The Analysis of a Late Holocene Bison Skull from Fawn Creek, Lemhi County, Idaho, and Its Implications for Understanding the History and Ecology of Bison in the Intermountain West

By

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Executive Summary

In 1995 the skull of a subadult male bison was recovered from the cutbank of Fawn Creek, Lemhi County, Idaho, by a ranger for the Salmon-Challis National Forest. After slowly drying the skull for about a year it was turned over to the Midwest Archeological Center in order to be stabilized and analyzed for clues to the ecology of Late Holocene bison in the Intermountain West.

A number of analytical techniques were applied to the skull in order to understand its age of deposition and ecology. Radiocarbon dating revealed a recent age of 170 ± 70 yr B.P., which calibrates to about the late eighteenth to early nineteenth century. Identification of macrobotanical remains recovered from the infundibulum of the molars, in association with the analysis of pollen and phytoliths extracted from tooth tartar, indicates this bison subsisted on festucoid grasses and other cool-season grasses in an open forest setting. The stable-carbon-isotope analysis is consistent with the plant data—this particular bison lived its life in the mountainous region of the Salmon River. There is no indication of long distance migrations into the lower valleys of the Lemhi or Snake rivers.

In addition to the physical analyses, an overview of the historic and archeological literature citing bison is presented. The information from these sources indicates that bison were most abundant in the wide grass-covered valleys of the Lemhi River and Snake River. Archeological data indicate that bison may have become more abundant during the Late Holocene, although the statistical correlation is weak.

Acknowledgements

To begin, I would like to express my gratitude to Stephan Matz, archeologist for the Salmon-Challis National Forest, for supporting this research endeavor. Also, thanks to Dr. Ralph Hartley of the Midwest Archeological Center for allowing me the opportunity to do the work. I would also like to acknowledge the other members of the research team who contributed their knowledge and expertise to bringing this project to a successful conclusion. These include Dr. Linda Cummings and Cathy Puseman, who conducted the macrobotanical, pollen and phytolith analyses; Dr. Richard Marlar and his staff, who used numerous techniques in an attempt to isolate bison DNA from our specimen; and Larry Tieszen and Michael Chapman, who conducted the stable-isotope analyses. Thanks to Dr. Tieszen for never tiring of my e-mail requests and providing me with unpublished data on plants and Yellowstone bison. Conversations with Alan Osborn and John Ludwicksen concerning stable-isotope analysis were of great help in clarifying several issues. Rob Bozell read over an earlier draft and provided thoughtful comments. Diane Schult and Breck Hudson of the Salmon-Challis National Forest read over an earlier version of the vegetation section and provided detailed comments that make this section much more accurate.

Production of this manuscript is attributed to a number of individuals: Carrol Moxham for production oversight, John Andresen and Ken Gobber for their diligent editorial skills, Marie Johnson for typing the manuscript, and Carrol Moxham and Jim Dahlin (freelance illustrator) for figure production. Even though a number of people worked on this project, the interpretations presented here are mine and any errors in the data reporting or interpretation are my burden.

The cover illustration was reproduced from H. R. Schoolcraft's *Indian Tribes of the United States*, published in 1860.

Contents

Tables

Figures

Introduction

During the last 20 years, anthropologists have become increasingly aware of the complexity of the ecology of bison, especially on the Great Plains. One result of this awareness has been an increased interest in investigating the relationship between the ecology and the methods used by aboriginal groups to procure these gregarious ungulates (e.g., Arthur 1975; Bamforth 1988; Hanson 1984; Morgan 1980; Bozell 1995). Numerous articles have been published (see Arthur 1985) on these animals in an effort to reconstruct a model of their pre-Euroamerican ecology based on modern studies (e.g., Meagher 1973) and historic records (e.g., Roe 1970), or a combination of both (e.g., Bamforth 1987). Probably the most significant aspect of the bison debate has focused on the degree of predictability in bison movements, both seasonal and long term, and its effect upon human settlement and hunting patterns (Bamforth 1987:2 and references cited). These studies have been centered on the Great Plains of North America, with little research effort being extended to the Intermountain West. This was for good reason, since the Great Plains region is the heart of bison range (McDonald 1981a:Figure 23; Reynolds et al. 1982:Figure 49.1). Ecology of pre-Euroamerican bison in the Intermountain West is generally poorly understood, based almost exclusively on the study of managed herds on public lands (e.g., Meagher 1973), a few archeological investigations (Butler 1971a; Butler et al. 1971; Swanson 1972; Agenbroad 1976), and anecdotal descriptions by early explorers or trappers (e.g., Newberry 1857; Cutright 1989).

In a recent article, Van Vuren (1987:65) reviews the current debate on the distribution and occurrence of bison west of the Rocky Mountains, identifying four possible explanations for their low density: (1) the relative isolation of the region, coupled with human-caused mortality; (2) low protein content of available forage; (3) "lack of synchrony between forage plant phenology and the bison reproductive cycle"; and (4) periodic severe winters that caused catastrophic die-offs without significant replacement. In his view, the low carrying capacity of the steppe communities in the west and the periodic local extinctions followed by low recruitment both contributed to a low density of bison west of the Rocky Mountains (Van Vuren 1987:67). While the low carrying capacity of the steppe communities in comparison with the Great Plains has been demonstrated, the ability of bison to adapt to local conditions is also demonstrated in the literature. For example, significant consumption of sedges and browse has been noted among bison occupying riverine and woodland habitats (Borowski et al. 1967).

In 1995 the skull of a Late Holocene bison was recovered from the Salmon-Challis National Forest. It provided an opportunity to apply a number of laboratory techniques in order to determine the types of foods that provided sustenance for the bison, and thereby possibly determine its migration patterns. For example, did it live solely in the uplands or were there seasonal migrations into the valleys. In order to address the issue of diet and migration, three techniques were applied to samples collected from the bison: extraction and identification of phytoliths and pollen from calculus, extraction and identification of macrofossils from impacta, and stable-isotope analysis.

Microscopic analysis of tooth tartar and the plant fragments trapped and preserved in the infundibulum of the cheek teeth can provide information on diet and ecology (Guthrie 1990:176-177, 1992). Another means of assessing diet and ecology is the analysis of bone collagen and apatite for carbon isotope variation. Cool (C_3) and warm (C_4) weather grasses have been demonstrated to have distinct ratios of ^{13}C to atmospheric CO_2 due to their particular photosynthetic processes. By analyzing the carbon isotope relationships of animal bone we can begin to understand their diet, and possibly their seasonal migration patterns.

This information also has implications for a number of social and ecological issues (Van Vuren 1987:65), such as the management and restoration of ecosystems (Lyman 1996), plant ecology and evolution (Daubenmire 1978; Stebbins 1981; Mack and Thompson 1982), zoogeography (Lyman and and Livingston 1983), and ethnography (Bamforth 1988).

Even though the following report focuses on a number of issues relating to bison from the upper Salmon River country of east-central Idaho, adjacent regions are also included. This report should be considered as a first attempt at bringing together a number of issues concerning intermountain bison ecology and not as an end in itself.

Environment

Modern Environment

The mountainous region of north-central Idaho is classified within the Central Rocky Mountain biotic zone. Fawn Creek, which originates on the northern slope of Swan Peak, is a tributary of Panther Creek, which flows into the main fork of the Salmon River. The headwaters of Fawn Creek are at about 2,256 m (7,400 ft) AMSL. The drainage is generally steep and narrow, with a Douglas fir (*Pseudotsuga menziesii*) dominated overstory and western and southern aspects vegetated with open sage/grass communities. Lodgepole pine (*Pinus contorta*) is also present in the overstory, with subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) on the more northerly and mesic sites. It was along the northern bank of the creek at about 2,134 m (7,000 ft) amsl that the skull was recovered (Figure 1). The following environmental section is produced from a review of vegetational communities in Idaho and from information provided by Salmon-Challis National Forest District Silviculturalist Breck Hudson and District Wildlife Biologist Diane Schuldt.

Common understory species within the mesic Douglas fir community include bearberry (*Arctostaphylos uva-ursi*), grouse whortleberry (*Vaccinium scoparium*), elk sedge (*Carex geyeri*), Ross' sedge (*Carex rossii*), pinegrass (*Calamagrostis rubescens*), heartleaf arnica (*Arnica cordifolia*), sticky geranium (*Geranium viscosissimum*), and raceme pussytoes (*Antennaria racemosa*). Grasses include Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*). Both of these species are important forage for both stock and game animals (Davis 1952). The distribution and abundance of these major species is controlled by slope aspect and edaphic conditions—bluebunch wheatgrass is more abundant on dry slopes and flat areas and Idaho fescue on protected slopes (Daubenmire 1952:4-5).

In more xeric areas, such as south and west aspects, lodgepole pine is mixed among the Douglas fir. Single or small groups of Douglas fir are found interspersed on these more open slopes, with sagebrush and bunchgrasses common. On these drier sites, understory species include mountain mahogany (*Cercocarpus ledifolius*), bitterbrush (*Purshia tridentata*), mountain big sagebrush (*Artemesia tridentata vesevana*), mountain snowberry (*Oreophilus symphoricarpos*), Idaho fescue, bluebunch wheatgrass, arrowleaf balsamroot (*Balsamorhiza sagittata*), sandwort (*Arenaria* spp.), lupine (*Lupinus* spp.), and biscuitroot (*Lomatium* spp.).

Downstream in the Salmon River Canyon in unforested areas there occur steep, dissected drainages and typically steep, convex bunchgrass slopes, with numerous outcrops containing mountain mahogany and locally dense patches of Glossopetalon (*Glossopetalon nevadense*). Conifer community types include xeric Douglas fir and ponderosa pine.

The deeper soils in these areas allow for a more developed grassland community. The grass community commonly consists of Stipa (*Stipa* spp.), oatgrass (*Danthonia* spp.), and bluegrass (*Poa* spp.). Other important species include lupine (*Lupinus* spp.), Indian paintbrush (*Castilleja* spp.), geranium, prairie smoke, potentilla (*Potentilla* spp.), crazyweed (*Oxytropis* spp.), onion (*Allium* spp.), and mariposa lily (*Calochortus* spp. [Steele et al. 1981]). Forbs, such as *Astragalus* spp., arrowleaf balsamroot, and yarrow (*Achillea lanulosa*), are also common, but they never dominate the grasses (Daubenmire 1952:4-5).

Although the previous review of vegetation communities may be an appropriate initial assessment, community structures change through time and space in respect to local variabilities such as exposure and edaphic conditions. Climate data from the Frank Church-River of No Return Wilderness indicate the

