The Palaeoindian Bison Assemblage from Charlie Lake Cave, British Columbia

Jonathan C. Driver[†] and Claudine Vallières[‡]

Abstract. A small assemblage of bison bones from the Palaeoindian (10,700 to 9500 BP) components at Charlie Lake Cave, British Columbia is dominated by elements from the middle and lower limbs. The skeletal element frequencies are not typical of a kill site. The lithic assemblage, the lack of evidence for burning, and the ratio of long bone shaft fragments to epiphyses suggest that the assemblage was not produced at a residential site nor at a specialized processing area. We propose that the assemblage resulted from storage of frozen bison limbs in a series of meat caches, probably located in a small cave that would have been difficult for scavengers to enter.

Résumé. Un petit assemblage d'ossements de bison provenant des composantes paléoindiennes (10,700 à 9500 AA) du site Charlie Lake Cave, Colombie-Britannique, est dominé par des éléments des membres inférieurs et moyens. Les fréquences d'éléments squelettiques ne sont pas typiques d'un site de tuerie. L'assemblage lithique, l'absence d'indice de feu, et le ratio entre les fragments de diaphyses d'os longs et les épiphyses suggèrent que l'assemblage n'est ni le produit d'un site résidentiel, ni celui d'une aire de boucherie spécialisée. Nous proposons que cet assemblage reflète l'entreposage de membres de bison gelés dans une série de caches à viande, probablement localisées dans une petite cave, difficilement accessible aux charognards.

CHARLIE LAKE CAVE (CLC) IS ONE of the few archaeological sites in western Canada that has been dated to >10,000 BP (Driver 1998a) and is a rare Canadian example of a Palaeoindian site that contains well-preserved faunal remains in clear association with stone tools. The site location, structure, dating and culture history have been described in some detail in previous publications (Driver *et al.* 1996; Fladmark 1996; Fladmark *et al.* 1988). Most faunal studies of the site have emphasized palaeo-ecological analysis, notably the marked transition between late Pleistocene and early Holocene faunas (Driver 1988, 1998b, 1999a, 2001). An analysis of raven skeletons has suggested Palaeoindian ritual use of the site (Driver 1999b), but little attention has been paid to the activities represented by other culturally deposited faunal remains. In this paper we discuss the bison bone assemblage dating from about 10,500 to 9500 BP (all dates uncalibrated). We describe the collection, evaluate different hypotheses for the processes that created the assemblage, and suggest some implications for interpretation of Palaeoindian adaptations.

Located in northeastern British Columbia, CLC (HbRf–39) lies to the east of the Rocky Mountains in rolling

[†] Department of Archaeology
Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6 [driver@sfu.ca]

[‡] Department of Anthropology, McGill University, 855 Sherbrooke Street W., Montreal, QC H3A 2T7 [Claudine.vallieres@mail.mcgill.ca]

terrain mantled by glaciolacustrine deposits. The site has an unusual topography (Figure 1). Sandstone bedrock outcrops as a low cliff along the side of a hill overlooking a creek. In the cliff is a small cave probably formed by subglacial water exploiting joints in the sandstone. After the formation of the cave, and probably after ice melted and glacial lakes drained, a very large slab of sandstone ("the parapet" in Figure 1) became detached from the vertical cliff face and moved down slope a few meters. The slab remained in an upright position, partly because its base was wider than its apex, and partly because it was supported on the down slope side by glacial sediments that covered the hillside. The down slope movement of this slab created a steep-walled gully running parallel to the hillside, whose north (up slope) side consisted of the vertical face of the bedrock cliff from which

the slab had detached. The cave was exposed in this face a few meters above the floor of the newly created gully. The south (down slope) wall of the gully was formed by the north (up slope) side of the vertical slab. The floor of the gully sloped steeply from north to south, and was littered with sandstone boulders and crushed sandstone (stratigraphic Zone I). The gully was only a few meters wide at the base.

Shortly after the formation of the gully, sediments began to accumulate. For the most part these were redeposited glaciolacustrine deposits derived from the hillside above the gully. As these were washed over the edge of the cliff and into the gully, their further down slope movement was impeded by the large slab, thus allowing sediments to build up in the gully. The steep slope of the gully floor caused a thicker accumulation of sediments on the south side of the gully,
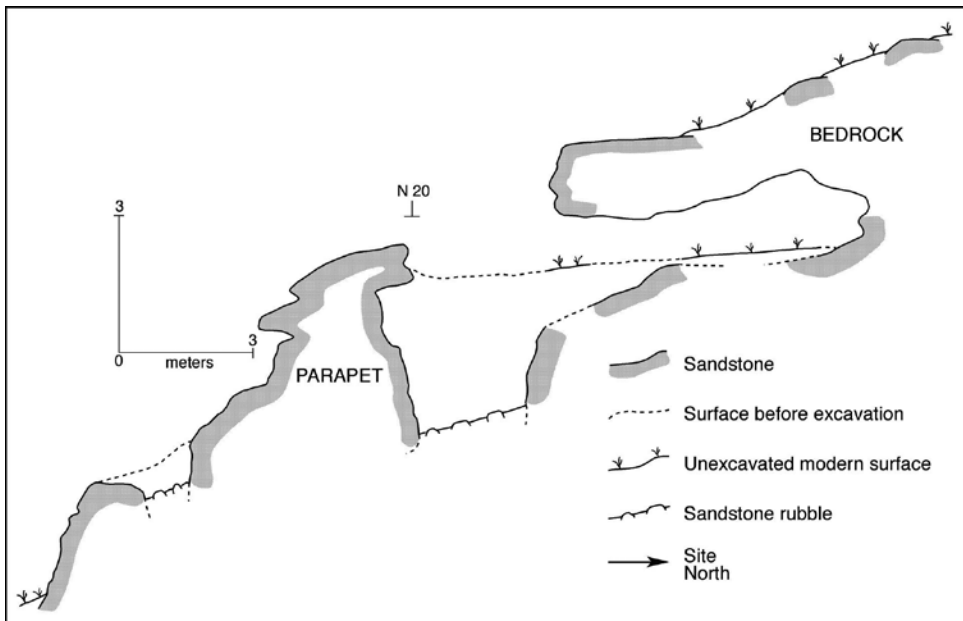

FIGURE 1. Cross-section of Charlie Lake Cave site, showing position of gully in which bison bones were deposited. Reprinted by permission from *American Antiquity* 64(2).

where excavations revealed up to 1 meter of fine sediments deposited between 10,700 and 9500 BP (stratigraphic Zone II). Over the southern two-thirds of the gully these sediments allowed excellent preservation of bone. However on the north side there has been continual leaching of deposits due to runoff from the hillside above the site. As a result, there is virtually no bone preserved on the north side of the gully. Although the rate of sediment deposition was reduced after 9500 BP, deposits continued to accumulate throughout the Holocene, together with cultural and faunal material (Driver *et al.* 1996; Fladmark *et al.* 1988). The lowest layers of Zone III, that form subzone IIIa were also included in this analysis. This was done because a few bison specimens recovered from the base of IIIa could be articulated with specimens in the upper part of Zone II.

