Date Approved: July 22. 2004

Abstract

The goal of this research is to investigate the subsistence activity – or activities – represented in the Paleoindian bison assemblage from Charlie Lake Cave. To achieve this goal, standard zooarchaeological methods are used, including quantification of skeletal element frequency, identification of bone modifiers, and reassembly of specimens. It is demonstrated that the assemblage was not affected to a significant extent by weathering, density-mediated attrition, or carnivore damage. Instead, the skeletal element frequency recognized in the assemblage is predominantly the result of human action. The patterns observed in the bison assemblage reveal an emphasis on limb bone elements, and an absence of axial elements. It is argued that an emphasis on limb elements would be advantageous for their transportability coupled with high marrow content. Comparisons with neighbouring sites and site-function models demonstrate that Charlie Lake Cave was neither a kill site nor a campsite, although its function as a campsite midden could not be ruled out. Outside of the kill site/camp site dichotomy common in Paleoindian archaeology, the assemblage is compared to a number of other site-function models, including hunting party monitoring station, storage facility and ritual location. A combination of these hypotheses, with an emphasis on storage, is put forward as the probable subsistence activities represented in the Paleoindian strata of Charlie Lake Cave.

Acknowledgments

First and foremost, I need to thank Jon Driver. It is difficult to put into words how much you have helped me. You gave me your time, and funding, with patience and good humour. You calmed me down when I was on the verge of panic, you were available when I needed to double check and triple check the slightest detail that worried me, and you pushed me gently but steadily to perform and advance through all of this. Thank you so much.

I also need to thank Mike Wilson for his contagious enthusiasm for my topic, and for making sure that I understand the weight of every word I use. I have learned so much about everything from English grammar to geological processes because you cared enough to explain it. Thank you.

Other people have helped me through parts of this thesis, each in their own way. Robyn, your kindness is appreciated so much, I hope you know it. You care, and that is really important to stressed out students lost in a confusion of paperwork, deadlines, and the obvious stress of writing a thesis. I also want to thank Stan Wilmoth, Montana's state archaeologist, for guiding me through masses of reports and publications with kindness and interest. Thank you to my friends in the department, Mike, Karine and Erin, for being my friends and acting accordingly! It is important to have a life outside of school, and your friendship kept me sane.

Finalement, merci à mon groupe de soutien au Québec : ma mère Claire, mon chum Phil, et ma meilleure amie Marilie. Je n'aurais pas pu demander mieux en frais de d'encouragement. Vous croyez en moi beaucoup plus que je crois en moi, et ça m'aide à avancer, ça me donne du courage. Merci.

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Introduction

Zooarchaeological analysis is an accepted tool in the discipline of archaeology for investigating cultural activities in archaeological sites, with much of this research relating to subsistence. The North American Plains and adjacent mountains have been the theatre of pioneering research in zooarchaeology. The great bison bonebeds found in the region attracted early on the attention of researchers like George C. Frison (1970) and Joe Ben Wheat (1972). Their interest in butchering practices and skeletal element frequencies in faunal assemblages provided a stepping stone for the burgeoning subdiscipline of zooarchaeology. However, the physical magnitude and numbers of bison bonebeds, their greater statistical potential, and their high archaeological visibility have attracted much of the attention of archaeologists, leaving smaller faunal assemblages in their shadow.

In North America, early Paleoindian research is dominated by lithic analyses stimulated by the impressive fluted point traditions, and the lack of preserved bones, especially at sites to the east of the Mississippi. Impressive bison bonebeds in the central and western plains are also regularly analysed, but smaller faunal assemblages are rarely the subject of comprehensive faunal analyses, when such sites are found at all. There is a need in Northwestern Paleoindian studies to analyse faunal assemblages of a more limited nature that will help us envision the full range of early Paleoindian subsistence strategies. This call for more diverse studies is not new. Greiser (1985) presented models of Paleoindian subsistence in which site function, location, and content, would vary greatly in response to climatic differences, notably between the seasons: a diversity not yet seen in the archaeological record. The site of Charlie Lake Cave could provide an example of that diversity because it has an early Paleoindian component where a limited bison assemblage was found in association with a number of stone tools, including one fluted point.

Charlie Lake Cave is an archaeological site whose earliest occupation period dates to from around 10 500 BP to 9 500 BP, spanning the Late Pleistocene/Early Holocene boundary. The site is situated in northeast British Columbia, east of the Rocky Mountains. Early Paleoindian sites are rare in western Canada; thus little is known about the groups living in that region during this period. This situation makes it imperative that one exploits every piece of information available on Charlie Lake Cave. A number of publications were produced from the material excavated at the site (Driver 2001, 1999a, 1999b, 1998a, 1998b, 1996, 1988; Driver *et al.* 1996; Fladmark 1996; Fladmark *et al.* 1988; Handly 1994), but no detailed faunal analysis of the early Paleoindian bison assemblage has yet been undertaken. Consequently, the goal of this thesis is to use zooarchaeological methods to explore the possible subsistence activity – or activities – recorded in the Paleoindian strata of Charlie Lake Cave.

In order to investigate the role of Charlie Lake Cave in early Paleoindian times through the use of zooarchaeological methods, a number of steps are taken. First, an introduction to previous work on Charlie Lake Cave is needed. Chapter 2 presents the site to the reader, including a description of the site, its excavation history, its stratigraphy, and its dating. Second, the methodology to be employed is critically assessed. Chapter 3 discusses the different zooarchaeological methods necessary for this research. Issues addressed involve quantification, identification of bone modifiers, and reassembly of bone fragments and elements.

The third step towards a better understanding of the bison assemblage in the Paleoindian strata of Charlie Lake Cave is to present the data gathered from the analysis. This is done in Chapter 4. Skeletal element frequencies of the assemblage are presented, and then the influence of taphonomic processes on the assemblage is explored. An evaluation is made of possible density-mediated attrition of bones, a common factor influencing the presence and absence of skeletal elements in faunal assemblages. The data are plotted against utility and bone grease indices to evaluate whether the skeletal element frequencies are correlated with these factors. Finally, the incidence of human modifications on the elements is presented.

Once patterns in the assemblage are identified and its taphonomic history understood, the assemblage is compared to other sites in the area and to site-function models. Comparisons are the focus of Chapter 5. The intent behind such comparisons is to understand the place of Charlie Lake Cave's bison assemblage in a general early Paleoindian subsistence strategy. The first set of comparisons is between Charlie Lake's bison assemblage and other faunal assemblages found within the surrounding region. This is followed by comparisons with site-function models and hypotheses. Finally, a discussion of the possible function or functions of Charlie Lake Cave during its early Paleoindian occupations is presented.

2

Charlie Lake Cave

A multitude of publications already exist concerning the archaeological significance of Charlie Lake Cave (Driver 2001, 1999a, 1999b, 1998a, 1998b, 1996, 1988; Driver *et al.* 1996; Fladmark 1996; Fladmark *et al.* 1988; Handly 1994). The majority of the information contained in this section is taken from these various works, to which the reader is referred for more detailed explanations.

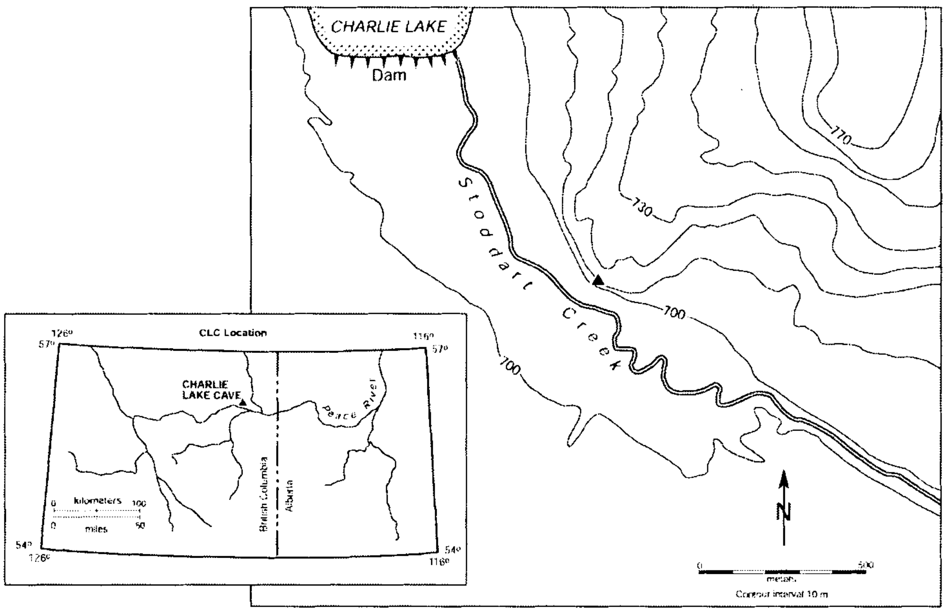

Figure 2.1 Location of Charlie Lake Cave (HbRf 39). From Driver 1999a, used by permission of the SAA.

2.1 Description of Charlie Lake Cave

Charlie Lake Cave is situated on a hillside overlooking Stoddart Creek, which drains to the Peace River in northeast British Columbia. Although it is situated within the posited "ice-free corridor", its dates of occupation are too late to be included in any "peopling of the New World" polemics. The cave was probably created during the last glaciation when the sandstone bedrock was carved by sub-glacial water (Driver 2001). By around 10 500 BP, a large joint-fractured boulder (referred to as "the parapet") detached itself from the sandstone bedrock, moving three metres downslope without toppling over. This event exposed the cave, and created a twelve metre-long gully with a steep-angled floor littered with boulders. At the time of the gully's formation, the cave was situated about three metres above the floor of the gully. Rapid downslope redeposition of glaciolacustrine sediments ensued for about a thousand radiocarbon years, the sediments stopping their course downslope at the junction of the gully floor and the parapet base, creating layers of uneven thickness on the steep-angled floor. The name of the archaeological site is somewhat misleading as the cultural components have not been excavated within the cave, but rather in the gully below the mouth of the cave. The gully is open on the east and west sides, so people could walk into and through it by walking along the hillside.

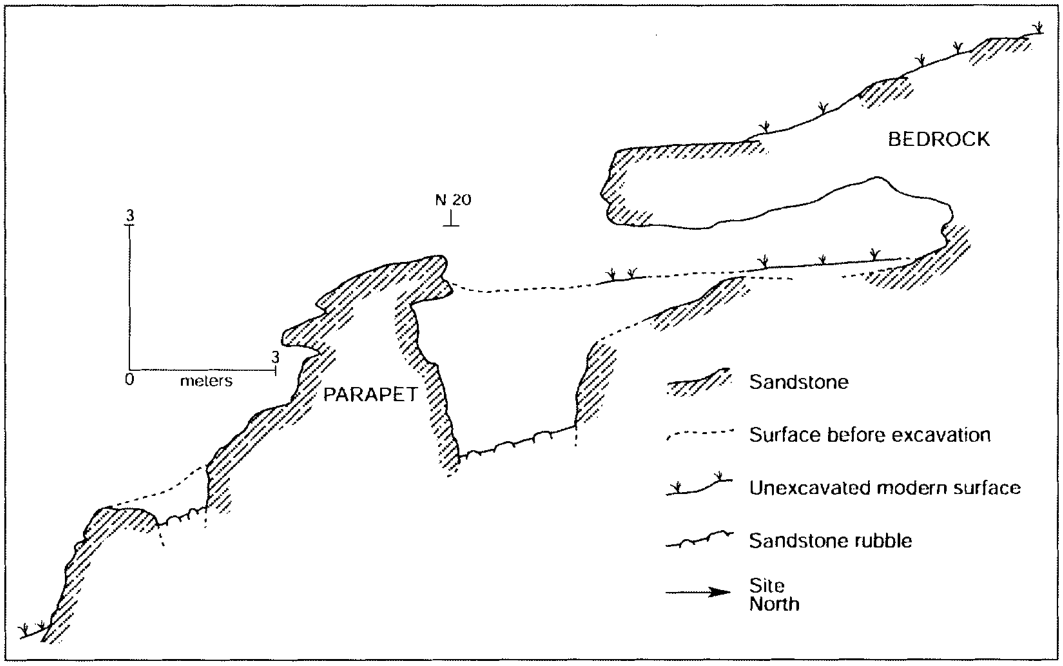

Figure 2.2 Cross-section of Charlie Lake Cave site. From Driver 1999a, used by permission of the SAA.

The excavation of Charlie Lake Cave revealed an almost continuous occupation of the site from 10 500 BP to the 20th century (Driver *et al.* 1996), although site form and use undoubtedly changed through time. Materials recovered include lithics (for a detailed analysis, see Handly 1994), ranging from debitage to a fluted point, and faunal assemblages. Previous studies on the faunas of Charlie Lake Cave provide us with an account of the changing environments that marked the region during the transition from the Pleistocene to the Holocene. Driver (2001, 1999b, 1998a, 1988, Driver *et al.* 1996) points out that the earliest fauna excavated at Charlie Lake Cave (Subzones IIa and IIb, see section 2.3 in this thesis) is markedly different from the later faunas. Basically, from Subzone IIa to the end of Subzone IIIa, the taxa represent a change from an open habitat with no stable aquatic environment, to an increasing amount of taxa associated with a boreal forest and aquatic environment, until all open habitat faunas disappear except for grassland-adapted bison. This period of environmental change from an open habitat to a boreal forest represents the time span dealt with in this thesis.

2.2 Excavation History

Charlie Lake Cave was first recorded and tested by Knut R. Fladmark in 1974. He returned in 1983 for a full excavation season. Fourteen one-by-one metre units were opened, demonstrating a long cultural and paleoenvironmental sequence beginning with a Paleoindian occupation and ending with a historic component. This excavation generated a lot of excitement because a fluted point was found in the Paleoindian component in association with well preserved, datable fauna, an uncommon find in Canadian archaeological sites.

Another team of excavators, co-directed by Jon Driver and Knut Fladmark, returned to the site for two field seasons in 1990 and 1991, intent on investigating in more detail the Paleoindian level. Those two archaeological seasons added artifacts and faunas to the sample collected previously from the Paleoindian component. Within the three seasons of excavation at Charlie Lake Cave, a total of twenty-three one-by-one metre units were placed in the gully and the mouth of the cave. Of those units, thirteen reached the Paleoindian levels with which we are here concerned. Two units located in the mouth of the cave yielded very few cultural materials, a situation that could be explained by the frequent use of the cave by twentieth-century children. Many people living in the area indicated that they had dug in the shallow deposits in the cave in their youth, some even stating that stone artifacts were found (Driver *et al.* 1996).

During the three field seasons test pits were made above and below the site, that is, above the cave and below the parapet. However, no cultural components were found there. In sum, during the three excavation seasons held at Charlie Lake Cave a long cultural sequence was uncovered only in the gully facing the mouth of the cave, even though the mouth of the cave, the hillside above the cave and the area below the parapet were tested.

2.3 Stratigraphy and Dating

The stratigraphy at Charlie Lake Cave is complex. Four zones were identified at Charlie Lake Cave based on sediment type, rate of sedimentation and soil formation (Driver *et al.* 1996). They were labelled using Roman numerals. The division of the stratigraphy into four zones was the result of the 1990 and 1991 field seasons, while the stratigraphy was divided into five zones during the 1983 seasons. It is important to keep this in mind when reading publications on Charlie Lake Cave predating the second wave of excavations. Subzones represent minor variations within the zones. Individual layers were identified by colour and texture. During excavation thick layers were divided into ten-centimetre arbitrary levels following as much as possible the general slope of the deposits.

Finally, cultural components were defined by the excavators on the basis of stratigraphy rather than the nature of the artifacts. That is, artifacts found within the same subzone were classified as a component, without trying to identify different occupations since most of the subzones only contained a few artifacts.

Zone I is formed by the lowest boulders on the floor of the gully. No faunal remains or artifacts were found within this zone. The redeposited glaciolacustrine sediments that accumulated on top of the boulders for around a thousand radiocarbon years form Zone II. Once again, the stratigraphic units of 1983 were refined after 1990. Zone II was formerly divided into two subzones, but after 1990 four subzones were identified: Subzones IIa through IId. Radiocarbon dating of the bones found within Zone II places its deposition from around 10 500 BP to around 9500 BP. Zone III signals the end of the rapid redeposition of upslope glaciolacustrine sediments which allowed enough time for visible soil formation to begin. This zone was divided into eight subzones, Subzone IIIa through IIIh, spanning 9500 BP to 4600 BP (Handly 1994). Finally, Zone IV represents the last 4600 years at the site, including a few historical disturbances and artifacts (Handly 1994).

2.4 The Paleoindian Layers

The Paleoindian strata, spanning Subzone IIa through Subzone IIIa, are the focus of the present analysis. Three cultural components were identified within the Paleoindian strata, each representing only a few hours to a few days of human occupation (Driver 2001).

Component 1, in Subzone IIb, dates to approximately 10 500 BP. Lithic material found within this component includes a few debitage flakes and unformed tools, one fluted point, one bead, and two cores. The cores and the unformed tools display extensive crushing (Handly 1994). This component also holds one of two raven skeletons that Driver (1999a) argues could represent a ceremonial occurrence. Component 2, in Subzone IIc, dates to around 10 000 BP. It contains around thirty debitage flakes, three unformed tools and one core. The core and unformed tools were expediently produced but no associated debitage was present. The larger unformed and core artifacts contained in both components were probably used to smash open bones (Driver *et al.* 1996; Handly 1994). Component 3, in Subzone IIIa, dates to around 9 500 BP and contains the second largely complete raven skeleton. Lithics found in this component include a significantly larger number of debitage flakes (n=160, in Handly 1994), suggesting the resharpening of two bifaces (Driver 2001), one unformed tool and a wedge-shaped microblade core. This microblade core was found at the foot of the raven skeleton.

The content of the three components suggests short-term use of Charlie Lake Cave. It was proposed that the lack of debitage from tool manufacture in Components 1 and 2 shows that the hunters came to the site with tools prepared at another location, using expedient tools to complement their "tool kit" (Driver 2001). The fluted point itself provides us with information, if not on the use of the site, at least on the origin of its users. This projectile point shares features with similar points found, out of dated contexts, in the Peace River area and central and southern Alberta (Driver *et al.* 1996). Furthermore, a similar unfinished point was found at the Indian Creek site in Montana. This point was associated with a date of 11 000 BP. Still in Montana, at the Mill Iron site, basally-thinned but unfluted projectile points have been described. This led investigators to believe that the first users of Charlie Lake Cave were probably related to the users of a late fluted point tradition such as those seen in Montana; that is, that the site's Paleoindian occupants were part of a bison-hunting population that migrated north with the retreat of the ice-front and the draining of glacial lakes (Driver *et al.* 1996). This is why, later in this thesis, the data from Charlie Lake Cave are compared to sites of similar age in exactly those areas, ranging from Alberta to Montana.

A final word should be said on the Paleoindian stratigraphy at Charlie Lake Cave. It was mentioned that Zone II was filled by one metre of sediment within a short geological time-span. It was difficult for excavators to establish whether the cultural and faunal assemblages found within those sediments gradually accumulated or if they represent discrete events. The radiocarbon dates for the Paleoindian strata of Charlie Lake Cave do not suggest clusters of occupations separated by hundreds of years. Rather, as seen in Fig. 2.3, from subzone IIa to subzone IIc the dates are relatively congruent.

Specimen no.	Element	Species	Unit	Layer	Lab	Date	S.D.
2296	Tibia	Bison	5	12-1	SFU 300	10 450	150
2292	Ulna	Bison	4	5-6	SFU 378	10 380	160
1830	Sacrum	Bison	5	11-4	SFU 355	9760	160
1849	Humerus	Bison	5	14-1	SFU 454	10 770	120
3429	Humerus	Bison	3	15-6	RIDDL 393	9990	150
1848	Humerus	Bison	5	14-1	OxA 11961	10 378	36
2294	Radius	Bison	4	5-8	OxA 12084	10 340	40
16422	Carpal	Bison	26	105-1	OxA 12085	10 505	45
20043	Tibia	Bison	29	98-8	OxA 10588	10 230	55
15000	Phalanx 1	Bison	26	98-2	CAMS 2136	9670	150
15001	Phalanx 3	Bison	28	105-4	CAMS 2134	10 560	80
15002	Scapula	Raven	26	105-4	CAMS 2317	10 290	100
15003	Scapula	Raven	27	92-1	CAMS 2318	9490	140
15004	Humerus	Bison	24	106-4	CAMS 2129	10 500	80
	Femur	Squirrel	3	15-10	RIDDL 392	10 100	210

Table 2.1 Radiocarbon dates (BP) of the Paleoindian strata of Charlie Lake Cave.

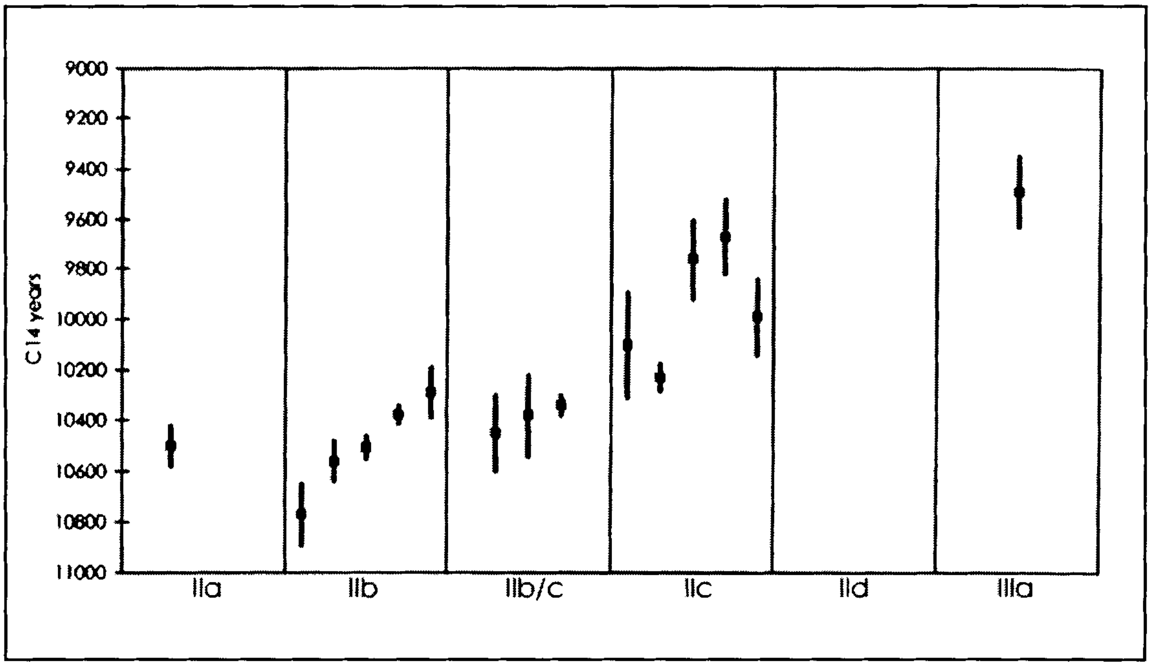

Figure 2.3 Radiocarbon dates of the Paleoindian strata of Charlie Lake Cave. Error bar 1 σ.

Two distinct sets of dates are nonetheless apparent, the second set of dates spanning subzones IIc to IIIa. This is not to say that there were only two occupations of the Charlie Lake Cave site. Like most archaeological sites, it is difficult to pinpoint exact times of occupation. However, radiocarbon dating does suggest that the majority of the assemblage discussed in this thesis accumulated within a few hundreds of years even though it is spread through a considerable thickness of sediments. More needs to be done to understand fully the occupation time span of Charlie Lake Cave. An attempt is made here to resolve this conundrum by linking radiocarbon dates with stratigraphic levels, and by adding bone refitting to the equation in Chapter 4.