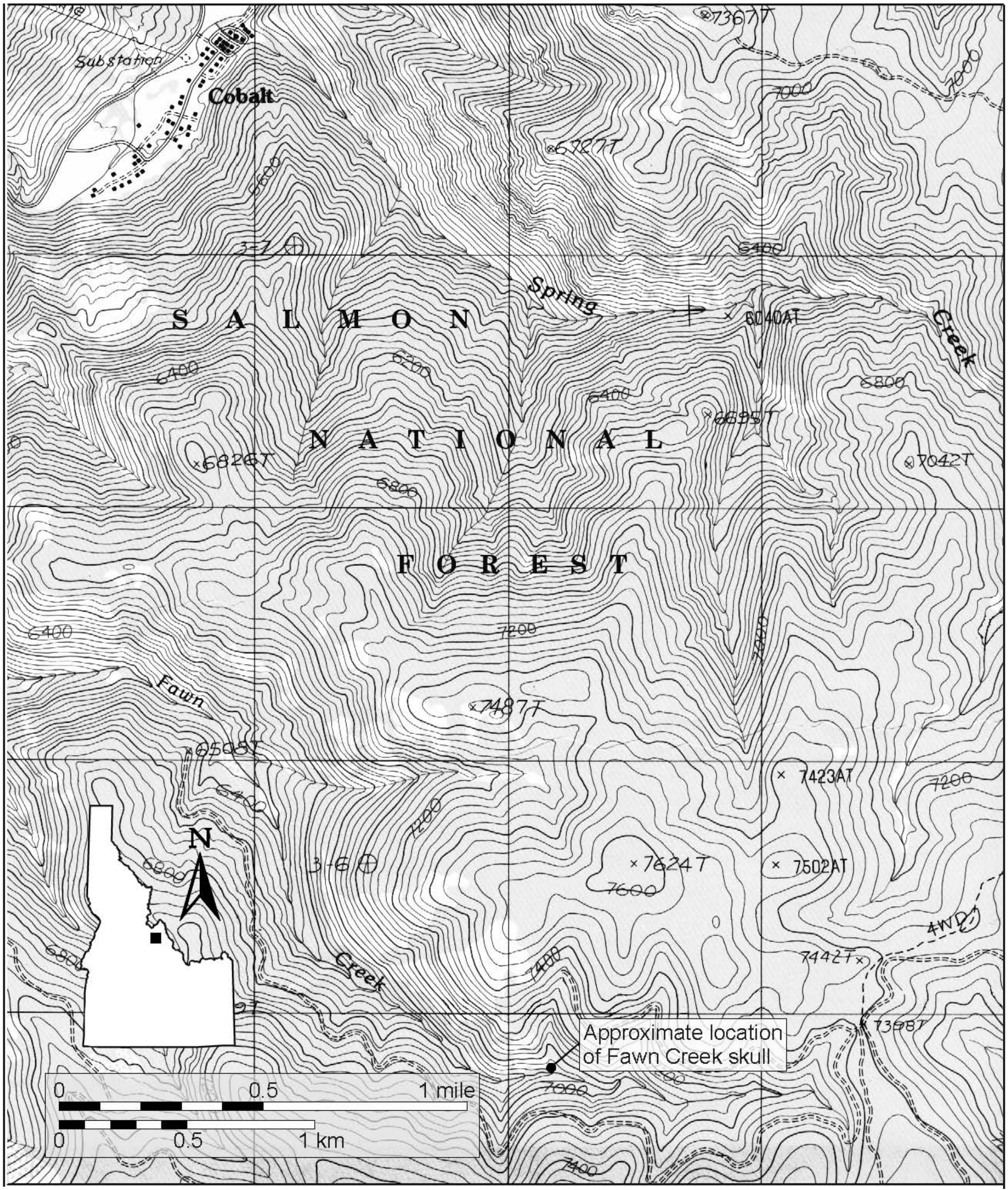

Figure 1. Find location of the Fawn Creek bison skull. Reproduced from U.S. Geological Survey Cobalt, Idaho, 7.5 minute topographic quadrangle.

complex, rugged terrain has significant influence over weather patterns (Finklin 1988), an important consideration for vegetation community structure and ungulate grazing. Environmental perturbations, such as fires, are also an important source of community change. During the course of the Holocene, broad-scale vegetational community structure has changed due to shifts in climatic patterns (Thompson et al. 1993), with more localized change being the result of human activities (Barrett 1981) as well as climate. Due to the recent age of the bison, the Late Holocene environmental sequence will be considered and its possible influence on available vegetation and ungulate populations.

Paleoenvironment

The Late Holocene (6000 B.P. to present) has previously been viewed as a period when little change occurred (e.g., Mehringer et al. 1977). However, with improved methodological techniques researchers have been able to interpret climatic proxy data in greater detail, increasing their ability to determine when shifts in climate and vegetation have occurred (Thompson et al. 1993). Moister, cooler conditions of the Late Holocene have been labeled the *Neoglacial* and *Neopluvial*, but regional studies have shown these conditions to be time-transgressive and elevationally variable even over relatively short distances (Thompson et al. 1993:492, 495). For example, at Grays Lake in southeastern Idaho cooler, moister conditions occurred between 7100 and 5800 B.P. (Beiswenger 1991), while in Yellowstone National Park this occurred around 1600 B.P. (Gennett and Baker 1986).

A pollen record from Lost Trail Pass, at an elevation of 2,152 m in the Bitterroot Mountains, provided a 6.7-m sediment core that records the vegetation history of the last 12,000 years (Mehringer et al. 1977). The record of the last 4,000 years did not reveal any "readily interpretable fluctuations in pollen content that suggest important changes in forest composition" (Mehringer et al. 1977:367). A cooler and/or moister climatic interval is suggested by deepening water in the pond between 3700 and 3450 B.P. Although no drastic changes in the vegetation are indicated, an increase in charcoal during the last 2,000 years is interpreted as evidence for frequent small (or low to medium intensity) fires, possibly due to changing patterns of human land-use (Mehringer et al. 1977:366).

Frequent and recurrent fires can produce a mosaic of different-aged stands, or an environment of high diversity (Cannon 1996:4). Post-fire studies of lodgepole pine succession indicate that the number of species of plants, birds, and mammals increases continuously for about 25 years following fires, then decreases rapidly following canopy closure (Taylor 1969). Increased fire frequency and the opening of forests may have had significant effects on local bison populations occupying the forested mountains.

To the southeast in the Pahsimeroi River Valley, James Chatters (1982) extracted a pollen core from Bisonweh Pond on the east side of Spring Creek near Doublespring Pass. The pond was formed by the impoundment of a spring-fed creek after a massive landslide and provided a pollen record for most of the Holocene. Although Chatters (1982:Figure 48) analyzed the entire pollen column, his discussion is limited to the last 500 years. One reason for this is that the record shows very little change in the structure of the vegetation community over the last few thousand years, and secondly he was mainly concerned with discerning whether cultural selection or climatic change was responsible for shifts in various ungulate ratios, specifically bison to antelope, during the Late Holocene. The correspondence of the ratio of sagebrush to grasses with that of bison to antelope remains recovered from Buck Creek Cave is compelling and led Chatters (1982:357) to suggest climate may be responsible for these shifts in availability.

To further test the role of climate on ungulate species availability, Chatters (1982:370-385) cored several Douglas fir and limber pine in the vicinity of Doublespring Canyon in order to develop a local dendrochronological record for assessing past local climatic conditions. His results indicated a period of aridity from 1013 to 600 B.P.[1], with fluctuations between slightly moist and very dry conditions having a periodicity of less than 100 years. There is then a shift to consistently moist conditions with rare dry periods from 600 to between 300 and 350 B.P. Another drying trend began about 250 B.P., lasting to around 100-150 B.P., with moister conditions occurring during the last 50 years. However, the last 75 years are more accurately described as a period of extreme variability in weather patterns, with wet conditions being prevalent from 50 to 25 B.P., followed by extreme drought lasting to after 10 B.P. This pattern is similar to that of the Great Plains (Bozell 1995).

According to Chatters (1982:388-389), the proxy data indicates climatic shifts significant enough to affect the population dynamics of the valley's ungulates, particularly the ratio of antelope to bison, which in turn impacted the antelope-dominated economic system of the valley's residents who began to prey upon the more common bison.

Shifts in climatic patterns can have significant influences on local vegetational communities, influences that depend for their effect on a number of other factors that include elevation, edaphic conditions, and slope aspect. And as a result, climatic change and the accompanying vegetational changes can have different results on the populations of foraging ungulates. During periods of cool, moist conditions forage quality can be expected to improve, with a corresponding increase in ungulates. This is generally what is believed to have occurred on the Great Plains between A.D. 1500 and A.D. 1700 (Reher 1978; Bozell 1995) and possibly in the Pahsimeroi Valley during this period (Chatters 1982).

In a recent simulation model for historic vegetation communities in the Upper Columbia River Basin, Keane et al. (1997) suggest that Douglas fir sites were more open prior to 1850, with lodgepole pine numbers reduced. The openness of these sites is believed to have been maintained by more frequent non-lethal ground fires. Under these more open conditions grass and forbs, which require higher intensity light, were probably more abundant.

However, as grassland biomass increased, so too did forest cover. With increased effective moisture, disturbances such as fires also decreased, forest canopies closed, and encroachment occurred on open meadows. This pattern reduced bison populations from these areas due to a reduction in forage. While this scenario may be simplistic, it does provide a model of how "improved" climatic conditions have significantly different effects upon bison populations in two adjacent biomes.

As is apparent from this short review, proxy climatic data has shown significant differences in local environmental conditions over relatively short distances. These patterns may be due to a number factors including preservation and the ability to discern small-scale shifts, as well as orographic effects.

[1]Chatters (1982), when discussing the timing of climatic conditions, refers to ages derived from dendrochronology studies as B.P. These ages should be referenced to A.D. 1975 and not confused with radiocarbon years designated as B.P. and referenced to A.D. 1950.

Prehistoric Evidence of Bison in the Region

Introduction

During the past five decades a number of archeological investigations have been conducted within the Salmon River drainage of central Idaho (Figure 2). While problem-oriented archeology has been conducted for a long period of time, it has not been a continuous process. The most ambitious of these endeavors were those designed by Earl H. Swanson, Jr., of Idaho State University. While the efforts of Swanson, his colleagues, and students are laudable, their work only scratched the surface in providing an understanding of the region's prehistory, and recently their methodologies and interpretations have come under criticism (Lohse and Sammons 1994). Since this time, few research-driven investigations have been conducted, and much of the work, as in most parts of the country, has been driven by the Section 106 compliance process of the National Historic Preservation Act of 1966.

Eleven sites in the three-county area of north-central Idaho (Custer, Lemhi, and Valley) have faunal remains reported from subsurface deposits (Table 1). This represents 49 components dating from the terminal Pleistocene into the historic period for which ungulate remains are reported. Of these 49 components, 22 contain bison or cow/bison elements. Further afield, bison remains have been recovered from paleontological and archeological contexts from at least the last 15,000 years.

Birch Creek Valley Investigations

Under the direction of Earl H. Swanson, Jr., the Birch Creek Valley investigations were begun in 1958 as part of an agreement between the National Park Service and the Idaho State College (now Idaho State University) for the survey and inventory of proposed reservoirs in the Snake and Salmon river systems in order to begin a systematic appraisal of Idaho's archeological resources (Swanson et al. 1959). Two of the major questions set for the Birch Creek investigations to answer were: "(1) whether the Northern Shoshoni were recent migrants or old inhabitants of the northern Rocky Mountains, and (2) whether they were big game hunters before or after the arrival of the horse" (Swanson 1972:187).

Two rockshelters in the Birch Creek Valley (Figure 2) were selected for further investigation based on their potential for a long stratigraphic sequence (Swanson and Bryan 1964). From 1960 through 1967, studies of natural and cultural deposits were conducted near the ecotone between the Snake River Plain to the south and east, and the Northern Rocky Mountains to the north and west. Support for these studies came from the National Science Foundation.

A detailed overview of the work is presented in Swanson (1972) and need not be repeated in detail. However, some of the important results of this work and its implications for the current understanding of the region's cultural and environmental history, specifically the presence of bison, will be discussed.

Based upon the work in the Birch Creek area, as well as at other sites in the region (e.g., the Shoup Rockshelters), Swanson (1972:187) identified five cultural phases, all of which are included within the term *Bitterroot Culture*, which he argues represents "the archaeological expression of the Northern Shoshoni." Swanson's (1972:65-66) cultural chronology was based on the "recurrence [of artifact types] in superimposed natural layers and, secondly, upon related changes in proportions of artifact types to one another." The socioeconomic pattern expressed archeologically is one of big game hunting and food collecting coextensive with the sagebrush-grassland or prairie communities of the northern Rocky Mountains of eastern Idaho and extending out onto the Snake River Plain (Swanson et al. 1964). He goes on to suggest this pattern developed potentially due to the abundance and diversity of game associated with the locally diverse intermontane ecosystem (Swanson 1972:187).

Table 1. Archeological sites in region which produced ungulate faunal remains. Bison abundance at each site is presented as number of identified specimens (NISP) and minimum number of individuals (MNI).

SITE	AGE OF DEPOSIT	ABUNDANCE OF BISON (NISP/MNI)
Challis Bison Kill (10CR196)	Layer la/b Mid-nineteenth century based on glass trade beads.	Poorly preserved faunal remains, but Butler (1971b:6) estimates 20-30 bison were killed in single event.
Quill Cave (10CR197)	Stratum 2 1270 ± 90 BP	359/11
10CR334	Soil 4 1985 ± 100 BP	2/-
	Soil 3 1435 ± 80 BP	2/-
	Soil 1	19/-
Buck Creek Cave (10CR525)	30-40 cm 300-500 BP	1/-
	20-30 cm 150-300 BP	5/-
	10-20 cm 75-150 BP	5/-
	0-10 cm <75 BP	3/-
10CR526	Area T, Stratum 1	8/-
	Area T, Stratum 2	13/-
	Area R, Stratum 1 225 ± 95 BP	1/-
Weston Canyon Rockshelter (10FR4)	Layers 3/4 (1969) ca. 1500-200 BP	-/4
	Layers 4/5 ca. 2500-3000 BP	-/2
	Layers 6/7/8 3740 ± 147 BP	-/1
	Layer 9 ca. 5000 BP	-/1
	Layers 12/13 >5000 BP	-/1

Table 1. (concluded).

