LE BISON : GIBIER ET MOYEN DE SUBSISTANCE DES HOMMES
DU PALÉOLITHIQUE AUX PALÉOINDIENS DES GRANDES PLAINES
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Linking trajectories of intra-site faunal use with food management strategies at the Bugas-Holding site :

attribute-based spatial analysis of a high altitude winter habitation, Wyoming, USA

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RÉSUMÉ

Bien que les recherches archéologiques dans les Grandes Plaines du Nord-Ouest aient en permanence identifié le bison comme étant le gros gibier préférentiellement exploité par les populations préhistoriques en quête de ravitaillement, cette simple observation est trop souvent devenue l'évidence a priori d'une stratégie de subsistance qui aurait été pratiquée par les habitants de ces régions entre les périodes paléoindiennes et protohistoriques. À Bugas Holding, habitation de la Préhistoire récente (500 ± 100 BP) située sur la bordure occidentale des Plaines, la présence d'un nombre approximativement équivalent de bisons (NMI = 15) et de mouflons (NMI = 14), chacun contextuellement associé à une occupation hivernale de quatre à cinq mois, offre l'occasion d'évaluer les rôles joués par chacun de ces taxons dans la stratégie d'acquisition globale de nourriture élaborée par les occupants des sites. Un programme d'analyse spatiale fondée sur les attributs est utilisé pour estimer les facteurs de décision concernant l'acquisition et le traitement des proies selon les caractéristiques d'éthologie, de taille, de sexe et d'anatomie économique, ainsi que les tactiques de chasse, les techniques de traitement, les choix de transports, les modes de conservation et de consommation. L'approche analytique ici mise au point est applicable aux matériels archéologiques de toutes régions et toutes époques.

ABSTRACT

Although archaeological research on the northwestern Great Plains has consistently identified bison as the predominant big game species exploited by prehistoric forager populations, this simple observation has too often become a priori evidence for the inferred subsistence strategy practiced by the regions' inhabitants from Paleoindian through Protohistoric periods. At the Bugas-Holding site, a Late Prehistoric (500 ± 100 BP) habitation located along the western edge of the Plains, the presence of approximately equal numbers of bison (MNI = 15) and bighorn sheep (MNI = 14), each contextually associated with a four- to five -month

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winter occupation, offers an opportunity to evaluate the roles played by each of these taxa in the overall food management strategy of the sites' occupants. A program of attribute-based spatial analysis is employed to assess decision making on procurement and processing of prey according to characteristics of ethology, body size, sex, and economic anatomy, as well as hunting tactics, processing techniques, transport choices, and modes of storage and consumption. The analytic approach developed here is applicable to archaeological materials from all regions and time periods.

Introduction

This paper addresses the interplay between recently developed theoretical models of faunal use at individual archaeological localities and the development of regional models of prehistoric hunter-gatherer subsistence and settlement in high altitude settings along the northwestern margins of the North-American Great Plains. The goal is to demonstrate that attribute-based faunal analysis, in combination with principals of site structure and other analytic techniques, can provide a series of powerful inferential tools, not only for investigating site function, but also for linking subsistence-related patterning to inferred strategies of short-term mobility. This study also provides insights on aspects of game procurement, hunting tactics, transport choices, storage practices, and processing techniques.

Modeling resource structure in the northern Rocky Mountains

The Bugas-Holding site is located within overbank alluvial deposits of Sunlight Creek, in the Sunlight Basin of northwestern Wyoming (Rapson, 1990). Elevations range from 2 050 m on the valley floor to more than 3 700 at the summit of the surrounding peaks (fig. 1 and 2). The site is located in a steeply profiled valley, an area of rugged topography in the Rocky Mountains, immediately adjacent to the Great Plains physiographic province (Fenneman, 1931). Despite its location, the structure of the faunal resource base here is distinctly unlike that found on the Plains proper. Owing primarily to the marginal and discontinuous nature of big game habitat in this area, faunal carrying capacity is limited. As a result, the primary big game species throughout the prehistoric period (bison, deer, and bighorn sheep) would have occurred in limited numbers, and as spatially dispersed resource patches lacking the long-range migratory behavior often associated with bison in the grassland biome (Frison, 1978).

For pedestrian hunter-gatherers in this area, severe winter weather and significant snow accumulation make winter residential mobility extremely costly. As a result, based on current knowledge, we might expect an emphasis during the late fall and early winter on behaviors that seek to increase the relative degree of aggregation (or

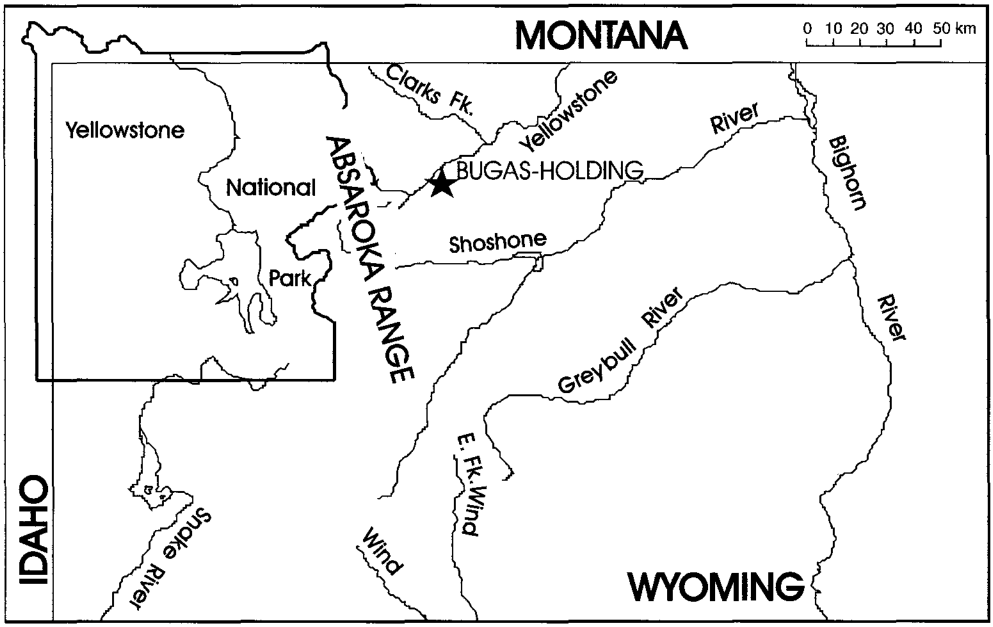


Fig. 1. Regional setting of the Bugas-Holding site (48PA563) in northwestern Wyoming.

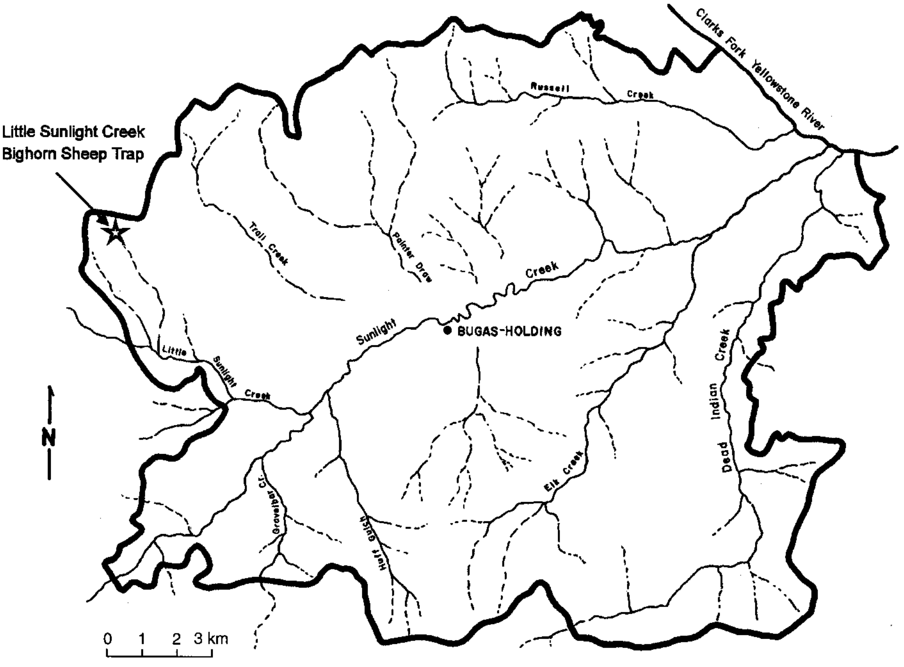


Fig. 2. Map of the Sunlight Basin showing the location of the Bugas-Holding site and the Little Sunlight Creek sheep trap (adapted from Hyde and Beetle, 1964, fig. 2).

time utility [Binford, 1978b, p. 91]) of spatially dispersed resources for long-term food stores (Binford, 1980 ; Kelly, 1983).