3

Methodology

A sound methodology forms the basis on which behavioural inferences rest. In zooarchaeological studies, the methodology entails the identification of specimens, their description, their quantification, the identification of bone modifiers, and the conjoining of specimens, among other things. The issue of quantifying data of a faunal assemblage is not a straightforward one. Yet, it is the foundation for describing skeletal element frequencies, which are the basis for inferences about taphonomy, subsistence and transport strategies. Skeletal element frequencies are not only influenced by the counting units an analyst chooses, but also by the different natural and cultural processes that have transformed them from the time of the animal's death to the excavation of the archaeological assemblage. Taphonomic analyses help unravel this process. The recognition of natural and cultural bone assemblage modifiers needs to be undertaken carefully in order to infer cultural behaviours from the assemblage. Analysis of conjoinable bone fragments and elements can help refine both the quantification of an assemblage and the site's stratigraphy and taphonomy. All these aspects of zooarchaeological methods are discussed in this chapter.

3.1 Quantification

Zooarchaeological studies generally start by identifying and documenting the different specimens found in the faunal assemblage. In this particular study, interest focuses upon the bison bone elements; therefore, the first step was to separate bison bones from other taxa. To do so, all bone elements and fragments that could be recognised as coming from a medium- to large-sized mammal were put aside. Then, each was compared to a modern male bison comparative skeleton. When the bone element could not be identified to any part of the comparative skeleton, it was put aside to be examined by either Dr. Jon Driver or Dr. Michael Wilson. Unidentifiable fragments were kept with the bison assemblage in case refitting with other fragments would reveal their assignment. Once positively identified as bison, and to the particular elements, the information was recorded in a spreadsheet using Driver's unpublished coding system for elements and parts, with some personal additions (see Appendix A). Unidentified fragments that were not successfully refitted to an identified element were nonetheless kept in the assemblage in case future researchers or excavations revealed their affiliation. However, these unidentified fragments were not included in the present analysis. In addition to the coding of the parts, each element of the assemblage was drawn for a more accurate depiction of the part represented. This is one of the advantages of having such a small assemblage, as opposed to bison bonebed assemblages from mass-kills (*e.g.*, Todd and Frison 1992).

The basic counting unit in zooarchaeology is the Number of Identified Specimens, or NISP. For an extensive review and critique, the reader is referred to Grayson (1984). The NISP counting unit is simply the number of separate specimens that have been identified to a specific taxon within an assemblage. Although it is simple to compile, the NISP is plagued with problems if used for comparisons between taxa and assemblages. It is highly dependent on two basic factors: (1) the number of bones present or identifiable in a complete skeleton for each taxon, and (2) the degree of fragmentation the bones have endured.

The first factor refers to the reality that not all animals have the same number of bones. Therefore, a comparison of species abundance between assemblages from two different species based on NISP could suggest that reliance on one species was more important than on another. However, the highest NISP might result from individuals of one species having more elements in a skeleton than the other species. Furthermore, some species are only identifiable from a small number of elements, the rest of their skeletons being identical to other animals from the same family. (For example certain rodents are recognized only on the basis of cranial features). The NISP will be considerably smaller for those animals due to the zooarchaeologist's inability to identify their bones positively, and not necessarily because their bones were not found. Thankfully, our assemblage is spared these difficulties since we are only interested in bison bone elements.

The second factor, fragmentation, is of greater concern to this analysis. It is affected by a number of inputs, from deposition through to excavation (Grayson 1984). For example, NISP will be influenced by the butchering process chosen at the site, and by bone transport decisions. For medium- to large-sized animals, on-site butchering coupled with differential transport often occurs, "editing" some of the bones from the assemblage left behind at a kill, and diminishing the NISP count at a campsite. Furthermore, NISP does not take into account the effect of breakage, either by humans or natural processes, that will inflate the count by creating numerous fragments from one bone. This contributes to a greater problem for NISP: the issue of interdependence (see Grayson 1984). Simply put, for NISP to be useful in comparison, the analyst often assumes that every specimen counted comes from a different animal. The problem with this is that "assuming independence does not create independence among the units being counted" (Grayson 1984: 26). Breakage will have affected the assemblage by giving it a higher NISP count, even though those fragments come from the same element, and the same goes for transport practices. It is likely that some bones would have been transported as articulated sets while other bones could have been left behind.

For these reasons the NISP counting unit is not used in the interpretation of the Charlie Lake Cave assemblage, other than as an illustration of the small size of the assemblage. NISP data are presented alongside the raw data in Appendix B. The problem of the interdependence of specimens, as well as the other problems mentioned above, prompted the use of other quantitative methods for zooarchaeological assemblages.

Another counting unit used in zooarchaeology is the MNI, Minimum Number of Individuals. At its inception, MNI values were used to estimate the *minimum* number of individuals necessary to account for all the skeletal elements found at the site, given that we already know how many of each skeletal element a complete skeleton includes. MNI solved the problem of interdependence, but generated new problems. To calculate the MNI of an assemblage, the analyst needs to calculate how many of each skeletal element are present, separating paired elements into rights and lefts. The highest number of unique specimens is the MNI of the assemblage. For example, if the highest number of unique specimens is 25 right tibiae, then at least 25 different individuals would be needed to create the assemblage.

One of the greatest concerns with the use of MNI is in the effect of aggregation. The cumulative MNI of an assemblage will vary as a function of the approach to aggregation the analyst chooses. That is, the more the assemblage is divided into smaller sets, the higher the total MNI will be. One could divide up the assemblage until every specimen becomes an aggregation and the MNI equates to the NISP of the assemblage (the maximum number of individuals). Furthermore,

> it should be clear that minimum numbers are necessarily independent of one another only when one can be sure that the faunal aggregates from which they are defined are totally independent of one another. In many cases, total independence can be guaranteed only by treating an entire site as having provided a single faunal aggregate (Grayson 1984: 66).

It was also discovered that MNI are related to NISP in a predictable way, defined by two equations, so that if one increases so does the other (Grayson 1984). Finally, this counting unit only provides a means to compare the frequencies of taxa between assemblages but was not intended to provide much information on butchering techniques and transport strategies.

To remedy this problem, zooarchaeologists use MNE counts (Minimum Number of Elements). MNE can be used to count different elements or parts of elements (*e.g.*, proximal humerus, rib) or different body portions (*e.g.*, thoracic section). Basically, it is different from MNI as its goal is not to compare relative frequency of different taxa at the site but rather the relative frequency of different body parts of a single taxon. One drawback of both MNI and MNE is that their calculation is derived from NISP, and therefore dependent on decisions by the analyst. Indeed, when determining the minimum number of elements present one can, but is not required to, take into account the age, sex, or size of the animals represented by the skeletal elements. The greater the number of criteria used, the higher the MNE values. Therefore, it is imperative that zooarchaeologists state what they take into account when counting the MNE at their site. Providing the raw data of the assemblage (NISP) is also a good way to ensure that results can be used in comparisons to the assemblages of other sites, as other analysts can recalculate the MNE using criteria they deem important. This justifies the extent of the data provided in the different Appendices of this thesis.

The MNE counting units can be used to compare the minimum number of elements present at a site with similar data from other sites. It is possible to see that, for example, at site A there are 6 proximal humeri and 46 ribs, while at site B there are 50 proximal humeri and 8 ribs. Comparisons can be drawn (*i.e.* site A has fewer proximal humeri but more ribs than site B), but it is not possible to use the MNE data to compare one element to another at the same site without further calculations. For example, site A might seem to show there was an emphasis on obtaining ribs, but one needs to bear in mind that there are 28 ribs in a complete bison skeleton, and only 2 proximal humeri. This is the kind of reasoning Binford (1978) used when he devised the Minimum Animal Unit (MAU) counting unit.

Binford (1981) was more interested in comparing elements to elements and recognized a need to standardize the data in order to do so. To obtain MAU values, the analyst needs to divide the MNE value of each element by the number of each of the elements a complete skeleton contains. So site A has an MAU of 3 for proximal humeri (6/2) and an MAU of 1.6 for ribs (46/28). The MAU values can then be normalized on a scale of 1 to 100 to facilitate intrasite and intersite comparisons. To do so, one divides all MAU values of the assemblage by the highest MAU value, and multiplies them by 100 to obtain a percentage value (%MAU). Those normalized values can then be used in conjunction with utility indices (these will be discussed in Chapter 4), or alone to compare assemblage composition between sites. Discussions on the use of MNE, MAU and %MAU in this thesis, including the criteria used to determine them, will be included in

Chapter 4 as a part of the data presentation.

The implementation of quantification methods that standardized faunal data gave archaeologists a tool with which to understand the influence of different agents on the skeletal element representation in a faunal assemblage. Researchers investigated the effects of differential density-mediated attrition within an assemblage (Lam *et al.* 2003; Lyman 1984; Marean 1991) and for different species (Elkin 1995; Kreutzer 1992; Stahl 1999). Utility indices were both produced for other species (Diab 1998; Emerson 1990; Lyman *et al.* 1992) and critically evaluated (Grayson 1989; Lyman 1985; Metcalfe and Jones 1988), notably through ethnoarchaeological work (Bartram 1993; Bunn *et al.* 1988; O'Connell *et al.* 1988). Actualistic studies were developed to recognize and differentiate the signatures of certain taphonomic agents such as carnivores from human behaviour in faunal assemblages (Blumenschine and Marean 1993; Capaldo and Blumenschine 1994; Cruz-Uribe 1991; Garvin 1987; Haynes 1983; Lam 1992; Marean and Bertino 1994; Marean and Spencer 1991). The interpretation of skeletal element frequencies became a recurrent aspect of archaeological research, opening up new avenues for archaeology at the same time as creating a number of debates.

A good archaeological example of the application of studies of taphonomy and quantification to the interpretation of the skeletal element frequency of an assemblage is the debate around the "Klasies pattern." The Middle Stone Age site of Klasies River Mouth, in South Africa, produced hominids bearing modern traits associated with faunal and artefact assemblages. In an effort to determine whether the faunal assemblage is the result of hunting or scavenging, a number of archaeologists studied the skeletal element frequencies. Animals of five different size classes are present in the assemblage (I being the smallest and V the largest), and the frequencies of skeletal parts for animals of size I and II is markedly different from the frequencies of skeletal parts for animals of size IV and V. Animals of size III present a mixture of both frequencies. The debates focus on explaining why the larger animals are represented by elements of the head and lower limbs, while the smaller ones are dominated by upper limb elements.

Klein (1989) argued for hunting, explaining the differences in skeletal element frequencies on the basis of carcass size affecting transport and survival through taphonomy. Binford (1984) had previously argued for scavenging of the larger animals given that the elements present were of low utility, but Klein (1989) argued that lack of bone elements does not necessarily mean lack of access to them, citing the example of the Hadza who strip the meat from high-utility bones. Bartram and Marean (1999) used ethnoarchaeology and bone refitting studies to explain the "Klasies pattern." They blame the pattern on the taphonomic history of the assemblage, followed by a methodological problem. They suggest a higher incidence of long bone fragmentation for the largest size classes. Carnivores then focussed on the long bone epiphyses, deleting those easily identifiable specimens and leaving behind hard to identify shaft fragments. Finally, they believe that those long bone shaft fragments were excluded from the analysis either by being discarded in the field or being labelled as non-identifiable, thus completely erasing the presence of upper long bones from the large mammal assemblage. Klein *et al.* (1999) replied that there was not much evidence for carnivore damage in the assemblage, adding that if the pattern was really created in part by carnivore damage, one would need to explain why the carnivores only consumed the epiphyses of the largest animals. They also dismissed the methodological problem and reiterated an explanation of the "Klasies pattern" based on carcass size.

Outram (2001) also criticized Bartram and Marean (1999) for only looking at long bones while the greatest discrepancy between large and small animals is in their scapula frequencies. Outram (2001) looked at whether scapulae from larger animals were more susceptible to taphonomic loss than the ones from smaller animals. His results show that scapulae from large animals are more likely to survive than those from small animals, thus suggesting that the pattern is not caused by natural processes and, in particular, not caused by density-mediated attrition. On the higher occurrence of lower limb bones, Outram (2000) suggested that stress in animals – linked to seasonality – could explain it. Citing zoological studies, he argued that in times of seasonal stress, such as drought periods, the lower limb bones are less fat-depleted than upper limb ones. Furthermore, malnutrition leads to higher rates of death thus increasing scavengeable resources. However, to verify this hypothesis it would be necessary to demonstrate seasonal stress for the region and time period. Besides, this does not explain the skeletal element frequencies of smaller animals.

Standardization in quantification allowed for easier comparison and interpretation of skeletal element frequencies. The debate around the "Klasies pattern" is an interesting example of how the interpretation of skeletal element frequencies is improved by the number of studies on the effects of taphonomic agents, the quantification of shaft fragments, and on ethnoarchaeology, which refines concepts of utility and transport, thus giving us an insight on the breadth of interpretation zooarchaeologists can produce through working on skeletal element frequencies.

3.2 Bone modifications

For zooarchaeologists, one of the most significant factors affecting an assemblage is its degree of weathering. An assemblage that has suffered greatly from weathering will have been robbed of some of the cultural and non-cultural modification it originally bore. Weathering is, as Behrensmeyer defines it:

> the process by which the original microscopic organic and inorganic components of a bone are separated from each other and destroyed by physical and chemical agents operating on the bone in situ, either on the surface or within the soil zone. Physical damage caused by carnivore mastication, trampling, fluvial transport, and geochemical changes which take place diagenetically during fossilization are excluded from consideration here, although such processes are closely related to weathering in its broader context (1978: 153).

The last part of the quotation relates to the tricky situation of recognizing bone modifications in general. Most categories of modification contain in their definition what they are, but also what they are not. This creates problems of description and interpretation as one tries to isolate factors that are rarely found isolated from each other.

Behrensmeyer (1978) divided the results of weathering on bone into six distinct stages from stage 0 (no weathering) to stage 5 (the highest level of weathering), each recognizable by descriptive criteria. In the present analysis, these criteria and the classificatory system have been used to describe the bison assemblage at Charlie Lake Cave (see Appendix B). It is important to remember that not all bone elements weather at the same rate. Therefore bone elements deposited at the same time may not be categorized in the same stage. Furthermore, weathering is a continuous process that we are trying to fit into arbitrarily divided stages. Therefore certain elements that exemplify characteristics from two different stages might be harder to categorize. Behrensmeyer (1978) accounted for this by devising three rules. First, "the most advanced stage which covers patches larger than one cm^2 of the bone's surface is recorded" (152). Second, shafts and flat surfaces of bones should preferably be used for the identification, especially since edges and epiphyses are usually prone to physical damages of other kinds (*e.g.*, carnivore and rodent modifications). Finally, "all observers must agree concerning the stage before it is recorded" (152).

For the purpose of this research, given the general good preservation of the bones, the specimens were observed macroscopically to identify their weathering stages. Usually, the different stages should represent the relative amount of time a bone was exposed before being buried under sediments. An assemblage consisting of bone elements in all weathering stages could be interpreted as being attritional, representing a long-term gradual accumulation over years. However, it is believed here that the rapid redeposition of glaciolacustrine sediments at Charlie Lake Cave would make such a distinction invisible, as the bones were probably quickly protected from subaerial exposure.

The identification of natural and cultural modifications on the bones is an intricate process. An extensive literature (*e.g.* Binford 1981, Fisher 1995, Lyman 1994, White 1992) is available on the description of diagnostic marks left by human, carnivore, and natural agents. These sources were used to guide the current analysis, and most of the information offered stems from those readings. As Fisher (1995) argues, no criterion is unambiguously attributable to one modifying agent over the other. That is, one cannot determine the exact cause of a single mark on a bone by looking exclusively at its characteristics. One must take a more holistic approach and take into consideration its context.

Cutmarks left by stone tools are often characterized by a v-shaped cross-section whereas carnivores usually leave a u-shaped cross-section. However, carnivores can leave such a v-shaped imprint at times. The difference, then, is that a cutmark should not follow the contours of the bone. Furthermore, cutmarks are often the result of a sawing motion to detach a piece of muscle or ligament, and such a motion should leave more than one mark in a restricted area. Other features of cutmarks have been identified as caused by human agents, like "shoulder effects", "barbs" and "splitting" (Fisher 1995). On the other hand, carnivore damage often includes scoring alongside punctures and furrowing in a concentrated area.

To distinguish percussion pits from rockfall pits, the placement of the pits needs to be observed. Rockfall pits and pitting caused by trampling of a bone against stone should be haphazard in distribution whereas percussion pits caused by human or carnivore agents should have a more organized appearance. The differences between human and carnivore-induced percussion pits are morphological in nature. Pits produced by stone tools should be more irregular in outline and internal topography. Furthermore, experiments have shown that stone tool pitting is accompanied by macroscopically visible microstriations while such striations should not be visible macroscopically when caused by carnivores (Fisher 1995).

To distinguish between excavator damage and stone tool cutmarks one has to look at the colour of the mark. If a mark is old, then the inside of the mark should have weathered like the rest of the bone and should have the same finish and staining. Furthermore, metal tools used by excavators polish the marks they leave, so the detection of a sheen within a cutmark is usually indicative of a recent mark. Stone tools leave microstriations on the sides of the cross-section as their edges are rough. Metal tools should not leave such microstriations. Finally, good supportive evidence of a mark left before the bone was excavated is when it is still covered partially by sediment, provided the bone was not bagged with some damp sediments.

Two other modifications recognized on the Charlie Lake Cave bison assemblage are created by root-etching and rodent-gnawing. The effects of those modifiers are fairly simple to recognize. Root etching is characterized by a meshing of rather curvy lines, often concentrated in an area or side of the bone specimen (Fisher 1995, Lyman 1994). As for rodent gnawing, its signature is affected by the prominent incisors that characterize these animals. Rodent damage will consist of flat incisor grooves with a series of small ridges representing the gap between incisors. Furthermore, rodent damage placement is usually on the edges of bone specimens since they are easier for small rodents to gnaw upon.

Each specimen was carefully analysed under a microscope using all the criteria discussed in this section. The results are discussed within the presentation and interpretation of the data, but the information is also available in the raw data table (Appendix B).

3.3 Reassembly

Another important method used to gather information on a faunal assemblage is to attempt conjoining of bone elements and bone fragments. In accordance with the vocabulary used in Todd and Frison (1992), when discussing the conjoining of bone fragments of a single element the term "mechanical refitting" will be used. When discussing the reassembly of different bone elements from a single animal, the term "anatomical refitting" will be used.

Typically, Paleoindian bison faunal assemblages are more extensive than those at Charlie Lake Cave. To aid in the identification of possible anatomical refits, the analysts use measurements and age-sex attributes (Todd and Frison, 1992). All bones within a certain range of variation are then visually evaluated to identify possible matches. In the current investigation, given the small number of specimens in the assemblage, it was possible to display all specimens on a table and include them all in the visual assessment. All specimens were separated by elements and sides. Next, it was a matter of trial and error, trying adjacent element articular ends one on another. A number of matches have been successful and are presented in Figures 4.1 and 4.2 in Chapter 4.

All fragments were put aside and mechanical refitting was attempted between fragments and identified specimens. This tedious exercise was eased once again by the small number of bones in the assemblage. In attempts to conjoin fragments, special attention was given to the shape of the edges of each fragment, to find its "negative image" on other specimens. Once again, a number of fragments were successfully conjoined. When previously unidentified fragments were associated with an identified specimen, the fragment's classification was changed from UN (unknown) to the element's code (see Appendix A) in the data spreadsheet (Appendix B). Subsequently, the mechanical refits (the fragments and the previously identified element) were counted as one element for quantification purposes. The mechanical refits give more confidence than anatomical conjoining as the outline of the fracture is usually replicated precisely on both the fragment and the specimen to which it conjoins. Anatomical refitting is more prone to error as articular ends do not always fit perfectly but leave space for cartilage and ligaments. The identification of an anatomical refit is often based on analogous measurements of the elements when dealing with a large number of specimens. The interest in conjoining elements and fragments in the case of the Charlie Lake Cave assemblage ultimately lies in the fact that it permits us to test the stratigraphy of the Paleoindian strata, to understand how bones were deposited, and to identify transported/butchering units that arrived together.

Even though measurements were not necessary for the reassembly of elements and fragments, the bones were measured according to the systems devised by Morlan (1991), Speth (1983) and von den Driesch (1976). The measurements are available in Appendix C. Typically, those measurements could be used to determine sex and age for elements of modern bison. However this could not be implemented on the Charlie Lake Cave bison assemblage for a number of reasons. First, the size of the assemblage is so small that there are not enough of each element to produce significant correlations. Second, we know from mtDNA studies done on four specimens from the assemblage that two different clades of bison are present at the site (Shapiro 2003). It would not be possible to know if differences in sizes represent individuals of different sex, age or clades.

3.4 Summary

Descriptive data on the assemblage are presented in Appendices B and C. For each specimen information is provided on element, part of element, and modifications resulting from natural and cultural processes, using criteria that are well established in the literature. Attempts were made to identify conjoinable fragments from the same element, and also to identify different elements that originally articulated with each other in the same individual bison. Standardized measurements were taken on as many elements as possible. The assemblage is quantified in various ways, including NISP, MNE and MAU.

4

Data presentation

One important question to consider before presenting the data from the "Zone II" or "early period" Charlie Lake Cave bison bone assemblage is whether it is justifiable to lump all the bones together for analytical purposes. This is investigated using a variety of methods, ranging from the size of the assemblage to mtDNA analysis.

The NISP of the bison bone assemblage at Charlie Lake Cave is 115. If the assemblage was divided in smaller aggregates, for instance if we studied all layers separately, certain layers would become analytically insignificant. For example, the specimen count for layer 106 would be 4. This number is too small to allow any kind of inferences on transport, butchering practices, etc. Even a %MAU ratio would be insignificant since the MAU of all three elements represented is 1. Obviously, other layers would have a somewhat higher specimen count. Yet, when investigating a site that already has a very limited number of specimens, the statistical loss of specimens associated with nearly barren layers significantly reduces the sample size. Furthermore, the stratigraphy of the site is complicated and it is possible that the layers identified do not represent clearly separated events.

The issue of whether the collection should be treated as a single assemblage can be further investigated by testing the stratigraphy through conjoining bone elements and fragments. Figures 4.1 and 4.2 are simple graphic representations of the stratigraphy of layers 98 and 105, the two major layers in Zone II. The stratigraphy is divided into layers (bold lines), and subdivided into arbitrarily defined levels used during excavation. It should be noted that the levels were excavated at an angle to follow the gully's slope, however, it was not possible to illustrate this in the graphic representations. The figures are vertically divided by lines representing the north side of excavation units. Radiocarbon dates are placed in appropriate layers and levels, and between appropriate "north" lines. Individual faunal specimens are marked by their specimen numbers and the groups of refitted specimens are differentiated by joining them with different types of lines. Note that arbitrary levels within layers were assigned separately for each unit. Because layer thickness varies between units, the number of arbitrary levels also varies. For example in Figure 4.1 it can be seen that a maximum of four arbitrary levels were defined in layer 98 in units north of N22, whereas up to eight levels were defined south of N21.

All refitted bison specimens cover at least two arbitrarily divided levels, and a few of the anatomically refitted specimens even cross layers. It should be noted that certain refitted elements from the thoracic spine (20015, 20017, 20021, 20025, 20026 and 20027) were found in close contact, yet they span several levels. This can be explained by the fact that this long specimen was lying at an angle steeper than the angle used to excavate the levels. This means that some of the refitted elements covering multiple levels result from the excavators' selection of excavation angle coupled with the generally large size of bison elements. However, those cases are not sufficient to explain all refitted segments, especially the ones that cross layers.