SITE	AGE OF DEPOSIT	ABUNDANCE OF BISON (NISP/MNI)
Wilson Butte Cave (10JE6)	Stratum C 6850 ± 300	-/1
	Stratum B 940 ± 120	-/2
	Stratum A 425 ± 150	-/2
Veratic Rockshelter (10LH3)	Birch Creek Phase 10,950-7150 BP	3/2
	Bitterroot 7150-3400 BP	7/3
	Beaverhead 3400-2900 BP	128/22
	Blue Dome 2900-700 BP	319/38
	Lemhi 700-100 BP	77/13
Bison Rockshelter (10LH10)	Birch Creek Phase 10,950-7150 BP	20/4
	Bitterroot 7150-3400 BP	37/9
	Beaverhead 3400-2900 BP	32/5
	Blue Dome 2900-700 BP	153/33
	Lemhi 700-100 BP	478/41
Corn Creek (10LH124)	Dwelling 5 1280 ± 50 BP	1/1
Malad Hill (10OA2)	Occupation II 950 B.C. to A.D. 1250	Indicated as present only.

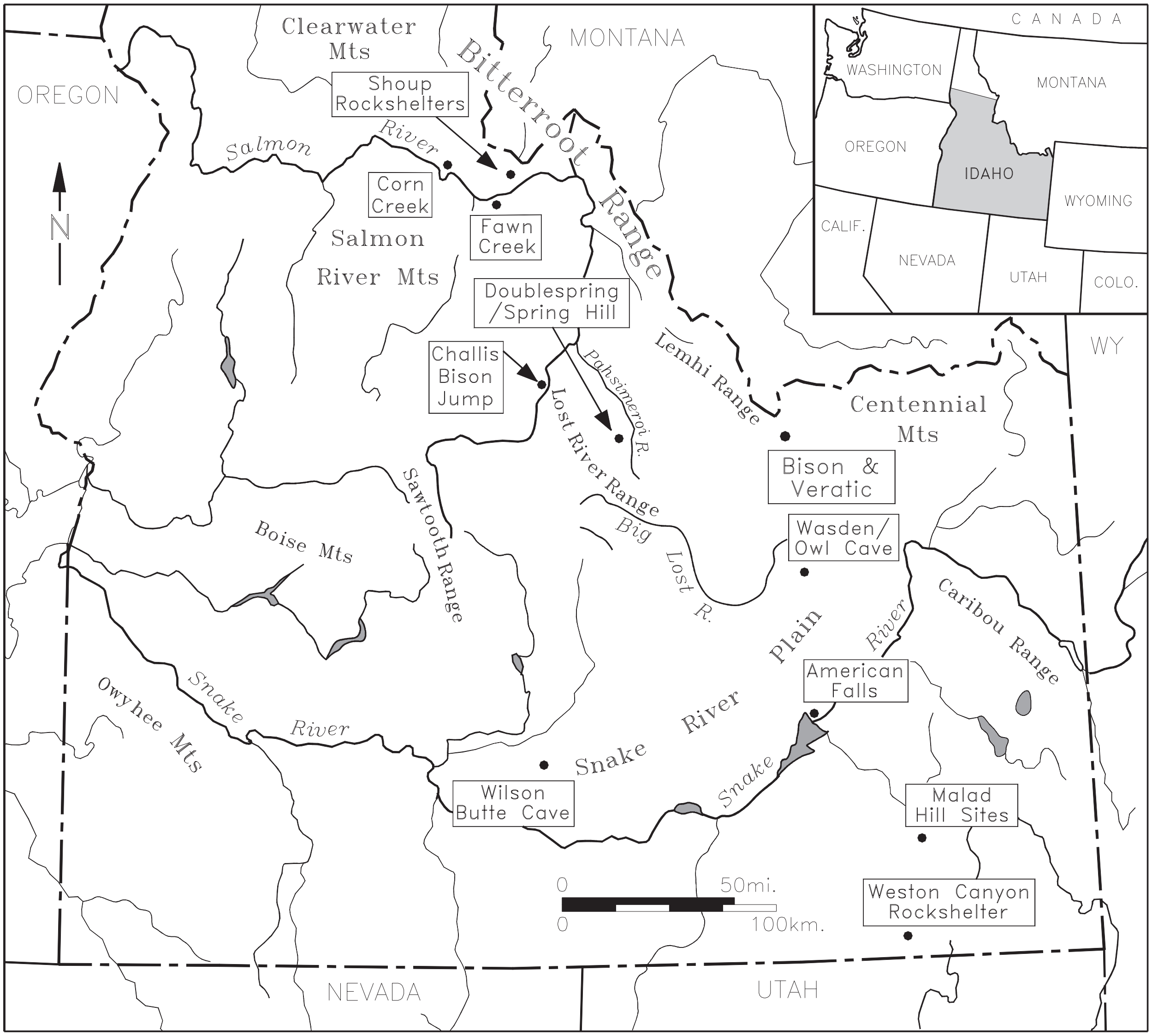

Figure 2. Regional archeological and paleontological sites in which ungulate remains were recovered.

The earliest archeological phase within the Bitterroot Culture, *Birch Creek*, dates between 10,950 to 7,150 years ago and corresponds to Swanson's *Period II* climatic episode, which is described as primarily cold and moist but drier at the beginning of the period and at the end. The socioeconomic organization of these groups centered around the hunting of big game, specifically bison (Swanson 1972:92).

Although the faunal assemblage from Veratic (10CL3) and Bison (10CL10) rockshelters is limited for this time period, bison are the dominant large mammal remains recovered (Figures 3-4). While bison were the only ungulate elements recovered at Bison Rockshelter during this time period, antelope and bighorn sheep, as well as bison, were recovered from Veratic Rockshelter (Swanson 1972:Tables 16-19). Two radiocarbon ages were obtained from this unit: 10,340 ± 830 B.P. on unburned bison bone from Layer 32b and 6925 ± 200 B.P. on charcoal from Feature 23 in Layer 30 (Swanson 1972:91).

Swanson's grouping of lanceolate projectile points through four different geologic periods (in his terms [Swanson 1972:91] Depositional Periods) led him to argue that these points span the time period from 8400 to 950 B.C. Criticisms of chrono-stratigraphic problems such as this, and of the basic cultural historical reconstruction, have recently been articulated in the literature. This is in large part due to Swanson's "fieldwork methodology wherein cultural features and occupations were lumped stratigraphically within gross natural depositional units, and the cultural phases *a priori* made synonymous with inferred climatic and accompanying erosional cycles" (Lohse and Sammons 1994:36; italics in original).

Large, side-notched projectile points, labeled Bitterroot points, characterize the Mid-Holocene Bitterroot archeological phase. Coextensive with the Bitterroot phase is Swanson's (1972:55) Depositional Period III, which is "distinguished by thick eolian silts which alternate with colluvial fan gravels .... [indicating] a marked aridity at that time .... The rest of the Period alternates stream flood gravels with eolian silts and this situation appears to represent alternation of semi-arid with arid conditions." However, Swanson (1972:56) cautions that these extreme conditions of aridity were not uniform throughout the period. By about 5,800 years ago conditions become cool and moist, with deposition marked by thick roof fall deposits (Swanson 1972:56). Six radiocarbon ages from Veratic Rockshelter are assigned to this period. These ages range from 6282 ± 229 to 3995 ± 470 B.P. (Swanson 1972:Table 1). During this time period, Pleistocene megafauna are replaced by Holocene ungulates (e.g., bison and bighorn sheep), which became prey for these groups .

A much more diverse assemblage of large mammal elements was recovered from the Birch Creek rockshelters' Bitterroot deposits. At Veratic Rockshelter (10CL3) bighorn sheep dominate the assemblage, followed by antelope, deer, and bison (Figure 3). Bison continue to dominate at Bison Rockshelter (10CL10), although bighorn sheep are nearly as numerous (Figure 4). Other ungulate species include deer, antelope, and elk (Swanson 1972:Tables 16-19).

Deposits of silt and periodic episodes of sheet flooding are apparent during the Beaverhead phase, indicating semi-arid conditions. Swanson (1972:60) suggests a further refinement of this period: an earlier arid interval represented by eolian deposits, followed by a period of cool, moist conditions, and then a return to semi-arid conditions.

Bison were again the dominant fauna taken during this time period, as indicated by the identified elements from the Birch Creek rockshelters. However, at Veratic Rockshelter the ungulate assemblage is more diverse than at Bison Rockshelter, and includes bighorn sheep, antelope, deer, and elk (Figure 3). Bison, sheep, and deer are the only ungulate species represented at Bison Rockshelter (Swanson 1972:Tables 16-19; Figure 4).

The Blue Dome phase is characterized by an increase in the reliance on corner-notched points over side-notched points. Swanson (1972:194), in citing

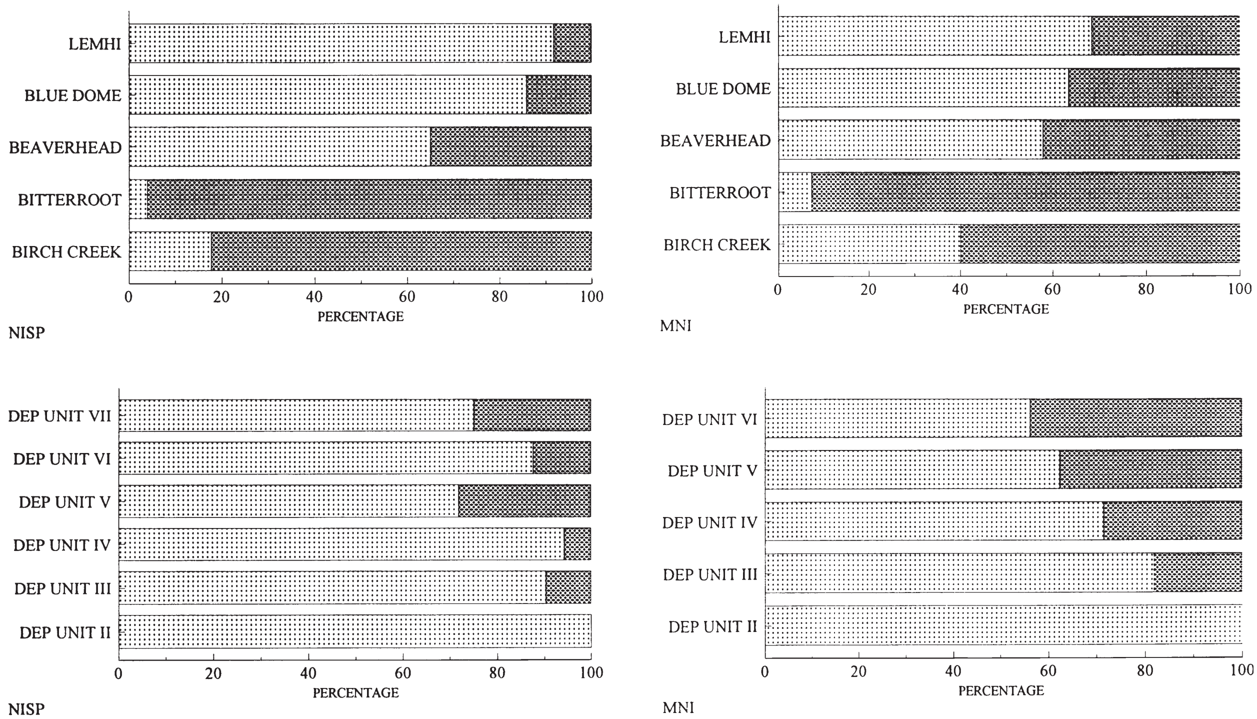

Figure 3. Bar graph of relative percentages of bison and other ungulates recovered from Veratic Rockshelter (10LH3). Upper charts are organized using Swanson's cultural chronology, while the lower charts are his depositional units. Bison percentages are represented on the left side (light shading) of the graphs.