Until quite recently, the Sunlight Basin provided sheltered winter range for both bison (Meagher, 1973) and bighorn sheep (Honess and Frost, 1942). Although bison might intuitively seem to be the first-choice resource target for providing the necessary food for long-term storage, this was not always the case during the Late Prehistoric period. In order to investigate the causal factors involved, it is necessary to consider differences in the aggregation, predictability, and storage potential of these two species, all of which have important implications for the organization of Late Prehistoric hunting strategies.

Based on behavioral observations by McHugh (1958) and Meagher (1973) in nearby Yellowstone National Park, bison group sizes in these montane areas were usually small. Although subject to some variation (McHugh, 1958 ; Roe, 1972), bison behavior during the late fall in mountain valley settings would probably not have included large group aggregations on a regular or highly predictable basis. As a result, reliance on mass bison kills during the late fall to provide food for long-term storage would have been a relatively high-risk strategy.

Unlike subsequent Protohistoric adaptations (Frison, 1978), which included the use of horses to transport meat to sheltered valley locations (Ewers, 1955), an adaptation based on transport of bison killed on the Plains would present significant logistical problems for Late Prehistoric occupants of the Sunlight Basin. Encounter hunting of dispersed bison throughout the winter, however, would offer a potentially significant food source owing to their large average body size, and the relative ease of tracking in deep snow conditions (McHugh, 1958). Meagher (1973, p. 84) notes that mature males are somewhat more sedentary during mid-winter than female groups, often spending entire winters in one location. This behavior, combined with the higher average fat content of males during this period (Speth, 1983), makes male bison somewhat more predictable than, as well as nutritionally superior to, female bison at this time of year.

Bighorn sheep, on the other hand, represent a potentially aggregated and highly predictable resource in this environment during the late fall. Behavioral studies (Blood, 1963 ; Geist, 1971 ; Honess, Frost, 1942) indicate that, with the advent of continuous snow cover at higher elevations during the early fall (late September to late October), bighorn sheep move down from their high-elevation summer range and congregate in large bands for up to 5 weeks before the rut, which occurs from late November to late December in the Absaroka Mountains (Mills, 1937 ; Oldemeyer, 1966 ; Thorne *et al.*, 1979). During this pre-rut aggregation, band sizes may reach 45 to 65 individuals (Geist, 1971 ; Honess, Frost, 1942 ; Mills, 1937 ; Thorne *et al.*, 1979). This behavior, which is closely related to the advent of winter snow accumulations at higher elevations, results in both large average group sizes and the most highly predictable migratory behavior of the year (Geist, 1971).

Frison *et al.* (1989) have documented the importance of bighorn sheep hunting on the northwestern Plains from Paleoindian to early Historic periods. Despite the considerable difference in body weight and total usable meat between bighorn sheep and bison, the predictable, aggregated nature of bighorn sheep behavior during the critical late fall time period makes its selection, in combination with encounter hunting of bison, a relatively high return strategy.

The Bugas-Holding site

The Bugas-Holding site (48PA563) is a single-component occupation characterized by cultural materials occurring within a well-defined level at an average depth of slightly more than 50 cm below ground surface. Exact site boundaries are unknown, but the deposits are extensive, covering at least 2 800 m^2. Chronologically diagnostic items, including projectile points and ceramics, indicate a Late Prehistoric occupation of possible Shoshonean affiliation (see Frison, 1978). Charcoal from a hearth produced a MASCA corrected radiocarbon date of 500 ± 100 years (380 BP ± 100, uncorrected, RL1871).

Geomorphological analyses indicate the site was buried shortly after abandonment by gentle overbank fluvial deposits from nearby Sunlight Creek (Albanese, 1987). The lack of size sorting or preferred orientation of materials, combined with evidence of low-energy fluvial sedimentary structures, indicates that little non-cultural modification has affected the spatial distribution of items. Excavation methodology included piece-plotting of all materials larger than 5 mm and fine-mesh water screening. A total of 84,25 m^2 were excavated in the central block area discussed here, including more than 51 000 piece-plotted items (Rapson, 1990).

Faunal remains include numerous highly fragmented specimens of both bison (*Bison bison bison*, Minimum Number of Individuals [MNI] = 15, Number of Identified Specimens [NISP] = 1108, mean maximum length of identified fragments = 106 mm) and bighorn sheep (*Ovis canadensis*, MNI = 14, NISP = 780, mean maximum length of identified fragments = 72 mm), along with a limited number of elk (*Cervus eleaphus*, MNI = 2, NISP = 24) and pronghorn (*Antilocapra americana*, MNI = 1, NISP = 1). Several species of carnivores are also represented, and a large number of microfaunal remains were collected. The bison and bighorn sheep exhibit evidence of human processing in the form of cut marks, impact fractures, patterned breakage of elements, and burning. Although traditional techniques of excavation and analysis have largely ignored the small or fragmentary component of similar assemblages, piece-plotting and intensive attribute analysis of these materials provide critical information for assessing aspects of the formational history of the deposit (Schick, 1986), as well as isolating evidence of the organizational factors influencing the distribution of activities and debris (O'Connell, 1987).

Features in the central excavation area consist of eight hearths and one probable dump area (a dense concentration of bone fragments, ash, and debitage indicated by the dotted line in the northwestern corner of fig. 3). Numerous fire-cracked rock fragments, stone tools, debitage, worked bone, and antler are also present around these hearths.

Based on previous research (Rapson, 1990 ; Rapson, Todd, 1992), all eight hearths, plus the dump area (Feature 9), are contextually associated with a single 4 to 5-month winter occupation, although they were probably not used simultaneously. In addition, although the bison and bighorn sheep remains display significant differences in spatial patterning and attribute states, they appear to be derived from the same occupational episode. Non-cultural formation processes, such as weathering and carnivore modification, have not significantly altered or obscured the character of assemblage patterns. All hearths within the central excavation area exhibit a similar pattern of item distributions, with small items (retouch flakes in particular) occurring regularly on the west sides of the features, and high densities of larger materials and bone fragments occurring on the eastern sides (see fig. 4 ; around Features 6 and 7, the pattern is shifted slightly, with flakes to the south and bone fragments concentrated to the north). Since the prevailing wind in the Sunlight Creek drainage is from the southwest (down the valley), this distribution is suggestive of an « upwind » work area and a « downwind » discard area (Binford, 1978a, 1978b, 1983). This fact, along with other information (see Rapson, 1990), indicates that all of the hearths are associated with outside (primarily resource processing) activities rather than within-structure activities.

Season of occupation is indicated by 75 fetal bison bones (tabl. 1). Along with tooth eruption and wear studies of the lower dentitions of both the bison and bighorn sheep (tabl. 2), these data indicate a 4 to 5-month period of occupation extending from November to March or April. Two closely-spaced periods of mortality (during the fall) are indicated for the bighorn sheep (tabl. 2). Unlike the bighorn sheep, the bison remains indicate a widely dispersed mortality pattern, of at least 4 to 5 months between November and March.

Gestation Stage[a]	NISP[b]	MNI	Season of Death[c]
I (4-5 months)	19	3	November-December
II (6-7 months)	7	2	January-February
III (8-9 months)	49	2	March-May
Total	75	7	

a. Based on metric and morphological comparisons with comparative specimens from the University of Wyoming Anthropology Department Osteology Collection (UWAC collection) ; b. Number of Identified Specimens (Grayson 1979) ; **c.** Inferred birth pulse : April-May.

Tabl. 1. Season of maternal death for fetal bison bones from the Bugas-Holding site.