As can be seen from Figure 1, because the floor of the cave was located well above the base of the gully, and because there was no source for sediments to be deposited in the cave, very little sediment accumulated in the cave itself until late Holocene times, when the level of sediment in the gully reached the same level as the floor of the cave. Archaeological excavations have therefore concentrated in the gully, with most lithic and faunal specimens from Zone II being found at the bottom of the gully just to the west of the cave entrance (Figure 2).

The dating of post-glacial events along the eastern foothills and adjacent plains of the Canadian Rockies has been bedeviled by a long-standing discussion concerning the "ice-free corridor". Enthusiasm to date organic materials has led to unsuitable samples being selected. For example, MacDonald *et al.* (1987, 1991) show that radiocarbon dates on plant remains from lake bed cores are inaccurate because some aquatic plants incorporate dissolved carbonates derived from ancient limestone. A review by Arnold (2002) suggests that a significant
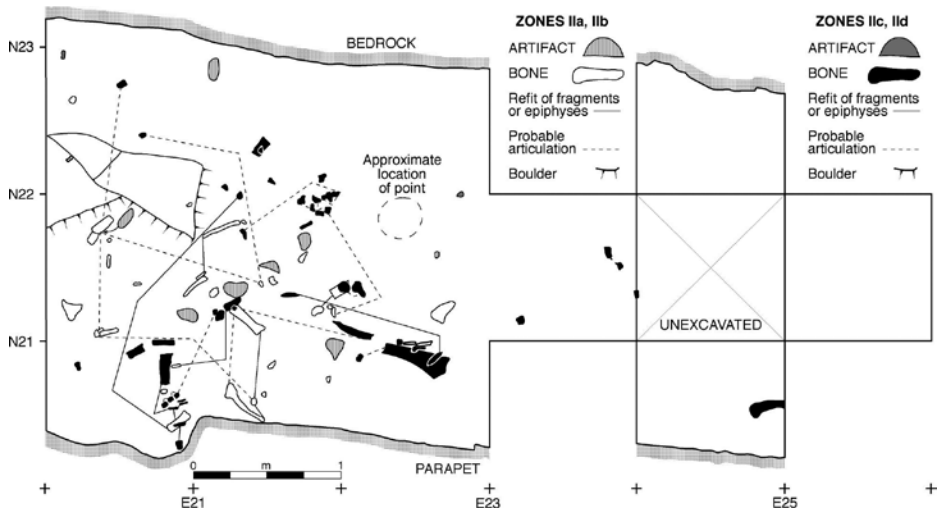

FIGURE 2. Distribution of artifacts and bison bones at the base of the gully in Zone II. Approximate position of fluted point is also shown. Cave entrance is well above the gully floor in bedrock approximately E24 to E25. Reprinted by permission from *American Antiquity* 64(2).

number of radiocarbon dates from this region are not dating events to which they are supposedly connected. In the Charlie Lake area there is evidence for a Laurentide ice advance after 22,000 BP and before 13,000 BP (Catto *et al.* 1996; Hartman 2005). This was followed by a period when Glacial Lake Peace covered much of the area, including CLC, but the lake is poorly dated. However, an articulated bison skeleton dating to about 10,500 BP was recovered from gravels within the modern Peace River valley (Apland and Harington 1994) and similar radiocarbon dates are found under sediment fans that post-date the earliest Peace River terraces (Geertsma and Jull 2002), so Glacial Lake Peace must have drained and the Peace River must have begun its incision by the time that people occupied CLC.

Northeast of CLC MacDonald (1987) documented a pre-10,000 BP vegetation of shrubs, herbs and grasses, with spruce forest arriving by 10,000 BP. Studies of vertebrates from CLC suggest a similar sequence of open landscape at 10,700 BP, with boreal forest and associated vertebrates arriving around 10,000 BP (Driver 1988, 2001). Recent maps of major vegetation zones in the western interior of North America constructed from pollen core data also suggest a transition from open to forested landscapes in northeastern British Columbia between 12,000 and 10,000 BP (Strong and Hills 2005). It therefore seems likely that Glacial Lake Peace drained some time before 10,700 BP, allowing the establishment of a pioneer vegetation of grasses, herbs and shrubs around CLC. It was on to that landscape that Palaeoindians moved. By 10,000 BP the open landscape was being replaced in the CLC area by boreal forest, and this is best documented in the vertebrate fauna by the decline in

ground squirrels and their replacement by snowshoe hare (Driver 2001).

THE BISON ASSEMBLAGE

Excavations at CLC attempted to follow stratigraphic layers, but when these were thicker than 10 cm they were arbitrarily subdivided. The thick lower deposits at the site were formed rapidly by redeposition of glacial lake sediments and are relatively homogeneous, so arbitrary levels were used when stratigraphic boundaries could not be identified. An attempt was made to "contour" these levels to the overall slope of the deposits. Distribution of elements from a complete raven skeleton show that sediments sloped steeply and that there was probably down slope movement of bones after deposition (Driver 1999b). It is also possible that some slumping of these sediments occurred. Refitting of bison bone fragments and rearticulation of specimens (Vallières 2004) shows that there was both lateral and vertical movement of specimens, probably due to the steeply sloping, unstable sediments in the bottom of the gully (Figure 2).

Vallières reanalyzed the bison assemblage, independently of the original analysis by Driver (see Vallières 2004). As a result, there are some minor differences between numbers reported here and in previous publications. Some of these differences are due to a minor re-evaluation of stratigraphy prior to the second analysis. In addition, there were a couple of coding errors in both analyses. Some specimens that could be refitted were considered as one specimen in one analysis and two specimens in the other. Such differences are to be expected when different analysts work on the same material. In this paper we have followed Vallières' (2004) identifications, except in the case of coding

errors, that have been corrected for this report.