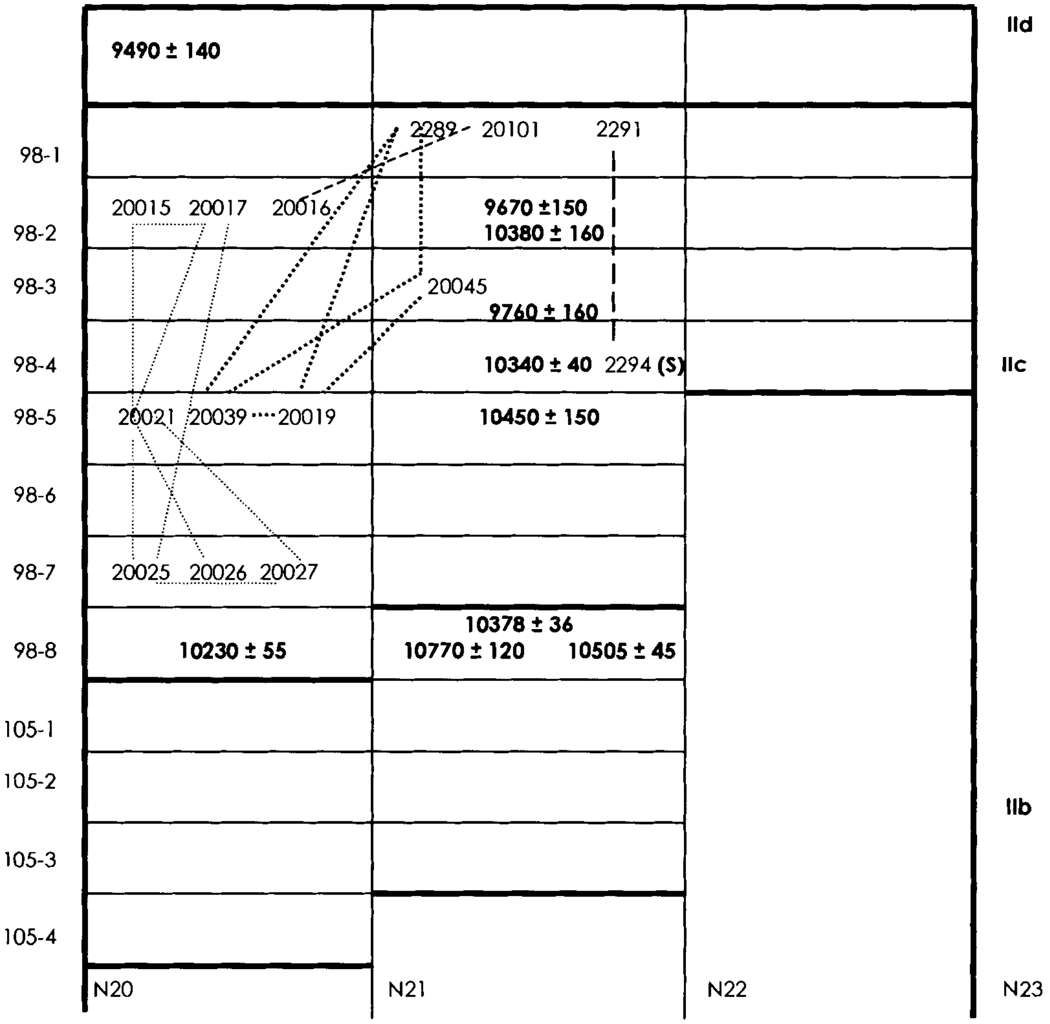

Figure 4.1 **Mechanical refitting of bison bone specimens, groups of refits differentiated by line types. Radiocarbon dates in bold are provided in their respective levels. Northern clade specimen is marked with (N), and southern clade specimens by (S).**

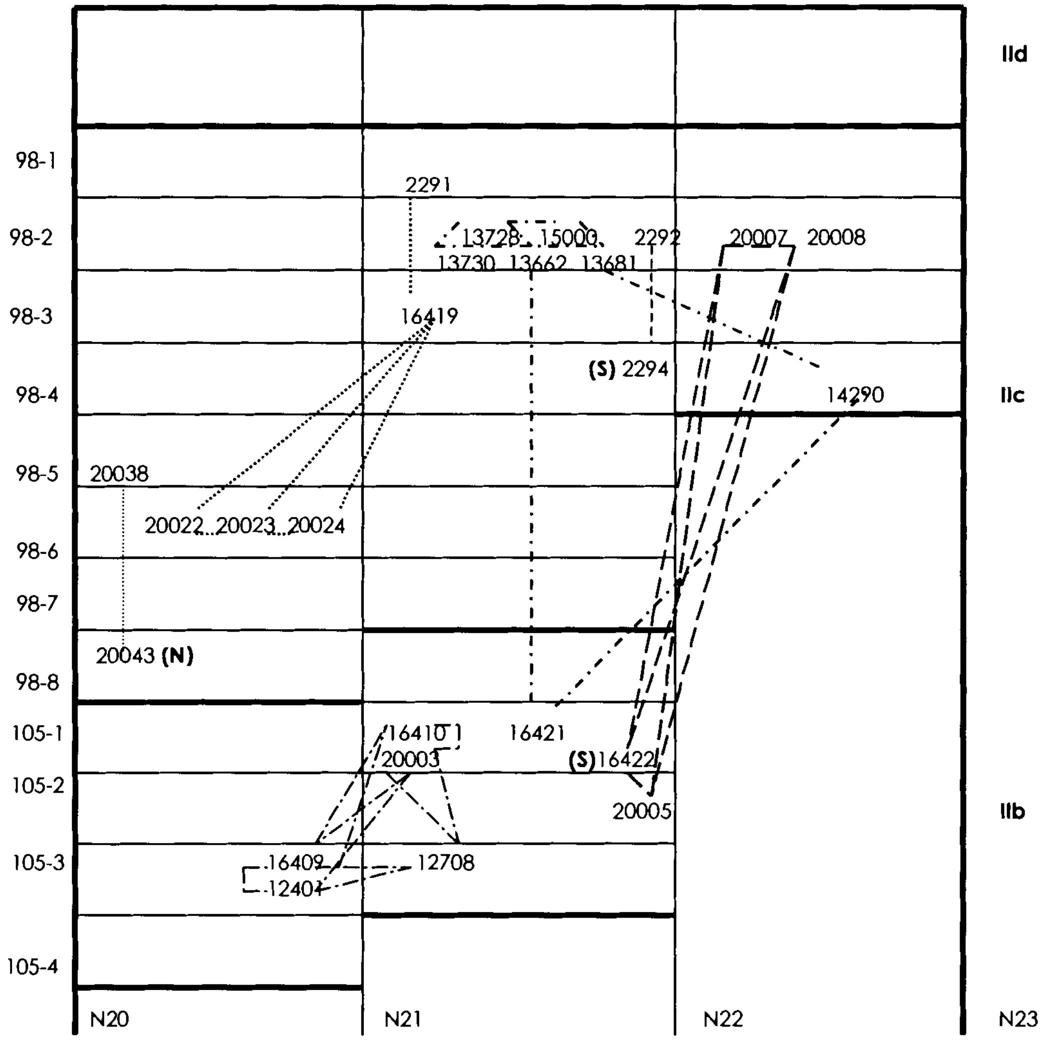

Figure 4.2 Anatomical refitting of bison bone specimens, groups of refits differentiated by line types. Northern clade specimen is marked with (N), and southern clade specimens by (S).

The anatomically refitted bison bones 20007, 20008, 16422 and 20005 stand out in Figure 4.2. All four elements are carpals spatially separated by a minimum of seven levels and found both in layer 98 and layer 105. The layer where specimens 20007 and 20008 were found was deposited on and behind a concentration of rock debris from a rock fall. The reason why two of the bone elements are on top of the rock fall debris and the other two are at the bottom of the gully is still uncertain. It seems unlikely that humans consciously placed two carpal elements on top of a pile of rocks and two other carpals at the bottom of the gully. Furthermore, the fact that more than one set of carpals and tarsals were conjoined suggests that the leg elements were still held together by tendons and ligaments when they were discarded. What happened for them to be found dispersed so far apart remains to be determined. If they were discarded with tendons and ligaments holding them together, subsequent scavenger action could be responsible for the dispersal. Alternatively, the specimens may have been deposited as an articulated set, and were separated after soft tissue decayed.

The case can be made that secondary movement of sediment (*e.g.* slumping) occurred at the site, based upon the distribution of the bone elements. One example of this is illustrated in Figure 4.3 which represents all the bones of a raven skeleton found in the Paleoindian strata of Charlie Lake Cave. It is likely that this skeleton was fully articulated when deposited (see Driver 1999a for a thorough discussion on the presence of raven skeletons at the site). Although most of the bones are found within layer 105, some bone elements are found at the bottom of layer 98. This suggests that the excavators may not have recognized the transition to layer 105 in time, a situation that reinforces the idea that stratigraphy alone might not be a good indicator of distinct episodes. The distribution of the bones within layer 105 is most interesting. A concentration of bones is found on top of layer 106, yet another concentration is also seen some 60 centimetres lower further south next to layer 106. This idiosyncrasy suggests that displacement occurred after the skeleton was deposited, even though the exact nature of the displacement cannot be established with certainty. The unusual interface between layers 105 and 106 also suggests local movement of sediments. Vertical movement of bones and artifacts within discrete layers of sediments and between them has been recognized in other archaeological sites through the use of refitting studies and justifies the modelling of archaeological sediments as "fluids" rather than "solids" (Villa 1982).

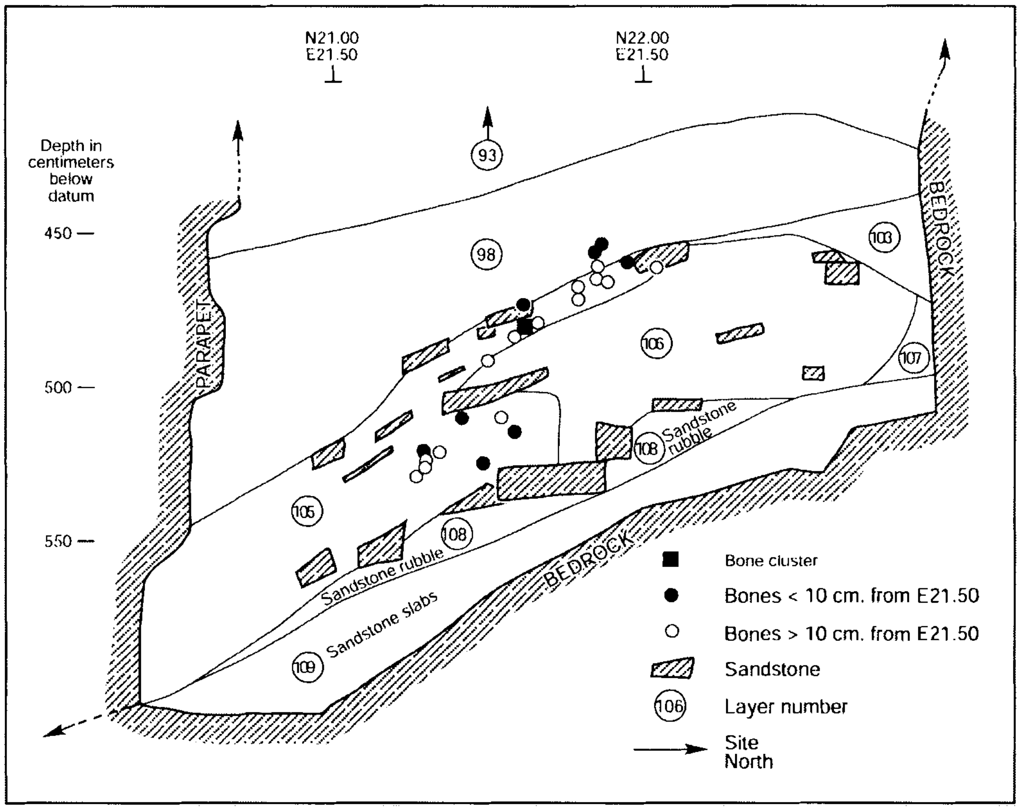

Figure 4.3 Location of bones of one raven in stratigraphy of Charlie Lake Cave

Another reason for hypothesizing that slumping occurred at the site is the general slope south that refitted elements show. Generally speaking, looking at Figures 4.1 to 4.3, there is a trend in refitted elements and fragments such that the specimens found in the south side of the gully (N20, N21) refit with specimens in units more to the north and higher up. That is, bones that were probably discarded as an articulated unit are found up to a metre apart from one another, with the specimens found closer to the parapet situated lower than the specimens found in units closer to the face of the cave. An example of this is found in Figure 4.2 with the group of refits including specimens 16409, 16410 and 12401. These elements, a radius, an ulna and their unfused distal epiphysis, were most likely discarded as a single unit with the unfused parts still held together by cartilage and ligaments. Their subsequent movement could be explained by either or both movement within the sediments and/or carnivore action. The latter proposition is explored in the next section. However, given that this is a general trend throughout the assemblage, and that vertical movement within sediments is a recognized factor in number of archaeological assemblages (Villa 1982), the influence of a generalized downslope movement of sediments and bones following the gully slope seems a likely variable.

The mtDNA studies done on four of the Charlie Lake Cave specimens (Shapiro 2003) could illuminate the issue of single accumulation versus multiple events. Of the four samples identified, two proved to be of Northern descent (*B. b. occidentalis*?) while the two other ones are of Southern descent (*B. b. antiquus*?). Based on the assumption that the two clades were not interbreeding, and therefore not living in the same herds, it can be argued that their presence suggests different hunting events. However, once plotted in the stratigraphy, the number of separate occurrences is not so obvious. Because the mtDNA samples were also radiocarbon dated, we can see their relationship in

Figure 4.1. Radiocarbon dates 10 230 ± 55 and 10 378 ± 36 represent the two specimens of the Northern clade. Radiocarbon dates 10 505 ± 45 and 10 340 ± 40 represent the two specimens of the Southern clade.

Three of these specimens have been refitted with other specimens. The Southern specimen dating to 10 505 ± 45 (16422) anatomically refits with specimens 20005, 20007 and 20008. The other Southern specimen (2294, dating to 10 340 ± 40) refits anatomically with specimen 2292, and mechanically with specimen 2291 which in turn refits with a few carpals. It should be noted here that during the refitting analysis, specimen 2291 was particularly difficult to match as it was a close fit with two sets of carpals (in Figure 4.2 the groups associated with 20007 and 16419). The final decision to refit 2291 with the group associated with 16419 was based on radiocarbon dating. Since 2291 is clearly associated with 2294, which dates to 10 340 ± 40, and the 20007 groups contains a date of 10 505 ±45 from a Southern specimen, the undated group of carpals was deemed a more appropriate association. Finally, Northern specimen 20043 (dating to 10 230 ± 55) refits anatomically with specimen 20038. It can be hypothesized that at least two different hunting events are represented by animals from two different clades, therefore possibly of different herds. Unfortunately, the other bones deposited during those events, if any, are not identifiable spatially. Bones from the same animal are found in different layers, and two of the sampled specimens were found at the same level in two adjacent units. Therefore, no single levels or layers can be associated with a single event based on the mtDNA data available. However, we can hypothesize that the assemblage represents more than one event.

Even though it is likely that the assemblage represents a number of events, they cannot be distinguished from one another. Given that the assemblage is small, that layers are not indisputably separated from one another, that the radiocarbon dates tend to be homogeneous throughout the thick sediments, and that the presence of different clades of bison cannot be discriminated with distinct strata or by date, it seems reasonable to treat the assemblage of the Paleoindian strata as a single collection for analytical purposes. However, this is problematic since it is probable that the accumulation of bones represents more than one event. It is impossible for the investigator to know what was deposited when, so one has to assume that all events were homogeneous. If more than one inherently different event occurred at Charlie Lake Cave, their occurrence would be blurred by the amalgamation of the data, potentially leaving the investigator with an assemblage that is not representative of any one event. Nevertheless, to varying degrees this is a problem that is faced in all archaeological research. Rarely can an assemblage be refined with certainty down to a single event.

4.1 General presence/absence of skeletal elements

Skeletal element frequencies in an assemblage are the baseline upon which to build analyses of taphonomy and cultural activity (see Chapter 3 for discussion). Basically, before inferring human behaviour from an assemblage, the analyst should try to identify patterns and test the possibility that factors other than human action affected what is represented. MNE, MAU and %MAU were first tallied to calculate the skeletal element frequencies of Charlie Lake Cave (Table 4.1 and Figures 4.4 and 4.5).

Element	MNE	MAU	%MAU	Element	MNE	MAU	%MAU
CRANIA	1	1	28.57	CARPALS	3	1.5	42.86
ATLAS	0	0	0	P. METACARP.	1	0.5	14.29
AXIS	0	0	0	D. METACARP.	2	1	28.57
CERVICAL 3-7	1	0.2	5.7	P. PHAL.	3	0.38	10.86
THORACIC	1	0.07	2	M. PHAL.	7	0.88	25.14
LUMBAR	0	0	0	T. PHAL	8	1	28.57
RIB	3	0.11	3.14	INNOMINATE	2	1	28.57
SACRUM	1	1	28.57	P. FEMUR	0	0	0
SCAPULA	1	0.5	14.29	D. FEMUR	0	0	0
P. HUMERUS	3	1.5	42.86	P. TIBIA	7	3.5	100
D. HUMERUS	4	2	57.14	D. TIBIA	5	2.5	71.43
P. RADIUS	5	2.5	71.43	TARSALS	3	1.5	42.86
D. RADIUS	5	2.5	71.43	P. METATARS.	2	1	28.57
P. ULNA	3	1.5	42.86	D. METATARS.	2	1	28.57
D. ULNA	2	1	28.57	HORN CORE	1	0.5	14.29

Table 4.1 Skeletal element frequencies data used for Figures 4.4 and 4.5

The criteria used to calculate the MNE values were simply whether the specimens belonging to the same bone element shared the presence of skeletal features that cannot be duplicated in a single bone specimen, and also whether refitting could be demonstrated. The size of the elements was not taken into account, unless it pointed directly to significant age differences. That is, a neonatal specimen was not counted in the MNE with another non-overlapping specimen from the same element if the latter was from an adult individual. Given that the MNE values were calculated separately in long bones for proximal and distal parts, this distinction was not essential. In the present analysis, the differentiation of neonatal specimens from adult ones was only necessary for the pelvic area. Specimen 20042 does not overlap any other pelvic specimens, however its neonatal characteristics clearly separated it from any association with the other specimens. Once the MNE values were determined, the MAU and %MAU values were calculated according to the explanations given in section 3.1 of this thesis. This allows us to compare the relative abundance of skeletal elements. It is important to note that the calculation of the long bone MNE was done separately for proximal and distal parts but this does not refer literally to the epiphyses. A point at the middle of each element was defined as the demarcation between proximal and distal. Long bone shaft specimens are included in this analysis. For example, if three specimens consisted of the distal humerus shaft and fused epiphysis, a distal humerus shaft fragment would be counted as another MNE if it overlapped with shafts of the first three specimens.

Looking at Figures 4.4 and 4.5, the most obvious feature is absence. There are no mandibles (MN), atlas (AT), axis (AX), lumbar (LU) or caudal (CD) vertebrae, or femora (FE). It should also be noted that certain elements are represented by very small %MAU values. For example, the 3rd to 7th cervical vertebrae (CE) are represented by only one fragment, giving the group a %MAU value of 5.7%. The ribs (RI) also merit our attention. Only three fragmented ribs were found in the assemblage while a bison skeleton includes 28 ribs. The %MAU in the case of ribs is 3.14%. To continue with the axial skeleton, the thoracic (TH) vertebra numbers are based on a single thoracic spine, tallying a %MAU of only 2%. No complete cranium was found, only small fragments that were not

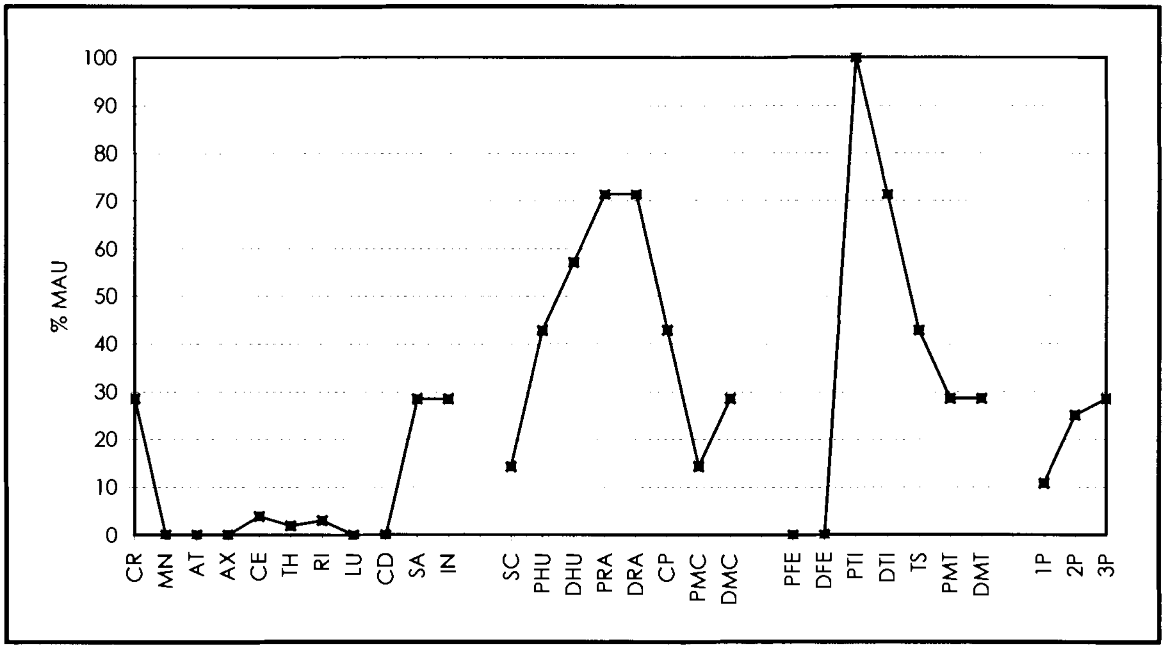

Figure 4.4 Skeletal element frequency (%MAU) for bison at Charlie Lake Cave (see codes in Appendix A)

identifiable to specific cranial features. For this reason the MAU for cranium is 1 and %MAU is 28.57%. The sacrum is represented by only one fragment and gives a %MAU of 28.57%. Finally, four innominate specimens were excavated. However, of those specimens one was definitely from a neonatal animal. The innominate is a paired element, therefore the MNE needs to be divided by two, which gives it an MAU value of only 1 and a %MAU value of 28.57%. Zooarchaeologists disagree on whether the innominate should be included in the axial skeleton when zoologists do not, but in the present analysis its cultural association with the axial elements was chosen over its anatomical association. That is, it is believed that in a butchery context, the innominate will not be removed as part of the limb element but instead will be kept with the rest of the axial skeleton. From this set of data, it is safe to say that the axial skeleton is not highly represented in the assemblage.