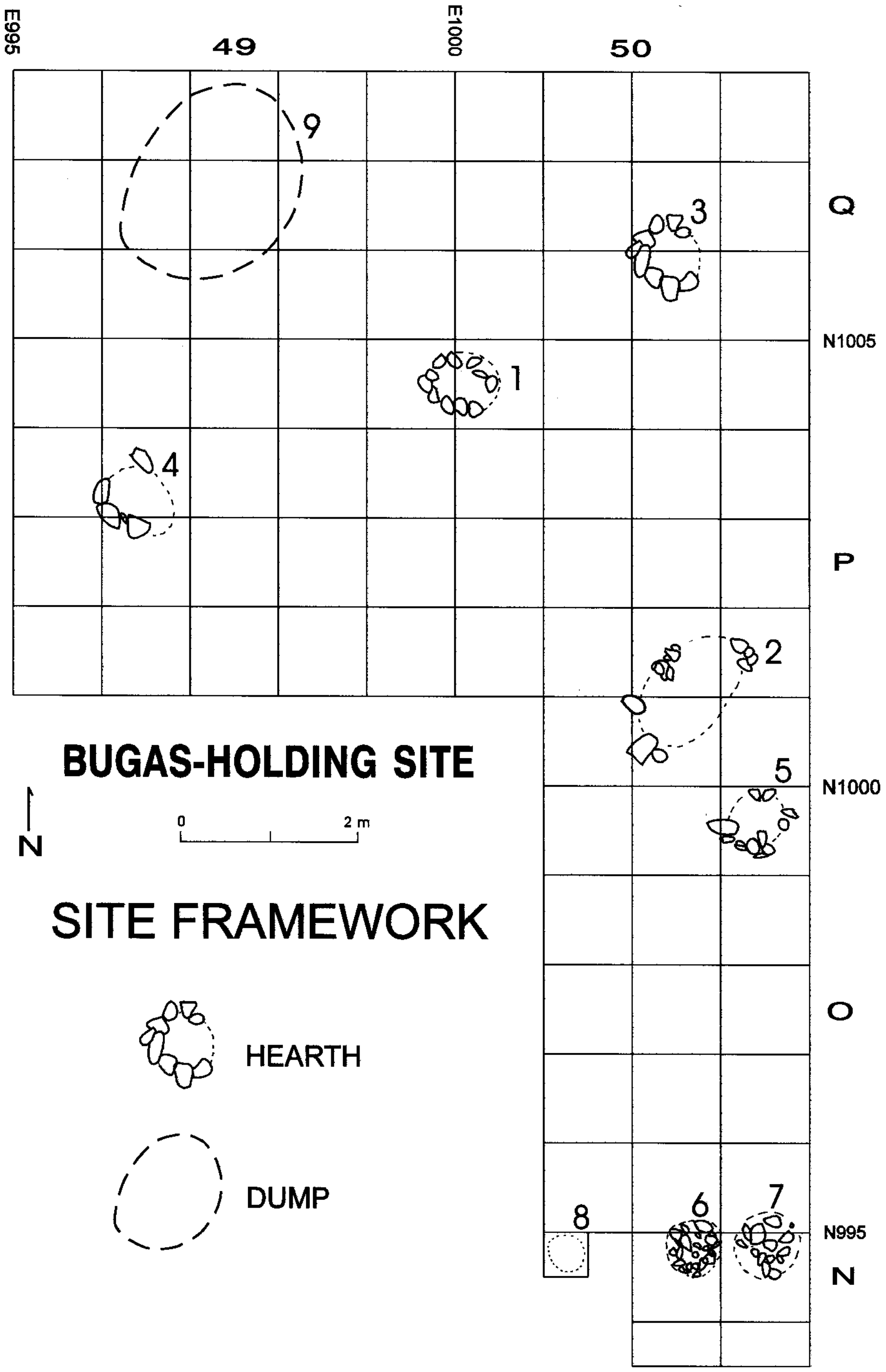


Fig. 3. Plan of site framework (spatial distribution of features) at the Bugas-Holding site.

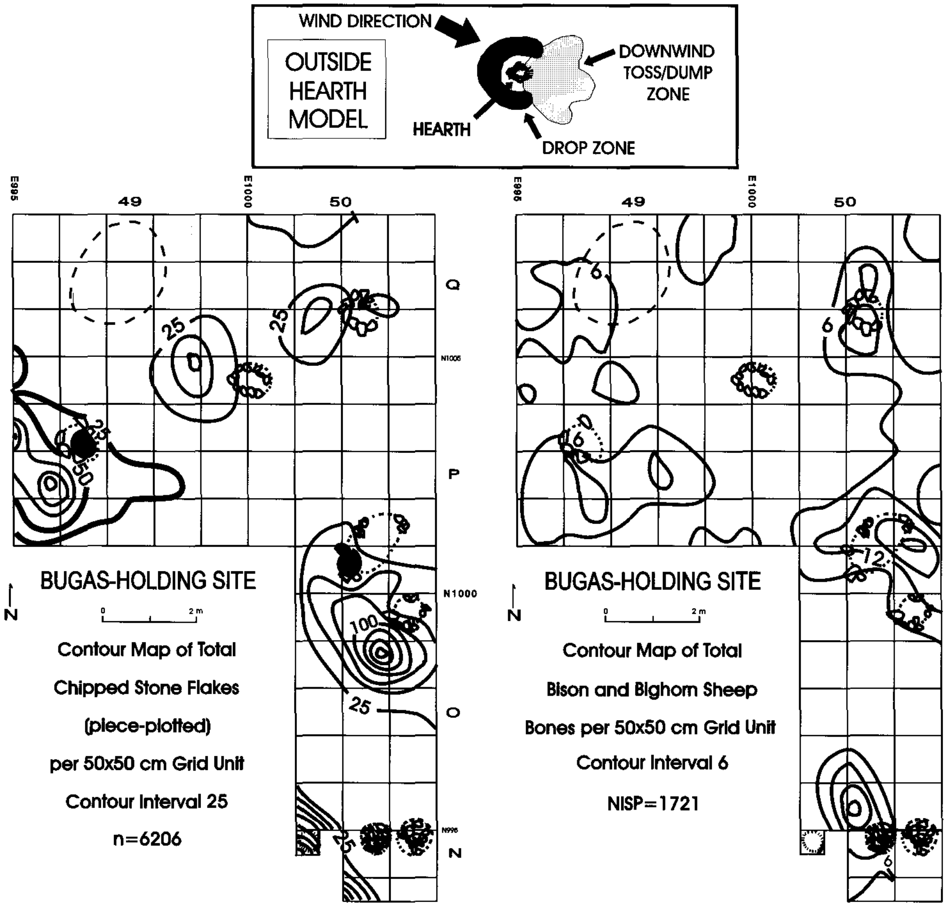


Fig. 4. Contour map of (a) total piece-plotted chipped stone flakes ; and (b) all identified (piece-plotted) faunal remains (bighorn sheep and bison, NISP = 1721) from the block excavation area at the Bugas-Holding site.

These data suggest two distinct patterns of use - bighorn sheep were killed during a restricted period in the fall, whereas bison were taken throughout the winter. This observation provides an opportunity to investigate the role of these two species in the overall organization of the subsistence economy as represented at this site. For instance, recent ethnoarchaeological studies (Binford, 1978b ; O'Connell *et al.* 1988a, 1988b, 1990) have noted a number of significant differences in the treatment of food packages obtained from dispersed game species, hunted and procured opportunistically, either as individuals, or in small groups, as opposed to game species taken in one or more mass kills, over a short period, and put up in stores for processing and use later in the occupation. If in fact this is the case here, we might expect certain patterned differences among the faunal remains as well as their spatial distributions, indicating that bighorn sheep remains were processed for long-term storage, while the bison were utilized on a more immediate basis.

				Season of Death^b					
Specimen No.	Description^a	Side	Age Group	Sept	Oct	Nov	Dec	Jan	Feb
Q49-23-359	*Ovis* MR	L	2	—	—				
O50-23-213	*Ovis* CRN	L	2	—	—				
O50-23-11	*Ovis* CRN	R	2	—	—				
O50-23-210	*Ovis* MR	R	2		—				
P50-19-411	*Ovis* MR	R	3			—			
P50-19-602	*Ovis* MR	R	3			—			
P50-18-25	*Ovis* MR	L	3			—			
P49-14-489	*Ovis* MR	R	4			—	—		
P49-3-446	*Ovis* MR	R	4			—	—		
P49-14-613c	*Ovis* MR	R	4			—	—	—	—
P49-8-111c	*Ovis* MR	L	4			—	—	—	—
P50-3-231	*Cervus* CRN	R	3			—	—	—	—
P49-6-409	*Bison* MR	R	1					—	—
P50-9-167	*Bison* MR	L	4					—	—

a. MR = mandible ; CRN = maxilla ; b. Inferred birth pulse : *Ovis* June ; *Bison* April-May ; *Cervus* May-June ; c. Mated pair.

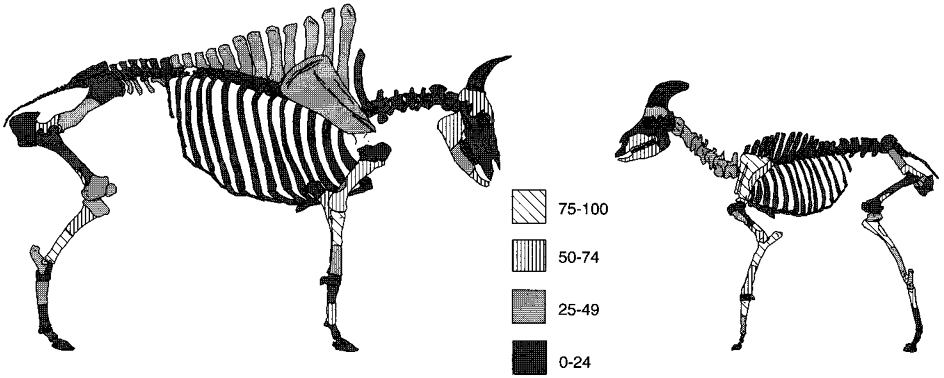
Tabl. 2. Season of death summary for selected dentitions from the Bugas-Holding site (see Rapson 1990 for definition of age groups).