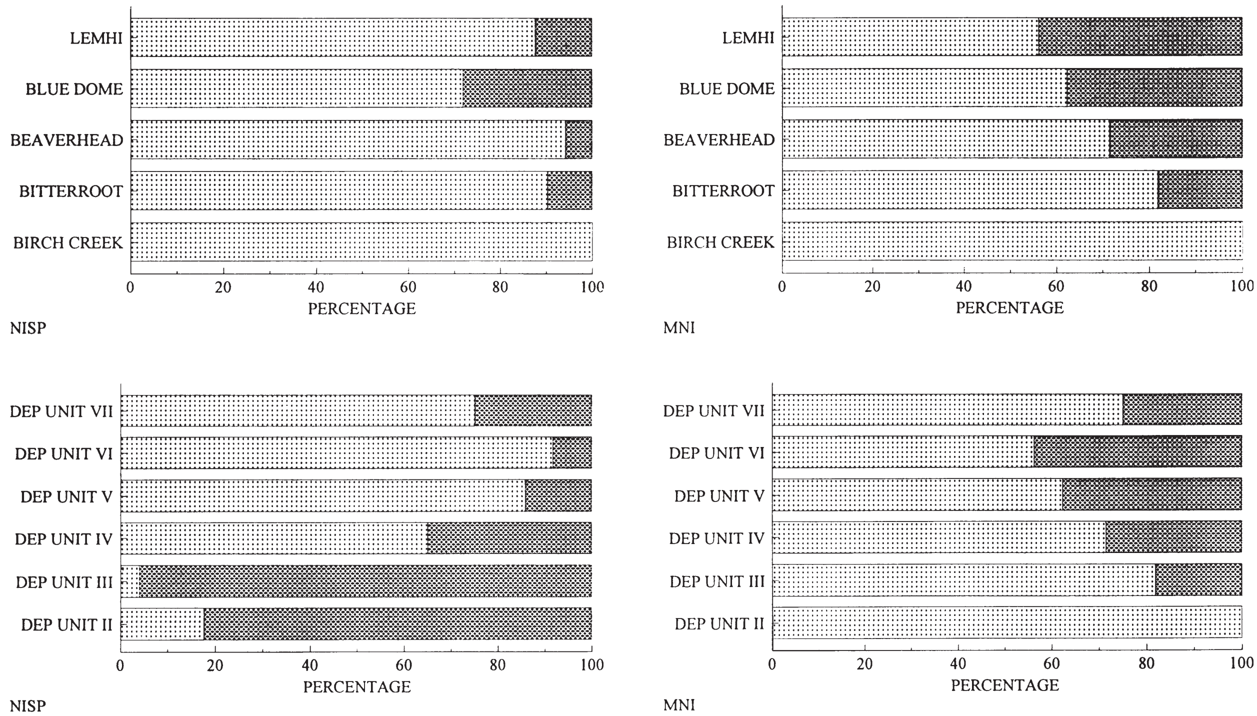

Figure 4. Bar graph of relative percentages of bison and other ungulates recovered from Bison Rockshelter (10LH10). Upper charts are organized using Swanson's cultural chronology, while the lower charts are his depositional units. Bison percentages are represented on the left side (light shading) of the graphs.

other region reports, suggests that projectile point styles are indicative of ethnic and subsistence patterns. For example, corner-notched points are associated with Shoshone bighorn sheep hunting, while side-notched points were used exclusively for hunting bison.

More bison appear in deposits attributed to this time period than bighorn sheep by a ratio of about 3:1, suggesting to Swanson (1972:193) that hunting was concentrated on the sagebrush-grassland community (Figures 3-4). However, Swanson (1972:194) goes on to suggest that bison density may have been reduced at this time, and hunting may have been reduced to trapping local herds under conducive topographic situations.

The Lemhi phase is the final period of aboriginal occupation beginning about 700 years ago and continuing into the historic period. During the beginning of this period eolian deposits indicate a brief episode of aridity. However, the climate appears to stabilize and moist, cool conditions eventually dominate (Swanson 1972:60-61).

Bison again dominate the assemblages (Figures 3-4). Cool, moist conditions may have influenced a resurgence in the grasslands benefitting the bison populations. Cool, moist conditions would have had a positive influence on forage quality. In response to high forage production, Bamforth (1988:Table 6-1) proposed that bison would respond with high population density, large herds, and herds that move slowly, over shorter distances, and within smaller home ranges. In effect, bison would become more predictable prey for hunters.

Bozell (1995) archeologically illustrates this pattern for the Central Plains, where bison remains increased as a response to conducive climatic conditions. However, he does caution that this pattern may be more apparent than real due to a number of socioeconomic decisions, as well as preservation and archeological recovery techniques.

As we noted previously, criticism has recently been leveled at Swanson's work, particularly his assumption that shifts in the popularity of specific artifact types were indicative of socioeconomic shifts due to environmental change (Lohse and Sammons 1994:36). These authors argue that broad-spectrum hunter-gatherers occupying this region in the past developed a very flexible economic system that allowed them annual, and even seasonal, responses to shifting resource availability. They further argue that the scale of environmental change documented for the region would "never have been noticeable within a human generation let alone seasonally, and the consistently successful cultural adaptation should never have felt significant stress or have had to alter basic socioeconomic organization" (Lohse and Sammons 1994:36).

What is important for this study is the persistence of bison throughout the record as an important prey species for aboriginal hunters. Bison appear to have been locally available, and in most instances may have been preferred over other large game.

Shoup Rockshelters

The Shoup Rockshelters, Alpha (10LH23) and Beta (10LH63), were initially documented in 1965 during a Forest Service road survey by Idaho State University students (Figure 2). A number of sites were identified for testing due to their proximity to the road project, two of which were the Shoup Rockshelters. The results of the testing indicated a long sequence of stratified natural and cultural deposits imperative for understanding prehistoric human-environmental relationships for the region. Swanson and Sneed (1966:1) outlined research problems that could be addressed by the deposits within the rockshelters:

> we knew there was a natural sequence that could be compared with Birch Creek, and which would, therefore, form a common standard for comparison of potentially differing culture sequences. Secondly, the Shoup Rockshelters were 150 miles away from Birch Creek, and 3,000 feet lower in altitude

> than the Bison and Veratic Rockshelters near Blue Dome. Thirdly, the Shoup sites were on the Salmon River at the northern boundary of Northern Shoshoni territory in the 19th century ..., so that relations with Plateau cultures and the Plains might show up in the archaeological record. A fourth consideration was the fact that Birch Creek opens onto the Snake River Plain, where Clovis, Folsom, and other lanceolate points have been found in large numbers, while the overhangs on the Salmon River were more deeply within the Northern Rocky Mountains. The net effect of the excavations at Shoup would be to provide a link in an east-west transect of stratified archaeological sites in the Pacific Northwest, which extend from British Columbia to eastern Idaho.

The rockshelters were excavated in geologic units using the same methodology applied to the Birch Creek rockshelters. Based on the projectile point styles and radiocarbon dates, occupation of the shelters probably dates back to the early Mid-Holocene and continued into the Late Holocene. A number of radiocarbon ages were obtained from soil deposits that at best represent minimum ages for soil formation. However, two of the ages were from shell and may not be accurate.

An interesting aspect of the shelters is the difference in the intensity of use between the two. At Beta, few artifacts were recovered in comparison with Alpha, suggesting less intense use of the site through time. Differences in material type selection and artifact class between the Shoup and Birch Creek rockshelters is also described by Swanson and Sneed (1966:25). While both areas illustrate the greatest use during Swanson's Bitterroot phase, intensity of use at the Shoup shelters decreases dramatically during later times. Swanson and Sneed (1966:25) suggest this may be ecological in origin, but further data from the Salmon River Valley is necessary before this can be adequately addressed.

Faunal remains from both Alpha and Beta rockshelters are dominated by bighorn sheep, with deer and undifferentiated artiodactyl also present in varying percentages (Henrikson n.d.). No bison remains were recovered from either of the rockshelters, which may be a reflection of their availability or of game preference.

As with the Birch Creek Valley excavations, the interpretations made from the Shoup deposits are of limited value, mostly because of excavation methodologies that did not distinguish cultural deposits from natural ones (Lohse and Sammons 1994).

The Challis Bison Kill (10CR196) and Quill Cave (10CR197)

At the foot of the Salmon River Mountains, near the mouth of Warm Springs Creek, a bison kill site was excavated in the summer of 1970 by Idaho State University students and volunteers under the direction of B. Robert Butler (Figure 2). The kill area excavations were concentrated at the foot of the talus slope extending out onto the alluvial terrace. The deposits lie at the base of a steep escarpment that forms the north wall of the Salmon River Canyon. The escarpment is dissected by two lateral stream-cut canyons that bracket what is interpreted as the drive lane and jump (Butler 1971b:4-5).

Excavations revealed at least two stratigraphic occupations dating to the Late Holocene. The lower component (Layer 1c) produced a lithic assemblage of 20 items, including several types of projectile points. These include "Bitterroot side-notched, broad and sharply-barbed corner-notched, and stemmed, indented base" types (Butler 1971b:7). A radiocarbon age of 1030 ± 159 B.P. (SM-1354) was obtained from a charcoal sample at the surface of this deposit. Butler (1971a:7) assigned this assemblage to the Beaverhead phase following Swanson's Birch Creek chronology (cf. Swanson et al. 1964). The range of projectile point types and the problems associated with Swanson's chronology (cf. Lohse and Sammon 1994), plus Butler's (1971a:6) description of possible soil development in this stratum, would imply an accretional deposit of artifacts over time, and not a single event.

The upper component (Layer 1a/b), dated to the early historic period, consists of 175 lithic artifacts and poorly preserved bison bone. Due to the poor preservation, a minimum number of individuals could not be determined. But Butler (1971a:6) suggests at least 20-30 animals were killed in this single event.

His MNI is based on the number of projectile points (n=117) recovered divided by an average of 4 to 5 points it would take to kill each bison according to Ewers (1955:155) ethnographic account of bison hunting among the Blackfoot.

Projectile point styles associated with this component include Cottonwood Triangular, several varieties of Desert Side-notched, Elko Earred, and one which Butler (1971a:8) refers to as Bitterroot Side-notched. The mid-nineteenth-century date for this component is based on the projectile point styles and glass trade beads (Butler 1971b:13). Two features were also associated with this component downslope and downstream from the kill area, although no bone was found associated with them. These features have been interpreted as representing areas for heat-treating lithic materials and not for cooking or roasting bison (Butler 1971a:6-7). Radiocarbon dates were not obtained from this unit. The mix of projectile point styles suggests to me that this component may also be accretional and not a single event. One way of assessing this problem would be through obsidian-hydration dating of the projectile points, although this can be problematic even under what are considered ideal situations (e.g., a deep, well-stratified rockshelter; Thomas 1983:410).

Another deposit(s) investigated at this time was Quill Cave (10CR197), a small cavity in the escarpment at the head of the talus slope. Four depositional units were recognized in the cave that extend to a depth of approximately 1.5 m before reaching bedrock. The cultural assemblage was limited, represented by only four projectile point fragments and debitage (Butler 1971b:12).

Stratum 2, dated to 1270 ± 90 B.P., produced faunal remains of sage grouse, *Sylvilagus*, *Lepus*, porcupine, marmot, coyote, wolf, bighorn sheep, and bison. This deposit has been interpreted as representing material dragged to the cave by carnivores (e.g., coyote or wolf) using it as a den. The cultural material presumably predates the use of the cave as a carnivore den (Butler 1971b:12-13).

As Butler (1971a:13) has pointed out, the site provides important information on the population dynamics of bison in the region during the later part of the Holocene, as well as a broader view of subsistence patterns of prehistoric groups using the area. The projectile point assemblage of corner-notched and side-notched points from the same stratigraphic unit is problematic and implies multiple episodes of use. However, recent excavations at the Dagger Falls site (10VY76) on the Middle Fork of the Salmon River provide similar “mixed” assemblages from dated stratigraphic units (Torgler 1993). One means of addressing the issue of chronology would be the geochemical analysis and obsidian-hydration dating of the projectile points. The sample of points manufactured from volcanic glass is large enough to allow meaningful interpretation. Taphonomic investigations of the bone, in the context of recent studies of bone beds by Todd and Rapson (1991), is probably not possible due to the poor preservation. However, in the light of more recent regional investigations and advances in methodologies, more definitive answers to some of the issues raised may be possible through reanalysis of collected materials.

James Chatters' Dissertation Research

Building on data and models developed by Swanson and his colleagues during the Birch Creek investigations, James Chatters (1982) sought to investigate local human adaptation in the Pahsimeroi Valley. An area of the Upper Pahsimeroi Valley was selected by Chatters (1982:77) for its ability to meet the geologic, biotic, and archeological criteria he identified. A major topographic feature of the project area is Spring Hill, an isolated block of Mississippian limestone and Tertiary volcanics (Figure 2). Other important features include Doublespring Creek and Pass, Mahogany and Burnt creeks, and the Pahsimeroi River and alluvial fan.