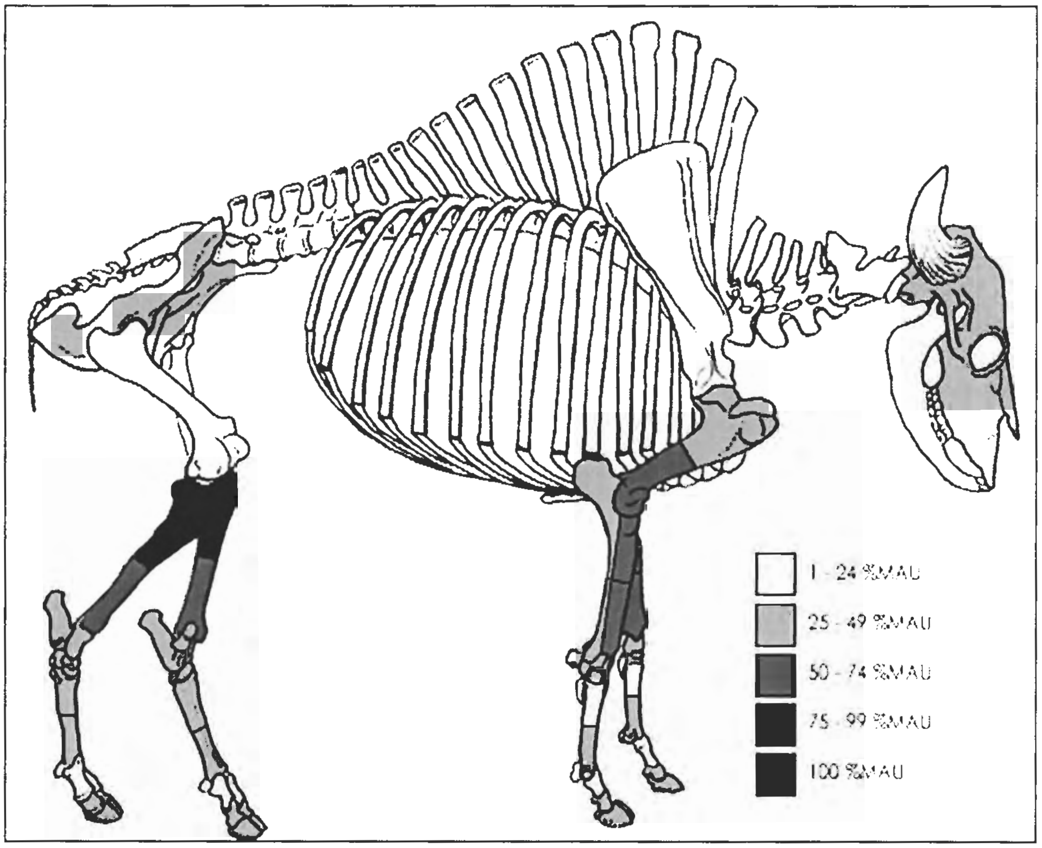

Figure 4.5 Presence/absence of bison elements at Charlie Lake Cave.

The element that has the highest MAU value in the Charlie Lake Cave assemblage is the proximal tibia, represented by an MNE of 7 and an MAU of 3.5. It is followed in descending ranking by the distal tibia and proximal and distal radius, all represented by a %MAU of 71.43%. The last element in the over 50% category is the distal humerus, represented by a %MAU value of 57.14%. Proximal humerus, proximal ulna, carpals (represented by 3 intermedia) and tarsals (represented by 3 calcanea) all have a %MAU value of 42.86%. The rest of the elements that correspond to the 25 – 49 %MAU category in Figure 4.5 have a

%MAU of 28.57% except for the second phalanges at 25.14%. The limb elements are therefore present in higher relative frequencies than the axial skeleton, and Figure 4.4 clearly illustrates a focus on mid-limb elements. However, while the proximal tibia represents the highest MAU, the femur is completely absent. This idiosyncrasy is not replicated in the forelimb elements, where both radius-ulna and humerus are more equally present.

4.2 Bone density

Skeletal element frequencies can be influenced by a variety of factors, one of which is the effect of differential bone density. Processes such as weathering, trampling or carnivore activity tend to impact the least dense bones the most heavily. Attention was brought to this issue by Brain (see 1981 for fuller account) who noticed in the mid-1960s that "the consistent absence of certain skeletal parts from the Sterkfontein valley fossil assemblages could well be related to their original delicacy and inability to survive destructive influences" (1981: 11). While in the Namib desert, in Southwest Africa, he used Khoisan villages as an experimental ground for the study of human and carnivore action on differential representation of goat bones. His observations led to the realisation that the survival of a skeletal part is linked to its structural resistance; thus skeletal parts of a whole animal should survive differentially in a patterned way. To explore this argument, bone density indices were developed (*e.g.*, Lyman 1984). The idea behind them is to plot the skeletal element frequency of an assemblage, using %MAU as the counting unit, against the bone density values of those elements and thus to see if the pattern of representation corresponds to the predicted pattern of survival. In other words, it allows the analyst to assess whether the assemblage composition is a function of the structural density of its skeletal elements.

Although skeletal parts survive differentially in a patterned way, the pattern need not be the same for every species (Kreutzer 1992, Lyman *et al.* 1992, Stahl 1999) and different bone density data should be collected for each species studied. Such a specialized index exists for bison (Kreutzer 1992) and the %MAU values calculated from the present assemblage were plotted against Kreutzer's index (see Figure 4.6). Before discussing this, there are a certain number of concerns that need explanation.

Lam *et al.* (2003) recently pointed out that the methods used to derive bone mineral density data are not homogeneous between studies. This creates differences in density data between species that could be interpreted as being animal-specific patterns of bone density, but in reality only illustrate differences in methodology. Most zooarchaeological studies of bone mineral density mentioned above, including Kreutzer's (1992) study, use a technology called photon densitometry which measures the bone mineral content across a scanned section of bone. The volume has to be determined before the density can be measured. This has been done in a variety of ways, which is a main concern of Lam *et al.* (2003). In Lyman's (1984) pioneering research, the volume was calculated as a rectangle from maximum width and thickness. The problem is that this not only underestimates the bone density of any scan sites, but it does so differentially between scan sites.

Kreutzer (1992; see also Lam *et al.* 2003) modified Lyman's (1984) methodology, making a number of different measurements at each scan site to create a geometric estimate of the bone's cross-section. This is an improvement, but according to Lam *et al.* (2003), a problem remains as the photon densitometry cannot differentiate internal heterogeneity. That is, it cannot see if the bone is hollow or not. This means that "PD [photon densitometry] values for scan sites with internal cavities significantly underestimate density" (Lam *et al.* 2003: 1703), or simply put, shaft scan sites are denser than PD-derived bone density indices suggest. This is something that needs to be kept in mind when interpreting bone density data for Charlie Lake Cave. However, given that shafts are already some of the denser scan sites in bone density measurements and that preservation of weak bones at Charlie Lake Cave seems excellent, this new information should not greatly affect the interpretation of the influence of density-mediated attrition in the present assemblage.

Notwithstanding the methodological problems encountered while collecting density data, a long-standing criticism of both bone density and utility indices is that they are ordinal scales at best (Lyman 1994). That is, they are usually based on only a few individuals that do not convey the usual range of individual variation found within a living population. Degrees of malnourishment and age are variables that could influence the frailty of bone elements yet they are rarely part of the sampled population. Nonetheless, a bone density index used as an ordinal scale can provide the grounds upon which to build inferences.

Another critical problem with the use of bone density indices is that its outcome, coupled with the outcome of utility indices of the same assemblages, can produce a case of equifinality. The problem lies in the observation made by Lyman (1985) that often elements ranking high in utility rank low in structural density. This means that an assemblage that has suffered greatly from density-mediated attrition will have most of its high-utility bone elements disappear and leave a preponderance of low utility specimens resembling a kill-site, an assemblage with an emphasis on low-utility elements. One solution proposed involves a change in the counting units used for bone density scatterplots. At its inception, both utility and bone density scatterplots calculated only the %MAU of long bones' proximal and distal ends. However, shafts are more likely to survive than their epiphyses (Lyman 1994). By using only the ends of long bones to see the effect of density-mediated attrition the analyst loses precious information on the presence/absence of the bone element. Lyman (1994) believes that this problem can be alleviated by using scan sites to calculate the %MAU when plotting the bone density versus the skeletal element frequencies in scatterplots. This is what has been done in Figure 4.6 using the scan sites provided by Kreutzer (1992).

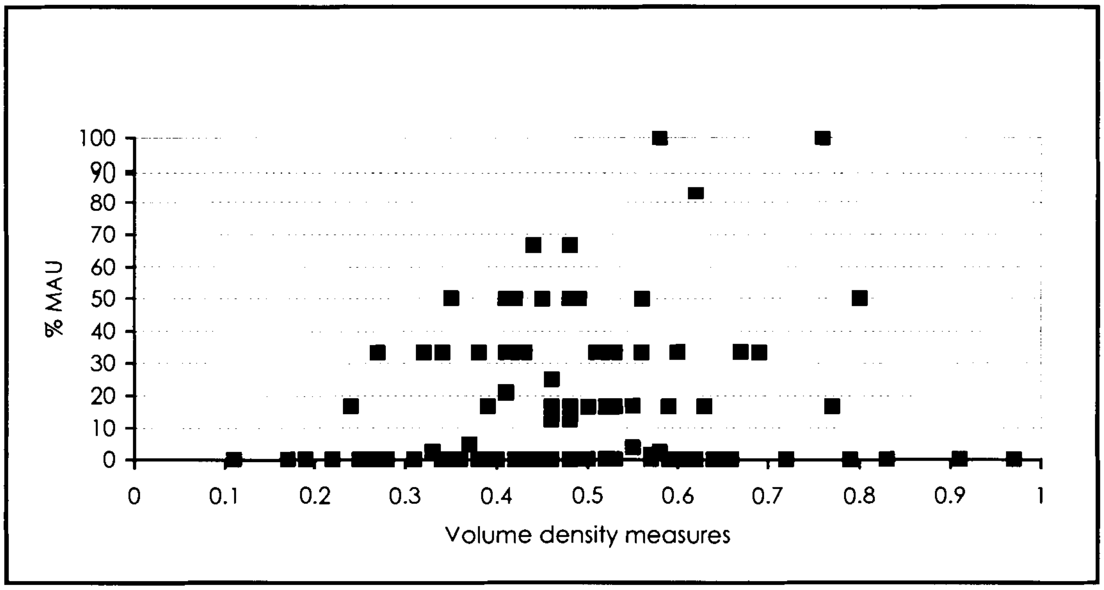

Figure 4.6 Influence of bone density on the Charlie Lake Cave assemblage based on Kreutzer's (1992) density data. The %MAU of scan sites present in the bison assemblage are plotted against volume density data.

On the whole, when looking at the scatterplots of bone volume density measures against the %MAU of every scan site present in the assemblage (Figure 4.6), it is noticeable that very few of the less-dense scan sites are present. As density measures increase, the %MAU of scan sites in the assemblage also increases for a number of scan sites until a sudden drop of the highest-density ones. It is also interesting to note that absent scan sites display the whole range of structural density recorded. Furthermore, the bulk of the scan site frequencies is situated at mid-density levels. However, this is true of complete bison skeletons too, as is exemplified in Figure 4.7.

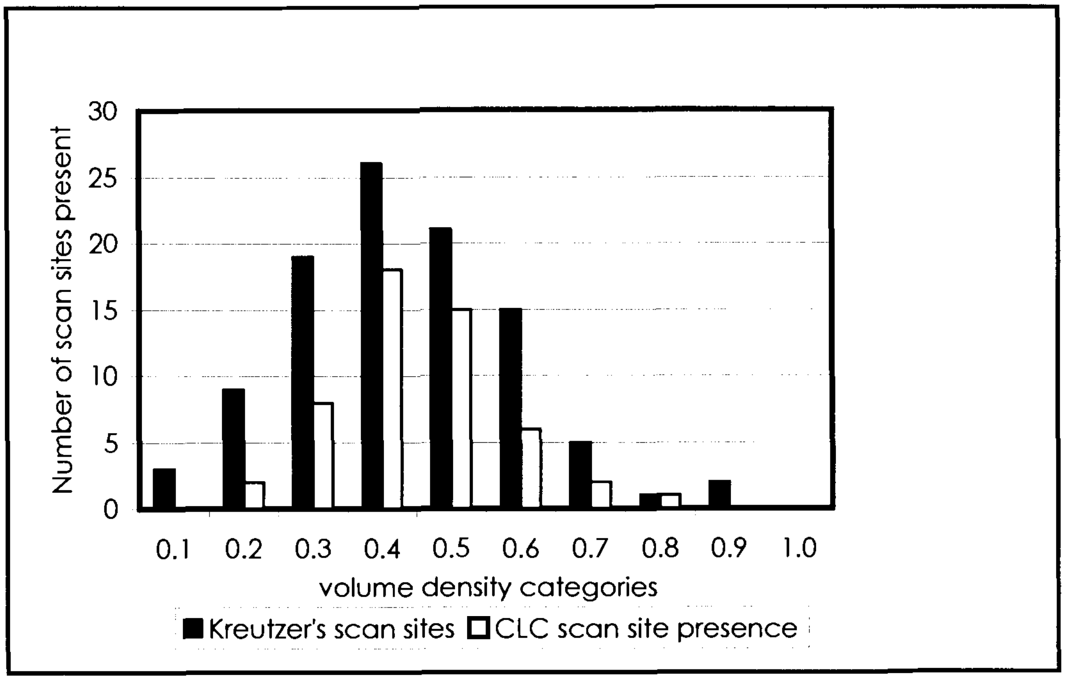

Figure 4.7 Distribution of Kreutzer's (1992) scan sites for *B. bison* compared to the distribution of scan sites present in the Charlie Lake Cave assemblage

Figure 4.7 illustrates the distribution of scan site density measures given by Kreutzer (1992). It is noticeable that very few scan sites have a density value higher or equal to 0.7 while the vast majority of scan sites have density values between 0.3 and 0.7. That is, density levels are not distributed evenly throughout a bison skeleton. Rather the majority of the scan sites are situated at mid-level density, with a few outliers displaying very high or very low density. Figure 4.7 also displays the presence of those scan sites in the Charlie Lake Cave assemblage, not taking into account how often they are encountered, only whether they are encountered at all. That is, the analyst noted for each scan site provided by Kreutzer (1992), in every density category, whether the equivalent scan site was found in the Charlie Lake Cave bison assemblage. If a scan site was found, notwithstanding whether found on only one specimen or on all specimens, it was counted as present. Given that the majority of scan sites have a value between 0.3 and 0.7, it seems logical that a high proportion of scan sites within an assemblage will be found between those values.

Looking back at Figure 4.6, the distribution of the %MAU of scan sites is underlined in the sense that knowing that the majority of the scan sites present in a bison have fairly homogeneous mid-level density values, the %MAU of those scan sites should also be homogeneous if density created the skeletal element frequencies. However, they are not. Rather, the distribution of the %MAU of scan sites is wide-ranging, in nearly all categories of density measures, from complete absence to strong presence. This needs to be explained by factors other than density-mediated attrition of complete bison carcasses, suggesting instead that some of the patterns in skeletal element frequencies seen in the assemblage were there from the time of deposition.

Thus, the skeletal element frequencies of the assemblage do not seem to be a direct function of the structural density of the skeletal elements, even if a slight skew was visible from lowest to highest-density scan sites, otherwise we would not see such a range in frequencies at similar levels of structural density. Furthermore, due to the presence of less dense specimens, it is safe to conclude that the absence of the highest density bones is not linked to their structural density. Rather, it is more likely that they never made it into the assemblage. According to Kreutzer's (1992) work, those structurally dense bone elements that are absent are the axis and atlas vertebrae, and the mandible. Given that the observation of weathering stages (Appendix B) shows that the assemblage was not significantly affected by post-depositional agents on or within the soil, except for 6 specimens, it can be concluded that density-mediated attrition due to weathering or the burial environment was not a strong influence in shaping the skeletal element frequencies of the assemblage. Other variables must be at play. One should also note the very poor representation of the cranium and the virtual absence of teeth, all suggesting that bison heads were not frequently deposited at the site.

Carnivore damage can also influence the skeletal element frequencies of an assemblage. Marean and Spencer (1991) along with other researchers cited in their publication, argue that in an assemblage ravaged by carnivores the epiphyses have less chance of survival than do long bone shafts. The probable cause for this pattern would be that epiphyses have a higher bone grease content than the bone grease content of shafts, excluding the marrow cavity, along with the fact that long bone epiphyses are generally less structurally dense. Marean and Spencer (1991) devised an experiment in which they fed hyenas with sheep limb bones. Most of the bones were already broken open for marrow extraction, recreating what a human occupation site assemblage could look like, in order to explore the further transformations induced by carnivores. However, some of the limb bones were left intact. In those instances, Marean and Spencer (1991) noticed that hyenas used their bone-crushing jaws to open the shaft first. However, when fed *Bos taurus* the hyenas could not succeed in smashing open the shaft. Instead, they would eat the epiphyses away until they reached the marrow cavity. From their experiment, Marean and Spencer (1991) observed that the MNE count of end pieces of long bones before and after carnivore ravaging changed by up to 80%, a result far more dramatic than for the MNE count of shaft pieces.

In a similar study, Blumenschine and Marean (1993) pointed out that the ratio of epiphyseal to shaft fragments can be used to identify the degree of carnivore involvement in an assemblage. Their experiments involved the comparison of three different types of assemblages, one affected only by carnivore agents, one created through hammerstone breakage, and the last one created by feeding hammerstone-broken bones to carnivores. They found that "this simple ratio value of fragment counts (NISPs) can provide an accurate estimate of epiphysis loss through carnivore agencies" (p. 286), notwithstanding the carcass size. The long bone assemblage of Charlie Lake Cave comprises 16 epiphyses compared to 14 shaft fragments, thus a ratio of 1.14:1. Compared with the data from figure 16-5 in Blumenschine and Marean (1993), the ratio from Charlie Lake Cave corresponds to their hammerstone-only site. Carnivore-only assemblages presented ratios of 0.1:1 and less, and "simulated sites" ratios were below 0.4:1. All assemblages with ratios above 0.4:1 corresponded to hammerstone-only assemblages. A problem with the comparison of Charlie Lake Cave with the assemblages from this experiment is that culturally-produced assemblages ("simulated sites" and hammerstone-only) contained only bones broken open for marrow consumption while many of the long bones from Charlie

Lake Cave were not broken open, and therefore did not leave behind a large number of shaft fragments. However, Blumenschine and Mearean's (1993) carnivore-only assemblages consisted of whole bones yet their ratios do not compare to the ratio of Charlie Lake Cave.

Carnivores most likely to have been at Charlie Lake Cave are canids, such as wolves and dogs. Garvin (1987) studied the effects of canids on cow and horse long bones, an analogy more attuned to the present assemblage. He found that although dogs and wolves do go for epiphyses first, in order to get at the flesh not completely removed from butchering and the bone grease, canids do not eat all epiphyses indiscriminately. While wolves will destroy the proximal epiphyses of the humerus down to parts of the shaft when given the time, they showed no interest in the distal end. The same goes for the radius-ulna package, where the olecranon process of the ulna is removed first, followed by scoring of the proximal radius. No damage was found on the distal end of the package. Garvin (1987) believes that a likely cause to this pattern is because the carpals were still attached to the radius-ulna with tough dried ligaments. Tarsals were also left attached to the distal tibia by the canids. Studies of wolves in the wild have also been done (Binford 1981; Haynes 1982), however these observations were based on wolf-kills and not wolves scavenging a human-produced assemblage. The data are not comparable as the wolves are more interested in the flesh than in the bones, at least in the first stages of consumption. Haynes (1982) did find that wolves can break open the shafts of bison long bones, but only after the bison was dead for six months and its bone was weathered and dried.

The carnivore damage on the Charlie Lake Cave assemblage was recorded in the raw data table (Appendix B) using a classificatory system of stages. The easiest classification is the stage 0 category, where no carnivore damage can be observed on well-preserved bone specimens. The next category is stage 1 representing some carnivore damage without the complete destruction of a feature. A bone element specimen that seems to have lost a feature, most commonly one of its articular ends, is classified in the stage 2 category. The final category is stage 3 and represents the specimens that were severely affected by carnivore ravaging (see Figure 4.8 for example), assuming that anything damaged even more than stage 3 would become analytically invisible. Bone fragments that could not be identified to element, after attempting to refit them mechanically, were not further analysed so they are excluded from this discussion. The same goes for the few small skull fragments. The total of unanalysed bone fragments is twenty-five, therefore the number of specimens under investigation in the present discussions drops from 115 to 90. Furthermore, to account for the possible conflation of data coming from bone breakage, the specimens that could be mechanically refitted together were counted as one bone element specimen. This produces a total of 78 bone elements for this analysis.

Twenty-one specimens did not show any signs of carnivore damage, that is, 26.9% of the specimens under investigation. Twenty-seven specimens showed light carnivore damage, representing 34.6% of the assemblage. Fourteen specimens had one feature destroyed by carnivore ravaging, representing 17.9% of the assemblage. Ten out of the seventy-eight specimens showed substantial carnivore damage, representing 12.8% of the assemblage. Finally, identification of carnivore damage was inconclusive for six specimens, often due to their heavy weathering stage. Those specimens represent 7.7% of the assemblage.

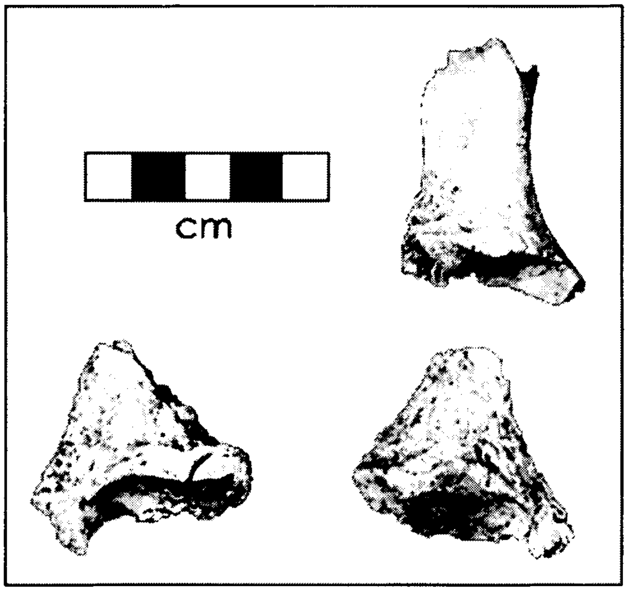

Figure 4.8 Carnivore damage on three bison calcanea from Charlie Lake Cave. Examples of the stage 3 category for carnivore damage.

From these data, it is noticeable that more than half of the assemblage has suffered only light carnivore damage, if any at all. The heavily damaged bone specimens represent all three calcanea (see figure 4.8), two juvenile tibiae, one metatarsal and one metacarpal, a sacrum, a tarsal and a second phalanx. One mature tibia is in the stage 2 category, and another tibia (1840) cannot be assessed for carnivore damage as it was completely destroyed by the C14 process, which leaves one complete mature tibia (20043) untouched by carnivores. The fact that at least three of the tibiae were ravaged on at least one end reinforces Garvin's (1987) claim that the tibia, especially the proximal tibia, is an attractive bone element for carnivores. One possibility for the lack of carnivore damage on 20043 could be that more attractive foods were readily available for carnivore consumption at the time of the deposition, for example humeri or maybe even one or a few femora. Garvin's (1987) thesis does suggest that femur is the most likely bone to be transported away from the bone accumulations for extended gnawing.