Characteristics of the Bugas-Holding faunal assemblage

Following Brain (1981), skeletal element frequencies are summarized here in terms of body size classes. Body size 3 (medium bovids) consists primarily of bighorn sheep remains (NISP = 778 ; 99,0 %) plus all medium-sized bovid fragments that cannot be definitely identified to the level of species (NISP = 8 ; 1,0 %). Bison (NISP = 1108 ; 99,2 %) and similarly-sized remains (NISP = 9 ; 0,8 %) are classified as body size 4 (large bovids).

In terms of skeletal element representation (fig. 5, 6) within the block excavation area as a whole, the bighorn sheep remains display little segmental or sexual selection – that is, most body parts of both sexes are being returned to the occupation site for processing.

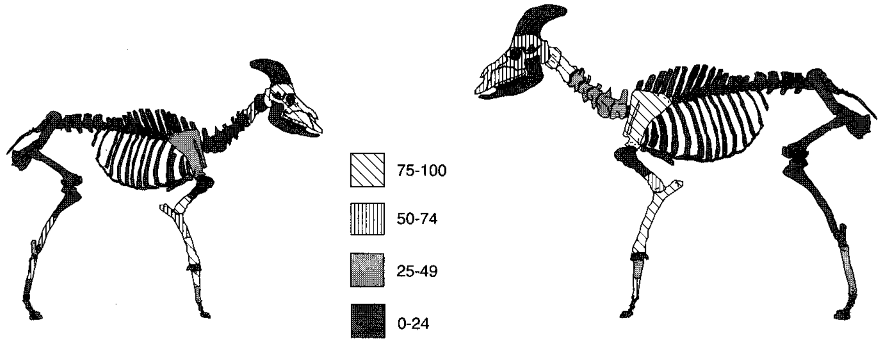
Bison materials, on the other hand, display evidence of more selective transport to the site, based on body part. For example, figure 5 (total bison) illustrates a significant decrease in anatomical unit frequency between the distal femur/lateral malleolus (MAU % = 100.0) and the tarsals (MAU % = 26,3). Bison remains also reflect a selective preference for male over female animals (fig. 7). This pattern is most apparent in the major limb bones. Elements of the lower rear leg, however, are more evenly distributed between male and female individuals. This pattern may relate to selective decisions made by the site occupants concerning the relative nutritional state of male *versus* female bison during the mid- to late winter (Speth and Spielmann, 1983), or to differential selection for processing in this area of the site.



Total Bison MAU %
(body size 4) NISP = 1117

Total Bighorn Sheep MAU %
(body size 3) NISP = 786

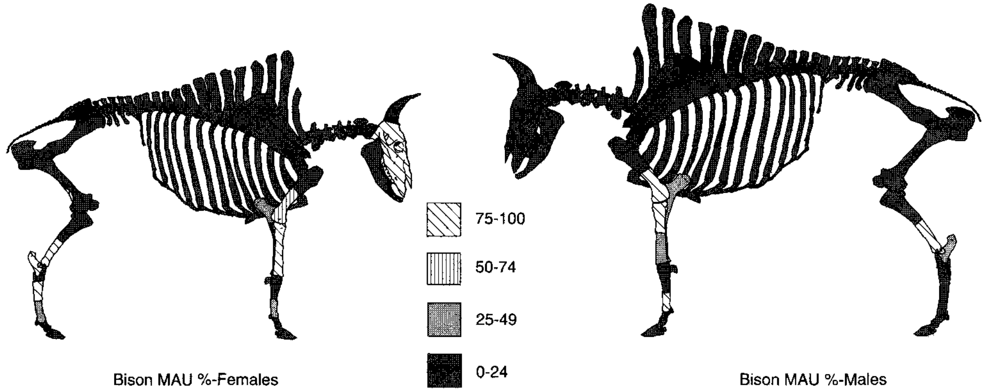
Fig. 5. Standardized minimum animal units (ratio MAU) values for total bison and total bighorn sheep remains from the Bugas-Holding site.



Bighorn Sheep MAU %-Females
(body size 3) NISP = 81

Bighorn Sheep MAU %-Males
(body size 3) NISP = 85

Fig. 6. Standardized minimum animal units (ratio MAU) values for female and male bighorn sheep remains (sexed elements only) from the Bugas-Holding site.



Bison MAU %-Females
(body size 4) NISP = 57

Bison MAU %-Males
(body size 4) NISP = 95

Fig. 7. Standardized minimum animal units (ratio MAU) values for female and male bison remains (sexed elements only) from the Bugas-Holding site.

The bighorn sheep assemblage does not indicate this form of sexual selection, nor does it appear to represent a primary food source processed for immediate consumption. Instead, it reflects the introduction of relatively complete anatomical packages to the residential site, with little selective culling of portions of marginal economic utility. Following the high altitude resource structure model outlined above, this behavior may reflect an attempt to maximize the bulk of the resource for processing into long-term storage, as opposed to the sex- and age-related selection associated with more immediate consumption indicated by the bison remains.

Analysis of inflicted marks and behavioral inference

Another piece of information on strategies of faunal use involves documentation of cut marks and impacts to specimens by body size and sex. Tables 3 and 4 present the results of a chi-square matrix of expected *versus* observed modifications to individual elements by body size. These results are reported as single-cell adjusted standardized residuals (Everitt, 1977), which identify those elements that display more or less modification than can be explained by chance alone. Patterning in the frequency of cut marks among these elements suggests that the number of cut marks is positively correlated to the economic utility of the various elements.

The quantification of cut mark frequencies exclusive of dismemberment marks (which are relatively rare in the Bugas-Holding assemblage) has been proposed as a generally applicable measure of the intensity of labor invested in the extraction of meat and tissue (Binford, 1988, p. 127). In order to evaluate the utility of this approach for the Bugas-Holding assemblage, we employ a technique for estimating both the surface area of the specimen and the number of cut marks per unit area. This approach provides a summary measure of cut mark intensity, which controls for differences in specimen size and is applicable to specimens of both body sizes. The surface area of each piece is estimated by multiplying the maximum length of the specimen by an approximate measure of specimen width – the « weathering profile height »– which is derived by measuring the distance in millimeters between the maximum weathering surface and its opposite aspect (fig. 8 ; Rapson, Todd, 1987). The number of cut marks per unit area is obtained by multiplying the total cut marks per specimen times 1 000 and then dividing by the specimen area (tabl. 5). The figure obtained is the number of cut marks per 1 000 mm^2 of bone surface area. Table 5 summarizes mean surface area (in mm^2) and mean cut marks per unit area for all bighorn sheep and bison specimens from the Bugas-Holding site. It is not surprising that bison specimens display a larger average surface area than bighorn sheep specimens ; however, their standard deviation (*s.d.*) is also much larger. Mean number of cuts per unit area, on the other hand, displays an unexpected pattern, with bighorn sheep bones receiving more cuts per unit area (6.42), compared to 3.13 for bison specimens.