During analysis, some specimens were identified positively as *Bison*, and these are specimens that display enough diagnostic features to be sure that they are not from other large artiodactyl genera present in North America during the late Pleistocene. Ancient DNA analysis has confirmed the identity of four of these specimens as *Bison* (Shapiro *et al.* 2004). Other specimens were identified to a more generic category, such as "large ungulate". Because all of the identifiable large mammal specimens from this period at CLC are from *Bison*, we have felt justified in assuming that all large ungulate specimens are also from *Bison,* and when we refer to *Bison* throughout this paper we are including specimens identified only to the "large ungulate" category. Following Driver (1992) we only consider specimens identifiable if the skeletal element can be specified.

As reported elsewhere (Driver 1988) the CLC bison were significantly larger than middle and late Holocene bison, and the dimensions of their limb bones are consistent with other late Pleistocene/early Holocene specimens from the region. Lack of cranial material precludes assessment of their relationship to other bison populations using morphological traits. However, analysis of ancient DNA from four specimens demonstrated that some CLC specimens had maternal ancestry from Beringian populations in the north, whereas others were descended from populations that lived south of the late glacial ice sheets (Shapiro *et al.* 2004). This suggests that post-glacial colonization of the eastern slopes and adjacent plains regions was undertaken by southern populations moving north, and by northern populations moving south, and apparently meeting at about 10,500 BP. This conclusion was reached earlier by Wilson (1996) from morphological evidence, and he attributed this, as do we, to the final opening of a viable corridor down the east slopes and foothills of the Rockies just before the end of the Pleistocene. CLC is currently the only known site in North America where both bison clades are found commingled.

The complete bison assemblage from Zone II and Subzone IIIa is presented in Table 1. As can be seen, the sample is quite small relative to Palaeoindian sites in the western interior of the USA. However, this is still the largest, best preserved and best dated bison assemblage from a pre-10,000 BP Palaeoindian archaeological site in western Canada. One of the problems of analyzing the assemblage as a single unit is the likelihood that it represents multiple events. There are a number of lines of evidence that point to this. First, bison specimens were obtained from a reasonably well stratified sequence. Even though some mixing has occurred, radiocarbon dates fit well with stratigraphy (e.g., Driver 2001) and it is likely that there was more than one depositional event. Second, ancient DNA demonstrates that two distinct populations were hunted, suggesting a minimum of two hunting episodes. Third, radiocarbon dates on bison collagen range from 10,770 to 9760 BP (see Driver *et al.* 1996 and Shapiro *et al.* 2004 for date lists), and this suggests that bison were deposited on more than one occasion at CLC.

So, if the assemblage is the result of multiple events, why consider it as a single assemblage? First, most archaeological assemblages are probably the product of multiple events. In fact, we have very few methods that allow us to discover how many discrete occupation events are represented on transitory

hunter-gatherer sites, and many sites that are referred to as "single component" cannot be shown to be the result of a single episode of occupation. Bailey (2007) has discussed this at some length, employing the phrase "cumulative palimpsest" to refer to the mixing or integration of material residues of discrete activities. Lyman (2003) points out that most archaeological assemblages are "time averaged". In other words, they usually represent a series of discrete events that the processes of site formation, excavation and dating compress into a single analytical unit. At Charlie Lake Cave we cannot disentangle the discrete events that created a rather small sample of animal bones that span more than a millennium. Second, we have evidence at CLC for some mixing of deposits. Bison skeletal elements can be refitted and rearticulated within Zone II deposits, so even if discrete events were once present, subsequent site formation processes have blurred them. Because we cannot isolate discrete depositional events, we have to assume that the kinds of activities that resulted in bison bone deposition at the site were similar during each event, and that the assemblage has some kind of validity as a marker of human activity. We emphasize that this is a frequent, unwrit-

TABLE 1. Bison elements, Zones II and IIIa, Charlie Lake Cave, 1983 and 1991 seasons. w=whole. f=fragment. p=proximal. d=distal. s=diaphysis.

Element	Right	Left	Unsided	MNE
Cranium			ffffffffffff	1
Tooth			w	
Cervical 3–7			f	1
Thoracic			ffffff	1
Sacrum			f	1
Rib			fff	3
Scapula	f			1
Humerus	ppddds	s		4
Radius	pppds	wddss		5
Ulna	p	p		3
Carpal	wwwwwwww	ww		3 sets
Metacarpal	ds			2
Innominate		ffff		2
Tibia	wd	pddssss	pd	6
Tarsal	wwff	wff		3 sets
Metatarsal	p	d		2
Prox. phalanx			www	3
Medial phalanx			wwwwpdd	7
Distal phalanx			wwwwwddf	8
Sesamoid			www	3

ten assumption of most archaeological studies of hunter-gatherer sites.

THE LITHIC ASSEMBLAGE

The Palaeoindian lithic assemblage (Driver *et al.* 1996; Handly 1993) has been divided into three chronological components. The first two are most strongly associated with the bison assemblage, and consist of 51 specimens. The third component dates to about 9500 BP, and there is little associated bison bone. Almost all of the 162 specimens in component 3 are debitage resulting from the production or maintenance of two bifaces. We therefore focus on components 1 and 2, where the artefacts are most strongly associated with the bison assemblage.

In addition to 36 pieces of debitage, components 1 and 2 contain 15 further modified artifacts, including a projectile point. Eight are large quartzite tools, with weights ranging from 300 to 2,400 grams (see Driver *et al.* 1996 and Handly 1993 for illustrations). In spite of the variety in weight, there is uniformity in maximum dimensions, with seven specimens between 13 and 17 cm in length, and the largest 21 cm. Technologically, these range from barely retouched cobbles to a symmetrical biface and a uniface. Remarkably, there is no quartzite debitage from the components, although there is plenty of chert debitage. Therefore these tools were produced elsewhere, brought to the site, used and then discarded without resharpening.

ELEMENT FREQUENCIES AND BONE DENSITY

Element frequencies are presented in Table 1. Each specimen is represented by a simple code, signifying what portion of the element was represented, and specimens are assigned a side where appropriate. Minimum number of ele-ments (MNE) calculations were based on visual examination of the entire collection, and in some cases are not clearly deducible from the number of identified specimens (NISP) data in Table 1. For example, the six thoracic fragments are all conjoinable, and were reconstructed as a single neural spine. One humerus shaft fragment overlapped with the same anatomical area on three distal humeri, and therefore an MNE of four was calculated. An ulna shaft fragment was fused to a radius shaft fragment (with the specimen recorded as a radius), creating a third MNE for ulna, even though only two fragments are recorded. This analysis resulted in somewhat higher MNE values for some long bones than would be deduced simply from the NISP data alone. Carpal and tarsal MNE values are presented as the minimum number of sets, rather than as MNE values for each individual carpal or tarsal.