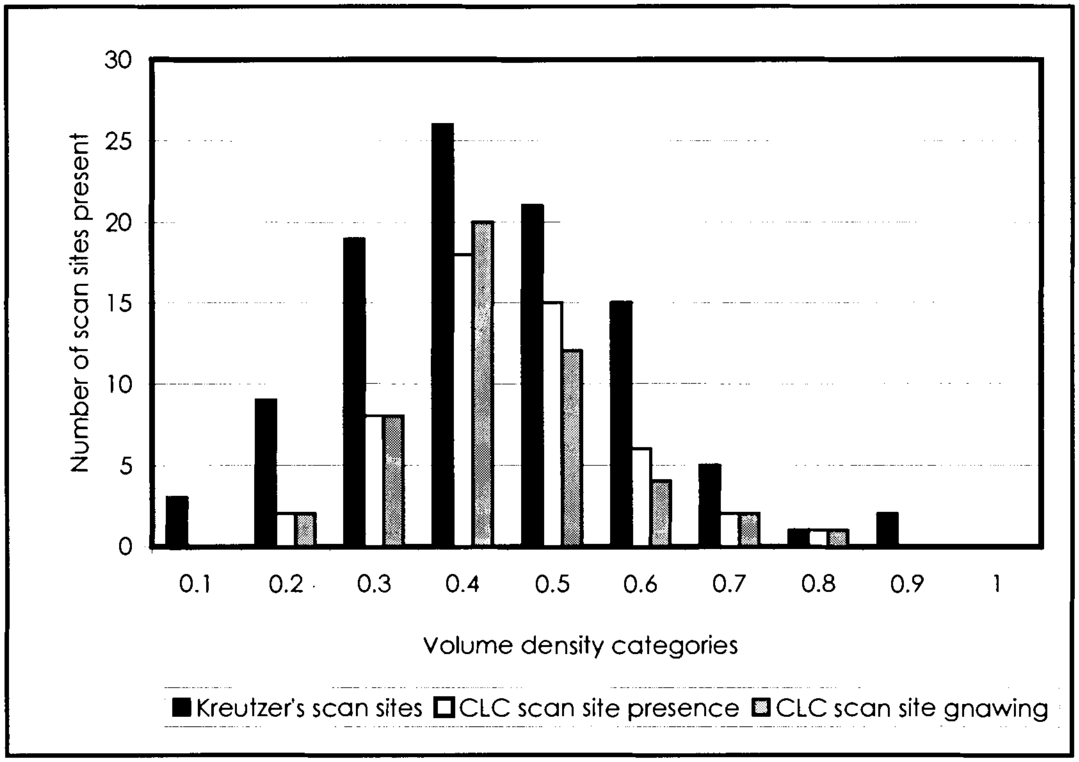

Figure 4.9 Distribution of Kreutzer's (1992) scan sites for *B. bison* compared to the distribution of scan sites present in the Charlie Lake Cave assemblage and to the presence of carnivore damage on the specimens

Figure 4.9 was devised to investigate the relationship between density and carnivore interest. It contains the same data as figure 4.7 for the first two columns, but another column was added. The new set of data represent the number of scan sites in all density categories that have been ravaged by carnivores, no matter what degree of the damage. It is important to note that in the 0.4 category for measured density the number of scan sites ravaged by carnivores is actually higher than the number of scan sites found in the Charlie Lake Cave assemblage. This can be explained by the investigator's belief that those scan sites are analytically absent due to carnivore damage. Therefore, they were counted as ravaged by carnivores but they cannot be counted as present in the assemblage. For example, if the proximal end of a long bone was completely removed by carnivores, it could not be included in the assemblage NISP, but would be considered in the count of carnivore damage. It is recognized that this reasoning presents a certain analytical circularity. To infer that the cause of absence of a scan site is one agent instead of the other is problematic when investigating the relationship between structural density and carnivore interest. However, the suggestion that those two particular scan sites disappeared because of carnivore action was based on the presence of tooth marks and furrowing on the edge of the nearest scan sites. An alternative interpretation – the subsequent gnawing of a carnivore on a bone already altered by density-mediated attrition of another type – seems unlikely.

Looking at Figure 4.9, it is noticeable that carnivores had a taste of the vast majority of the scan sites available in the assemblage, no matter what density. Interestingly, it was previously mentioned that more than one-quarter of the assemblage suffered no carnivore damage. This means that some parts of the skeletal elements were attractive at times, and not so much at other times. Why do we find such a diversity in the patterning of carnivore damage in this assemblage? This suggests that the selection of bone elements available to carnivores for consumption probably varied, which brings up again the issue of multiple episodes. The recurrent carnivore damage to carpals, a reputedly unattractive food source in regard to their higher bone density, could suggest that this part of the leg was discarded with tendons and ligaments still holding them together. This is supported by the fact that so many of the carpals were effectively refitted together, and with their respective distal radius. If this were true, this concentration of tissue could prompt carnivores to consume this part before other bone elements considered more attractive due to their low density and high bone grease content.

Furthermore, the presence of carnivore damage through the range of densities suggests that there probably was not a concentration of the most attractive bone elements, *i.e.* the axial elements, those being the first bones to be damaged by wolves feeding on fresh bison (Haynes 1982). A single bison skeleton possesses twenty-eight ribs, attached to fourteen thoracic vertebrae. There is a minimum number of five individuals in the total assemblage which would have left one hundred and forty ribs behind, and seventy thoracic vertebrae. Yet, we only have three rib fragments, and one thoracic vertebral spine. If we hypothesize that the axial skeleton was present at deposition but was edited from the assemblage through carnivore scavenging, we need to explain how they managed to destroy such a large amount of elements yet leave behind other attractive parts of elements like the proximal tibia. Both Binford (1981) and Haynes (1982) observations of packs of wolves feeding on a carcass for extended periods of time mention that proximal ribs are often left behind, and vertebrae are most commonly gnawed on the spines and processes but are not consumed in their entirety. In fact, Haynes noticed that "splinters of ribs and vertebrae usually mark a prey animal's death site" (1982: 275). Thus there is good evidence that if the axial elements were deposited at the site, more evidence of their presence would have been found. Given that the density-mediated attrition of the assemblage was deemed low, that the weathering analysis suggests excellent preservation, and the above discussion of carnivore damage, it seems justifiable to assert that the absence of the axial skeleton in the assemblage is not significantly attributable to any of those factors.

To explain the variability of carnivore damage on different specimens of the same element, it is possible that carnivores would focus on juvenile bone elements as opposed to fully mature ones. The case of the tibiae mentioned above does seem to suggest such a trend. However, when looking at the raw data table (Appendix B), there does not seem to be a general strong correlation between the fusion state of the bones and the degree of carnivore damage. For example, one unfused radius (16410) has no carnivore damage, while its distal epiphysis (12401) has only light carnivore damage on it. Another unfused distal radius epiphysis (13731) was found with only light carnivore damage on it. This cannot be explained by a general lack of interest in distal radii by carnivores as specimen 20101 has its distal end completely erased through carnivore action.

There does not seem to be a correlation between carnivore damage and the spatial distribution of the bones within the gully either. Given the rapid rate of sedimentation at the site for the Paleoindian time period, and the slope of the gully floor, it is possible that bone elements deposited closer to the parapet would have been buried more rapidly than the ones deposited higher up slope, deterring carnivores from ravaging interred bones. Such a situation would be visible in the raw data by associating higher carnivore damage patterns with units closer to the cave wall. Furthermore, it is hypothesized that the weathering stages of the bone elements closer to the parapet would be less severe than the ones upslope near the cave wall. Units 4, 26, 27,28 and 29 are all within approximately one metre of the parapet. Looking at the raw data available in Appendix B, no correlations between the spatial distribution of the bone elements and the carnivore damage or weathering stages could be recognized. However, it was mentioned previously that sediment slumping occurred at the site therefore spatial distribution of bone elements excavated probably does not correspond to their distribution at deposition. So, if natural processes such as weathering, differential bone mineral density, and carnivore action have played minor roles in shaping the skeletal element frequencies of the assemblage at Charlie Lake Cave, cultural processes may be implicated too.

4.3 Utility indices

Binford first introduced the idea of utility indices in his 1978 book *Nunamiut Ethnoarchaeology*. With this book, Binford (1978) intended to derive specific knowledge of what a group of hunters get out of their butchering practices. To do so, he measured the amount of meat, marrow, and grease associated with skeletal parts of two domestic sheep and one caribou, and then constructed indices of the food utility of carcass parts for human consumers. To this General Utility Index (GUI), Binford added modified values accounting for "riders" to create a Modified General Utility Index (MGUI). Basically, some carcass parts with a low GUI are attached to carcass parts of higher utility, and therefore will be transported along. Binford (1978: 74) gave those less attractive yet often transported body parts a utility value equivalent to the average of their GUI value and the GUI value of the high utility element it "rides" with. The MGUI values are then normalized on a scale of 1 to 100 by dividing all derived values by the greatest value, and are referred to as %MGUI. To understand human transport and utilization behaviours with those data, one would have to plot the %MGUI against their carcass part skeletal frequency in the assemblage, creating curves that can be associated with butchering and transport strategies. The counting unit Binford (1978) uses for the skeletal element frequencies is the Minimal Animal Unit (MAU).

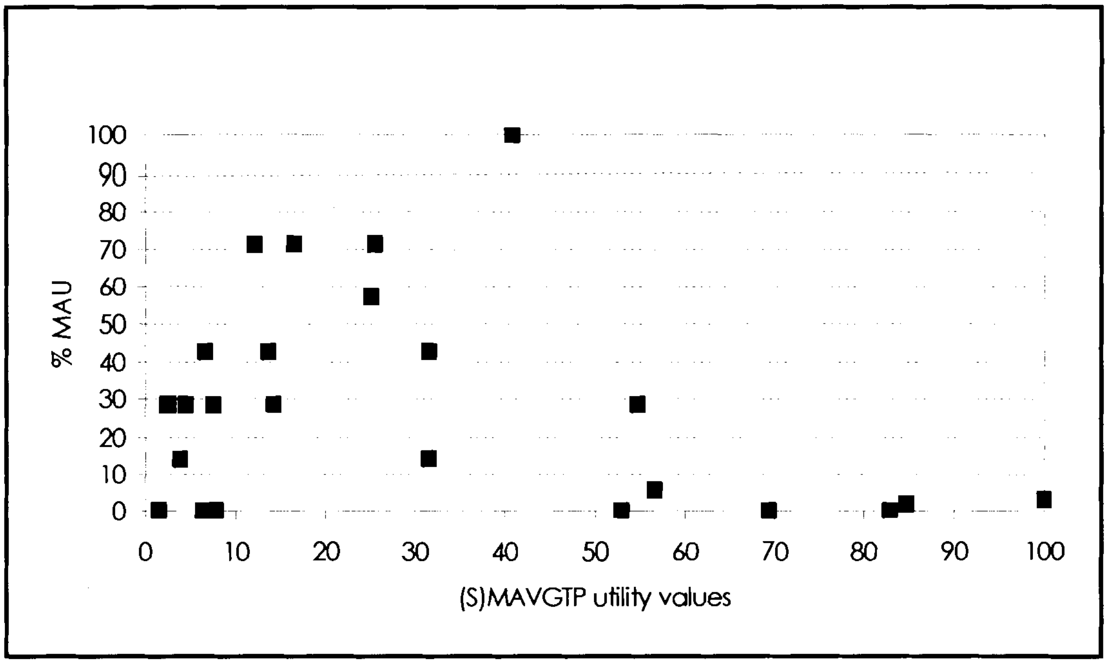

Figure 4.10 Charlie Lake Cave %MAU values plotted against Emerson's (1990) (S)MAVGTP utility values

Emerson (1990) created a utility index for *Bison bison* based on Binford's (1978) pioneering work. Using four bison of different age and sex, she created a number of different utility indices, sometimes focussing on a particular product (for example marrow content), based on single individuals, or incorporating both. The index used in this thesis is the Standardized Modified Average Total Product, or (S)MAVGTP. The index is modified to account for riders, averages the data from all four bison and uses the totality of the products available on a bison carcass to measure utility.

It should be noted that measurements of long bones (see Appendix C and Figure 4.11) indicate that the Charlie Lake Cave bison were substantially larger than the modern ones used by Emerson (1990). However, the index is still used for this analysis for a number of reasons. First, it can be hypothesized that although Late Pleistocene bison were substantially larger than their modern counterpart, the distribution of meat and fat from one element to the next may be relatively similar to the distribution found in a modern bison. Second, as discussed previously, utility indices are at best ordinal scales because they are based on a very small number of individuals. So the figures that result from plotting the utility data with the skeletal element frequencies of an assemblage should only be viewed as general pointers of trends. Finally, it is common practice in archaeology to use the utility index of a completely different species when an index for this species has not been devised. For example, Binford's index for caribou has been used for other ungulate species such as pronghorn antelope (Hill 2001).

Figure 4.11 Difference in size between specimen 20043 (upper specimen) with modern male analog (lower specimen). See Appendix C for measurements of both specimens.

When plotted against the %MAU of the Charlie Lake Cave assemblage in Figure 4.10, it becomes evident that the highest-utility elements are nearly absent. Instead, mid-range utility elements are abundant and low-range utility elements are present. According to Emerson's (1990) (S)MAVGTP index, the most useful elements are the ribs, and the thoracic and lumbar vertebrae, all elements of the axial skeleton that are noticeably absent from the assemblage. The mid-range utility elements represent the upper part of the limb bones, notably the femur, tibia and humerus. This once again indicates an emphasis on limbs as opposed to the axial skeleton.

It could be that the assemblage represents a kill site and that the axial skeleton was favoured for transport to the camp site. However, the low presence of very low utility elements (such as carpals, atlas and axis vertebrae, caudal vertebrae, and skull elements including teeth) is conspicuous given that they also are the densest and therefore least likely to disappear through taphonomic processes other than human transport. Although the absence of skulls could represent removal for ritual use, this cannot explain absence or low values for other low utility elements. Another possibility is that although the axial elements bear the most meat and fat, their transport is more difficult due to the animal's large size. Limb elements on the other hand would still contain a decent amount of meat in a package easier to carry. Ethnographies of modern hunter-gatherers undertaken after the concept of utility indices was established by Binford (1978) have shown that a tremendous amount of variation exists in transport behaviours of an animal from the kill site to the camp site, depending on a diversity of factors often difficult to identify in the archaeological record (Bartram 1993; Bunn *et al.* 1988). One of those important factors is the carcass size, which can be easily recognized in the archaeological record. If indeed the size of the bison influenced the transport decision of the hunters, and the limbs have been transported as a result, then the assemblage could represent a camp site. The concept of utility curves is limited to "identifying" either home base or kill site, while other types of site exist too. Furthermore, as discussed previously, the bison assemblage is probably the result of a multitude of events that could represent different activities. In other words, we could be looking at the accumulation of strikingly different activities for the same site. Finally, given once again that those indices are ordinal scales not representative of an entire population, even less so of the utility of two different clades of bison, other avenues need exploring to approach the analysis of the Charlie Lake Cave bison assemblage.

Brink (1997) investigated the amount of bone grease within each limb element and its possible correlation with carnivore selection and/or human transport. Bone grease is similar to marrow but this index does not include marrow. Rather, bone grease is defined as the substance that impregnates the bone material. Brink's focus on bone grease is due to the fact that bone grease "probably represents the most dependable fat source in large mammal carcasses" (Brink 1997: 259). Its extraction, however, is time-consuming as it requires smashing the bone and cooking the pieces in boiling water for a long period until one can collect the floating grease. Brink's (1997) study reported a moderate inverse correlation between the percentage of bone grease within an element and its bone mineral density according to Kreutzer's (1992) data. In other words, elements with strong bone mineral content have a low percentage of bone grease while elements with low bone mineral density have a high percentage of bone grease. Brink (1997) also compared his data with Marean and Spencer's (1991) study on hyena ravaging of sheep hind legs. He found that hyenas select bone elements in close accord with the percentage of bone grease the elements contain, except for the proximal metatarsal which was chosen early even though it does not rank high in bone grease content. This was attributed to the fact that the tarsals were left attached to the proximal end of the metatarsal with the tendon and ligament mass (Marean *et al.* 1992 in Brink 1997: 270).

There is no evidence for the boiling technology needed to extract bone grease at Charlie Lake Cave, although there is a good presence of large artifacts most likely used to smash up bones. Reeves (1990) suggested that boiling technology was not developed until much later in the Holocene. Driver (1989) showed that bone grease preparation in a late prehistoric site resulted in high percentages of small fragments, but such fragments are not present at Charlie Lake Cave. Furthermore, epiphyses that have been purposefully eliminated are attributable to carnivore activity rather than human induced smashing. Long bones, when they show any modifications, are either smashed open, presumably to get at the marrow cavity, and/or have been ravaged by carnivores. This apparent lack of interest in the bone grease content by humans at Charlie Lake Cave may indicate that they did not need to rely on this resource for their fat intake.

4.4 Human modifications

The presence and absence of human modifications, along with their location on the elements, are the most significant piece of evidence when it comes to arguments for human involvement with a bone assemblage. Cutmarks are fairly easy to recognize and they point directly to human action. Yet the intention behind the action may be difficult to interpret. Eighteen elements in the bison bone assemblage of Charlie Lake Cave have either cutmarks, percussion pits or flake scars attributable to human action. Most long bones, albeit not all, have had their shaft broken. Given the strength of bison long bone shafts – bone-crushing animals like Marean and Spencer's (1991) hyenas could not break open the shaft of *B. taurus* long bone, and shafts generally rank higher than their epiphysis in bone density tests – one can hypothesize that the force needed to break those bones could come from humans using stone implements, although some fractures could also be caused by boulders falling into the gully onto the bone elements left there. If the latter occurred repeatedly, however, one would expect that mechanical conjoining of fragments would demonstrate that the breakage occurred within the gully. Admittedly, bone fractures on large ungulates are more difficult to attribute to human action than are cutmarks (Morlan 1983) . Yet, some fractured bones in the bison assemblage do show percussion marks and/or flake scars near the fractured edge (see Figure 4.12).

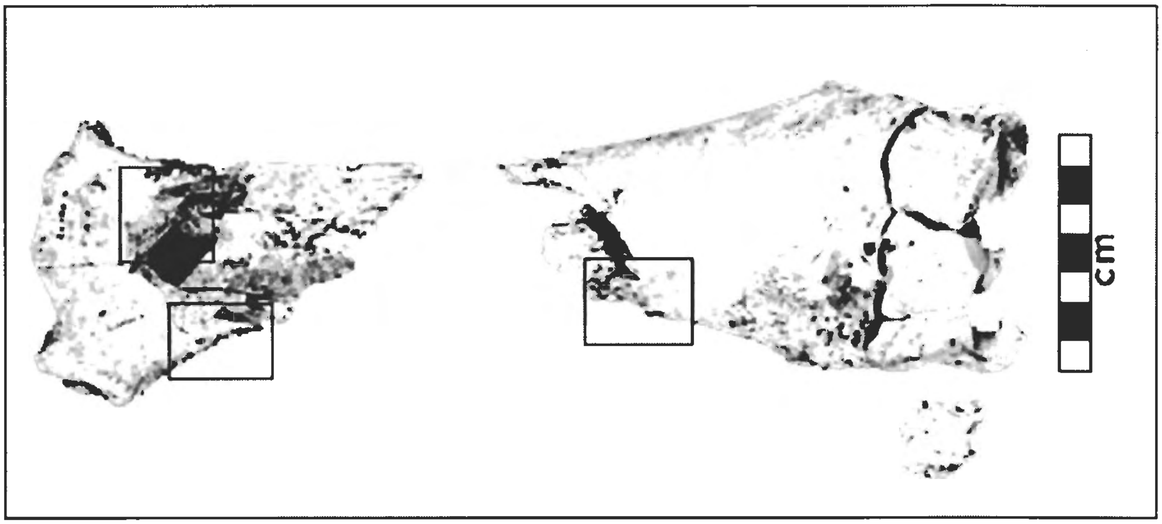

Figure 4.12 Photograph of specimens 20 000 and 2291. Squared areas indicate presence of identified flake scars and percussion pits

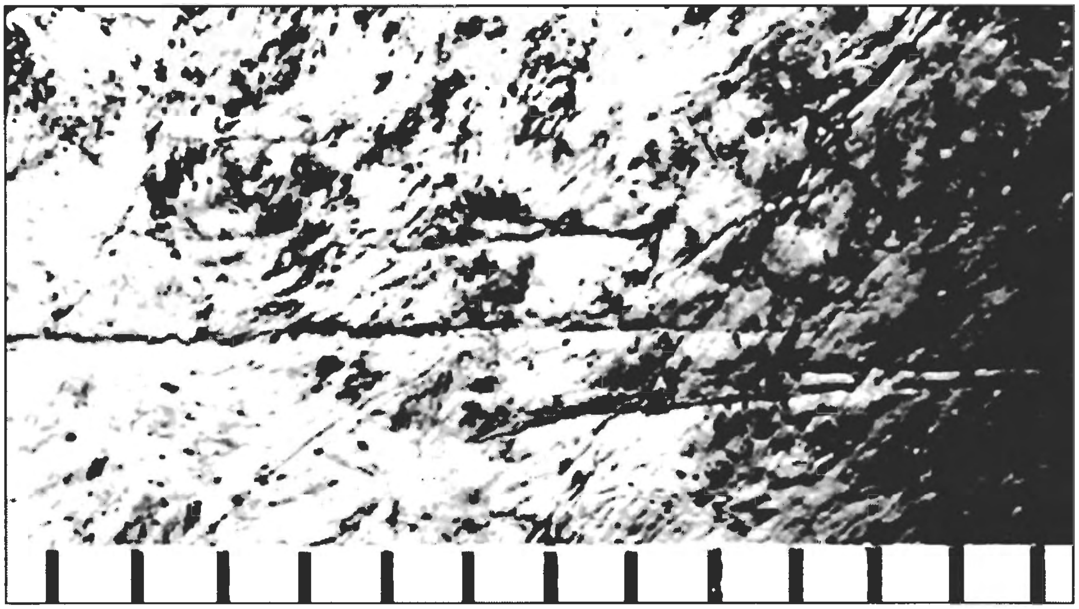

Figure 4.13 Cutmarks on humerus specimen 1849 (scale in mm)

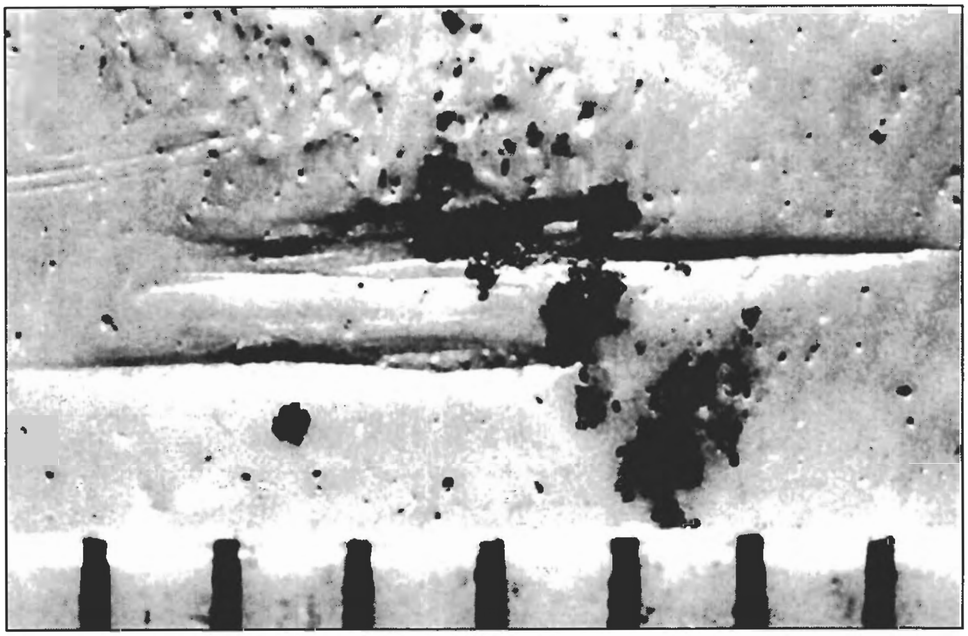

Figure 4.14 Cutmarks on humerus specimen 1848 (scale in mm)

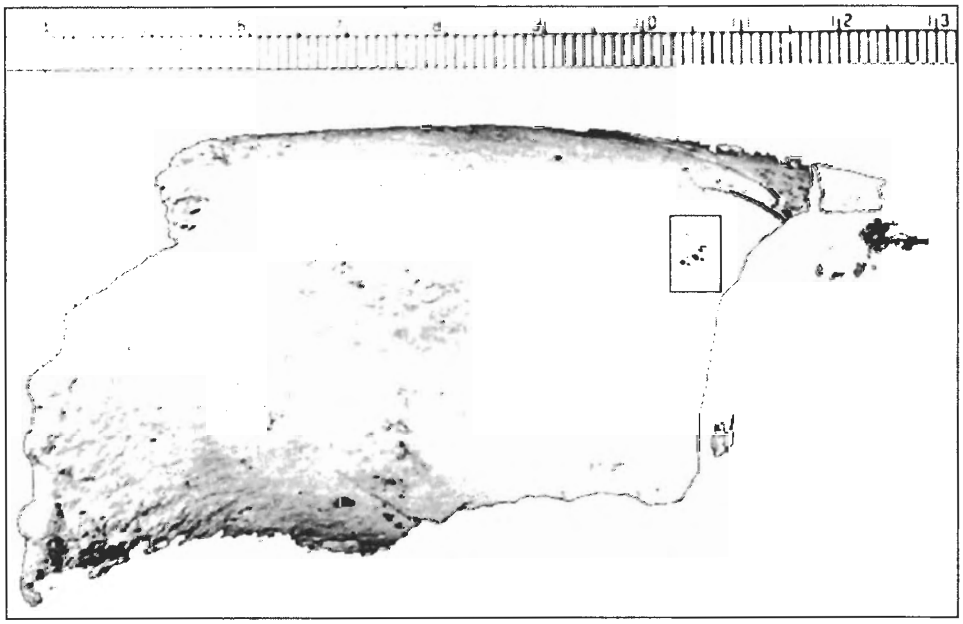

Figure 4.15 Humerus specimen 1848 with area of cutmarks squared (scale in cm)

As was the case for the distribution of carnivore damage, cutmarks are found on all represented long bones and axial elements (excluding skull pieces and the cervical vertebra fragment) although not all specimens of each bone type bear cutmarks. For example, some tibiae have cutmarks although other tibiae are free of any human modifications. The same goes for metacarpals and metatarsals, radii and ulnae. All three rib fragments display cutmarks, as does one of the thoracic spine fragments. Two of the humerus fragments have clear cutmarks on their distal end (see figures 4.13, 4.14 and 4.15). Furthermore, one ulna (2292) bears cutmarks on the external face of its semi lunar notch. These cutmarks could be evidence for an attempt at separating the humerus from the radius-ulna package. However, it was not possible to determine whether this ulna (2292), which refits with radius (2291 and 20 000), refitted also with one of the cutmark-bearing humeri as both the ulna and the humeri have been considerably modified for radiocarbon dating. A series of about eight small cutmarks are also found in the middle of the dorsal (or posterior) side of the shaft of an ulna (16409), which suggests the butcher's intention to cut through the thinning muscle mass that attaches the radius-ulna to the rest of the distal front limb elements. Radii on the other hand, when showing signs of human modifications, exhibit flake scars and percussion pits associated with bone breakage and marrow extraction, rather than cutmarks that can be related to cutting of the muscle mass. Interestingly, the radius (16410) that refits with ulna 16409 displays no sign of modification, either by humans or by carnivores, even though the ulna has cutmarks and carnivore damage. There seems to have been no attempt to break radius 16410 open for marrow consumption. Finally, one of the two metacarpals has a flake scar and a few cutmarks next to the edge of its midshaft fracture, which could indicate an interest in breaking it open for marrow extraction.