	Cut marks		Burning		Carnivore Gnawing		Weathering Stage[a]		Profile Height[b]	
	Present	Absent	Present	Absent	Present	Absent	1-2	3-5	<30 mm	>30 mm
cranium	0,8	-0,8	-1,5	1,5	0,2	-0,2	0,3	-0,3	**-2,6**	**2,6**
hyoid	1,9	-1,9	-0,7	0,7	-0,4	0,4	1,1	-1,1	1,0	-1,0
mandible	**2,2**	**-2,2**	0,4	-0,4	**-2,0**	**2,0**	0,3	-0,3	**2,2**	**-2,2**
atlas	-1,2	1,2	-0,8	0,8	-0,5	0,5	-0,9	0,9	**-5,5**	**5,5**
axis	-0,4	0,4	-0,6	0,6	0,0	0,0	**-3,2**	**3,2**	**-7,1**	**7,1**
cervical 3-7	**-3,0**	**3,0**	-0,6	0,6	3,2	-3,2	**-7,7**	**7,7**	**-11,2**	**11,2**
thoracic	0,8	-0,8	-0,4	0,4	**-1,2**	**1,2**	-0,7	0,7	0,4	-0,4
lumbar	-1,7	1,7	-0,6	0,6	**3,7**	**-3,7**	**-3,2**	**3,2**	**-5,0**	**5,0**
sacrum	-0,9	0,9	-0,3	0,3	-0,5	0,5	0,4	-0,4	0,3	-0,3
caudal	-1,2	1,2	**5,5**	**-5,5**	-0,6	0,6	0,0	0,0	0,5	-0,5
os coxae	1,7	-1,7	-1,1	1,1	**5,6**	**-5,6**	0,9	-0,9	**-3,1**	**3,1**
ribs	**-2,7**	**2,7**	**-2,3**	**2,3**	1,3	-1,3	1,8	-1,8	**3,7**	**-3,7**
scapula	**5,5**	**-5,5**	-1,7	1,7	**3,6**	**-3,6**	0,9	-0,9	0,6	-0,6
humerus	1,5	-1,5	0,4	-0,4	-0,9	0,9	-0,6	0,6	**-2,3**	**2,3**
radius	0,6	-0,6	**2,1**	**-2,1**	-0,5	0,5	-0,5	0,5	0,0	0,0
ulna	0,2	-0,2	**-0,4**	**0,4**	**4,0**	**-4,0**	1,0	-1,0	1,0	-1,0
carpals	**-4,5**	**4,5**	-0,7	0,7	**-2,6**	**2,6**	-0,8	0,8	**2,0**	**-2,0**
metacarpals	-1,2	1,2	-0,8	0,8	1,9	-1,9	-0,9	0,9	**2,1**	**-2,1**
5th metacarpal	-0,9	0,9	-0,3	0,3	-0,5	0,5	0,4	-0,4	0,3	-0,3
femur	**2,8**	**-2,8**	-0,9	0,9	-1,8	1,8	**3,0**	**-3,0**	1,4	-1,4
patella	-1,2	1,2	-0,4	0,4	-0,6	0,6	0,0	0,0	0,5	-0,5
tibia	0,7	-0,7	**3,1**	**-3,1**	**-2,3**	**2,3**	0,5	-0,5	**3,2**	**-3,2**
lateral malleolus	-1,9	1,9	2,0	-2,0	-1,4	1,4	1,0	-1,0	1,0	-1,0
astragalus	1,8	-1,8	1,8	-1,8	-1,4	1,4	1,1	-1,1	1,1	-1,1
calcaneus	**2,9**	**-2,9**	-0,8	0,8	-0,5	0,5	1,1	-1,1	1,0	-1,0
tarsals	**-3,5**	**3,5**	**2,0**	**-2,0**	-1,9	1,9	0,0	0,0	-0,1	0,1
metatarsal	-1,6	1,6	-1,4	1,4	-0,5	0,5	-0,2	0,2	0,7	-0,7
2nd metatarsal	-0,9	0,9	-0,3	0,3	-0,5	0,5	0,4	-0,4	0,3	-0,3
proximal sesamoid	-1,2	1,2	-0,4	0,4	-0,6	0,6	0,5	-0,5	0,5	-0,5
distal sesamoid	-1,5	1,5	-0,4	0,4	-0,8	0,8	0,7	-0,7	0,6	-0,6
first phalanx	-0,7	0,7	-1,0	1,0	-1,1	1,1	-0,1	0,1	1,4	-1,4
second phalanx	**-2,3**	**2,3**	-0,7	0,7	-1,2	1,2	1,0	-1,0	0,9	-0,9
third phalanx	-1,7	1,7	-0,5	0,5	0,4	-0,4	0,8	-0,8	0,7	-0,7
N	331	455	49	737	134	652				
%	(42,1 %)	(57,9 %)	(6,2 %)	(93,8 %)	(17 %)	(83 %)				

a. modified from Behrensmeyer (1978), with stage 1 representing unweathered, and stage 6 bone falling apart *in situ* ; b. weathering profile height (Rapson, Todd, 1987) is derived by recording the most weathered aspect of a bone fragment, the weathering stage of the exterior surface directly opposite the most weathered aspect, and measurement of the distance (in mm) separating the maximum weathering surface from its opposite aspect – providing an estimate of the relative exposure potential of bone to weathering processes. All values are read as standard normal deviates, values in bold face are significant at $p < 0.05$ or better : ± 2.0, $p < 0.05$; ± 2.6, $p < 0.01$; ± 3.3, $p < 0.001$.

Tabl. 3. Adjusted standardized residuals by element for the Bugas-Holding bighorn sheep (body size 3).

Next, all elements with cut marks were sorted by sex (elements that could not be sexed were excluded) and body sizes. Several interesting relationships are indicated in the summary presented in table 6. Male bighorn sheep elements are larger on average than female elements ; however, female bison elements are larger on average than male elements, although the *s.d.* is much larger for the females. In terms of mean cut marks per unit area, the bison male and female elements are quite similar. In contrast, among the bighorn sheep elements, females display considerably more cuts per unit area than do males. A two-sample t-test comparing the sample means of cut marks per unit area for males and females of each body size (tabl. 6)

	Cut marks		Burning		Carnivore Gnawing		Weathering Stage[a]		Profile Height[b]	
	Present	Absent	Present	Absent	Present	Absent	1-2	3-5	<30 mm	>30 mm
cranium	**-3,1**	**3,1**	-0,8	0,8	**-2,8**	**2,8**	0,2	-0,2	0,7	-0,7
hyoid	0,2	-0,2	-0,9	0,9	-0,2	0,2	1,8	-1,8	**2,1**	**-2,1**
mandible	1,7	-1,7	**2,8**	**-2,8**	**-3,0**	**3,0**	0,8	-0,8	0,3	-0,3
atlas	-0,8	0,8	-0,2	0,2	-0,4	0,4	**-2,1**	**2,1**	-1,8	1,8
axis	0,3	-0,3	-0,3	0,3	1,3	-1,3	-1,1	1,1	**-2,5**	**2,5**
cervical 3-7	**-3,2**	**3,2**	-0,3	0,3	-0,8	0,8	-1,6	1,6	-1,2	1,2
thoracic	1,7	-1,7	0,4	-0,4	**4,6**	**-4,6**	**-2,9**	**2,9**	**-2,3**	**2,3**
lumbar	**3,6**	**-3,6**	0,1	-0,1	**4,2**	**-4,2**	-1,2	1,2	**2,4**	**-2,4**
sacrum	-1,4	1,4	-0,4	0,4	-0,8	0,8	0,8	-0,8	-0,4	0,4
caudal	**-2,4**	**2,4**	1,0	-1,0	-0,3	0,3	1,3	-1,3	1,6	-1,6
os coxae	-0,2	0,2	-1,3	1,3	**3,1**	**-3,1**	-0,3	0,3	-0,9	0,9
ribs	**3,3**	**-3,3**	**-2,9**	**2,9**	**8,3**	**-8,3**	**-4,3**	**4,3**	**8,4**	**-8,4**
scapula	**2,2**	**-2,2**	0,2	-0,2	-1,7	1,7	0,2	-0,2	0,9	-0,9
humerus	0,6	-0,6	-1,6	1,6	0,1	-0,1	-1,2	1,2	**-3,1**	**3,1**
radius	-0,2	0,2	-1,3	1,3	**-3,4**	**3,4**	1,4	-1,4	**-4,2**	**4,2**
ulna	1,6	-1,6	-1,3	1,3	1,6	-1,6	1,2	-1,2	0,4	-0,4
carpals	-1,8	1,8	**5,4**	**-5,4**	-1,3	1,3	1,5	-1,5	0,3	-0,3
metacarpals	-0,8	0,8	0,1	-0,1	**-2,0**	**2,0**	**-2,6**	**2,6**	**-4,1**	**4,1**
5th metacarpal	-1,7	1,7	-0,5	0,5	-0,9	0,9	1,0	-1,0	1,1	-1,1
femur	0,3	-0,3	-1,2	1,2	**-2,4**	**2,4**	**2,8**	**-2,8**	0,6	-0,6
patella	**-2,0**	**2,0**	-0,6	0,6	**5,5**	**-5,5**	**-2,0**	**2,0**	**-4,4**	**4,4**
tibia	-1,6	1,6	1,4	-1,4	**-4,5**	**4,5**	**5,0**	**-5,0**	-0,3	0,3
lateral malleolus	**3,0**	**-3,0**	**2,2**	**-2,2**	-1,3	1,3	-1,3	1,3	1,9	-1,9
astragalus	0,9	-0,9	-0,5	0,5	-1,0	1,0	**-2,4**	**2,4**	**-4,0**	**4,0**
calcaneus	-0,7	0,7	-0,6	0,6	-1,2	1,2	0,3	-0,3	**-4,7**	**4,7**
tarsals	**-2,9**	**2,9**	-0,8	0,8	-1,5	1,5	1,7	-1,7	-0,8	0,8
metatarsal	-0,7	0,7	-1,1	1,1	**-2,1**	**2,1**	0,5	-0,5	-1,0	1,0
2nd metatarsal	-1,4	1,4	-0,4	0,4	-0,8	0,8	0,8	-0,8	1,0	-1,0
proximal sesamoid	**-4,2**	**4,2**	**2,6**	**-2,6**	**-2,2**	**2,2**	**2,1**	**-2,1**	**2,8**	**-2,8**
distal sesamoid	**-2,2**	**2,2**	-0,6	0,6	-1,2	1,2	1,1	-1,1	1,5	-1,5
first phalanx	0,1	-0,1	**2,9**	**-2,9**	-1,2	1,2	-0,1	-0,1	**-2,1**	**2,1**
second phalanx	-0,8	0,8	**2,5**	**-2,5**	-1,8	1,8	1,1	-1,1	**-6,0**	**6,0**
third phalanx	**-2,5**	**2,5**	0,8	-0,8	-1,3	1,3	**-2,0**	**2,0**	**-3,0**	**3,0**
N	449	667	55	1061	183	933				
%	(40,2 %)	(59,8 %)	(4,9 %)	(95,1 %)	(16,4 %)	(83,6 %)				

a. modified from Behrensmeyer (1978), with stage 1 representing unweathered, and stage 6 bone falling apart *in situ* ; b. weathering profile height (Rapson, Todd, 1987) is derived by recording the most weathered aspect of a bone fragment, the weathering stage of the exterior surface directly opposite the most weathered aspect, and measurement of the distance (in mm) separating the maximum weathering surface from its opposite aspect – providing an estimate of the relative exposure potential of bone to weathering processes. All values are read as standard normal deviates, values in bold face are significant at $p < 0.05$ or better : ± 2.0, $p < 0.05$; ± 2.6, $p < 0.01$; ± 3.3, $p < 0.001$.