A pedestrian survey of various tracts in the project area was the initial step in identifying potential sites for further investigation. Documented locales were defined by functional class and time period for investigating temporal patterns of settlement and land use. In addition, Chatters chose to partially excavate three sites, two open sites and one rockshelter in order to more fully assess environmental and socioeconomic patterns. Site 10CR334 is an open site on the lowest terrace on the east bank of the Pahsimeroi River opposite the mouth of Mahogany Creek. Ten 1-m^2 units were excavated in 20-cm arbitrary levels within geologic deposits over 1 m in depth (Chatters 1982:255-256).

Another open site (10CR526) was excavated on the toe of the Spring Hill landslide adjacent to an unnamed tributary of the Pahsimeroi River. Ten 1-m^2 units were excavated in 3-cm arbitrary levels. In addition to lithics and faunal remains, a Shoshoneware pot was recovered within one meter of a hearth (5 cm deep by 80 cm in diameter). Using the Spearman's Rank Correlation Coefficient to assess functional comparability of the two sites based on the recovered tool assemblage, Chatters (1982:267) concluded both sites operated similarly in the settlement system as domestic occupations.

Seven lithic occupations were identified in the excavations. Faunal remains from Periods 4-6 (ca. 100-2500 B.P.) were dominated by three ungulate species: bison, bighorn sheep, and antelope. Season of use appeared consistent through time as late spring to late summer based on a limited number of subadult ungulate mandibles. Temporal changes in the relative abundance of the ungulates and the distribution of sites and isolated finds in the area suggest shifts in settlement and group size, as well as hunting technology. Chatters (1982:283) observes that large groups were hunting small ungulates in open ground (antelope in the plain, bighorn sheep in rugged land) prior to 400 B.P., followed by a shift to small groups taking bison by ambushing them in riparian areas.

In order to assess whether the changes in the relative abundance of ungulates during the last 2,500 years was the result of cultural selection or a reflection of the availability of the various species in the local environment, Chatters (1982:285) made paleontological collections in the project area. He argued that changes in the relative abundance may possibly be due to shifts in the climatic regime that would favor one species over another. Collections came from two sources: (1) Buck Creek Cave (10CR525), a small limestone cave that had limited evidence of human occupation; and (2) surface deposits of modern carcasses along sample transects.

While discerning patterns of aboriginal lifeways encompassed a major portion of Chatters research, Euroamerican settlement and its response to climatic change was also investigated. Chatters taxonomically differentiated between aboriginal and Euroamerican settlements by referring to them as Lithic and Metallic Traditions, respectively. He notes that by A.D. 1879, the native Lithic Tradition was entirely supplanted "by a distinct adaptation using metal tools and relying on pastoralism of ungulates—cattle, horses and sheep. The settlement pattern had two forms: permanent buildings and corral complexes; and large, temporary campsites. Both were situated in the canyon mouths or along rivers and streams of the open plain. By 38 B.P. a new form of settlement, the small hunting camp, appeared, and gradually, along with a hunting-dominated pattern of land use, replaced its predecessor" (Chatters 1982:394). Chatters (1982:394) argues that climatic events after 400 B.P. were a key element of the "transposition."

By about A.D. 1850, cool, dry conditions shifted to weather patterns dominated by warmer, alternately dry and moist conditions until 1975, arguably affecting the carrying capacity of range lands. In relative terms, grass cover deteriorated and sagebrush increased, favoring antelope and mule deer over domestic stock. At this time, bison were largely extirpated from the region. By 20 B.P., proportions of cattle to antelope declined, while the horse and domestic sheep are absent. In the early 1970s, permanent settlements in the Upper Pahsimeroi Valley were almost completely abandoned, and only seasonal grazing of cattle was conducted. While pastoralism remains the predominant economic pursuit in the lower Pahsimeroi, the upper valley is used almost exclusively for hunting and fishing (Chatters 1982:396-397). Although the effect of shifting climate should not be ruled out as a factor in abandonment of ranching in the upper Pahsimeroi, other factors, such as the economics of sheep and cattle herding, and the impact of irrigation and overgrazing on the local system, should also be considered as contributing to, in Chatters (1982:396) words, "the fitness of the pastoral adaptation."

The extent of work conducted by Chatters has important implications for future studies and provides a plausible model for explaining interaction of local human systems and the biotic environment. As Chatters (1982:391) states "my purpose has not been to argue for or against specific causes of adaptive change in Central Idaho..." but "to demonstrate the feasibility of a method sensitive to evolutionary and ecological theory." This he accomplished.

Corn Creek

The Corn Creek site (10LH124) is downstream from the Shoup Rockshelters, and about 11 km downstream of the confluence of the Middle Fork and main Salmon River. Corn Creek is an open site consisting of at least 13 circular depressions within a 1,500 m^2 area on the north bank of the Salmon River (Figure 2). Limited excavations of the site were undertaken by the Idaho State University Field School during June and August of 1984 under the direction of Dr. Richard Holmer. Concern that the site was being severely impacted by camping and recreation use, the U.S. Forest Service contracted with Idaho State University to conduct data recovery excavations to mitigate further damage (Holmer and Ross 1985).

The ISU excavations at Corn Creek provide evidence of an extremely important resource for understanding prehistoric occupation of the upper Salmon River. The high degree of preservation and the time depth represented have led the authors to recommend the site as potentially eligible for National Register inclusion. Another important aspect of the site is its interpretive value. Since the site is easily accessible and in an area heavily utilized, it makes an excellent candidate for an interpretive display for educating people on the prehistory of the region and the value of archeology (Holmer and Ross 1985:93-94). Of importance to this study is the presence of only a single bison element from a Late Prehistoric context (1280 ± 50 B.P.).

The Weston Canyon Rockshelter

The Weston Canyon Rockshelter (10FR4) is within Weston Canyon, a steep-walled canyon that bisects the southern portion of the Bannock Range and the northwestern Malad Range in the southeastern Idaho county of Franklin (Figure 2). The rockshelter has been interpreted as a seasonal residence from about 8,000 to 2,000 years ago. The inhabitants probably represented a small band or extended family who focused upon the exploitation of bighorn sheep, although deer, elk, and bison, as well as other small mammals and birds, were also exploited (Miller 1972).

The rockshelter was formed in the eastern mouth of the canyon as a crevice caused by vertically faulting of the cliff limestone. The rockshelter is within the blue oolitic limestone of the Blacksmith Formation and capped by shale and limestone of the Bloomington Formation (Miller 1972:1-2).

The rockshelter is at an elevation of 1,590 m amsl. Several vegetation communities exist in the immediate area. Included are sagebrush-dominated plains, lodgepole pine stands, aspen stands, and at higher elevations, Engelmann spruce, subalpine fir, and Douglas fir are present (Miller 1972).

The depositional history of the rockshelter is the result of weathering of the limestone walls and roof of the shelter, as well as mass wasting of the bedrock and outside colluvium. Strata at the shelter are distinguished by the variation in the amounts of the major sediment components. Based upon these characteristics, 17 stratigraphic layers were described, and have been combined into seven major stratigraphic layers (Miller 1972). Bison are present in all but the oldest units.

The 1969 test excavations conducted by B. Robert Butler produced the remains of 4 individuals from Layers 3 and 4. These units are probably Late Prehistoric in age. The 1970 excavations were more extensive and included the remaining deposits of the rockshelter. Layers 4 and 5 were combined by Miller (1972: Table 1) for faunal counts. A minimum of two bison were recovered from these units, which date to about 2500-3000 B.P. One bison was recovered from Layers 6/7/8, which radiocarbon dated to 3740 ± 147 B.P. This date is considered to be problematic in that it may have been disturbed by previous occupations, and it is not clear which of the Layer 7 and 8 occupations it may apply to (Miller 1972:33-34). Layer 9 produced also produced a minimum of one bison and dates to about 5000 B.P. (Miller 1972:34). A single bison was recovered from combined Layers 12 and 13.

Malad Hill Sites

In a rather confusing and internally inconsistent article, Swanson and Dayley (1968) describe the excavation of two sites in southeastern Idaho, 10OA1 and 10OA2 (Figure 2). Since the sites were facing potential destruction during the construction of I-15, they were excavated by the Idaho State University team in 1965 under the direction of Dr. Earl Swanson. The Malad Hill sites have been interpreted as a hunting station with two major periods of occupation—Swanson's Blue Dome and Bitterroot. Site 10OA2 lies within alluvial and eolian deposits along the left bank of Devil Creek about five miles north of the town of Malad. The headwaters of the stream are a series of springs in rolling uplands. From there it flows north through sagebrush-grasslands, and eventually flows into the Portneuf River, a tributary of the Snake River. The site is at an elevation of 1,524 m (5,000 ft) amsl and is situated in a protected basin at the foot of Malad Hill (Swanson and Dayley 1968:59).

Two occupations are noted by the excavators. Occupation I, which lies within the paleosol Layer 5, predates an ash deposit assumed to be Mazama. A radiocarbon date of 6860 ± 659 yr B.P. was obtained from "butchered cervid remains which may have come from the top of Layer 5" (Swanson and Dayley 1968:60). Ungulate species from this unit probably include bighorn sheep and/or antelope (Swanson and Dayley 1968:Table 2). The youngest occupation, Occupation II, is associated with the paleosol Layer 2 and has been dated by the authors to between 1500 B.C. and A.D. 1400. Bison are present from this unit, but no counts are provided.

Snake River Sites

The earliest evidence of bison on the Snake River Plain comes from paleontological sediments at the American Falls locality north of Pocatello (Figure 2). The sediments have been interpreted to be more than 30,000 years old, and they contain the remains of *Bison latifrons* and *B. alleni*, as well as horse (*Equus*), camel (*Camelops*), and mammoth (*Mammuthus*) (Hopkins et al. 1969).

Wilson Butte Cave (10JE6) in northeastern Jerome County produced a succession of deposits containing bison (Figure 2), the earliest of which is Stratum C. In this unit, bison elements were recovered from the middle and upper portion. Camel remains were recovered from the lower and middle portion of the unit, and are associated with bison in the middle portion. The middle portion of Stratum C produced seven specimens (MNI=1) and the upper portion produced 13 specimens of bison (MNI=1). A human molar was also recovered from the middle part of the unit, but no artifacts. In the upper portion of the unit a charcoal sample yielded a radiocarbon age of 6850 ± 300 B.P. (Gruhn 1961:26-27).

Stratum B also produced a diverse faunal assemblage, with the large-mammal portion dominated by bison. Thirty-seven bison specimens were recovered, representing a minimum of two individuals. At the front of the cave, charcoal from a hearth produced a radiocarbon age of 940 ± 120 B.P. (Gruhn 1961:30-31). The upper stratum, A, also produced bison remains. Twenty-nine bison specimens were recovered for a minimum of two individuals. A sample of wood from the middle part of Stratum A at the rear of the cave was dated to 425 ± 150 B.P. (Gruhn 1961:33-37).

The Wasden site, in Bonneville County on the eastern Snake River Plain, consists of three rockshelters formed by the progressive collapse of a lava tube system (Figure 2). The main focus of several years of investigations has been the central rockshelter, Owl Cave (10BV30). Excavations have revealed over 5 m of deposits that include both archeological and natural strata. The earliest deposits date to ca. 11,000 B.P. and contain evidence of human occupation—three fluted projectile points and flake tools in association with mammoth (*Mammuthus* cf. *columbi*) and bison (*B. b. antiquus*) bones, as well as other vertebrate and invertebrate species (Miller 1989:381).

An 8,000-year-old bone bed produced the greatest number of bison (*B. b. antiquus*) at the site. Originally estimated at approximately 60 individuals (Butler 1971a), a more recent estimate places the number of bison killed at 150 (Miller and Dort 1978:137). Based on the analysis of tooth eruption and wear, the population includes yearlings as well as adults (Butler et al. 1971:128-129).

Post-Mazama deposits are also represented at the site. An age of 3340 ± 575 B.P. was obtained from a cultural feature. Miller and Dort (1978:137) indicate that bison hunting and processing continued at the site into the Late Holocene; however, at the time of publication, analysis of the faunal remains had not been completed.

Summary

Since the late 1950s when Earl Swanson began his long-term investigations in the intermontane valleys of Central Idaho, a few additional projects have provided evidence of long-term occupation of the region. However, with the exception of Swanson's research, and Chatter's dissertation project, compliance-driven projects have characterized the rest of the archeological investigations conducted. While not minimizing the efforts of these investigations, project constraints often hamper the ability of investigators to understand fully the context of their studies, especially since land management agencies, despite the best efforts of agency archeologists, are not capable of funding more than inventories of cultural properties. In order to adequately protect and manage resources, a more concerted effort must be made to fully assess the contribution a cultural resource can provide. The 11 sites in the region that did produce bison faunal remains provide valuable data about the availability of bison from various ecological zones and climatic periods.