The hind leg bone elements show significantly less human modification than the front legs, although this impression might stem from the lack of femora in the assemblage which makes the number of meat and marrow-bearing hind leg elements much smaller. The acetabular fossa fragment (14689) does have cutmarks, which can be suggested to be related to detaching a femur from the innominate. Of the five tibiae that are represented by more than 50% of their shaft, only one displays cutmarks (1829) and another seems to have been smashed opened by humans and displays one flake scar (20039). That leaves three tibial shafts that show no signs of human modification. Like the metacarpals, of the two metatarsals present in the assemblage only one (13733) displays signs of human modification. There are eighteen cutmarks visible without the aid of a microscope on its proximal end, and its shaft was broken open. This concentration of cutmarks on the proximal end points to an hypothesized attempt to cut through the annular and suspensory ligaments and detach once again the distal elements of the leg from the more meat-bearing proximal leg elements.

5

Comparisons

5.1 Regional comparisons

With the core of the data presented in Chapter 4, the next step is to interpret what human behaviour – or behaviours – are represented in the Paleoindian bison assemblage of Charlie Lake Cave. This will be done by comparing the data of the faunal analysis with those from sites of similar age in the region. The "region" was defined for the purpose of this thesis as the open area south of Charlie Lake Cave comprising Alberta and Saskatchewan, and going as far south as Montana. This delimitation is based on the hypothesis that the hunter-gatherers who visited the site must have initially came from the south (Driver *et al.* 1996), and on Wilson's (1996) study of the timing of ecological opening and bison population movements within the ice-free corridor area.

To this date, Paleoindian archaeological sites in good stratigraphic contexts are rare in the region of interest. The closest site geographically is Vermilion Lakes, in the Rocky Mountains of Alberta. It has a sequence of dates from around 10 700 BP to 9600 BP and is interpreted as multiple campsites (Fedje *et al.* 1995). No detailed publication of the faunal data has been made, due to limitations of funding, but a report is available (Wilson 1984). Comparison with this site is difficult for a number of reasons. First, the preservation at Vermilion Lakes was very poor, thus only a small number of the skeletal elements could be identified to species. Second, only three skeletal elements identified belonged to bison, the vast majority being identified as *Ovis canadensis*. Given that this species is much smaller than bison, it can be argued that the transport strategies of the skeletal elements would be significantly different.

In Saskatchewan, a Paleoindian bonebed was excavated at Heron Eden (Corbeil 1995). The site has been dated to around 9000 BP, and interpreted as a kill-butchery site. Once again, the preservation of faunal material is very poor. However, faunal analysis of the bonebed was possible. The assemblage is considerably more extensive than Charlie Lake Cave's, the minimum number of individuals being 37. Another difference from Charlie Lake Cave's assemblage is the high presence of teeth and skulls at Heron Eden, the mandibular M3 tooth having the highest MAU of the entire assemblage. Atlas and axis vertebrae are represented respectively with %MAU values of 46.2% and 52.3%, with the rest of the cervical vertebrae counting for 37.5%. There is an overall strong presence of axial elements in the assemblage, except for a low representation of ribs and thoracic vertebrae. The skeletal element frequencies for leg elements range around 50% MAU for the long bones, and slightly higher for carpals, tarsals and phalanges.

Overall, the Heron-Eden bonebed gives a fair representation of all bison skeletal elements, yet ribs and thoracic vertebrae are noticeably less frequent in the assemblage (%MAU values of 16.7% and 28.1%). This can be as much a reflection of human transport as of poor preservation, possibly of both. The representation of long bones was probably less affected by density-mediated attrition due to their stronger mineral density. The Charlie Lake Cave Paleoindian component, in comparison, has a very low overall representation of axial elements, very low representation of skull and mandible, and general higher proportion of long bones, with tibia being the skeletal element with the highest MAU value. Charlie Lake Cave's Paleoindian assemblage is not similar to Heron Eden' bonebed in either extent or element distribution.

Three Paleoindian sites with bison assemblages in good stratigraphic contexts exist in Montana: Indian Creek (Davis and Greiser 1992), Mill Iron (Frison 1996), and Myers-Hindman (Lahren 1976). Indian Creek's Paleoindian levels date to approximately 10 980 BP. The site is interpreted as a short-term base-camp occupation (Davis and Greiser 1992: 266). Due to lack of funding, no complete faunal analysis was published on this site, other than mention of species present. The data used here are taken from an unpublished report (Wilson 1985). It is believed that levels 17 and 18 in Wilson's (1985) report are of approximately the same age as the Paleoindian levels of the published loci at Indian Creek, but they are in a different area of the site. Levels 17 and 18 contain a very limited bison assemblage, less extensive even than Charlie Lake Cave.

A great number of skeletal elements are absent from the assemblage, notably thoracic vertebrae, lumbar vertebrae, innominate, radius, femur, tibia, and metatarsal. All other elements are found in small proportions, with a preponderance of tooth and mandible fragments. One complete rib was uncovered, along with 117 rib fragments that Wilson (1985) suggested probably came from the same original piece. It appears the assemblage has a low frequency of axial elements, yet there is a low frequency of all elements (around 50 elements identified). Also noteworthy is the absence of many marrow-filled long bones. No clear pattern was recognized in the small sample, and no analysis of how taphonomic processes might have influenced the assemblage is available. It is interesting to note however that a horn core with an attached frontal fragment was excavated, along with the relatively high number of teeth. This shows that at least one skull was brought back to the campsite. Presence of scapulae and humeri, along with a proximal ulna fragment might indicate a preference towards the proximal portion of front limbs. The general paucity of limb elements is very different from what is found in Charlie Lake Cave' s bison assemblage.

The Myers-Hindman site (Lahren 1976) is interpreted as a Paleoindian campsite. The site, dating to 8925 ± 200 years ago, is also located in Montana and has a very small bison bone assemblage. Contrary to Indian Creek, and similar to Charlie Lake Cave, the tibia is the skeletal element found most frequently (MNE=4). Other than the tibia, skeletal elements represented in the assemblage are radius, metacarpal, metatarsal, maxilla, innominate, a caudal vertebra and astragalus. Only the mid-leg long bones are present, with no presence of either the proximal or distal extremities of the limbs. There is a clear lack of vertebrae, ribs and innominate. Charlie Lake Cave's assemblage also displays a focus on leg bones, but there is a stronger presence of all leg elements, with the exception of femur.

Finally, the Mill Iron site in Montana has both a kill area and a camp area, although it is still unknown whether those two areas were used at the same time (Frison 1996). Data on skeletal element representation for bison at Mill Iron were only available for the kill site bonebed, discussed in great detail by Kreutzer (1996). Therefore, only this portion of the site is included in the discussion. The bonebed is believed to be a single episode kill dating to around 10 700 BP (Kreutzer 1996). The assemblage is weathered and suffered from density-mediated attrition. However, the presence of skulls in the assemblage led Kreutzer to argue for a primary kill site, as it is unlikely that heavy bison skulls would be transported to a campsite (Kreutzer 1996), unless ritual use of skulls is involved.

The minimum number of animals for the bonebed is 21 for post-cranial elements, and 29 when taking teeth into the equation. The axis vertebra has the highest MAU and MNI values for post-cranial skeletal elements. Axial elements are numerous, except for thoracic vertebrae and ribs which have MAU values of respectively 2.4 and 2.3, giving them %MAU values of 11.4% and 10.9%. These skeletal elements are the ones that display the most severe stages of weathering, so the low numbers could be in part due to density-mediated attrition. Femur (with %MAU values of 11.9% for proximal and 2.4% for distal) and tibia (with

%MAU values of 2.4% for proximal and 19% for distal) are also underrepresented in the assemblage, more so than ribs and thoracic vertebrae, while innominate and tarsals range around 50% values. Front limb skeletal elements have higher frequencies than hind leg elements. The proximal humerus is almost absent with a %MAU value of 2.4%, but the distal humerus has a %MAU value of 33.3%. Radius-ulna is represented by %MAU values in the 40% range, with carpals rating slightly higher. Interestingly, the scapula has the second highest %MAU value of the entire assemblage with 88.1%. It seems that radii and ulnae were less interesting for transport than tibiae, as well as the distal end of the humerus being less sought after than the distal end of the femur, although these differ greatly in density. Caution must be used when dealing with these numbers once again as the assemblage was greatly transformed by density-mediated attrition and post-depositional carnivore damage. For example, the discrepancy between distal femur and distal humerus could be a reflection of the canid pattern of damage recognized by Garvin (1987) where dogs and wolves destroyed the distal femur while not displaying any interest in the distal humerus.

The Mill Iron bison bonebed data are different from Charlie Lake Cave for a number of reasons. The assemblage is much more extensive, although this can be an artifact of the larger area excavated. Mill Iron's bonebed also contrasts with Charlie Lake Cave's assemblage in that it has a much higher frequency of axial elements such as lumbar and cervical vertebrae, it represents a single event, and it has a low frequency of tibiae. Similarities include the low representation of femora, ribs and thoracic vertebrae, although this is likely skewed by poor preservation of those elements.

None of the assemblages discussed here display the same skeletal element frequencies as Charlie Lake Cave. Similarities are present, such as an overall low representation of ribs and thoracic vertebrae, although this may be an artifact of density-mediated attrition. Out of five sites available for comparison, Vermilion Lakes not only suffered from poor preservation but was dominated by a different species. Indian Creek, Myers-Hindman, and Vermilion Lakes had very small assemblages, smaller than Charlie Lake Cave's, which may suggest that a number of Paleoindian sites in this region are very small and that smaller sites could be the norm rather than the exception. However, a drawback of dealing with small sites is that patterning is harder to find in such small samples. Big assemblages such as Mill Iron and Heron Eden, although easier to interpret, are probably not so useful at determining transport patterning for small sites like Charlie Lake Cave because of the influence of an abundance of carcasses on transport decisions. That is, decisions on what to bring back to the campsite will be different when 21 carcasses are available (as at Mill Iron) from when one or two bison are killed at a time, which seems to have been the case for Charlie Lake Cave. To investigate further the place of Charlie Lake Cave in the Paleoindian subsistence strategy it is necessary to expand the scope of research and rely on site-function models.

5.2 Comparisons with models

What was the function – or functions – of Charlie Lake Cave during the Late Pleistocene/Early Holocene interval? Hypotheses to be explored are that it could have been a kill site, a campsite, a storage facility, a ceremonial place, a hunting party monitoring/rest area, or a carnivore den.

Two examples of Paleoindian kill sites in the Northwestern Plains region have already been discussed here, the Mill Iron and Heron Eden sites. Comparisons of the bison assemblage at Charlie Lake Cave with both assemblages demonstrates that the kill sites are different on a number of points. The size of the Charlie Lake Cave assemblage is far smaller than the two bonebeds. This is not to say that every Paleoindian kill site should be of great size, thus ruling out Charlie Lake Cave as a Paleoindian kill site on the basis on size alone. Generalizations on such a small sample of sites would be unrealistic, and smaller sites are harder to detect. Another difference from those kill sites relates to the skeletal element frequencies. Once again, this could stem from the number of animals killed which is a major factor in transport decisions by hunters. When dealing with an abundance of carcasses, hunters can allow the discard of high utility elements. It is possible that hunters presented with only one or two carcasses at a time will choose to transport the majority of the animals' parts. However, it seems unlikely that they would transport the bison skulls which are heavy and of poor nutritional value, unless they had ritual value. Kreutzer (1996) uses that argument to suggest that Mill iron is a primary kill site as opposed to a secondary butchery area. Teeth having a very high rate of survivorship, one can hypothesize that even in assemblages that suffered greatly from density-mediated attrition, the transport of skulls could at least be identified by the frequency of teeth. The assemblage at Vermilion Lakes is a good example of a poorly preserved assemblage containing mostly teeth, even though it is a campsite. One can hypothesize that meat-bearing elements were present in higher numbers at the time of deposition.

Finally, outside of the realm of faunal analysis, it can be expected that a kill site would contain stone tools associated with killing the animals and butchering them for transport. Wheat (1972) adds that some type of trap should be present. This does not always prove to be the case, as no such feature was found at Mill Iron, which partly explains the initial assessment that the bonebed was a secondary butchering area (Kreutzer 1996). Charlie Lake Cave's gully could be viewed as a bison trap, and stone tools were found associated with the assemblage. However, the majority of the tools found were large quartzite artifacts with hardly any sharp edges. Those stone tools were likely used to break open bones (Handly 1994) rather than to slice ligaments and muscle away to separate elements.

In sum, the low representation of skull elements and the paucity of vertebrae including lumbar and caudal suggests that Charlie Lake Cave was not a primary kill site during its Paleoindian occupations. The extent of the assemblage is quite different from the Paleoindian kill sites found in the northwestern plains, although it can be expected that kill sites of different sizes were created, depending on the number of bison encountered and killed. In larger kill site assemblages such as Mill Iron and Heron Eden, all skeletal elements of bison were represented in the assemblage, a pattern that was also used by Wheat (1972) to characterize Paleoindian kill sites. This is not the case at Charlie Lake Cave where a number of axial elements were clearly absent from the assemblage since the time of its deposition. Finally, the artifacts found in the gully do suggest processing of the carcasses but are not representative of killing and dismembering animals.

A general expectation for a campsite model is that its faunal assemblage would be the inverse of that of a kill site. In other words, the elements removed from the kill site were likely transported to a campsite, and the elements left behind at the kill never appeared in the campsite assemblage. This is part of Binford's (1978) model for utility curves. According to this model, high utility elements will be brought back to camp, while low utility ones will be left behind. Some lower utility elements will be transported along as "riders" when they are attached to high utility elements. Outside of Binford's utility model, other expectations for campsite would be the presence of hearths – and indirectly of burnt bones – and possibly some type of structure, along with evidence of tool manufacture and food processing. Campsites found within the general region selected for comparison, such as Vermilion Lakes, Myers-Hindman and Indian Creek, have considerably smaller faunal assemblages than the kill-site bonebeds discussed. Whether this is a trend that actually represents Paleoindian campsites or whether this is due to the small number of sites is not certain. Campsites in the region are not numerous and exhibited poor preservation of bones or thus far have lacked taphonomic analysis.

Charlie Lake Cave's Paleoindian bison assemblage lacks the highest utility elements defined by Emerson (1990): the ribs, and thoracic and lumbar vertebrae. It contains mostly limb elements, a mid-utility set of elements that gains in transportability what it lacks in total product utility. This can be a significant factor for transport selection in Class 4 animals such as the bison. Most ethnoarchaeological studies aimed at understanding transport strategies focussed on animals of smaller sizes (Binford 1978 and 1981; Bunn *et al.* 1988). Hill's (2001) analysis of the fauna of the Main Folsom Component, Area II, at Agate Basin in Wyoming, suggests that in general "one or two complete limb units were the usual bison transport package" (Hill 2001: 53). He argues that this focus on the limb elements instead of the axial ones could reflect the Paleoindians' interest in marrow nutrients present in long bones coupled with the importance of meat and fat. Obviously this is a generalization and variability is expected. However, such an emphasis on limb bones is echoed in the Charlie Lake Cave bison assemblage, with the exception of the apparent absence of femora. Thus, although it does not bear the highest-ranking elements with regard to Emerson's (1990) total product index, the assemblage at Charlie Lake Cave does contain high utility skeletal elements in the view of a "total package" model that gives more importance to marrow content and transportability. Yet, given the expected importance of marrow content for transporting long bones, it is odd that some of those long bones in the assemblage have not been broken open for this purpose.

Other predictions as to what a campsite should look like include the occurrence of hearths, possibly a structure, and evidence of activities such as tool manufacturing and food processing. There is no such evidence in the Paleoindian levels of Charlie Lake Cave, although later occupations at the site have all of the above. It has been mentioned before that during the Paleoindian occupations the gully was probably not in use for the very reason that no hearth or structures were found, along with the fact that at that time the gully was deep and narrow and therefore probably inhospitable. It is possible that the principal site of occupation was close to the gully, maybe on the hillside above it, but such a site was never found. If this was the case, the absence of hearths and structures cannot rule out the possibility that Charlie Lake Cave was used as a campsite in Paleoindian times. However, if the gully was used as a refuse area, or if certain objects inadvertently rolled down there from a campsite to create the assemblage, one can still be puzzled by the complete absence of burnt bones and tool manufacturing debris. The presence of a functional fluted point in the hypothesized refuse area is also hard to explain, unless it was dropped there without the owner's notice or embedded in meat. It could also be that it was left there, along with the other stone tools, for future reuse, and this hypothesis is explored next.

Although no storage facilities have been found in the region for early

Paleoindian times, it remains a possibility that Charlie Lake Cave was a storage site. In wintertime, the gully would have been filled with snow which would freeze any meat left behind. Furthermore, the cave could have been used to shelter the stored provisions from predators and/or weather conditions. The use of frozen meat caches has been put forward as the explanation for particular spatial distributions of bone elements in Paleoindian sites of the High Plains. In these cases, bones are deposited away from the primary kill site, with a winter season of occupation, and frequent lack of further modifications (Frison 1982; Frison and Stanford 1982). Additionally, evidence of later Paleoindian cold storage has been found in the Snake River Plain in Idaho (Henrikson 2003). In her article, Henrikson (2003) documents the use of cold caves for what seems to be storage activities that date back to 8000 years ago. Bison bones frozen within sagebrush stalk features were found associated with antler tines and stone "hammers" in caves that maintain a constant freezing temperature. The stone and antler tools were hypothesized to have been used to extract the frozen meat from the sagebrush features (Henrikson 2003). Direct analogies with these caves for the purpose of the present research are problematic because of both regional diversity and different time periods. However, this information can be used as a basis for discussion.

Differences are obvious between the Charlie Lake Cave site and the Idaho cold caves. While Henrikson's (2003) bison bone assemblages were found within sagebrush features deposited in the caves, the assemblage at Charlie Lake was found outside the actual cave, not associated with any features. It is possible, however, that the cave at Charlie Lake was used for storage and that the assemblages found in the gully were deposited after the cache had been opened and processed. At this point, the only common denominator is the meat freezing opportunities.

The skeletal element frequencies in the cold caves and Charlie Lake Cave's Paleoindian levels present a number of similarities, although a great number of fragments in the cold caves could not be identified to element, suggesting more bone smashing in the caves. The identified skeletal element frequencies in the cold caves are fairly uniform and are dominated by long bones and ribs. Occasionally, one or two vertebrae were found, and some cranial elements are also present in very low proportions. The presence of cranial elements in storage facilities is surprising in terms of utility, yet they are present in similar proportions in the Charlie Lake Cave Paleoindian assemblage along with higher utility elements. Differences in skeletal element frequencies between the Idaho assemblages and the one under study here are the apparent lack of distal limb elements in Idaho – namely, carpals, tarsals and phalanges – except for two metapodials and one calcaneus, and the stronger presence of ribs.

When trying to identify a storage feature through the use of faunal analysis, the analyst must bear in mind that the presence of an assemblage suggests a failure in the intended purpose to come back later and pick it up. Both the Idaho caves and Charlie Lake Cave contained assemblages created by multiple occupations. It could be that most of the time the feature was successfully used for storage and only a few elements remained, while a few times the elements left behind were not picked up before the meat spoiled. If this scenario is accurate, the actual skeletal element frequencies of what was left are unlikely to be the same from one storage facility to the next. For example, it could be that slabs of ribs were left at Charlie Lake Cave but picked up later.

The stone tool assemblages from Idaho caves and Charlie Lake Cave could also be interpreted as similar, although not identical. The majority of the stone tools found within the gully were large, heavy quartzite tools that present very few sharp edges. They were more likely used for their smashing power than their cutting capacities. Their purpose then could be similar to the stone "hammers" to which Henrikson (2003) refers. The Charlie Lake Cave quartzite tools were brought ready-made to the site, as no flakes of quartzite were found in the assemblage and this type of stone is not present in the sediments of the site. This suggests that the people brought them there with a purpose, possibly intending to get frozen elements out of the snow and to break open bones for marrow. The stone tools could have been brought along when opening the cache, or alternatively, they could have been cached with the meat. At this point, Charlie Lake Cave cannot be ruled out as a storage facility but cannot be demonstrated as such with confidence either, for lack of diagnostic patterns in faunal assemblages.

Another kind of site can be found, some type of station or rest area where a hunting party can prepare for the kill, monitor the animals, and/or rest after the kill (*e.g.* Binford 1978; Bunn *et al.* 1988). Such a site would be small, with a short-term occupation assemblage, maybe a few flakes from sharpening the edges of stone tools, and possibly evidence of snacking. The physical location of Charlie Lake Cave makes it a great vantage point to overlook the Peace River tributary below. This geographic characteristic could have been the reason why over the years Paleoindians reused the site. No model of what an early Paleoindian hunting party station should look like was found in the literature. However, this type of site was mentioned in ethnoarchaeological studies of the Hadza, for example (Bunn *et al.* 1988). Just as transport in itself depends on a variety of factors hard to identify in an assemblage, a short-term occupation site by a group of hunters would not leave a single pattern. The lack of model for such a site makes this hypothesis hard to demonstrate or refute. Charlie Lake Cave's Paleoindian component does represent a series of short-term occupations, has evidence of marrow consumption on the spot (under the hypothesis that long bone breakage in the assemblage is human-produced for marrow extraction), and is situated in a reasonable location to monitor game. Furthermore, Handly (1994) suggested that Charlie Lake Cave was once used for this purpose based on the presence of a microblade core and biface resharpening flakes.