Tabl. 4. Adjusted standardized residuals by element for the Bugas-Holding bison (body size 4).

shows that the sample means are not equal for bighorn sheep ($p = 0.02$), but are equal for bison bones ($p = 0.96$).

Figure 9 presents the mean number of cut marks per unit area by element for males and females of each body size (from data in tabl. 7). Of immediate interest here is the consistently greater cut mark intensity reflected by bighorn sheep females relative to males. Only the bighorn sheep male ulna and tibia approach the cut mark values displayed by the female specimens. Bison elements, on the other hand, are much more consistent in male-female cut mark frequency ; the data also show the

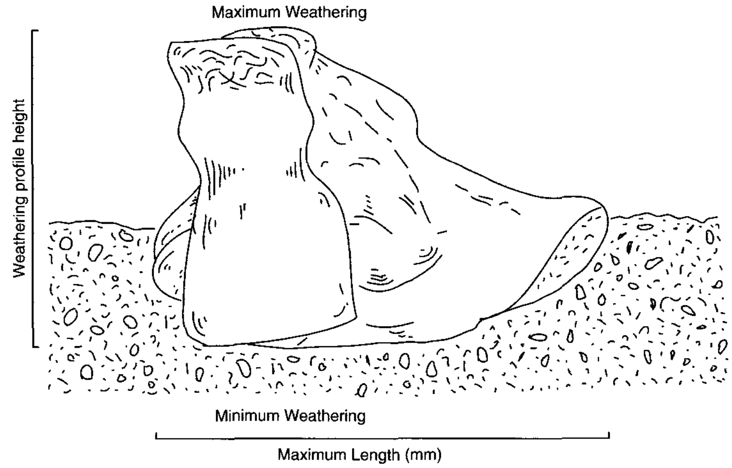


Fig. 8. Idealized model of weathering profile formation used to calculate specimen surface area (from Rapson and Todd, 1987).

Body Size[a]	x̄ Surface Area (mm²)[b]	s.d.[c]	x̄ Cut Marks per Unit Area[d]	s.d.	NISP
3	1176,90	1270,24	6,42	21,42	786
4	2670,89	3767,83	3,13	9,61	1117

a. Body Size Class : 3 (medium bovids) consisting primarily of bighorn sheep plus all medium-sized bovid fragments which cannot be definitely identified to species ; 4 (large bovids) consisting primarily of bison plus all large bovid fragments which cannot be definitely identified to species (Brain, 1981, tabl. 1). b. Surface Area = maximum length of specimen x weathering profile height. Weathering profile height is an approximate measure of specimen width, taken by measuring the distance in mm between the maximum weathering surface and its opposite aspect (see Rapson and Todd, 1987). c. s.d. = Standard deviation. d. Cut marks per unit area = (total cut marks per specimen x 1000)/specimen area.

Tabl. 5. Summary of surface area and cut mark area data for all faunal remains from the Bugas-Holding site.

lower average number of cuts per specimen of this size class. This evidence again suggests differential processing of male versus female bighorn sheep at the residential site, but no difference in male *versus* female bison processing.

Since the season of death for bighorn sheep overlaps with the rut (during early winter), mature males would have been approaching their poorest nutritional condition of the year (Speth, Spielmann, 1983). The meat of males is also less palatable when in rut (Binford, 1978b, p. 355). Both of these factors may be influencing decisions about the processing of male *versus* female bighorn sheep portions.

Figure 10 (tabl. 8) summarizes information on the occurrence of various forms of bone breakage (most of which is related to human processing) for both proximal and distal portions of all bison elements, all bighorn sheep elements, and male bighorn sheep elements lacking modification (*i.e.*, no cut marks or impacts present,

Body Size	Sex	$\bar{x}$ Surface Area (mm^2)^a	s.d.^{b}	$\bar{x}$ Cut Markst per Unit Area^c	s.d.	N	-test t value	Degrees of Freedom	Two-tailed Probability
3	M	2466,92	1459,25	6,10	5,90	39	-2,42	67,86	0,02
3	F	1884,60	1365,73	10,32	9,37	41			
4	M	5743,28	5271,37	3,14	3,70	42	0,05	68,00	0,96
4	F	7275,62	11069,68	3,10	3,73	28			

a. Surface Area = maximum length of specimen x weathering profile height. Weathering profile height is an approximate measure of specimen width, taken by measuring the distance in mm between the maximum weathering surface and its opposite aspect (see Rapson, Todd, 1987). b. s.d. = standard deviation. **c.** cut marks per unit area = (total cut marks per specimen x 1000) /surface area.

Tabl. 6. Summary of surface area and cut mark area data for sexed elements (with cut marks present only) from the Bugas-Holding site.

		Body Size 3					Body Size 4				
Element (1)	Sex (2)	$\bar{x}$ Surface Area (mm^2)^a (3)	s.d.^{a} (4)	$\bar{x}$ Cut Marks per Unit Area^a (5)	s.d. (6)	N (7)	$\bar{x}$ Surface Area (mm)^2 (8)	s.d. (9)	$\bar{x}$ Cut Marks per Unit Area (10)	s.d. (11)	N (12)
CRN	M	—	—	—	—	—	—	—	—	—	—
	F	3801,15	3941,20	2,43	0,64	2	61160,40	—	0,18	—	1
AT	M	—	—	—	—	—	—	—	—	—	—
	F	3249,40	—	6,46	—	1	—	—	—	—	—
AX	M	5295,50	—	7,55	—	1	—	—	—	—	—
	F	4567,40	—	15,76	—	1	—	—	—	—	—
CE	M	5164,60	175,93	0,59	0,02	2	—	—	—	—	—
	F	2694,40	—	9,28	—	1	7149,40	1640,14	3,39	2,06	3
SC	M	2793,65	1812,89	5,25	3,91	6	—	—	—	—	—
	F	2168,20	653,08	14,18	11,45	2	—	—	—	—	—
HM	M	2800,90	1578,23	7,85	7,05	5	14746,63	6343,18	1,97	1,98	7
	F	2849,63	711,28	10,61	5,82	6	9183,13	5460,31	1,03	1,09	3
RD	M	2071,27	861,14	5,23	4,20	10	5127,17	2685,06	1,70	1,71	6
	F	1878,59	1341,09	9,18	7,71	10	5617,06	3295,09	2,89	3,89	9
UL	M	1077,47	414,51	9,68	3,41	3	4230,14	2186,28	2,40	1,50	5
	F	1170,03	280,88	9,93	5,63	4	3208,83	1176,33	4,23	3,25	3
MC	M	1632,93	361,77	4,75	2,17	4	3166,27	481,86	1,87	0,92	3
	F	1318,95	89,73	7,71	7,52	2	—	—	—	—	—
FM	M	4237,45	860,76	10,30	9,60	2	—	—	—	—	—
	F	—	—	—	—	—	—	—	—	—	—
TA	M	2747,00	—	0,73	—	1	4840,11	2738,35	1,85	1,82	11
	F	1449,60	1501,90	1,49	1,54	2	4483,23	2288,58	3,36	5,55	7
LTM	M	—	—	—	—	—	975,94	228,02	7,59	5,08	5
	F	205,20	—	29,24	—	1	998,35	397,18	5,52	0,07	2
AS	M	974,40	—	4,11	—	1	—	—	—	—	—
	F	867,80	168,57	19,42	15,99	2	—	—	—	—	—
CL	M	2263,20	—	1,33	—	1	7409,00	—	1,08	—	1
	F	1328,70	445,05	2,70	0,38	2	—	—	—	—	—
MT	M	2157,75	166,52	1,59	0,86	2	2762,23	1295,93	7,74	6,84	4
	F	823,92	225,14	14,25	17,07	5	—	—	—	—	—
PHF	M	567,00	—	28,22	—	1	—	—	—	—	—
	F	—	—	—	—	—	—	—	—	—	—

a. See Table 6 for variable definitions.