Table 1 shows that the CLC assemblage is not a random sample of skeletal elements. Certain areas of the body are underrepresented (e.g., ribs and vertebrae), while limb elements are better represented. One of the most robust conclusions of taphonomic studies in zooarchaeology is that differential destruction of skeletal elements of large mammals can be caused by a range of agents, but that patterns of element loss and survival are highly correlated with bone density (e.g., Binford 1981; Brain 1981; Lyman 1994). While early studies used qualitative assessments, later studies have become increasingly sophisticated in measuring density values (Lam *et al.* 2003; Lyman 1994). Whenever skeletal element frequencies deviate from those expected in a complete skeleton, an obvious first approach is to see whether there is a correlation between bone density and the elements represented in an

assemblage. This is not a straightforward process. First, many published bone density values incorporate methodological problems (Lam *et al.* 2003; Lam and Pearson 2004). Second, there is a general correlation between bone density and the meat value of many parts of the mammalian body, such that low density bones tend to be from areas of the body with high meat values (Grayson 1989; Lyman 1985). Human behavior, such as removal of high meat value bones from a kill site, may therefore be confused with natural taphonomic processes, such as carnivores destroying low density elements. Third, bone density and strength values differ for the same element when mature and immature specimens are considered. In spite of these problems, it is important to establish whether or not patterns of element frequency are linked to, or independent of, bone density and morphology.

Both natural and cultural processes can affect element frequencies. One way to distinguish human decisions about bone transport from density-mediated destruction of bone is to measure the relative frequency of proximal and distal portions of limb bones, using skeletal elements where proximal and distal ends have different densities (Binford 1981). Assuming that people are likely to transport complete skeletal elements, divergent representation of proximal and distal ends should indicate that natural bone destruction played a role in structuring the assemblage. At CLC the humerus, radius and tibia can be assessed in this way. The ratio of denser to less dense ends is as follows. Distal to proximal humerus: 2:1. Proximal to distal radius: 1:1. Distal to proximal tibia: 2:1. Clearly there is some preferential destruction of less dense long bone ends, probably by carnivores (see below). However, the survival of some immature

specimens and some of the most desirable bones for carnivore consumption suggests that intensive ravaging of the assemblage did not occur. The ratio of long bone shaft fragments to epiphyses is about 1:1, and one would expect higher ratios in assemblages that were intensively processed by carnivores (Blumenschine and Marean 1993).

Table 1 shows that the CLC bison assemblage is over-represented in elements from the limbs, but equally dense or denser elements from other areas of the skeleton are either missing or present in insignificant quantities. For example, teeth, parts of the cranium, mandible, some vertebrae, the scapula and the innominate exhibit densities at least as great as those in some limb bones (Kreutzer 1992), but the axial skeleton is underrepresented at CLC. Generally, element frequency data show that density-mediated taphonomic processes, such as weathering or carnivore activity are unlikely to be the causes of overall skeletal element representation. If only high density and low meat value elements were surviving we would surely expect to see more teeth and petrous bones, as well as parts of the axial skeleton with densities comparable to limb bones.

Another way of examining the role of bone density is to plot frequency of skeletal elements against bone density. If there is a positive correlation between bone density and relative frequency of elements, we would suspect that one or more density-mediated processes had shaped the assemblage. Figure 3 plots the minimum number of animal units (MAU) values of selected areas of the limb bones against their density (Kreutzer 1992). Values are presented in Table 2. Elements of the axial skeleton are not shown, because all would cluster on the extreme left hand side
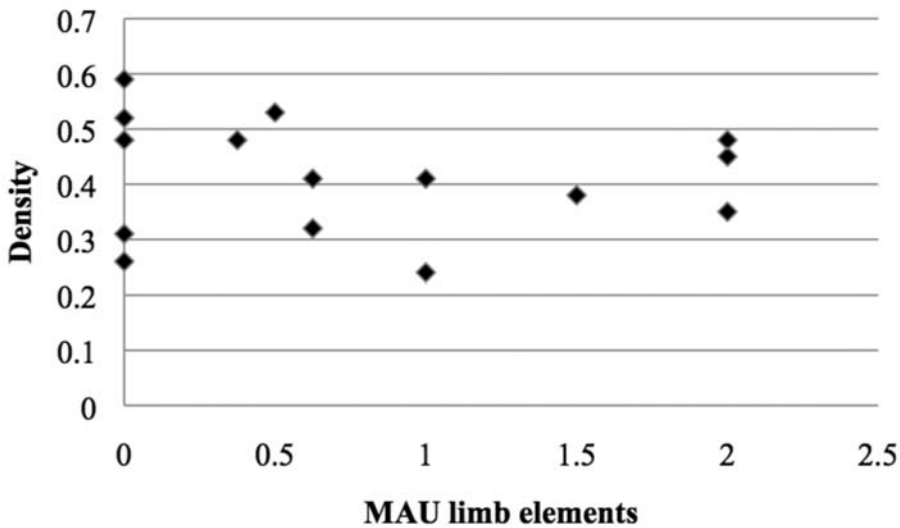
FIGURE 3. MAU values for selected areas of bison limb bones at Charlie Lake Cave plotted against bone density values for the same locations on modern bison limb bones.

TABLE 2. MAU values and bone density (Kreutzer 1992) for selected areas of bison limb bones at Charlie Lake Cave.

Element	MAU	Density
P Hum	1	0.24
D Hum	1.5	0.38
P Rad	2	0.48
D Rad	2	0.35
D MC	0.5	0.53
P Tib	1	0.41
D Tib	2	0.45
P 1phal	0.375	0.48
P 2phal	0.625	0.41
P 3phal	0.625	0.32
P MC	0	0.59
P MT	0	0.52
D MT	0	0.48
P Fem	0	0.31
D Fem	0	0.26

of the plot, due to MAU values close to zero. Figure 3 clearly shows that there is no relationship between frequency of a skeletal element and its density. So even if only limb elements were transported to the site, the assemblage has not been altered significantly after deposition by density-mediated processes.