This premise cannot, however, explain the presence of unmodified high-utility skeletal elements. The hunting party would be expected either to transport back the high-utility items or to use them for their own consumption in a resting area, not to leave them behind, untouched, midway into their travel back to the campsite. Furthermore, the transport of heavy quartzite tools to a monitoring/rest area is difficult to explain. If the tools were brought for marrow extraction, then a number of scenarios are possible. The hunters could have known before the kill was done that they would come back to this spot and therefore left some heavy quartzite tools behind or, once they killed the bison, they knew they would need big tools to smash them open in their travel and thus transported both the carcass parts and heavy tools they picked up en route to the campsite. Finally, they also could have stopped at the site after the kill, and realised that to extract marrow from the bones they would need heavy tools so they sent out to find appropriate stones to make the tools.

Driver (1999a) suggested that two raven skeletons found in association with the Paleoindian bison assemblage were left there for ritual purposes. Accordingly, it is possible that Charlie Lake Cave was a ceremonial location. Ritual in prehistoric contexts is often difficult to identify archaeologically, and the faunal patterns such a behaviour would leave behind would be idiosyncratic for each ritual, culture and time period. Hypotheses of what signature an early Paleoindian ceremonial site would leave behind in the archaeological record, even less so in a faunal assemblage, are not numerous in the literature. Muir and Driver (2004) suggest that ritual behaviour can be physically recognized in a faunal assemblage through ritual interments and/or ritual refuse. The former is implied by the presence of "virtually complete skeletons or unprocessed articulated elements" as well as with "unusual (improbable or odd) groups of elements or isolated crania" (Muir and Driver 2004: 131). Ritual refuse on the other hand would be implied by the accumulation of remains of animals unlikely to have been hunted for consumption (such as types of wild birds and carnivores), or evidence of special treatment to bone elements of a commonly hunted animal species.

The raven skeletons found in the Paleoindian component fit the "ritual interment" description above, but the bison assemblage does not correspond to any of the definitions for ritual behavior outlined by Muir and Driver (2004). Special treatment of bison bones would have to be demonstrated in opposition to "normal" treatment, and it was demonstrated before that there is not a lot of comparative material for the region and time period of Charlie Lake Cave's bison assemblage. There is no emphasis on cranial material in the assemblage, and what constitutes "unusual groups of elements" in this case is hard to argue given that it is not known what would be a "usual" group of elements. It has been argued here that a strong emphasis on limb elements for transport is practical given that it is an easier package to transport and its high marrow content made them attractive to Paleoindians. In that line of argument, the assemblage at Charlie Lake Cave would not be considered "unusual". It could be argued that the high utility limb elements were left behind as a type of offering, but the human modifications on the long bones, especially the ones broken open for marrow, tell another story. It is possible that some of the unmodified bone elements were left behind as offerings, and that the humanly modified ones are the remains of either food consumed by the people involved in the ritual activity or the remains of a different use of the site in a different time of occupation. However, these are only hypotheses that cannot be confirmed based on the data available both at the site and in the literature.

The last hypothesis on what activity created the bison assemblage at Charlie Lake Cave is that it was used by carnivores only. If the bones were all brought back into the gully by carnivores, a number of patterns would be expected. First, the faunal assemblage should have suffered greatly from carnivore damage, especially on attractive long bone epiphyses. This is not the case here; a number of long bones have no evidence of carnivore modification. Furthermore, a number of skull fragments were found at the site. It seems improbable that carnivores brought back a bison skull, given its weight. It seems also unlikely that they would bring back bone elements that have already been stripped of their nutrients by humans. Finally, the high incidence of heavy quartzite artifacts in the assemblage, and the presence of interred ravens are not expected in a carnivore den.

5.3 Discussion

None of the comparisons with neighbouring sites or with site-function models were conclusive as to the use of Charlie Lake Cave during Paleoindian times. This is due to the very small number of sites containing faunal assemblages available in the vicinity of Charlie Lake Cave. It is also possible that the assemblage cannot be associated with one function because it served different purposes during its multiple occupations.

Although comparisons did not allow a definite statement on the use of the site, it did permit the analyst to rule out certain hypotheses. For example, it can be said with confidence that Charlie Lake Cave was not used as a kill site. The low presence of cranial material, along with the presence of a tool kit ill-equipped to butcher carcasses, indicate the low probability of the site being used as a trap. It is also certain that Charlie Lake Cave is not the sole result of carnivore activities. Humans have created the assemblage to a large extent. The campsite hypothesis seems highly unlikely, and it is certain that the site was not used as a primary campsite. Nevertheless, it cannot be ruled out that Charlie Lake Cave was a midden for a nearby campsite. The lack of domestic debris (such as flakes from tool manufacture and high bone fragmentation from food processing)and lack of burnt bones are not suggestive of a campsite midden. However, examples of Paleoindian campsites and their middens are infrequent and their zooarchaeological signature unknown.

The bison assemblage at Charlie Lake Cave is probably not the result of ritual behaviours. However, probable ritual behaviour was recorded at the site in the form of deliberate burial of two raven skeletons. What becomes interesting then is that ritual interments of ravens are associated with non-ritual deposits, assuming that the unmodified bison limb bones were not left as offerings. It is possible that the interments were not ritual in nature. On the other hand, the assemblage's association with a ritual activity could reflect its importance. If

Charlie Lake Cave's Paleoindian component was not the refuse of another site, the gully could have been exploited for its other characteristics. It could not be refuted that the gully, or the actual cave, could have served as a frozen storage facility. If one argues that the skeletal elements, along with the stone artifacts, were left there for a purpose, then the association of the deposit with a ritual activity is plausible.

Another hypothesis that cannot be dismissed or accepted is that Charlie Lake Cave represents a hunting party monitoring and/or rest area. It is known from ethnoarchaeological research that this type of site is to be expected. However, no archaeological example of this could be found for the general period and area of interest here. It is expected here that such a site would be short-term, and leave evidence of both preparing for a kill and food consumption. Charlie Lake Cave was used for short-term periods in Paleoindian times, and evidence of tool resharpening was found, along with marrow extraction. It is also a good location to observe the movement of game over a wide area. However, the discard of marrow-filled long bones with no attempts to break them open seems counter-intuitive. Furthermore, the transport and discard of the large and heavy quartzite tools are puzzling for a monitoring/resting area.

It was mentioned before that it is possible that Charlie Lake Cave was used differently during its multiple occupations. It is therefore possible that the site was used both as a monitoring station and subsequently or previously as a storage area. The presence of untouched high-utility bones suggests storage activity and subsequent failure to get back to it, as does the transport and discard of large quartzite artifacts. The initial attraction to the site could be linked to its location above the valley, making it a great vantage point for game monitoring. The subsequent discovery of the gully, and/or the cave, and their potential for frozen storage could have altered its use. Furthermore, if the parapet moved in different episodes, the character of the gully could have changed through time and influenced a change in function too. The archaeological signature of a hunting party monitoring station would be feeble, while evidence of storage would be more visible. The ritual interment of raven skeletons would indicate the site's importance in the hunting cycle.

The argument that Charlie Lake Cave could have been used as a storage facility during its Paleoindian occupation counters part of Kelly and Todd's (1988) model for Paleoindian colonization. In this model, they posit that in a situation where no local knowledge of the area is available, the safest subsistence strategies will involve a focus on hunting, high logistical mobility, and the short-term exploitation of an area. Consequences of those choices would include a lack of storage facilities and of exploitation of unique features in the landscape. That is, when living in an unstable and unknown environment, Paleoindians would exploit a number of locations, and use them repeatedly for short-term periods without exploring the territory in more detail to see if a better feature exists. Furthermore, Kelly and Todd (1988) mention that a reliance on storage would greatly reduce mobility; thus in an environment where faunal resources are unreliable Paleoindians risked running out of both stored supplies and live animals. Instead, they suggest that early Paleoindians were on a continual search of resource, centring their efforts in the vicinity of a kill, until the resources are found so far from the initial campsite that the whole group moves into another area. However, this scenario is based on excavations of mass kill sites with nearby campsites. This does not reflect the situation of Charlie Lake Cave.

Charlie Lake Cave was neither a kill site nor a campsite associated with a mass kill site. Its function lies outside of the usual kill site/camp site dichotomy. In Kelly and Todd's (1988) model, there is an stress on logistical groups leaving a campsite to obtain resources, and such a group would leave a third type of site: a hunting party monitoring/rest area site. The hypothesis that Charlie Lake Cave was used by hunting parties was discussed previously and was deemed a possibility. However, certain features of Charlie Lake Cave's assemblage were peculiar in this functional context, notably the presence of unmodified high utility skeletal elements and of heavy quartzite artifacts. Those characteristics are more compatible with a storing facility function. Kelly and Todd's (1988) model for early Paleoindian colonization of North America argues that storage should not be expected for highly mobile groups. The evidence presented here suggests that this aspect of the model could be revised. Charlie Lake Cave's Paleoindian component has a very small assemblage which, although indicative of reuse more than twice in a thousand years, was probably not overly used. If the assemblage is indeed evidence of storage activities, the quantity of skeletal elements present, both humanly modified and not, are not suggestive of storing intended to sustain a group for an extended period of time. In that way, such a behaviour would not constrain mobility to as much an extreme as later storage activities did, because the frozen food could be abandoned without great costs.

6

Conclusion

The intent of this thesis was to recognize the type of subsistence activity represented in the Paleoindian strata of Charlie Lake Cave. It was believed that a thorough faunal analysis of the site's Paleoindian bison assemblage, along with the comparison of the data with the faunal assemblages of other sites in the region, could shed light on this issue. The results of the faunal analysis and the comparisons are presented in Chapters 4 and 5. In the discussion in Chapter 5, it is argued that Charlie Lake Cave, in Paleoindian times, was neither used as a kill site nor a campsite. Although no explicit use of the site could be demonstrated, a number of hypotheses were put forward. In light of the data available, it was proposed that Charlie Lake Cave could have been used for frozen storage, although its use as a monitoring station could not be ruled out. The steps taken to get to such a conclusion will now be described.

Chapter 2 introduced the site of Charlie Lake Cave, its location, its excavation history, its stratigraphy and radiocarbon dating. Emphasis was put on the Paleoindian strata, which are the focus of this thesis. The Paleoindian strata of Charlie Lake Cave span the Late Pleistocene/Early Holocene transition, with dates from approximately 10 500 BP to 9 500 BP. Other than the bison assemblage that forms the focus of this thesis, the Paleoindian strata also contained a fluted point, numerous heavy quartzite tools, and two complete raven skeletons, possibly ritually deposited.

Chapter 3 described the methodology used to analyze the bison assemblage, emphasizing both the advantages and disadvantages of each method. The importance of quantification was stressed, as it forms the basis of further inferences. The methods used to recognize the different bone modifiers that influence faunal assemblages were discussed, with reference to the literature on each of the subjects. Finally, a description of the refitting process was given.

Chapter 4 focussed upon the presentation of data gathered during the faunal analysis of the bison assemblage at Charlie Lake Cave. It was necessary first to argue for the amalgamation of all specimens found in the Paleoindian strata for analytical purposes. Even though Charlie Lake Cave's bison assemblage is likely the result of multiple occupations, the impossibility of identifying those individual occupations, coupled with the small size of the assemblage, warranted the treatment of the assemblage as a single collection. The skeletal element frequency of the assemblage showed that axial elements were underrepresented while limb elements, especially mid-limb elements, were preponderant. It was then demonstrated that this pattern was not influenced by density-mediated attrition nor carnivore action, although the latter was observed on some specimens.

Compared with utility values defined by Emerson (1990), the skeletal element frequency of Charlie Lake Cave's assemblage displays an emphasis on medium-utility elements, with high utility clearly absent, and a low representation of low-utility elements. There is clear evidence of human modification on some specimens in the presence of cutmarks. Furthermore, a number of long bone shafts have been broken open, most likely through human action. Presence of human modifications are noticeable on the majority of skeletal elements, although not all specimens of each element display human modification. A fair number of specimens have no indications of human modification, even though other specimens of the same skeletal element are heavily modified. Chapter 4 demonstrated that the skeletal element frequency of the Paleoindian bison assemblage at Charlie Lake Cave – namely an emphasis on limb elements and lack of axial elements – was mostly the result of human action.

Chapter 5 compared the data presented in Chapter 4 to faunal assemblages of archaeological sites found in nearby Plains areas – including Alberta, Saskatchewan and Montana – that dated to the Late Pleistocene and/or Early Holocene. Only five sites dating to this time period in the area described were found in the literature, limiting the strength of the comparisons. None of those sites possessed a faunal assemblage similar to the one found at Charlie Lake Cave. However, the majority of those sites suffered from density-mediated attrition, making comparison difficult given that the initial composition of the assemblage at deposition was unknown.

To compensate for this paucity of comparative material in the area, the comparisons were extended to site-function models. Different hypotheses were presented for the function of Charlie Lake Cave in Paleoindian times. That the site was a primary kill site was refuted because of the lack of cranial elements, low representation of low utility elements, and inadequate tool kit for butchering purposes. Charlie Lake Cave shows no signs of being a campsite, and it was not likely to have been used as a midden for a hypothetical neighbouring campsite, given the lack of tool manufacture evidence, lack of burnt bones, and the number of non-processed long bone elements. Comparisons with later caves used for cold storage demonstrated similarities in skeletal element presence, although patterning was difficult to identify in such small assemblages and a high number of specimens at the storage sites could not be identified due to heavy fragmentation. The large quartzite tools found at Charlie Lake Cave could have served the same purpose as the stone "hammers" associated with the cold caves. Another hypothesis explored was that Charlie Lake Cave was used by hunting parties as a monitoring/rest area. No model of what a Paleoindian archaeological signature for such an activity would be was found in the literature. This hypothesis was deemed possible, but the presence of unmodified long bones along with heavy quartzite tools did not correspond to expectations. Although raven skeletons found within the gully of Charlie Lake Cave may have been deposited there for ritual purposes, the bison assemblage did not seem to correspond to any ritual behaviour. Finally, it was shown that the Charlie Lake Cave Paleoindian faunal assemblage was not a carnivore den, given the presence of human modification and low degree of carnivore ravaging of the bison bones.

In sum, the faunal analysis of the bison assemblage in the Paleoindian strata of Charlie Lake Cave, and its comparison to both other sites and site-function models, demonstrated that the function – or functions – of Charlie Lake Cave for this time period has to be taken out of a kill site/camp site dichotomy. It was also demonstrated that although it contains probable ritual behaviour, the bison assemblage does not correspond to a ritual occupation. The possibility that the site was used as a monitoring station for a hunting party was raised, and it remains possible that it was once used for this purpose. However, if it was used for such an activity, it was not the only function of Charlie Lake Cave in Paleoindian times.

The most plausible hypothesis for the use of Charlie Lake Cave in Paleoindian times is that of a frozen storage facility, either in the gully or in the cave. This hypothesis is backed up by the presence of unmodified long bones and of heavy quartzite tools, along with a similar skeletal element frequency to that found in later cold storage caves. The presence of storage in an early Paleoindian site is uncommon, and counters a model for Paleoindian colonization (Kelly and Todd 1988) postulating that storage is not a behaviour that should be expected by the highly mobile early Paleoindians. However, the degree of reliance on storage of the type recognized at Charlie Lake Cave is not comparable to reliance on storage as seen in later Plains sites (*e.g.*, Reeves

1990). Given the size of the assemblage, and the fact that it is an accumulation of more than one occupation, it could not have been used to sustain a group for any extended period of time. The frozen bison elements could actually be abandoned without great cost if necessary.

It is a concern that such a small number of sites were available for comparison. There is a definite need for more excavations of early Paleoindian sites on the Northwestern Plains and adjacent mountains to ensure that all aspects of the early Paleoindian lifeways are acknowledged. Evidently this is easier said than done. Archaeological remains of highly mobile hunter-gatherers are notably difficult to find, except for the remains of the larger scale bison kills, which also are more attractive to archaeologists given the greater statistical potential for large assemblages. It is hoped that the work done in this thesis demonstrated that smaller faunal assemblages possess great potential for thorough analysis, and can represent important parts of the early Paleoindian lifeways.

Appendices

Appendix A : List of Abbreviations

Abbreviation list for the table in Appendix B (taken from Driver's unpublished Crow Canyon Archaeological Center Manual for Description of Vertebrate Remains, with personal additions).

Element codes

UN	UNIDENTIFIED
HC	HORN CORE
CR	CRANIAL
NS	NASAL
MX	MAXILLA
MN	MANDIBLE
AT	ATLAS
AX	AXIS
CE	CERVICAL #3-7
TH	THORACIC
RI	RIB
LU	LUMBAR
SA	SACRAL
CD	CAUDAL
SC	SCAPULA
HU	HUMERUS
RA	RADIUS
UL	ULNA
IT	INTERMEDIUM
MA	MAGNUM
SD	SCAPHOID
CU	CUNEIFORM
PI	PISIFORM
CP	CARPALS
MC	METACARPAL
IN	INNOMINATE
FE	FEMUR
TI	TIBIA
AS	ASTRAGALUS
CA	CALCANEUS
LA	LATERAL MALLEOLUS
NC	NAVICULO-CUBOID
TS	TARSALS
MT	METATARSAL
1P	PROXIMAL PHALANX
2P	MEDIAL PHALANX
3P	TERMINAL PHALANX
SE	SESAMOID

Tooth name code (1st letter)		**Tooth age code (2nd letter)**	
X	PREMOLAR	N	NOT KNOWN

Side codes

L	LEFT	R	RIGHT	I	IRRELEVANT	U	UNKNOWN

Part codes

HORN CORE

2	Fragment

CRANIUM

2	Fragment

VERTEBRAE

56	Spinous process, complete or fragment
57	Anterior or posterior zygapophysis

RIBS

72	Shaft fragment

SCAPULA

81	Blade fragment

INNOMINATE (PELVIS)

91	Ilium fragment
92	Ilium plus acetabulum
95	Acetabulum fragment

LONG BONES (INCLUDING PHALANGES)

1	Complete
100	Proximal end complete, plus >50% of shaft
101	Proximal end present but incomplete, plus >50% of shaft
102	Proximal end complete, plus <50% of shaft
103	Proximal end present but incomplete, plus <50% of shaft
104	Unfused proximal epiphysis
105	Distal end complete, plus >50% of shaft
106	Distal end present but incomplete, plus >50% of shaft
107	Distal end complete, plus <50% of shaft
108	Distal end present but incomplete, plus <50% of shaft
109	Unfused distal epiphysis
110	Diaphysis (shaft)

OTHER BONES (INCLUDING CARPALS, TARSALS AND SESAMOIDS)

1	Complete
120	Fragment with more than 50%
121	Fragment with less than 50%

Fusion Codes

Every specimen received a two letter code for fusion state. The first letter refers to the fusion state of the proximal end (or anterior end for axial elements), while the second letter refers to the fusion state of the distal end (or posterior end). This code always refers to the whole element, whether the specimen is complete or not.

F	FUSED
U	UNFUSED
N	CANNOT BE CODED BECAUSE THE BONE IS ABSENT

Appendix B : Table of raw data

Appendix B contains the raw data table for the faunal analysis of the Paleoindian bison assemblage of Charlie Lake Cave. "No" refers to specimen number, "Weath" to weathering stage, "Cutm" to cutmark and impact point, "Flake" refers to flake scar, "Carn" to carnivore damage stages, "Rdnt" to rodent damage, "Excv" to excavator damage, "Rock" to rock fall damage, and "Root" to root etching. When an "x" is in parentheses "(x)" it means that the damage was not equivocally attributed to the causal agent, but is a possibility. "n/a" is employed when the data are unavailable.

No	Unit	Layer	Level	Element	Side	Part	Fusion	Weath.	Cutm	Flake	Carn	Rdnt	Excv	Rock	Root
3429	3	93-102	n/a	HU	R	105	NF	1			2		x		
2284	4	93	n/a	UN	U		NN	2							
2289	4	98-105	n/a	TI	L	110	NN	1			0		x		
2291	4	98-105	n/a	RA	R	107	NF	1	x		0				
2292	4	98-105	n/a	UL	R	103	NN	1	x		1				
2293	4	98-105	n/a	SE	U	1	FF	1			0				
2294	4	98-105	n/a	RA	R	110	NN	1			0				
2295	4	98-105	n/a	CR	U	2	NN	2							
2296	4	98-105	n/a	TI	R	100	UN	2			3		x	x	
20000A	4	105	1	RA	R	102	FN	2		x	0				
20000B	4	105	1	RA	R	102	FN	1	x	x	0				
20001	4	105	1	TI	L	1	FF	1			0				
20002	4	105	1	HC	U	2		4			n/a				
20003	4	105	1	MA	L	1	NN	1			1				
20004	4	105	2	XN	U	1		2							
20005	4	105	2	IT	R	1	NN	1			1				
20006	4	105	2	CR	U	2	NN	3							
1787	5	77-81	n/a	HU	L	110	NN	2		x	1				
1828	5	98	n/a	2P	U	102	FN	2			3		x		
1829	5	98	n/a	TI	L	105	NF	2	x		2		x	x	
1830	5	98	n/a	SA	I		FF				3				
1831	5	98	n/a	IN	L	91	NN	3			1	x	x		

No	Unit	Layer	Level	Element	Side	Part	Fusion	Weath.	Cutm	Flake	Carn	Rdnt	Excv	Rock	Root
1832	5	98	n/a	CR	U	2		in							
1833	5	98	n/a	UN				in							
1840	5	102-105	n/a	TI	U	102	UN				n/a				
1847	5	102-105	n/a	RI	I	72	NN	1	x		1				
1848	5	102-105	n/a	HU	R	108	NN	1	x		2		(x)	(x)	
1849	5	102-105	n/a	HU	R	107	NF	1	x		2		x		
20100	6	98	n/a	1P	U	1	FF	2			1		x		
20101	6	98	n/a	RA	L	110	NN	2	x		2			x	
20102	6	98	n/a	2P	U	1	FF	2			1		(x)		
20007	23	98	2	SD	R	1	NN	1			1				
20008	23	98	2	PI	R	1	NN	1			1				
20009	23	102	1	CR	I	2		in							
20010	23	102	1	NS	U	2		1							
0	23	102	2	UN											
20012	23	106	1	CE	I	57	NN	in			1				
14173	24	93	4	UN	U	2		in							
14288	24	98	4	HU	R	110	NN	2			1		x		
14289	24	98	4	CA	L	121	NF	in			3				
14290	24	98	4	2P	U	1	FF	2			0		(x)		
14291	24	98	4	3P	U	105	NF	2			2		x		
12628	24	98	4	IN	R	91	NN	3		(x)	2				
13658	24	98	4	CA	R	121	NF	2			3		x		
14292	24	106	4	UN	U	2		in							
15004A	24	106	4	HU	R	104	UN	4			n/a		x		
14719	24	106	4	HU	R	104	UN	4			n/a				
12989	26	98	2	LA	L	1	NN	2			1				
12990	26	98	2	NC	R	121	NN	3			3		x		
13662	26	98	2	2P	U	1	FF	2	(x)		0		(x)		
13681	26	98	2	3P	U	1	FF	2			0		x		
13728	26	98	2	MC	R	107	NF	2	x	x	0	x	x		
13730	26	98	2	1P	U	1	FF	2			0		x		
13731	26	98	2	RA	L	109	NU	1			1		x		
13733	26	98	2	MT	R	103	FN	3	x		0		x		
13734	26	98	2	TI	U	104	UU	3			n/a				
15000	26	98	2	1P	U	1	FF	2			1		x		
12986	26	98	3	3P	U	1	FN	3			1				
13729	26	98	3	SC	R	81	NN	2			2				
16400	26	98	3	SE	U	1	NN	2			0				
16401	26	98	3	3P	U	110	NN	in			n/a				
16419	26	98	3	PI	R	1	NN	1			1		x		
20045	26	98	3	TI	L	110	NN	2		x	1				
13732	26	98	6	MT	L	105	NU	2			3				
14689	26	105	1	IN	L	95	NN	3			2				