Tabl. 7. Summary of surface area and cut marks per unit area by element for sexed elements (with cut marks present only) from the Bugas-Holding site.

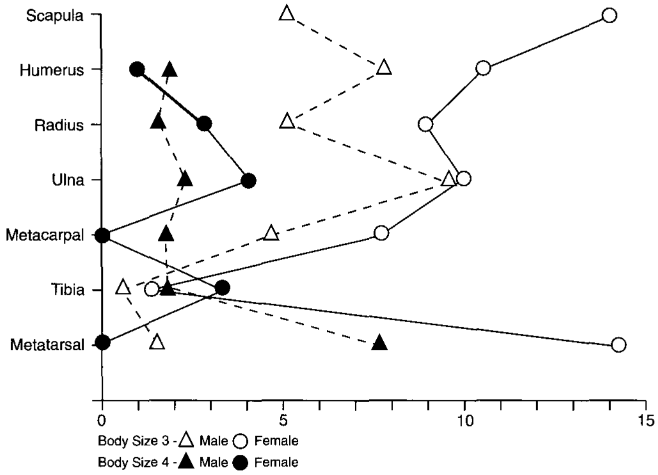


Fig. 9. Mean number of cut marks per unit area by body size, element, and sex (from table 7 : columns 5 and 10) for sexed bones (with cut marks present only) from the Bugas-Holding site.

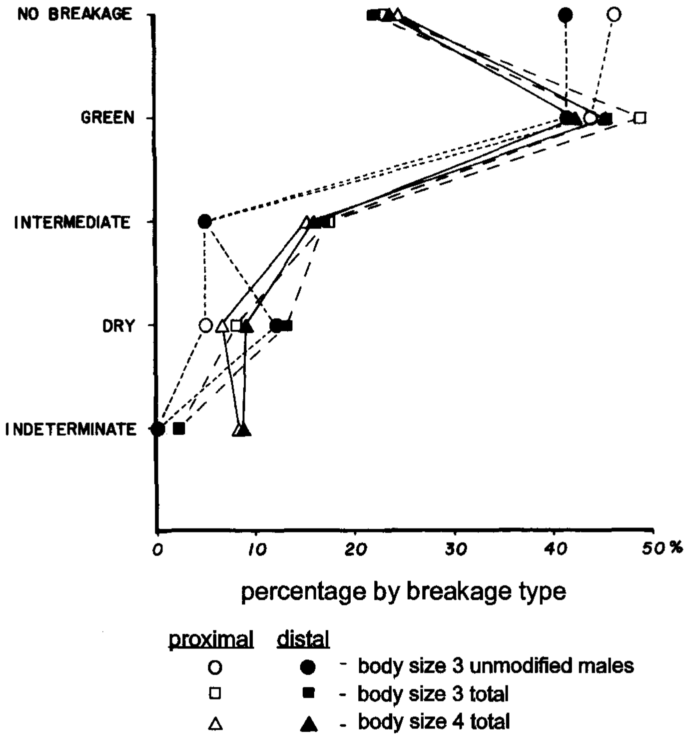


Fig. 10. Percentage of identified faunal elements by bone breakage type (both proximal and distal ends) for : 1) all bighorn sheep ; 2) all bison ; and 3) unmodified bighorn sheep males.

	Body size 3								Body size 4			
	Proximal		Distal		Proximal		Distal		Proximal		Distal	
	Male No Cut Marks		Male No Cut Marks		Total		Total		Total		Total	
Breakage Type	N (1)	(%) (2)	N (3)	(%) (4)	N (5)	(%) (6)	N (7)	(%) (8)	N (9)	(%) (10)	N (11)	(%) (12)
No Breakage	19	(46,3)	17	(41,5)	166	(23,2)	157	(22,0)	251	(24,6)	242	(23,7)
Green Bone	18	(43,9)	17	(41,5)	349	(48,9)	325	(45,5)	463	(45,3)	433	(42,4)
Intermediate	2	(4,9)	2	(4,9)	125	(17,5)	122	(17,1)	156	(15,3)	164	(16,0)
Dry Bone	2	(4,9)	5	(12,2)	58	(8,1)	95	(13,3)	67	(6,6)	93	(9,1)
Indeterminate	0	–	0	–	16	(2,2)	15	(2,1)	85	(8,3)	90	(8,8)
Totals	41		41		714		714		1022		1022	

Tabl. 8. Summary of bone breakage data from the block excavation area at the Bugas-Holding site.

NISP = 43). Male bighorn sheep elements lacking evidence of modification are much less frequently broken than any other bone category. In addition, 46,5 % (n = 13) of these unmodified male specimens have been identified as parts of articulated units (primarily articulated neck units, as well as some lower rear limb and upper forelimb units).

In his discussion of the Nunamiut, Binford (1978b) states that necks from nutritionally poor animals are considered of marginal utility, but may be placed in storage as « insurance meat » (Binford, 1978b, p. 97) in the event of late-winter food shortage. The presence of elements of the upper forelimb that are lacking any visible evidence of modification may reflect a similar strategy.

A chi-square matrix (tabl. 9) comparing expected and observed frequencies of specimens with cut marks present *versus* specimens with impacts present clearly indicates that among bighorn sheep males the presence of cut marks and impacts is positively correlated. The lack of correlation for female bighorn sheep or for bison elements of either sex is another indicator of selective utilization of bighorn sheep males, suggesting that within this category certain elements have been selected for processing, while other elements reflect limited processing investment.

Figure 11 presents a series of contour maps summarizing the distribution of various bighorn sheep elements within the excavation area. Unlike the bison remains (fig. 12), which are more widely scattered across the block area, bighorn sheep remains tend to be concentrated near individual hearths, especially the paired features 6 and 7 near the southern excavation boundary.

The spatially delimited, hearth-centered nature of the bighorn sheep distribution, together with the lack of segmental or sexual selection of elements represented, and the sexually specific character of decisions made concerning investment in processing suggest that final utilization and disposal of these materials occurred over a rela-

Body size and sex	Impact and cut mark Presence/absence correlated	Impact and cut mark Presence/absence not correlated
bighorn sheep males (body size 3 ; NISP = 85)	3,0*	-3,0
bighorn sheep females (body size 3 ; NISP = 81)	0,6	-0,6
bison males (body size 4 ; NISP = 95)	1,1	-1,1
bison females (body size 4 ; NISP = 57)	1,3	-1,3