From this data a couple of patterns are apparent. There appears to be an increase in the reliance on, and possibly the number of, bison through time (Figure 5); however, the correlation is statistically weak (r^2=0.02139). Significant reliance on bison appears to have been restricted to the wider valleys of eastern Idaho (Figure 6). Sites located within the main fork of the Salmon River do not contain bison remains. Reliance on other ungulates, especially mountain sheep, was probably a result of necessity, and possibly preference. Historic Shoshonean groups occupying the mountainous area of central Idaho referred to themselves as *Tukadüka*, or mountain sheep eaters (Steward 1938:187). In contrast, the Shoshone-Bannock of eastern Idaho referred to themselves as the *Kucundika*, or "buffalo-eaters," a reference to their mounted buffalo hunting (Hulkrantz 1958:150-151).

Bison populations in the mountains were probably of lower density and more dispersed. This pattern may have facilitated a different hunting strategy than the massive drives and traps that appear on the plains, and presumably in the wider valleys (e.g., the Snake River Plain). Evidence from Yellowstone and Grand Teton National Parks suggests hunting of bison was probably practiced by small groups of hunters either stalking individual animals or trapping small groups in a conducive topographic setting (e.g., a bluff edge or marshy area [Cannon 1991a]). This pattern has also been documented in the Northern Rockies by Reeves (1978). Butler (1978:111) also relates how small hunting bands of Shoshone on snowshoes would chase bison into deep snow where they could be easily killed with bow and arrow, butchered, and packed back to camp.

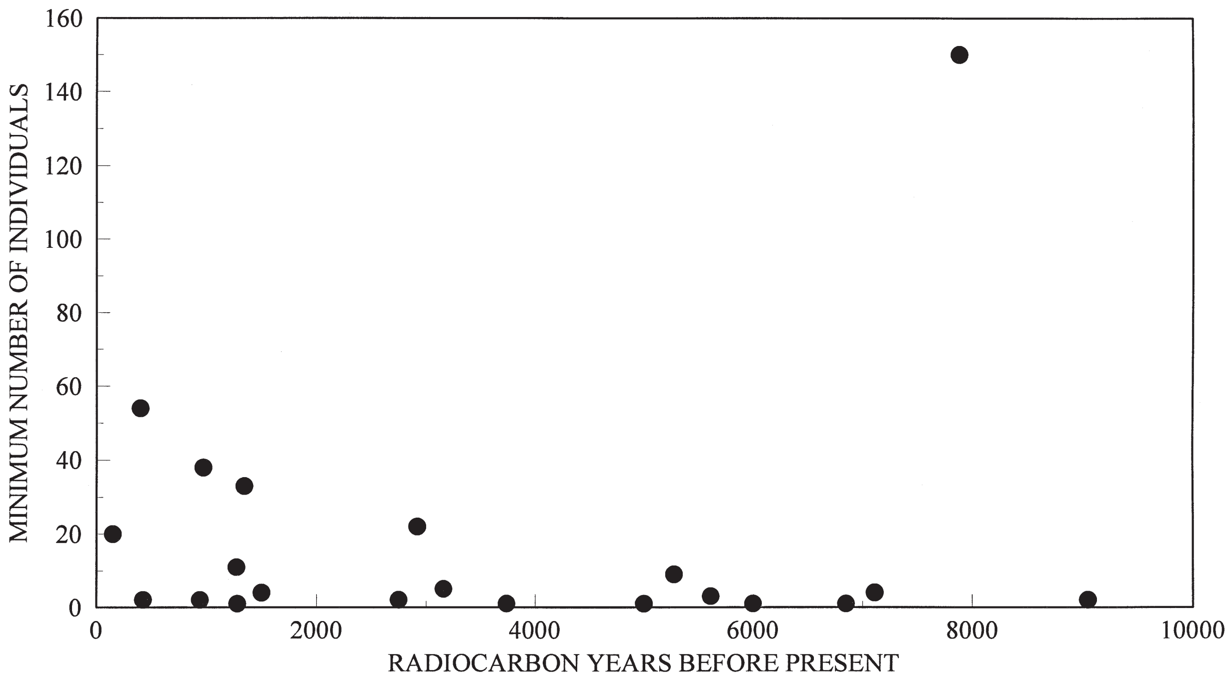

Figure 5. Plot of bison abundance through time. Minimum number of individuals (MNI) was chosen based on its consistent incorporation into reports. Age is based on radiocarbon ages and diagnostic artifacts. If more than one radiocarbon age was presented for an assemblage a mean age was calculated using the CALIB 3.0.3 program.

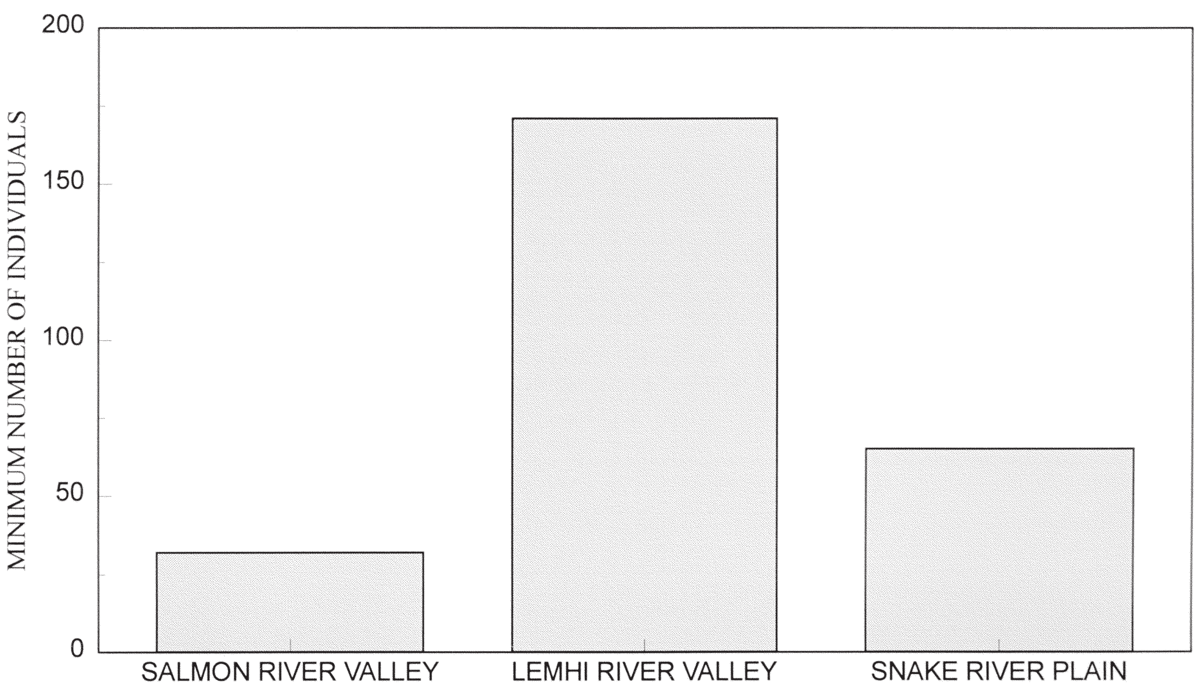

Figure 6. Bison abundance by region. Abundance is based on minimum number of individuals (MNI).

Historical Evidence of Bison in the Region

Introduction

Euroamerican explorers' and trappers' journals, as well as ethnographic documents, attest to the presence of bison in the upper Salmon River country (Kingston 1932). In his classic study, Steward (1938:186-192) discusses the economic pursuits of the northern Shoshone bands that occupied the Lemhi River Valley and the surrounding mountains.

> Throughout the mountains, subsistence was principally on seeds, roots, mountain sheep, deer, and salmon. Antelope were scarce; there was no buffalo. The fertile and lower Lemhi Valley had some antelope. Moreover, the Lemhi Shoshoni could keep horses with which to make expeditions to the south and east for buffalo (Steward 1938:189).

To the south along the eastern Snake River Plain, the Fort Hall Shoshone and Bannock relied more heavily on bison. They hunted them locally until about the mid-nineteenth century when they became rare; after that time they traveled across the divide to the headwaters of the Missouri and Yellowstone Rivers to hunt bison. This long excursion was made possible by the use of horses.

> Formerly buffalo could be had along the Snake River plains, not far from Fort Hall. After they were extinct in Idaho in 1840, large parties of Indians went to near Butte, Mont., and to Wyoming to hunt them, starting about when the leaves were turning in the fall (Steward 1938:203-204).

However, Steward (1938:200) did not feel that bison hunting had been a long-term economic pursuit of the Fort Hall Shoshone and Bannock due to the inadequacy of the grasslands to support bison and the inefficiency of hunting them without horses:

> No doubt the sage-covered plains were not their optimum environment, so that the arrival of trappers and the acquisition of fire arms and horses by the Indians was sufficient to exterminate them. It is improbable that in pre-horse days the buffalo was sufficiently numerous or means of taking it sufficiently developed to have made it an important feature in the economy.

In a review of the origin of bison in the Snake River Valley of eastern Idaho, Butler (1971a:1) uses as his launching point two quotes, one recent and one older. The first quote by Haines (1970:156-157) suggests that bison were only recent migrants west of the divide, having migrated from the Plains due to increasing hunting pressure after A.D. 1600:

> One place where the retreat of the herds can be followed rather accurately from contemporary accounts is the broad strip of pasture land extending northward from Great Salt Lake through Bear Valley, the upper Snake Valley, and the upper Missouri Basin. The buffalo had come to this country in rather recent times, probably no later than 1600. The herds had been crowded up the Yellowstone Valley across Bozeman Pass and into the Missouri headwaters. Once the region was well stocked, the animals moved south across the Continental Divide, through easy passes into the Upper Snake country. Even slight pressure from the north against the herds would be sufficient to account for this movement.

The second quote comes from John C. Fremont and is based on contemporary observations he made during his expeditions in the west during the mid-nineteenth century. Butler (1971b:1) suggests these quotes may have greatly influenced Haines ideas concerning the late arrival of bison in the region.

> [it would] be interesting to throw a glance backward through the last twenty years and give some account of their [bison] former distribution through the country, and the limit of their western range.
>
> The information is derived from Mr. Fitzpatrick, supported by my own personal knowledge and acquaintance with the country. Our knowledge does not go further back than the spring of 1824, at which time the buffalo were spread in immense numbers over the Green river and Bear river valleys, and through all the country lying between the Colorado, or Green river of the gulf of California and Lewis's fork of the Columbia river [the main Snake River]; the meridian of Fort Hall [on the Snake in eastern Idaho] then forming the western limit of their range. The buffalo then remained for many years in that country, and frequently moved down the valley of the Columbia [i.e., the Snake], on both sides of the

> river as far as the *Fishing Falls* [Shoshone Falls on modern maps, which is near Twin Falls, Idaho, at the western end of the Eastern Snake River Plain, emphasized in original].
>
> In travelling through the country west of the Rocky mountains, observation readily led me to the impression that the buffalo had, for the first time, crossed that range to the waters of the Pacific only a few years prior to the period we are considering; and in this opinion I am sustained by Mr. Fitzpatrick, and the older trappers in that country.

During the early and mid-nineteenth century a number of expeditions were mounted to explore the west for various scientific, political, and economic purposes. The following are a few references that specifically address the presence of bison in the upper Salmon River country or adjacent areas. Figure 7 is a regional map illustrating the general locations of the various historic records of bison sightings, and Table 2 provides a listing of the historic records.

While contemporary documents are important sources of information, they do have their limits. In order to be interpreted properly, they should be examined within the contexts in which they were collected (a more detailed discussion is presented in Bamforth [1987]). To begin with, historic documents under review are in general non-systematically collected accounts of bison encountered during various travels. Second, they are biased towards major travel corridors (e.g., river valleys) and do not represent systematic surveys of the countryside. Thirdly, the introduction and use of the horse for bison hunting created a very different pattern of group movement, procurement, and selection, and is not a relevant model for prehistoric groups.

The nineteenth century was a period of tremendous upheaval to native social systems, and this had a direct impact on wildlife, especially important prey species like the bison. With the introduction of the horse, native groups became much more mobile, and traditional hunting strategies, such as communal jumps or traps, became less important. Instead, mounted hunters would dispatch individual animals on the run. Bamforth (1987:9) suggests the use of the horse in hunting bison "probably increased herd size and almost certainly made the animals far more mobile than in prehorse times." While he is speaking specifically of herds on the Great Plains, a similar pattern may have occurred in the upper Snake River country where large herds seem to have been present. White bison hunters also impacted the herd dynamics by placing additional hunting pressures on them.