Most of the CLC bison specimens are very well preserved, with no evidence for transportation by water, and little evidence of differential weathering to suggest lengthy exposure on the ground surface. Surfaces are well enough preserved to display cutmarks. The primary natural taphonomic process represented is carnivore chewing but this did not result in wholesale removal of lower density long bone ends. The survival of long bone ends that are attractive to carnivores (e.g., the proximal tibia) suggests that carnivore damage has not been so severe as to account for the almost completely absent axial skeleton. In addition

there is only a single example of a long bone where both epiphyses have been removed, leaving a diaphysis with two chewed ends, a classic indicator of carnivore activity (Binford 1981).

Carnivore damage was assessed for 78 specimens (the reduced number being due to refitting and to removal of small cranial fragments from the analysis). Damage was coded as 0 (no damage), 1 (carnivore activity, but no destruction of anatomical features), 2 (destruction of at least one feature, such as an articular end), and 3 (heavy damage). Of the 78 specimens, 21 showed no damage, 27 were in class 1, 14 were in class 2, and ten were in class 3. Six could not be analyzed due to weathering.

In summary, although carnivore damage was the most obvious taphonomic process, it does not seem to have been sufficient to produce obvious patterns in the preservation of limb bones, and therefore cannot be the reason for the almost complete absence of the axial skeleton. The latter point is further supported by the fact that some dense areas of the axial skeleton are almost completely absent, whereas more vulnerable areas of the limbs (e.g., proximal tibia) survive.

HYPOTHESES FOR ASSEMBLAGE COMPOSITION

If density-dependent attritional processes did not shape the skeletal element frequencies, cultural processes may be responsible. An explanation involving cultural behaviour must account for a number of features of the assemblage. First, when compared with the utility data derived for bison by Emerson (1990), the MNE and MAU values from CLC show that high utility elements such as ribs and thoracic vertebrae are rare. Second, there is a strong presence of mid-utility elements (including leg elements such as tibia, ulna/radius and humerus), and variable representation of low-utility elements. Low-utility areas of the axial and cranial regions are poorly represented, but low utility parts of the limbs (e.g., phalanges) are well represented. Third, both people and carnivores left evidence of their interaction with the bison specimens. Fourth, some specimens were deposited as articulated elements. Fifth, some specimens were broken into pieces that can be refitted.

The first hypothesis is that CLC is a primary kill site. This might be supported by the articulated specimens, the lack of burning on bones, and the small lithic assemblage with little evidence for artifact production or maintenance. To account for the lack of some elements and the bone damage, we would have to postulate removal of some body parts by people, and subsequent carnivore scavenging. This hypothesis cannot account for a number of features of the site. Unlike many kills, there are no partially or fully articulated skeletons. There is also a lack of heavy crania that are typically left at kill sites. The stone tool assemblage includes only one projectile point. We conclude that there is no good evidence that CLC represents the location of a mass kill or of a series of individual kills.

It therefore seems more likely that this assemblage consists of specimens that were brought from a kill site to CLC and then deposited. Given the presence of lithic artifacts in the deposits, and cutmarks and percussion points on the bison specimens, we assume initial transportation by people.

The second hypothesis is that the assemblage was deposited at either a residential site or a butchering and processing site located near a kill site. It seems unlikely that these specimens

were transported to CLC because they were associated with large quantities of meat. Selection for mid and lower limbs would not be an effective way of maximizing the meat that could be transported. An assemblage dominated by long bones might have been accumulated because of the marrow content of diaphyses or grease content of long bone ends, as proposed by Hill *et al.* (2008) for the Clary Ranch site in Nebraska, and as modeled by Emerson (1993). However, this does not explain five features of the CLC assemblage: (a) the absence of the femur; (b) the relatively low frequencies of metapodials that contain high quality marrow; (c) the presence of some long bones that have not been broken open to obtain marrow; (d) the absence of any evidence for processing of epiphyses to obtain within-bone grease, and (e) the lack of long bone shaft fragments. Furthermore, there is no evidence for hearths, there is no charcoal in the sediments, none of the specimens is burnt, and there is little evidence for lithic artefact production, all of which we might expect in a location where residential and processing activities occurred.

A third hypothesis is that the gully lay downhill from a residential camp or butchery/processing area on the hillside above the gully, and that these faunal and lithic specimens are simply discarded material that either has been thrown into the gully or moved downslope. However, many of the same concerns apply, and the lack of weathering on the faunal specimens makes it unlikely that slow downslope movement brought them to the gully.

A fourth hypothesis, and the one that we favour, is that the bison limbs were cached at the site. There has been less discussion in the literature about the characteristics of meat caches, although

this possibility has been noted as a potential Palaeoindian strategy (Frison 1998). We suggest that the CLC bison assemblage consists of the remains of a succession of meat caches, some utilized (hence the bone breakage) and others abandoned (hence the complete specimens). Unfortunately, we have relatively little ethnographic data on the content of meat caches from the northern Plains and Rocky Mountains. Friesen (2001) documents caribou storage in the Canadian Arctic dominated by cranial and axial elements. These specimens were likely dried before being cached, and Friesen notes that axial elements are more likely to be preserved during storage of dried meat, due to higher surface area:volume ratios for the meat. Driver (1990) showed that long-distance transport of (probably dried) bison meat in New Mexico was represented almost exclusively by axial elements.

The most direct evidence for frozen caches of bison comes from caves in Idaho (Henrickson 2003). Spanning periods from about 8000 to 1000 BP, disarticulated bison bones were stored in brush-lined features within the frozen caves. Some caches seem to have been left intact, while others were recovered and the bones scattered during butchery. The MNE values from these sites are compared to MNE data from CLC in Table 3.

CLC and the Idaho assemblages share some characteristics, such as low values for vertebrae and high values for fore and hind limbs. The main difference between the two assemblages is that CLC has more elements from the feet, whereas the Idaho sites have better representation of ribs. Henrickson (personal communication 2005) reports that the values for ribs in her samples are based on number of fragments, and are

not MNE calculations, so the difference between the two assemblages may not be as great as the data suggest. However, even when measured by number of fragments, CLC contains few ribs and significantly more phalanges in relation to other limb elements, so there are still differences between the Idaho and CLC assemblages.

The hypothesis that the CLC assemblage results from meat caches is supported by other evidence. As noted previously, certain characteristics of a residential site are missing from the archaeological record. There is no evidence for hearths, none of the Palaeoindian faunal specimens are burnt, and there is no charcoal in the Palaeoindian layers. We suggest that this is consistent with the cache hypothesis. We also propose that the large quartzite tools were either cached with the meat for future use, or were brought to the site in anticipation of making use of the cached supplies. This would explain the absence of quartzite debitage. Henrikson (2003) documents a somewhat different recovery strategy for the Idaho ice caves, with antler picks and stone hammers being used to break open the ice over the cached meat. (But note that these tools were discarded beside the cache, as we are also hypothesizing for CLC). If CLC was the site of a cache, it is unlikely that the meat would have been covered with ice, because the cave is small and dry; we suspect that the large tools may have been used to disarticulate frozen limbs.