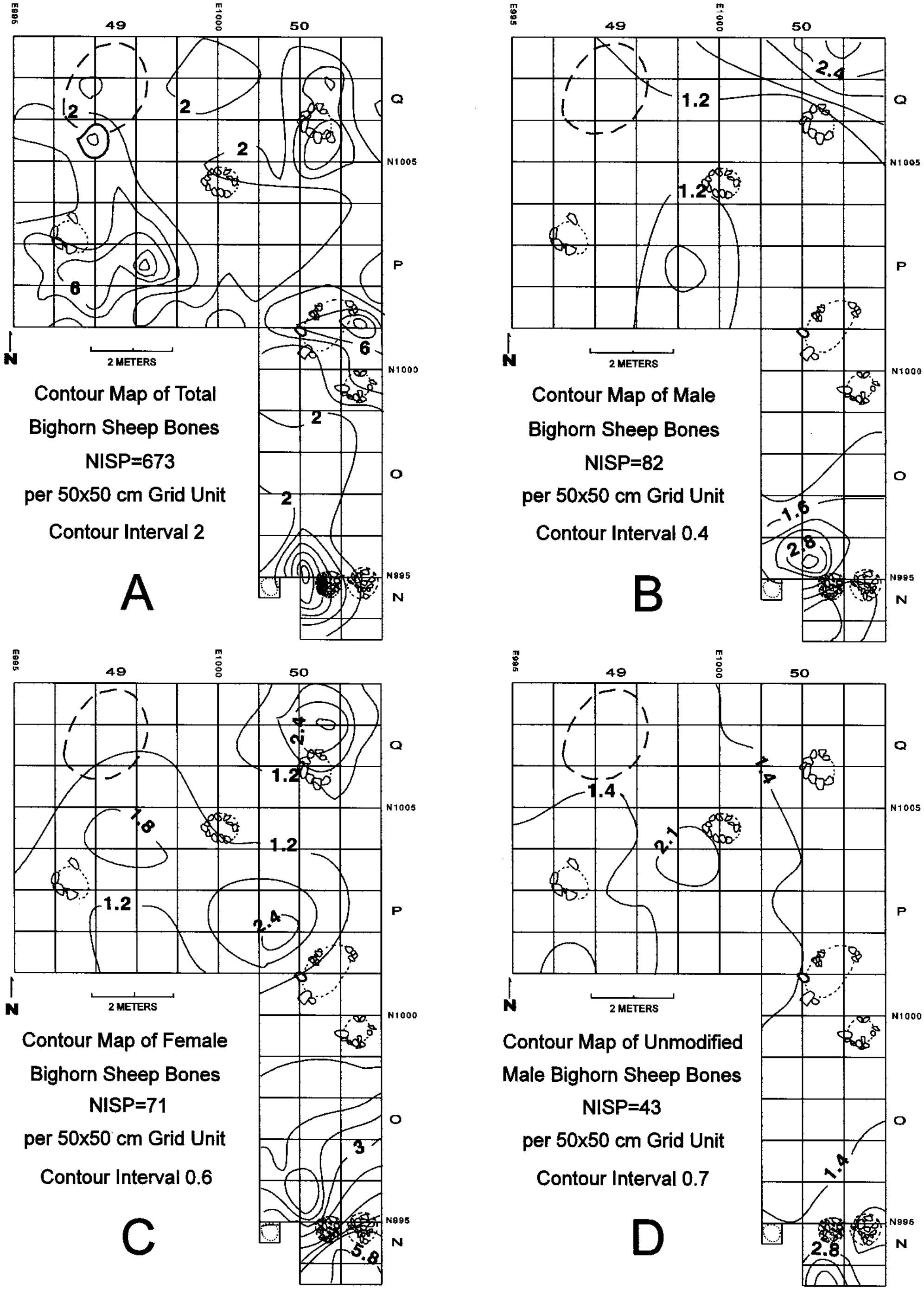
* - p < 0,01

Tabl. 9. Adjusted standardized residuals for bones with impact and cut mark presence correlated by body size and sex from the Bugas-Holding site.

tively short period of time, not in the context of exploitation of individuals, but rather of anatomical units removed from storage late in the occupation. The lack of evidence for marrow and grease processing on male bighorn sheep elements also indicates that a low priority was placed on these elements.

Bison remains, on the other hand, suggest that selective decisions were made at the level of individuals, with the utilization of specific portions varying according to element and sex. The different portions were subject to processing for the extraction of a variety of products, including meat, marrow, and bone grease (Rapson, Todd, 1987). As indicated by previous analyses (Rapson, 1990 ; Rapson, Todd, 1987), the bison remains are more spatially dispersed and include numerous inter-hearth conjoins of fragmented elements indicating staged utilization of elements throughout the course of the occupation. Although excavation is quite limited in the southern block area around Features 6 and 7, the apparent spatial concentration of bighorn sheep bones in this area is intriguing. The occurrence of both male and female bighorn sheep immediately northwest of Feature 6 (fig. 11B, C) and the character of the assemblage associated with these two features in terms of economic utility (i.e., dominated by elements of the head, neck, pelvis, upper forelimb, and rear limb) all suggest that this assemblage represents the remains from the final utilization and discard of skeletal portions that were minimally processed for storage during the early stages of the occupation.

The apparent spatial isolation of the unmodified male bighorn sheep group in an area south of Features 6 and 7 (fig. 11D) suggests that these skeletal elements were selected independently during final processing, since they lack evidence of processing in the form of cut marks or impacts, are often unbroken, and are frequently parts of articulated neck, or lower rear limb units. Given the intensive level of investment in processing reflected by all other classes of faunal material at this site, the apparent selective bias against male bighorn sheep remains suggests a conscious



Contour Map of Total Bighorn Sheep Bones NISP=673 per 50x50 cm Grid Unit Contour Interval 2

A

Contour Map of Male Bighorn Sheep Bones NISP=82 per 50x50 cm Grid Unit Contour Interval 0.4

B

Contour Map of Female Bighorn Sheep Bones NISP=71 per 50x50 cm Grid Unit Contour Interval 0.6

C

Contour Map of Unmodified Male Bighorn Sheep Bones NISP=43 per 50x50 cm Grid Unit Contour Interval 0.7

D

Fig. 11. A. Contour map of total piece-plotted bighorn sheep bones. **B.** Contour map of total piece-plotted male bighorn sheep bones. **C.** Contour map of total piece-plotted female bighorn sheep bones. **D.** Contour map of total piece-plotted unmodified male bighorn sheep bones.

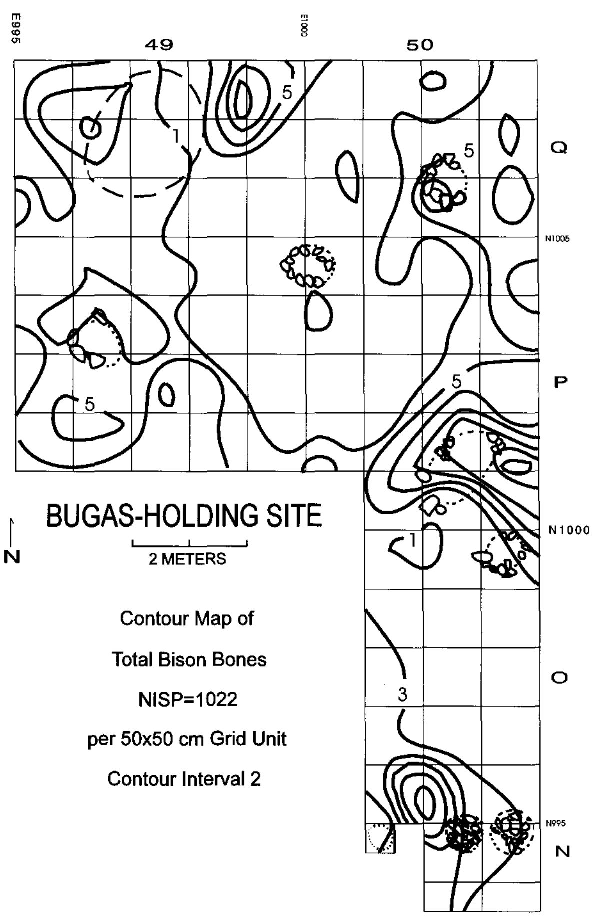


Fig. 12. Contour map of total piece-plotted bison bones.

decision on the part of the site occupants to limit the amount of effort expended in processing these elements. Although the limited nature of excavation in the southern area of the site makes a definitive interpretation of activity structure difficult, a distinct trajectory of faunal use seems clearly indicated for both the bighorn sheep *versus* the bison remains and the male *versus* the female bighorn sheep remains.

Conclusion

Based on the scenarios outlined above, several inferences can be drawn concerning the organization of mobility strategies, transport decisions, and techniques of processing, storage, and consumption by the occupants of the Bugas-Holding site.

Resource structure at Bugas-Holding, specifically characteristics of faunal aggregation, predictability, and storage potential, favor bighorn sheep as the most desirable high-bulk resource for long-term winter storage. Because of the limited faunal carrying capacity of the region, however, a mixed strategy that includes encounter hunting of bison during the winter offers the lowest levels of risk.

Bighorn sheep provided the storable resource « base line » for this occupation, owing to their predictability, both spatial (aggregation) and temporal (late fall). Because of the dispersed character of bison during the winter, monitoring of the bison resource would produce information of only short-term utility. As a result, movement of the majority of the bighorn sheep back to the winter camp as a storable resource « base line » may have been more effective, combined with encounter hunting of bison throughout the winter.

This type of detailed, attribute-based analysis illustrates how field methods and analytic techniques can be integrated in the investigation and development of theoretical models of hunter-gatherer subsistence-settlement systems, by linking subsistence-related patterning to inferred strategies of mobility. Current models of mobility, derived primarily from ethnographic data, see resource distribution and procurement as conditioning mobility. Archaeological analysis, on the other hand, starts with assemblage patterning, which is used to develop interpretations of resource procurement, which in turn provides the basis for inferred mobility patterns. Missing here is a body of archaeological methodology capable of isolating the organizational factors linking the record, resource procurement and mobility patterns. Critical to the resolution of this problem is an analytically rigorous basis for relating trajectories of resource use to mobility strategies.

For Bugas-Holding, we have shown that short-term mobility and resource use were linked through decisions about storage and game processing. The strategies employed are sensible given the short-term maximizing goal of greatest return per unit time, while reducing the risk of winter starvation. The analysis outlined here indicates that subsistence strategies in temperate environments can be complicated mixtures of specialized and generalized procurement. Although resource structure dictates certain hunting parameters, data from other sites in the region (Frison, 1978) suggest that the particular strategies outlined here are not the only ones employed. Instead, a variety of longer-term « risk-minimizing » strategies are apparently at work in temperate environments. Problem-oriented faunal analysis, in conjunction with distributional or site structural analyses, provides a central methodological tool in the recognition and investigation of such patterning.

Acknowledgments

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ACTES DU COLLOQUE INTERNATIONAL
Toulouse, 6-10 juin 1995

Sous la direction de
Jean-Philip BRUGAL, Francine DAVID,
James G. ENLOE, Jacques JAUBERT

Avec le concours
du Ministère de la Culture et de la Communication, Sous-direction de l'archéologie
de la DRAC de Midi-Pyrénées, Service régional de l'archéologie, Toulouse
du Centre de recherches archéologiques du CNRS, Valbonne

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