Corps of Discovery

The earliest of the American expeditions into the region was the *Corps of Discovery* led by Meriwether Lewis and William Clark. Between July and September of 1805 they traveled in the area of the headwaters of the Missouri River across Lemhi Pass into the Lemhi and Salmon River valleys, and then north across Lost Trail Pass to the Bitterroot Valley (Moulton 1988:Figure 2). However, while their journals do not describe direct contact with or sightings of bison in the area, the ethnographic information concerning the importance of bison to regional groups, specifically the Shoshone (Cutright 1989:190), suggests bison were either locally available or obtained on yearly hunting expeditions across the divide into the upper Missouri River Valley[2].

> from the middle of May to the firt of September these people reside on the waters of the Columbia .... during this season the salmon furnish the principal part of their subsistence and as this firsh either perishes or returns about the 1st of September they are compelled at this season in surch of subsistence to resort to the Missouri, in the vallies of which, there is more game even within the mountains. here they move slowly down the river in order to collect and join other bands either of their own nation or the Flatheads, and having become sufficiently strong as they conceive venture on the Eastern side of the Rockey mountains into the plains [Missouri River valley], where the bison abound (Moulton 1988:122-123).
>
> with these people the robe is formed most commonly of the skins of Antelope, Bighorn, or deer, dressed with the hair on, tho' they prefer the buffaloe when they can procure them .... their only thread used on this [elk skin shirts] or any other occasion is the sinews taken from the back and loins of Elk buffaloe &c (Moulton 1988:126-127).

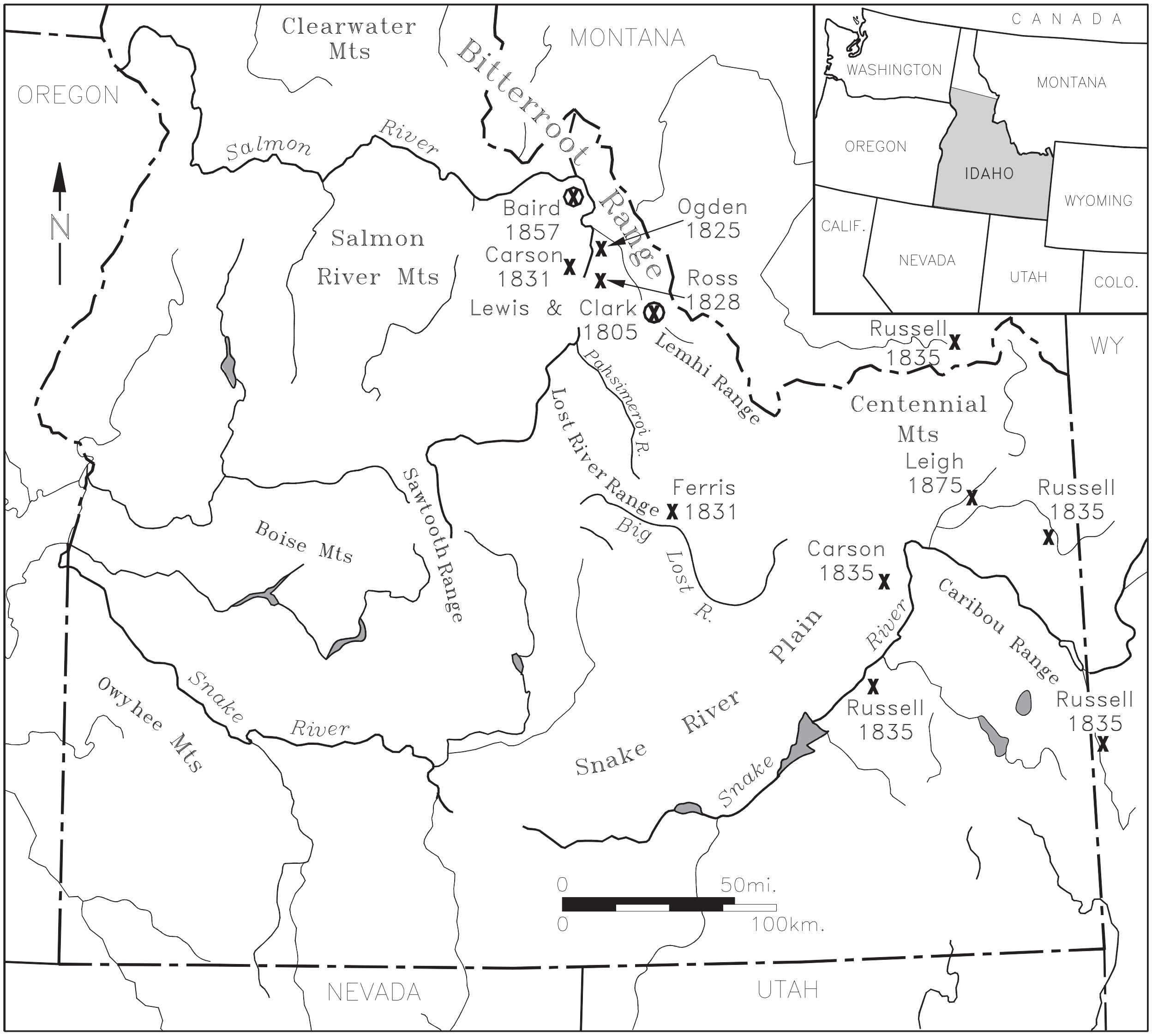

Figure 7. Regional map illustrating general locations of various historic references discussed in text. A direct observation is indicated by X; an indirect observation is indicated by circled X.

Table 2. Euroamerican explorers and trappers in north-central and eastern Idaho.

OBSERVER	DATE	AREA	OBSERVATION
Lewis and Clark	August 1805	Lemhi and Salmon River Valleys	Ethnographic reference to Shoshone use of bison. No direct observations reported.
Peter Skene Ogden	February 1825	Near the confluence of the Lemhi and Salmon Rivers	"as far as the eye can reach the plains appear to be covered with them [bison]".
Alexander Ross	1828	Lemhi and Salmon River Valleys	"buffalo were abundant; immense herds of these annimals were to be seen in every direction .... In one of the valleys through which we passed there could not have been less then 10,000 in one Herd!"
	1828	Little Lost River Valley	"the buffalo were in the thousands..."
Warren Angus Ferris	June 1831	Salmon River to Big Lost River Valley	"great numbers of bison...."
Kit Carson	Fall 1831	Upper Salmon River	"some four or five men when out hunting Buffalo" and were killed by Blackfeet.
	Fall 1835	Vicinity of Fort Hall	"killed a good many buffalo...."
Osborne Russell	2-10 May 1835	Salt River Valley in southwest Wyoming	"thousands of Buffaloe carelessly feeding ... in the green vales...."
	17 May 1835	Blackfoot River near its mouth on the Snake River Plain	"we found thousands of Buffaloe Bulls and killed a great number of them...."
	24 June 1835	Teton Valley, southeast Idaho	"abounds with Buffaloe Elk Deer antelope etc."
	16 September 1835	Ruby River Valley, southwest Montana	"large numbers of bison were scattered over the plains and among the hills."
	26 September 1835	Red River Valley, southwest Montana	"This valley ... was full of Buffaloe when we entered it and large numbers of which were killed by our hunters...."

Table 2. (concluded).

OBSERVER	DATE	AREA	OBSERVATION
S.F. Baird	1857	Upper Salmon River	Second-hand report from Lt. Day concerning Indians who had claimed to have killed bison in region.
Richard "Beaver Dick" Leigh	October 1875	Middle Fork of the Snake River	"They [Indians] ad shot a buffalo bull ... on the Middle Fork.... This is the first buffalo that as been seen since the spring of 1871".

> they also have spoons made of the Buffaloe's horn and those of the Bighorn. Their shield is formed of buffaloe hide, perfectly arrow proof, and is a circle of 2 feet 4 I. or 2 F. 6 I. in diameter (Moulton 1988:150).

Peter Skene Ogden

In February of 1825, Peter Skene Ogden, a trapper for the Hudson's Bay Company, and his company were trapping in the Lemhi Pass area and reported seeing a large number of bison on the west side of the divide:

> By February 11 [1825] they crossed from the east side of the Continental Divide through Lemhi Pass, which is now a political boundary separating Montana and Idaho, and "encamped in a fine spot" where hundreds of buffalo were seen. It was an imposing sight. Ogden wrote that "as far as the eye can reach the plains appear to be covered with them [journal entry 1 February 1825]. On the following day the freeman had a marvelous time pursuing the lumbering buffalo. Ogden noted: "Many [buffalo] were killed this day not less than 30 but not more than 300 wt. of meat came in to camp, the temptation of running buffalo is too great for them to resist (journal entry 2 February 1825; Cline 1974:54).

Kit Carson

In the fall of 1831, Kit Carson was trapping near the headwaters of the Salmon River where he and his companions overwintered. It was during the winter that "some four or five men when out hunting Buffalo" and were killed by Blackfeet (Grant 1926:21; Carter 1968:52). Traveling up the Snake River to Fort Hall in the fall of 1835, Carson relates that they hunted bison within a day of the fort.

> We were received kindly by the people, treated well and remained a few days, then started to hunt Buffalo, they not more than a days travel from the fort [Fort Hall]. We killed a good many buffalo and returned to the Fort (Carter 1968:67).

Alexander Ross

Alexander Ross was an American who originally trapped for the American Fur Company, but after Fort Astoria fell to the British in 1813 he joined the British North West Company (Spaulding 1967:xvi-xvii). In 1828 Ross was trapping in the Lemhi and Salmon River valleys where he recounts large numbers of bison:

> Withdrawing ourselves from this spot we journeyed on to the westward for some time until we reached a strong and rapid stream [Lemhi River] about fifty yards broad which empties itself into the great south branch [Snake River], called by our hunters, Salmon River[3].... This stream forces its way through a very bleak, sterile, and rocky part of the country, yet we crossed it and recrossed up the west side for upwards of nintey miles, till we got to a place called Canoe Point [confluence of the Lemhi and Salmon Rivers] where the different branches from four cardinal points of the compass form a cross. It runs in the direction of north west.
>
> But it did not prove rich in beaver .... the further we advanced the scarcer were the beaver, ... but buffalo were abundant; immense herds of these animals were to be seen in every direction; they were not fat at this early season.
>
> In one of the valleys through which we passed there could not have been less than 10,000 in one Herd! out of which our hunters killed sixty and we passed on leaving them still feeding on the young grass (Spaulding 1967:242-243).

During another trip, Ross describes a large herd of bison in the Lemhi River and Little Lost River valleys. Although not in the mountains proper, the citing gives evidence of local herds:

> The season having now arrived that I was to have sent to meet the Iroquois, who left us on the 16th of June, on leaving Canoe Point [mouth of the Lemhi River] I dispatched six men to the Trois Tetons [Grand Teton Mountains], south of Goddin's River [Big Lost River], the appointed rendezvous, while we proceeded on our journey in order to trap and make provisions for our voyage home .... As we advanced we reached in a short time an immense herd of buffalo and commenced laying in a stock of provisions until the men I had sent for the Iroquois should return (Spaulding 1967:282-283).
>
> On reaching Goddin's River ... I sent off eight men to trap downwards .... while the main party proceeded round a range of mountains in order to lay in a supply of buffalo meat, for we expected but few of these animals in the direction we were about to take, and moreover to prepare some of their hides

for making canoes, in case we might afterward require them.

The second day we got to the buffalo and encamped in Day's Valley [Little Lost River] .... It was a dreary looking place, the young grass scarcely got out of the soil so that our horses fared but poorly; nothing was to be seen but the tracks of buffalo and the traces of war parties.

While our party was employed in trapping and laying in provisions, I set off with ten men to examine the country to the southeast; we were absent four days on our trip and at the extent of our journey ascended high mountains, had a good view of the country, and saw the three Pilot Knobs [The Tetons] quite plain, in the direction of the east; we then passed for some distance along the waters of the main south branch .... having seen but few beaver on our trip. But the buffalo were in the thousands ... (Spaulding 1967:248-249).

Warren Angus Ferris

Warren Angus Ferris, a trader and trapper for the American Fur Company, traveled between the Big Hole Valley and the upper Salmon River country in June of 1831. During this time he traveled up the Salmon River into the Big Lost River Valley where he encountered "great numbers of buffalo" (Pedersen 1983:264).