No	Unit	Layer	Level	Element	Side	Part	Fusion	Weath.	Cutm	Flake	Carn	Rdnt	Excv	Rock	Root
16410	26	105	1	RA	L	1	FU	2			0	(x)	x	(x)	
16411	26	105	1	RI	L	72	NN	2	x		1	x		x	
16418	26	105	1	RA	R	103	FN	1	x		1		x		
16420	26	105	1	2P	U	1	FF	in			2				
16421	26	105	1	3P	U	1	FF	1			0				
16422	26	105	1	CU	R	1	NN	1			0		x		
16431	26	105	1	TI	L	104	UN	2			1		x		
13657	26	105	2	RI	U	72	NN	2	x		1		x	x	
16417	26	105	2	SE	U	1	NN	1			0				
0	26	105	2	UN	U										
12708	26	105	3	IT	L	1	NN	1			1				
13648	26	105	3	CR	U	2		in							
13656	26	105	3	CR	U	2		in							
13649	26	105	4	CR	U	2		in							
20013	27	98	2	CA	L	121	NF	2			3				
20014	27	98	2	MC	R	110	NN	2			3				x
20015	27	98	2	TH	I	56	NN	1			0			(x)	
20016	27	98	2	RA	L	110	NN	2	x		0				
20017	27	98	5	TH	I	56	NN	1	x		0				
20018	27	98	5	UN	U	2		in							
20019	27	98	5	TI	L	110	NN	1			0		x		
20020	27	98	5	UN	U	2		in							
20021	27	98	5	TH	I	56	NN	1			0				
20022	27	98	6	IT	R	1	NN	1			0				
20023	27	98	6	SD	R	1	NN	1			1				
20024	27	98	6	CU	R	1	NN	1			1				
20025	27	98	7	TH	I	56	NN	1			0				
20026	27	98	7	TH	I	56	NN	1			0				x
20027	27	98	7	TH	I	56	NN	1			0			(x)	
20028	27	98	7	UN	U	2									
20029	27	98	7	UN	U	2									
20030	27	105	1	CR	I	2		in							
20031	27	105	1	UN	U	2		in							
20032	27	105	1	CR	I	2		in							
20035	27	105	2	UN	U	2									
20036	27	105	3	CR	I	2		4							
20037	27	105	3	TI	L	105	NU	2			3		x		x
12270	28	105	3	2P	U	108	NF	2			2		x		
12278	28	105	3	2P	U	107	NF	2			2	x			
12279	28	105	3	3P	U	1	FF	3			2			(x)	
12401	28	105	3	RA	L	109	NU	1			1			x	
16409	28	105	3	UL	L	101	NN	2	x		1		x		x
12400	28	105	4	3P	U	1	FF	3			0			(x)	

No	Unit	Layer	Level	Element	Side	Part	Fusion	Weath.	Cutm	Flake	Carn	Rdnt	Excv	Rock	Root
15001	28	105	4	3P	U	105	NF	1			n/a				
20038	29	98	5	LA	R	1	NN	1			0		x	x	
20039	29	98	5	TI	L	110	NN	2		x	1		x	(x)	
20040	29	98	5	UN	U			in							
0	29	98	7	UN	U										
20042	29	98	8	IN	L	92	UU	3		x	2				
20043	29	98	8	TI	R	1	FF	1			0		x	(x)	(x)

NISP = 115

Appendix C : Measurements of the skeletal elements

Measurements of the specimens have been taken from three different measurement guides: von den Driesch (1976), Speth (1983), and Morlan (1991). The abbreviation for the authors' measurements are "V" for von den Driesch, "S" for Speth, and "M" for Morlan. The measurements are recorded in millimetres. Lettering of the measurements follow the individual author's usage.

Table a Measurements of the Paleoindian bison specimens at Charlie Lake Cave

Element	Specimen	Author	Measurements (in mm)			
Carpals						
Scaphoid	**20007**	M:	L=33.02	W=31.17	D=49.4	
	20023	M:	L=35.9	W=31.5	D=53.65	
Intermedium	**20005**	M:	L=27.0	W=*34	D=42.0	
	12708	M:	L=26.5	W=33.1	D=40.4	
	20022	M:	L=30.5	W=33.0	D=47.85	
Cuneiform	**16422**	M:	W=27.8	Lp=40.3	La=35.55	D=38.2
	20024	M:	W=30.5	Lp=42.2	La=38.75	D=40.85
Magnum	**20003**	M:	L=23.6	W=40.35	D=37.8	
		V:	GB=40.35			
Pisiform	**20008**	M:	L=26.45	W=16.8	D=37.8	
	16419	M:	L=26.9	W=16.9	D=31.7	
Tarsals						
Calcaneus	**14289**		too fragm.			
	13658		too fragm.			
	20013		too fragm.			
Nav-Cub	**12990**		too fragm.			
Lat. Malleolus	**12989**	M:	L=30.5	D=42.8	W=18.3	
		V:	GD=42.8			
	20038	M:	L=34.4	D=47.8	W=22.3	
		V:	GD=47.8			
Humerus	**3429**	V:	BT=91.8			
		S:	I=91.8			
	1787		none			
Humerus	**1848**		none			
	1849	V:	BT=99.2			
		S:	I=100.2 ?	M=87.2	J=64.7	

* pt missing

Element	Specimen	Author	Measurements (in mm)				
	14288		none				
	15004		too fragm.				
	14719		too fragm.				
Radius	**16410**	V:	GL=298	PL=280	Ll=266		
	16409		GLl=350*	GL=370*			* missing c.10 mm of the ulna Due to chewing
			Bp=82.8	BFp=79.3	Bd=75.1	BFd=73.8	
	12401		DPA=74.0				
		S:	A=82.8	B=43.6	C=29.5	D=48.6	
			E=42.7	F=?45.5	G=79.5	H=40.1	
			I=43.25	J=16.4	K=33.5		
	13731	V:	BFd=67.85				
		S:	G=*68.45	I=44.8	J=19.5	K=36.8	* no ulna epi
	20000	V:	BFp=86.8	Bp=96.3			
		S:	A=96.3	B=48.45	C=30.45	D=47.45	
			E=40.75				
	2291	V:	BFd=83.3	Bd=91.3			
		S:	G=91.3	H=42.55	I=52.3	J=21.2	
			K=48.4				
Tibia	**20043**	V:	Bp=140.3	Bd=85.3	Li=402	GL=451.5	
		S:	A=140.3	B=118.2	C=102.4	D=125.5	
			E=61.35	F=65.3	G=89.8	H=85.9	
			I=64.3	J=60.8	K=63.5	L=71.0	
	1829	V:	Bd=79.4				
		S:	H=79.4	I=56.7	J=55.9	K=45.3	
			L=55.1				
	16431	V:	Bp=98.1				
		S:	A=98.1	B=111.8	C=86.4	D=102.5	
			E=46.3	F=44.1	G=88.9		
	2296		too young				
	20037		too young				
Metacarpals	**13728**	V:	Bd=78.2				
		S:	D=72.0	E=37.8	F=36.5	G=31.0	
			H=28.3	I=43.25	J=41.7		
	20014		shaft only				
Metatarsals	**13733**		too fragm.				
	13732		too young				
Phalanx 1	**13730**	V:	GLpe=70.2	Bp=41.1	Sd=35.3	Bd=39.3	
	15000	V:	GLpe=70.4	Bp=39.8	Sd=36.6	Bd=40.3	
Phalanx 1	**20100**	V:	GLpe=68.6	Bp=40.1	Sd=35.0	Bd=37.2	
Phalanx 2	**13662**	V:	GL=49.9	Bp=40.3	Sd=30.7	Bd=35.2	
	16420	V:	GL=51.3	Bp=36.9	Sd=28.1	Bd=*31.7	* furrowed
	20102	V:	GL=51.2	Bp=41.3	Sd=30.9	Bd=35.4	
	14290	V:	GL=49.4	Bp=40.2	Sd=30.2	Bd=35.5	

Element	Specimen	Author	Measurements (in mm)		
	1828	V:	Bp=36.9		
	12278	V:	Bd=22.4		
	12270	V:	Bd=23.3		
Phalanx 3	**13681**	V:	DLS=*82.4	Ld=62.1	MBS=39.7
	16421	V:	DLS=86.5	Ld=64.1	MBS=38.8
	12279	V:	Ld=36.2	MBS=20.3	
	12400	V:	DLS=49.6	Ld=42.3	MBS=26.3
	14291	V:	MBS=33.3		
	15001	V:	MBS=34.9		
	12986	V:	DLS=66.4	Ld=56.2	MBS=41.7

* tip broken

Table b Comparison of measurements for specimen 20043 and male bison modern analog from Simon Fraser University zooarchaeological collection.

Specimen	Author	Measurements (in mm)			
20043	V:	Bp=140.3	Bd=85.3	Li=402	GL=451.5
	S:	A=140.3	B=118.2	C=102.4	D=125.5
		E=61.35	F=65.3	G=89.8	H=85.9
		I=64.3	J=60.8	K=63.5	L=71.0
modern	V:	Bp=114	Bd=69	Li=354	GL=401
	S:	A=114	B=96	C=84	D=103
		E=45	F=51	G=63	H=67
		I=51	J=45	K=45	L=52

Bibliography

Bartram, L.

1993 Perspectives on Skeletal Part Profiles and Utility Curves from Eastern Kalahari Ethnoarchaeology. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. Hudson, pp. 115-137. Center for Archaeological Investigations, Occasional Paper No. 21.

Bartram, L., and C. Marean

1999 Explaining the "Klasies Pattern": Kua Ethnoarchaeology, the Die Kelders Middle Stone Age Archaeofauna, Long Bone Fragmentation and Carnivore Ravaging. *Journal of Archaeological Science* 26: 9-29.

Behrensmeyer, A. K.

1978 Taphonomic and Ecologic Information from Bone Weathering. *Paleobiology* 4(2): 150-162.

Binford, L.

1978 *Nunamiut Ethnoarchaeology*. Academic Press, New York.

1981 *Bones: Ancient Men and Modern Myths*. Academic Press, New York.

1984 *Faunal Remains from Klasies River Mouth*. Academic Press, Orlando.

Blumenschine, R. J., and C. W. Marean

1993 A Carnivore's View of Archaeological Bone 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, Occasional Paper No. 21.

Brain, C. K.

1981 *The Hunters or the Hunted?: An Introduction to African Cave Taphonomy*. University of Chicago Press, Chicago.

Brink, J.

1997 Fat Content in Leg Bones of *Bison bison*, and Applications to Archaeology. *Journal of Archaeological Science* 24: 259-274.

Bunn, H., L. Bartram, and E. Kroll

1988 Variability in Bone Assemblage Formation from Hadza Hunting, Scavenging, and Carcass Processing. *Journal of Anthropological Archaeology* 7: 412-457.

Capaldo, S. D., and R. J. Blumenschine

1994 A Quantitative Diagnosis of Notches Made by Hammerstone Percussion and Carnivore Gnawing on Bovid Long Bones. *American Antiquity* 59: 724-748.

Corbeil, M. C.

1994 *The Archaeology and Taphonomy of the Heron Eden Site, Southwestern Saskatchewan.* Unpublished M.A. Thesis, Department of Anthropology and Archaeology, University of Saskatchewan.

Cruz-Uribe, K.

1991 Distinguishing Hyena from Hominid Bone Accumulations. *Journal of Field Archaeology* 18: 467-486.

Davis, L. B. and S. T. Greiser

1992 Indian Creek Paleoindians: Early Occupation of the Elkhorn Mountains' Southeastern Flank, West-Central Montana. In *Ice Age Hunters of the Rockies*, edited by D.J. Stanford and J.S. Day, pp. 225-283. Denver Museum of Natural History and University Press of Colorado.

Diab, M. C.

1998 Economic Utility of the Ringed Seal (*Phoca hispida*): Implications for Arctic Archaeology. *Journal of Archaeological Science* 25: 1-26.

Driver, J. C.

1988 Late Pleistocene and Holocene Vertebrates and Palaeoenvironments from Charlie Lake Cave, Northeast British Columbia. *Canadian Journal of Earth Sciences* 25: 1545-1553.

1989 Appendix 2: Faunal Analysis. In *The Ross Site(DlPd-3) 1980 Research*, by J.R. Vickers, pp. 125-158. Archaeological Survey of Manitoba, Manuscript Series No. 14.

1996 Significance of the Fauna from the Charlie Lake Cave Site. In *Early Human Occupation in British Columbia*, edited by R.L. Carlson and L. Dalla Bona, pp. 21-28. UBC Press, Vancouver.

1998a Late Pleistocene Collared Lemming (*Dicrostonyx torquatus*) from Northeastern British Columbia, Canada. *Journal of Vertebrate Paleontology* 18(4): 816-818.

1998b Human Adaptation at the Pleistocene/Holocene Boundary in Western Canada, 11,000 to 9000 BP. *Quaternary International* 49/50: 141-150.

1999a Raven Skeletons from Paleoindian contexts, Charlie Lake Cave, British Columbia. *American Antiquity* 64: 289-298.

1999b Stratified Faunas from Charlie Lake Cave and the Peopling of the Western Interior of Canada. In *Zooarchaeology of the Pleistocene/Holocene Boundary:Proceedings of a Symposium Held at the 8th Congress of the International Council for Archaeozoology (ICAZ), Victoria, British Columbia, Canada, August 1998*, edited by J.C. Driver, pp. 77-83. BAR International Series 800.

2001 Paleoecological and Archaeological Implications of the Charlie Lake Cave Fauna, British Columbia, 10, 500 to 9, 500 B.P. 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. 13-22. BAR International Series 944.

Driver, J. C., M. Handly, K. R. Fladmark, D. E. Nelson, G. M. Sullivan, and R. Preston

1996 Stratigraphy, Radiocarbon Dating, and Culture History of Charlie Lake Cave, British Columbia. *Arctic* 49(3): 265-277.

Elkin, D. C.

1995 Volume Density of South American Camelid Skeletal Parts. *International Journal of Osteoarchaeology* 5: 29-37.

Emerson, A. M.

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

Fedje, D. W., J. M. White, M. C. Wilson, D. E. Nelson, J. S. Vogel and J. R. Southon

1995 Vermilion Lakes Site: Adaptations and Environments in the Canadian Rockies During the Latest Pleistocene and Early Holocene. *American Antiquity* 60(1): 81-108.

Fisher, J. W. Jr.

1995 Bone Surface Modifications in Zooarchaeology. *Journal of Archaeological Method and Theory* 2(1): 7-68.

Fladmark, K. R.

1996 The Prehistory of Charlie Lake Cave. In *Early Human Occupation in British Columbia*, edited by R.L. Carlson and L. Dalla Bona, pp. 11-20. UBC Press, Vancouver.

Fladmark, K. R., J. C. Driver, and D. Alexander

1988 The Paleoindian Component at Charlie Lake Cave (HbRf 39), British Columbia. *American Antiquity*, 53(2): 371-384.

Frison, G. C.

1970 The Glenrock Buffalo Jump, 48CO304. *Plains Anthropologist Memoir* No 7.

1982 Paleo-Indian Winter Subsistence Strategies 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, no. 30.

1996 *The Mill Iron Site*. University of New Mexico Press, Albuquerque.

Frison, C. G., and D. J. Stanford

1982 *The Agate Basin Site: A Record of Paleoindian Occupation of the Northwestern High Plains*. Academic Press, New York.

Garvin, R. D.

1987 Research in Plains Taphonomy: The Manipulation of Faunal Assemblages by Scavenger. Unpublished M. A. Thesis, Department of Archaeology, University of Calgary.

Grayson, D. K.

1984 *Quantitative Zooarchaeology*. Academic Press, New York.

1989 Bone transport, Bone Destruction, and Reverse Utility Curves. *Journal of Archaeological Science* 16: 643-652.

Greiser, S. T.

1985 Predictive Models of Hunter-Gatherer Subsistence and Settlement Strategies on the Central High Plains. Memoir No. 20, Plains Anthropologist, vol. 30.

Haynes, G.

1982 Utilization and Skeletal Disturbances of North American Prey Carcasses. *Arctic* 35(2): 266-281.

1983 A Guide for Differentiating Mammalian Carnivore Taxa Responsible for Gnaw Damage to Herbivore Limb Bones. *Paleobiology* 9(2): 164-172.

Handly, M. J.

1994 Lithic Assemblage Variability at Charlie Lake Cave (HbRf 39): a Stratified Rockshelter in Northeastern British Columbia. Unpublished M. A. Thesis, Anthropology Department, Trent University.

Henrikson, L. S.

2003 Bison Freezers and Hunter-Gatherer Mobility: Archaeological Analysis of Cold Lava Tube Caves on Idaho's Snake River Plain. *Plains Anthropologist* 48(187): 263-285.

Hill, M. G.

2001 Paleoindian Diet and Subsistence Behavior on the Northwestern Great Plains of North America. Unpublished Ph.D. Dissertation, Anthropology Department, University of Wisconsin-Madison.

Kelly, R. L. and L. C. Todd

1988 Coming into the Country: Early Paleoindian Hunting and Mobility. *American Antiquity* 53(2): 231-244.

Klein, R.

1989 Why Does Skeletal Part Representation Differ Between Smaller and Larger Bovids at Klasies River Mouth and Other Archaeological Sites? *Journal of Archaeological Science* 6: 363-381.

Klein, R., K. Cruz-Uribe, and R. Milo

1999 Skeletal Part Representation in Archaeofaunas: Comments on "Explaining the 'Klasies Pattern': Kua Ethnoarchaeology, the Die Kelders Middle Stone Age Archaeofauna, Long Bone Fragmentation and Ravaging" by Bartram & Marean. *Journal of Archaeological Science* 26: 1225-1234

Kreutzer, L. A.

1992 Bison and Deer Bone Mineral Densities: Comparisons and Implications for the Interpretation of Archaeological Faunas. *Journal of Archaeological Science* 19: 271-294.

1996 Taphonomy of the Mill Iron Site Bison Bonebed. In *The Mill Iron Site*, edited by G.C. Frison, pp. 101-143. University of New Mexico Press, Albuquerque.

Lahren, L. A.

1976 The Myers-Hindman Site: An Exploratory Study of Human Occupation Patterns in the Upper Yellowstone Valley from 7000 B.C. to A.D. 1200. Unpublished Ph.D Thesis, Archaeology Department, University of Calgary.

Lam, Y. M.

1992 Variability in the Behaviour of Spotted Hyenas as Taphonomic Agents. *Journal of Archaeological Science* 19: 389-406.

Lam, Y. M., O. M. Pearson, C. W. Marean, and Xingbin Chen

2003 Bone Density Studies in Zooarchaeology. *Journal of Archaeological Science* 30: 1701-1708.

Lyman, R. L.

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.

1994 *Vertebrate Taphonomy*. Cambridge University Press, Cambridge.

Lyman, R. L., J. Savelle, and P. Whitridge

1992 Derivation and Application of a Meat Utility Index for Phocid Seals. *Journal of Archaeological Science* 19: 531-555.

Marean, C. W.

1991 Measuring the Post-Depositional Destruction of Bone in Archaeological Assemblages. *Journal of Archaeological Science* 18: 677-694.

Marean, C. W., and L. Bertino

1994 Intrasite Spatial Analysis of Bone: Subtracting the Effect of Secondary Carnivore Consumers. *American Antiquity* 59: 748-768.

Marean, C. W. and L. M. Spencer

1991 Impact of Carnivore Ravaging on Zooarchaeological Measures of Element Abundance. *American Antiquity* 56: 645-658.

Metcalfe, D., and K. T. Jones

1988 A Reconsideration of Animal Body-Part Utility Indices. *American Antiquity* 53: 486-504.

Muir, R. J., and Driver, J. C.

2004 Identifying Ritual Use of Animals in the Northern American Southwest. In *Behaviour Behind Bones: The Zooarchaeology of Ritual, Religion, Status and Identity*, edited by S. J. O'Day, W. Van Neer, and A. Ervynck, pp. 128-143. Proceedings of the 9th Conference of the International Council of Archaeozoology, Durham, August 2002. Oxbow Books, Oxford.

Morlan, R. E.

1983 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 and A. S. MacEachern, pp. 241-269. Archaeological Association of the University of Calgary, Calgary.

1991 Bison Carpal and Tarsal Measurements: Bulls versus Cows and Calves. *Plains Anthropologist* 36(136): 215-227.

O'Connell, J. F., K. Hawkes, and N. Blurton Jones

1988 Hadza Hunting, Butchering, and Bone Transport and their Archaeological Implications. *Journal of Anthropological Research* 44: 113-161.

Outram, A.

2000 Hunting Meat and Scavenging Marrow? A Seasonal Explanation for Middle Stone Age Subsistence at Klasies River Mouth. In *Animal Bones, Human Societies*, edited by P. Rowley-Conwy, pp. 20-27. Oxbow Books, Oxford.

2001 FOCUS: The Scapula Representation Could be the Key: A Further Contribution to the "Klasies Pattern" Debate. *Journal of Archaeological Science* 28: 1259-1263.

Reeves, B. O. K.

1990 Communal Bison Hunters of the Northern Plains. In *Hunters of the Recent Past*, edited by L. B. Davis and B. O. K. Reeves, pp. 168-194. Unwin Hyman, London.

Shapiro, B.

2003 Inferring Evolutionary History and Processes using Ancient DNA. Unpublished Ph.D. dissertation, University of Oxford.

Speth, J. D.

1983 *Bison Kills and Bone Counts: Decision Making by Ancient Hunters*. University of Chicago Press, Chicago.

Stahl, P.

1999 Structural Density of Domesticated South American Camelid Skeletal Elements and the Archaeological Investigation of prehistoric Andean Ch'arki. *Journal of Archaeological Science* 26: 1347-1368.

Todd, L. C. and G. C. Frison

1992 Reassembly of Bison Skeletons from the Horner Site: A Study in Anatomical Refitting. In *Piecing Together the Past: Applications of Refitting Studies in Archaeology*. Edited by J. L. Hofman and J. G. Enloe, pp. 63-82. BAR International Series 578.

Villa, P.

1982 Conjoinable Pieces and Site Formation Processes. *American Antiquity* 47: 276-290.

von den Driesch, A.

1976 *A Guide to the Measurement of Animal Bones from Archaeological Sites*. Peabody Museum Bulletin 1, Harvard University.

Wheat, J. B.

1972 Olsen-Chubbuck Site: A Paleo-Indian Bison Kill. *Society for American Archaeology, Memoirs No. 26*.

White, T.D.

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

Wilson, M.C.

1984 Faunal Remains from the Vermilion Lakes site, Banff National Park: First Report. In *Vermilion Lakes Archaeology – Interim Report Trans-Canada Highway Mitigation in Banff National Park,* by D. W. Fedje and J. M. White, pp. 163-188. Canadian Parks Service Microfiche Report Series 177, Ottawa.

1985 *Faunal Remains from the Indian Creek Site(24BW626), Montana: The 1982 Collection*. Report to Department of Sociology, Montana State University, Bozeman.

1996 Late Quaternary Vertebrates and the Opening of the Ice-Free Corridor, with Special Reference to the Genus *Bison*. *Quaternary International* 32: 97-105.