In summary, we believe that Palaeoindians used CLC as a meat cache. There are a number of other considerations that support this interpretation. The gully itself would not be an attractive habitation site. With a steeply sloping floor and narrow walls it would have been inconvenient and cold without the use of fire (for which we have no evidence). On the other hand, the cave would have been an excellent place to store meat. Even today it is very dry with a shallow layer of dusty sediment that preserves plant material and other organics. At the end of the Pleistocene the entrance to the cave was in a vertical sandstone face at least two meters above the floor of the gully and thus would have been difficult for scavengers to access. The differential treatment of long bones might reflect two different outcomes of caching. In some cases hunters returned to the cache, butchered limbs and broke the bones to obtain marrow. This resulted in scattered fragments of elements. In other cases the cache was not used; when the cave was visited to create a new cache, the complete elements of the previous cache were dumped into the gully, and preserved as unmodified specimens.

TABLE 3. Comparison of MNE of Idaho ice cave bison and CLC bison.

Element	Idaho	CLC
Cranium	1	1
Mandible	2	0
Vertebrae	3	3
Scapula	4	1
Rib	23	3
Innominate	1	2
Humerus	3	4
Radius	5	5
Ulna	5	3
Femur	4	0
Tibia	8	6
Metapodial	2	4
Carpal	0	3 (sets)
Tarsal	1	3 (sets)
Phalanx	1	18

CACHES, SUBSISTENCE AND PALAEOENVIRONMENTS

One of the problems of late Pleistocene archaeology is understanding the nature of environments in which hunter-gatherer groups operated. It has been suggested that late Pleistocene environments south of the ice sheets do not have direct analogues in late Holocene North America, because they were patchier and "mosaic"-like (e.g., FAUNMAP 1996; Graham 1976; Lundelius *et al.* 1983; Stafford *et al.* 1999). For this reason, Burke (2004) argues that hunter-gatherer settlement systems modeled from modern arctic and subarctic hunter-gatherers cannot be applied directly to situations in late Pleistocene mid-latitude locations.

The immediate post-glacial environment in the Peace River region is difficult to reconstruct based on available evidence, because there have been relatively few palynological sequences and faunal assemblages reported. However, based on what evidence is available, we would argue for an environment that was broadly zoned, with low species diversity and little evidence for a mosaic of habitats.

The few palynological sequences that have been published do not provide much evidence for habitat diversity. Immediate post-glacial landscapes may have been frozen and almost certainly lacked soil, so initial plant colonizers must have been those capable of surviving on poor soils. Furthermore, until nitrogen-fixing plants were established, soils would have remained poor (Pielou 1991: 89–90). Pollen diagrams have been published from regions to the north, east and south of CLC. Pre-10,000 BP pollen from Lone Fox Lake (east and slightly north of CLC) is dominated by birch, aspen, willow, sagebrush, cheno-ams, grasses and sedges. A very similar set of plants was also found at the nearby Yesterday Lake, and also at Snowshoe Lake, another 100 km north (MacDonald 1987). Further south, at Boone Lake a detailed postglacial pollen sequence has been recorded (White and Mathewes 1986). Beginning as early as 11,700 BP with an assemblage of aspen, willow, sagebrush, grasses and sedges, the local vegetation saw the addition of alder and birch by 11,200 BP. However, shortly before 11,000 BP coniferous pollen became dominant, suggesting that spruce forests were advancing from the south by this period. Faunal data from CLC (Driver 1988, 2001) and the pollen data from lakes to the east and north of CLC suggest that spruce forests did not reach the Peace River valley and regions to the north until about 10,000 BP.

MacDonald and McLeod (1996) suggest that the late Pleistocene vegetation of the "western corridor" east of the Rockies was similar over much of its length. However, they also caution that most pollen has been identified to genus level or higher, and therefore this apparent homogeneity may mask greater species (and hence habitat) diversity. Beaudoin and Oetelaar (2003) suggest that an open, shrubby landscape characterized the foothills region of the Rocky Mountains, with grassland further east.

Although a variety of mammalian species have been recovered from Late Pleistocene deposits (mainly gravel pits) in the Peace River region (Churcher and Wilson 1979), it is not clear how many of these would date to the same period as CLC. However, the earliest dated bison from the region fall within the same range of dates as CLC (e.g., Apland and Harington 1994; Wilson 1996), and there are no other large mammals from the region that have been directly radiocarbon dated to this period. This

suggests a regional fauna impoverished in large mammal species, in contrast to the greater variety of large mammals from slightly earlier deposits in southern Alberta (Beaudoin and Oetelaar 2003; McNeil *et al.* 2004; Wilson 1996). The Peace River region fauna may have been impoverished for two reasons. First, early communities would be composed of animal species capable of migrating into the area and capable of surviving on a relatively low diversity vegetative community dominated by grasses, herbs and shrubs. Second, the potential pool of large mammals (both to the north and the south) was depleted of species by Late Pleistocene extinctions that mainly pre-date 10,500 BP. Thus, even if the Peace River post-glacial environments had been suitable for species such as horse or mammoth, those taxa were already extinct by the time the Peace River region became habitable.

Bird and mammal remains from Charlie Lake Cave are consistent with the pollen data (Driver 2001). An open landscape occurred from about 10,500 to 10,000 BP, at which time forest species make their appearance, and then dominate the assemblage by 9500 BP. Given both local and regional evidence for an open, low diversity landscape, we should examine the potential role for meat caches in such an environment.

In hunter-gatherer societies food storage is important for three reasons connected to subsistence. First, stored food allows people to get through periods when food is unavailable. These periods may be predictable, especially in environments with highly seasonal climate and resource availability, or they may be random, caused by unpredictable events, such as unexpected weather conditions. For Palaeoindians moving into uninhabited (and therefore unknown) landscapes,

storage would also provide security from shortages caused by lack of knowledge. Meltzer (2002) suggests that the relatively common occurrence of early Palaeoindian lithic caches is explained by the need of mobile foragers to have a secure supply of raw material as they explore landscapes about which they have insufficient knowledge. Second, storage allows individuals and groups to take advantage of seasonal peaks in resource abundance. If more food is obtained than can be used immediately, storage allows the benefit of that food to be spread over a longer period of time. Third, storage may facilitate sharing (Waguespack 2002), providing a social mechanism for food redistribution in times of shortage.

On the northwestern Plains, the development of a sophisticated system for preparing and storing bison products is documented in mid- to late-Holocene times mainly by the presence of fire-cracked rock and boiling pits associated with the rendering of grease for the production of pemmican (Reeves 1990). Although there is no evidence for pemmican production in Palaeoindian sites, some archaeologists have suggested that frozen meat caches might have been used to store meat acquired during late fall or early winter kills, when animals would have been in good condition and meat could be kept cold (Frison 1998). Frozen caches are a rather special form of storage, because, unlike dried meat or pemmican, they are not transportable and the storage system fails once the weather changes. For the cache to be used effectively, the hunter must remain within a reasonable distance of the cache, so that retrieving meat and fat does not impose too great an energy burden.

Storage of food for subsistence purposes is likely to occur when there is seasonal variation in the availability of

one species, and a lack of alternative resources. The Peace River environment in early post-glacial times probably met these conditions. Excavations at CLC show that bison was the only large ungulate hunted. Although negative evidence must be treated cautiously, no other large herbivores seem to have been present in the region at this period. Fish were another important staple of the boreal forest diet of First Nations peoples in more recent times, and are present at Charlie Lake quite early, but do not appear in any quantity at the site until the mid-Holocene. There were good reasons for caching bison meat. Predators that subsist on single species are vulnerable to random fluctuations in prey abundance. Most large mammal prey species will exhibit such fluctuations, and this means that successful predators (including humans) are likely to experience times of abundance and scarcity. In an environment with relatively few alternate resources, storage would be an important strategy to reduce the likelihood of starvation. The other strategy would be mobility as argued by Kelly and Todd (1988). At present we have insufficient data to evaluate northern Palaeoindian mobility in any detail, although the lack of exotic lithics at CLC argues against lengthy annual rounds. Furthermore, there is in any case no reason to assume that mobility and storage strategies must be exclusive of each other.

CONCLUSIONS

Although there seems to be little doubt that bison hunting was the primary subsistence focus of later Palaeoindians in the northern and western plains of North America, there is variation in how bison were killed and processed (e.g., Hill *et al.* 2008), as well as variation in the composition of faunal assemblages over this large area (e.g., Hill 2008; Kornfeld and Larson 2008). The bison assemblage from CLC is smaller than most, but it is distinctive due to the dominance of fairly lightly butchered bones of the mid and lower limbs. We believe that these specimens were transported from a kill location, because of the absence of cranial and axial bones. However, they do not seem to be the residue of a processing site or a habitation site, due to the lack of many features that we might expect to find, including evidence of fire, production and maintenance of stone tools, and more intensive fragmentation of limb bones. We suggest that middle and lower legs were selected for cold storage in order to preserve meat and fat (marrow) for future use, and that the CLC assemblage reflects a mix of processed and unprocessed items from a series of storage events in the dry, inaccessible cave.

REFERENCES CITED

Apland, B., and C. R. Harington
  1994 Pleistocene Bison Skeleton (*Bison bison* cf. *occidentalis*) from Clayhurst Crossing, British Columbia. *Géographie Physique et Quaternaire* 48: 213–223.

Arnold, T. G.
  2002 Radiocarbon Dates from the Ice-Free Corridor. *Radiocarbon* 44: 437–454.

Bailey, G.
2007 Time Perspectives, Palimpsests and the Archaeology of Time. *Journal of Anthropological Archaeology* 26: 198–223.

Beaudoin, A. B., and G. A. Oetelaar
2003 The Changing Ecophysical Landscape of Southern Alberta During the Late Pleistocene and Early Holocene. *Plains Anthropologist* 48: 187–207.

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

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. M. Hudson, pp. 273–300. Occasional Paper No. 21. Center for Archaeological Investigations, Southern Illinois University at Carbondale, Carbondale.

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

Burke, A. M.
2004 Alternative Models of Spatial Organization for Pleistocene Hunter-Gatherers. In *Hunters and Gatherers in Theory and Archaeology*, edited by G. M. Crothers, pp. 192–210. Occasional Paper No. 31. Center for Archaeological Investigations, Southern Illinois University at Carbondale, Carbondale.

Catto, N., D. G. E. Liverman, P. T. Bobrowsky, and N. Rutter
1996 Laurentide, Cordilleran, and Montane Glaciation in the Western Peace River-Grande Prairie Region, Alberta and British Columbia, Canada. *Quaternary International* 32: 21–32.

Churcher, C. S., and M. Wilson
1979 Quaternary Mammals from the Eastern Peace River District, Alberta. *Journal of Paleontology* 53: 71–76.

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.

1990 Bison Assemblages from the Sierra Blanca Region, Southeastern New Mexico. *Kiva* 55: 245–263.

1992 Identification, Classification and Zooarchaeology. *Circaea* 9: 35–47.

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

1998b Late Pleistocene Collared Lemming (*Dicrostonyx torquatus*) from Northeastern British Columbia. *Journal of Vertebrate Paleontology* 18: 816–818.

1999a Stratified Faunas from Charlie Lake Cave and the Peopling of the Western Interior of Canada. In *Zooarchaeology of the Pleistocene/Holcene Boundary*, edited by J. C. Driver, pp. 77–83. BAR International Series 800. British Archaeological Reports, Oxford.

1999b Raven Skeletons from Paleoindian Contexts, Charlie Lake Cave, British Columbia. *American Antiquity* 64: 289–298.

2001 Paleoecological and Archaeological Implications of the Charlie Lake Cave Fauna, British Columbia. 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. British Archaeological Reports, Oxford.

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: 265–277.

Emerson, A. M.
1990 Archaeological Implications of Variability in the Economic Anatomy of Bison bison. Unpublished Ph.D. dissertation, Department of Anthropology, Washington State University, Pullman.

1993 The Role of Body Part Utility in Small-Scale Hunting Under Two Strategies of Carcass Recovery. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. M. Hudson, pp. 138–155. Occasional Paper 21. Center for Archaeological Investigations, Southern Illinois University at Carbondale, Carbondale.

FAUNMAP Working Group
1996 Spatial Response of Mammals to Late Quaternary Environmental Fluctuations. *Science* 272: 1601–1606.

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. University of British Columbia 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: 371–384.

Friesen, T. M.
2001 A Zooarchaeological Signature for Meat Storage: Re-thinking the Drying Utility Index. *American Antiquity* 66: 315–331.

Frison, G. C.
1998 Paleoindian Large Mammal Hunters on the Plains of North America. *Proceedings of the National Academy of Sciences* 95: 14576–14583.

Geertsma, M., and A. J. T. Jull
2002 Charcoal and Sedimentation Record from a Fan at Bear Flat, Northeastern British Columbia. Abstract 143–3, Annual Meeting, Geological Society of America, Denver.

Graham, R. W.
1976 Late Wisconsin Mammalian Faunas and Environmental Gradients of the Eastern United States. *Paleobiology* 2: 343–350.

Grayson, D. K.
1989 Bone Transport, Bone Destruction, and Reverse Utility Curves. *Journal of Archaeological Science* 16: 643–652.

Handly, M.
1993 Lithic Assemblage Variability at Charlie Lake Cave (HbRf 39): A Stratified Rockshelter in Northeastern British Columbia. Unpublished Master's thesis, Department of Anthropology, Trent University, Trent.

Hartman, G.
2005 Quaternary Stratigraphy and Geologic History of the Charlie Lake (NTS 94A) Map-Area, British Columbia. Unpublished Master's thesis, Department of Earth Sciences, Simon Fraser University, Burnaby, British Columbia.

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: 263–285.

Hill, M. E. Jr.
2008 Variation in Paleoindian Fauna Use on the Great Plains and Rocky Mountains of North America. *Quaternary International* 191(1): 34–52.

Hill, M. G., D. W. May, D. J. Rapson, A. R. Boehm, and E. Otárola-Castillo
2008 Faunal Exploitation by Early Holocene Hunter/Gatherers on the Great Plains of North America: Evidence from the Clary Ranch Sites. *Quaternary International* 191(1): 115–130.

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

Kornfeld, M., and M. L. Larson
2008 Bonebeds and Other Myths: Paleoindian to Archaic Transition on North American Great Plains and Rocky Mountains. *Quaternary International* 191(1): 18-33.

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.

Lam, Y. M. and O. M. Pearson
2004 The Fallibility of Bone Density Values and Their Use in Archaeological Analyses. *Journal of Taphonomy* 2: 99–112.

Lam, Y. M., O. M. Pearson, C. W. Marean, and X. Chen
2003 Bone Density Studies in Zooarchaeology. *Journal of Archaeological Science* 30:1701–1708.

Lundelius, E. L. Jr., R. W. Graham, E. Anderson, J. Guilday, J. A. Holman, D. W. Steadman, and S. D. Webb
1983 Terrestrial Vertebrate Faunas. In *Late Quaternary Environments of the United States, Volume 1, The Late Pleistocene*, edited by S. C. Porter, pp. 311–353. University of Minnesota Press, Minneapolis.

Lyman, R. L.
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.

2003 The Influence of Time Averaging and Space Averaging on the Application of Foraging Theory in Zooarchaeology. *Journal of Archaeological Science* 30: 595–610.

MacDonald, G. M.
1987 Postglacial Development of the Subalpine-Boreal Transition Forest of Western Canada. *Journal of Ecology* 75: 303–320.

MacDonald, G. M., R. P. Beukens, and W. E. Kieser
1991 Radiocarbon Dating of Limnic Sediments: A Comparative Discussion and Analysis. *Ecology* 72: 1150–1155.

MacDonald, G. M., R. P. Beukens, W. E. Kieser, and D. H. Vitt
1987 Comparative Radiocarbon Dating of Terrestrial Plant Macrofossils and Aquatic Moss from the "Ice-Free Corridor" of Western Canada. *Geology* 15: 837–840.

MacDonald, G. M., and T. K. McLeod
1996 The Holocene Closing of the 'Ice-Free' Corridor: A Biogeographi-

cal Perspective. *Quaternary International* 32: 87–95.

McNeil, P., L. V. Hills, B. Kooyman, and M. S. Tolman
2004 Late Pleistocene Geology and Fauna of the Wally's Beach Site (DhPg–8) Alberta, Canada. In *Archaeology on the Edge: New Perspectives from the Northern Plains*, edited by B. Kooyman and J. Kelley, pp. 79–94. University of Calgary Press, Calgary.

Meltzer, D. J.
2002 What Do You Do When No One's Been There Before? Thoughts on the Exploration and Colonization of New Lands. In *The First Americans: The Pleistocene Colonization of the New World*, edited by N. G. Jablonski, pp. 27–58. Memoirs No. 27, California Academy of Sciences, San Francisco.

Pielou, E. C.
1991 *After the Ice Age: The Return of Life to Glaciated North America*. University of Chicago Press, Chicago.

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., A.J. Drummond, A. Rambaut, M. C. Wilson, P. E. Matheus, A. V. Sher, O. G. Pybus, M. T. P. Gilbert, I. Barnes, J. Binladen, E. Willerslev, A.J. Hansen, G. F. Baryshnikov, J.A. Burns, S. Davydov, J.C. Driver, D. G. Froese, C. R. Harington, G. Keddie, P. Kosintsev, M. L. Kunz, L. D. Martin, R. O. Stephenson, J. Storer, R. Tedford, S. Zimov, and A. Cooper
2004 Rise and Fall of the Beringian Steppe Bison. *Science* 306: 1561–1565.

Stafford, T. W. Jr., H. A. Semken, R. W. Graham, W. F. Klippel, A. Markova, N. G. Smirnov, and J. Southon.
1999 First Accelerator Mass Spectrometry ^{14}C Dates Documenting Contemporaneity of Nonanalog Species in Late Pleistocene Mammal Communities. *Geology* 27: 903–906.

Strong, W. L., and L. V. Hills
2005 Late-glacial and Holocene Palaeovegetation Zonal Reconstruction for Central and North-Central North America. *Journal of Biogeography* 32: 1043–1062.

Vallières, C.
2004 The Paleoindian Bison Assemblage from Charlie Lake Cave. Unpublished Master's thesis, Department of Archaeology, Simon Fraser University, Burnaby, British Columbia.

Waguespack, N. M.
2002 Caribou Sharing and Storage: Refitting the Palangana Site. *Journal of Anthropological Archaeology* 21: 396–417.

White, J. M., and R. W. Mathewes
1986 Postglacial Vegetation and Climatic Change in the Upper Peace River District, Alberta. *Canadian Journal of Botany* 64: 2305–2318.

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