Osborne Russell

Osborne Russell was one of the few trappers of the nineteenth century who consistently kept a journal of his travels over the course of several years. After running away from home to go to sea at age 16, Russell spent three years with the Northwest Fur Trapping and Trading Company operating in Wisconsin and Minnesota. In 1834 he joined Nathaniel J. Wyeth's expedition to the Rocky Mountains and the mouth of the Columbia River (Haines 1965:v). The manuscript was originally published in 1914 as *Journal of a trapper, or, Nine Years in the Rocky Mountains: 1834 and 1843*, having been edited by his grandnephew, L.A. York (Haines 1965:i). The manuscript was prepared by Russell from his journal notes between 1845 and 1848 (Haines 1965:xii).

During the period of time covered by Russell's journal he hunted and trapped from the Great Salt Lake in the south to the headwaters of the Missouri in the north, and east into the Platte and Powder River valleys. Often he mentions the presence of bison and relates that they were hunted by himself and other trappers, as well as local Indian groups.

This river [Salt River in southwest Wyoming] derives its name from the numerous salt springs found on its branches it runs thro. the middle of a smooth valley about 40 miles long and 10 wide emptying its waters into Lewis fork of Snake River its course almost due North. This is a beautiful valley covered with green grass and herbage surrounded by towering mountains covered with snow spotted with groves of tall spruce pines which from their vast elevation resemble small twigs half imersed in snow, whilst thousands of Buffaloe carelessly feeding *feeding* [italics in original] in the green vales contribut to the wild and romantic Splendor of the Surrounding Scenery (journal dated 2-10 May 1835; Haines 1965:12).

17th [May 1835] we travelled down this stream [Blackfoot River where it opens to the Snake River Plain] about 15 Mls and stopped to kill and dry Buffaloe meat sufficient to load our loose horses. On the 22d We moved down 10 mls. where we found thousands of Buffaloe Bulls and killed a great number of them as the Cows were very poor at this season of the year (Haines 1965:13).

24th [June 1835] We crossed the North point of the valley [Swan Valley, Idaho] and ascended a small stream about 15 mls. NE where we encamped among the mountains of thickly covered with tall pines intermingled with fallen timber 24th Crossed the mountain 12 mls. East course and descended into South W. extremity of a valley called Pierre's hole [Teton Valley, Idaho] where we staid the next day. This valley lies in north & South in an oblong form abt. 30 mls long and 10 wide surrounded except on the Nth. by wild and rugged Mountains: the East range resembles Mountains piled on Mountains capped with three spiral peaks which pierce the cloud. These peaks bear the French name of Tetons or Teats [Grand Tetons] .... This is a beautiful valley consisting of a Smooth plain intersected by small streams and thickly clothed with grass and herbage and abounds with Buffaloe Elk Deer antelope etc (Haines 1965:15).

> 16 [September 1835] Travelled down the stream NW about 8 Mls The Valley [Ruby River, Montana] opened wider as we descended and large numbers of Buffaloe were scattered over the plains and among the hills (Haines 1965:33).

> 26 [September 1835] Crossed the valley [Red Rock River] about 16 Mls. and encamped on the East side. This Valley as a Mountaineer would say was full of Buffaloe when we entered it and large numbers of which were killed by our hunters we repeatedly saw signs of Blackfeet about us to waylay the Trappers (Haines 1965:34).

Later in the nineteenth century, bison were becoming increasingly rare west of the divide as indicated by contemporary observers. Osborne Russell writes: "The Buffaloe is already a stranger, altho numerous 10 years ago, in that part of the country which is drained by the sources of the Colerado, Bear, and Snake Rivers and occupied by the Snake and Bannock Indians" (Haines 1965:139).

S.F. Baird

In 1857 Professor S.F. Baird, Assistant Secretary of the Smithsonian Institution, made the following observations while recording the fauna along the various routes being explored for the trans-continental railroad:

> The range of the buffalo does not *now* extend beyond the Rocky mountains, but there are many Indian hunters who have killed them in great numbers to the west of the mountains, on the headwaters of the Salmon river, one of the tributaries of the Columbia (italics in original).

> While I was in Dalles [on the lower Columbia River], the part of Liet. Day, U.S.A., came in from an expedition to the upper Salmon river, and I was assured by the officiers that they had not only seen Indians who claimed to have killed buffalo there, but that, in many places, great numbers of buffalo skulls were still lying on the prairie (Newberry 1857:72).

Richard Leigh

Richard "Beaver Dick" Leigh, who traveled and trapped in the upper Snake River country of Wyoming and Idaho made two entries in his journal of 1875, the second of which is of particular importance to the population dynamics of the bison during this time.

> Sept. 19. There is a large fire buring from the mouth of Camas Creek to the North Fork a distance of 24 miles. The Bannock Indians passed here yesterday on their way to hunt buffalo. I think it is them set the fire for they generally do when they go thru this way to buffalo (Thompson and Thompson 1982:56-57).

> Oct. 2. Some Indians came here. They ad shot a buffalo bull breaking his hind leg on the Middle Fork. He ad come here and crossed to the west side of the river. The Indian hunters crossed this evening to hunt him up. This is the first buffalo that as been seen since the spring of 1871. It is likely there is a band of cows and calves in the vicinity of the Middle Fork of the North Fork (Thompson and Thompson 1982:58).

Summary

Historic sightings, while important, cannot be taken literally as ecological studies. Seasonal observations during the spring and summer may merely reflect seasons of the year when travel was easy or most common. Therefore, it is important to note that direct observations by contemporary travelers can not be directly converted to ecological studies (Chisholm et al. 1986:196). Also, the nineteenth century was a period of tremendous change to native groups. The adoption of the horse, for example, presumably had significant impacts on herd populations. With this in mind, a summary of the observations can be made:

1. Large populations of bison existed in the upper Snake and Salmon River country during the nineteenth century. However, these large herds may have been the result of unusually large aggregations due to hunting pressures being placed on them from mounted hunters.

2. Large herds of bison were encountered in the valleys during the late spring–early summer. This is a period when nursery herds congregate in order to protect and wean newborn calves. Nursery (or cow) herds consist of cows, first of the year calves, and adolescent bulls (McHugh 1958).

3. Large herds were also encountered during the fall in the valleys. This is also a period of aggregation associated with rutting (McHugh 1958).

4. Contemporary narratives, especially Leigh, provide a first-hand account of the demise of the great herds of bison in the intermountain west. Although 1850 (Seton 1929) has been viewed as the general date of the extinction of bison west of the Continental Divide, later accounts, such as Leigh's, indicate there were still some bison present in eastern Idaho in the latter part of the nineteenth century.

While the preceding narratives may not be exhaustive, they do provide some information about bison herds in eastern Idaho. However, biases in the record and how they might affect interpretation should be discussed. For example, the number of sightings is limited, and all occur during the spring or summer and along major water courses. This pattern is probably due to convenience of travel during these seasons and the use of river valleys as major travel corridors. None of the references explicitly discuss bison in mountains.

Negative evidence should also be considered when using the historic record for the reconstruction of ecosystems. Periods when bison were not seen may be due to the dispersion of the populations brought on by human pressures, and may not be an accurate reflection of habitat use.

As has been discussed in the literature, native groups have had significant effects upon ecosystems for thousands of years (Winterhalder and Smith 1981; Schrire 1984; Price and Brown 1985; Bettinger 1991). Massive kills of bison (Reeves 1983; Bamforth 1987, 1988) and antelope (Frison 1971) probably influenced migration patterns as well as populations, at least in the short term. Studies among the large herd animals in Africa suggest significant effects can be incurred from low-level hunting pressures, as well as through settlement (Laws et al. 1975; Mloszewski 1983). Irregular predation can cause herds to flee areas or create erratic (unpredictable) herd movements or the disintegration of herds. Settlements, permanent or otherwise, can have the effect of disrupting "normal" migration patterns. They can also cause larger herds to aggregate and be spaced more sporadically across the landscape, which in turn can exhaust local food resources and cause animals to move more frequently, a behavior which in turn can give the impression that a region is completely devoid of animals. All these patterns have obvious implications for interpreting the historic record.

Seasonal burning by native groups in the Northern Rockies has also been shown to influence the composition and productivity of ecosystems (Lewis 1978, 1980; Turner 1991). Since grazing animals have evolved to respond to seasonal fluctuations in nutritional qualities of grasses and forbs, we can assume aboriginal burning may in turn influence animal population dynamics

Therefore, these, as well as other factors, should be taken into consideration when using the historic record as proxy data for developing models of ecosystem dynamics.

---

[2] In this quote, as well as those following, no attempt has been made to correct errors in spelling, punctuation, or syntax.

[3] "Here Ross may have mistaken the Lemhi, which flows into the Salmon, for the Salmon itself. The Salmon subsequently empties into the Snake River. In journeying westward the party had crossed the Continental Divide, moving from the Beaverhead to the Lemhi drainage" (Spaulding 1967:242, note 8).

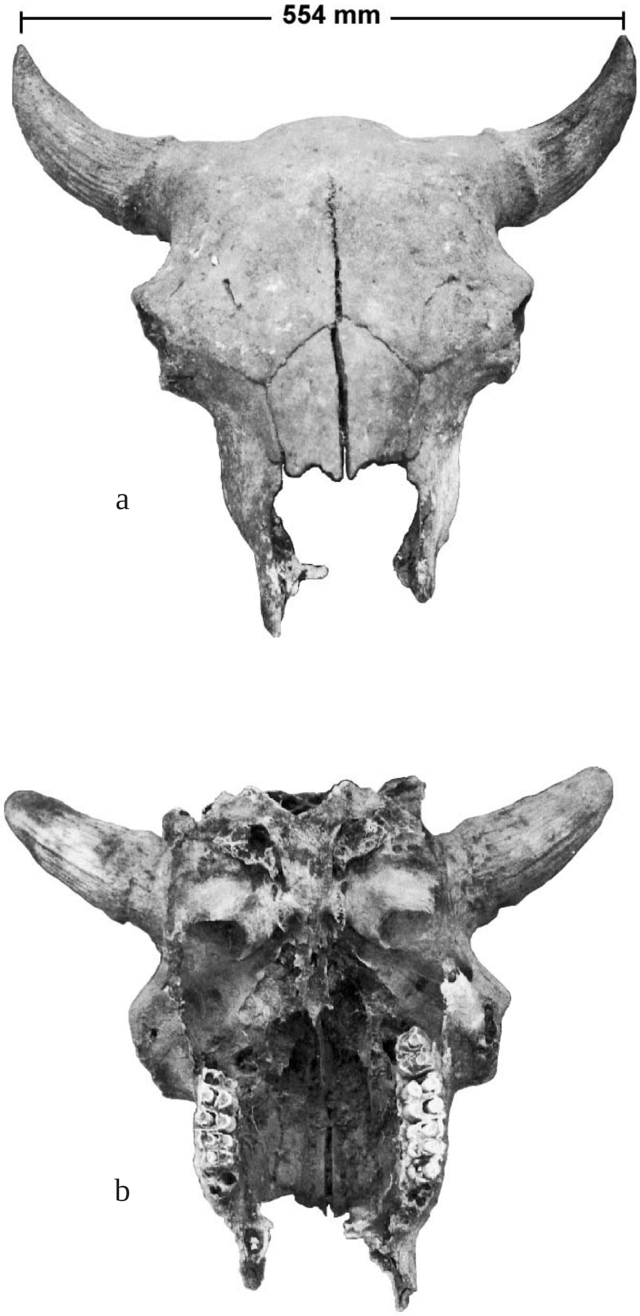

Figure 8. Fawn Creek bison skull after laboratory preparation: (a) dorsal view; (b) ventral view. Whitening on ventral surface is due to exposure of this portion of skull in cut bank.

Description and Examination of the Skull

Description

The Fawn Creek bison skull is almost a complete specimen. The distal portions of the premaxillae are missing, having eroded away (Figure 8a). This portion of the skull exhibits more extensive weathering due to its exposure in the cutbank (Figure 8b). Skull measurements were taken in accordance with those presented in McDonald (1981a:43-47) and are presented in Table 3.

Aging of the individual was based on the teeth wear patterns and suture closure. All of the molar teeth are in wear, although the M^3 is only slightly worn. This is in general agreement with Skinner and Kaisen's (1947) age class S-2, which is early maturity. McDonald (1981a:44) considered a skull mature

> if the sagittal frontal suture was completely fused posteriorly from about the midway between the planes of the orbits and bases of the horn cores, and if the frontal-parietal sutures were completely fused from the sagittal origin laterally and ventrally to below the level of the ventral horn core bases.

For the Fawn Creek skull, neither the frontal suture nor the frontal-parietal sutures are completely closed (Figure 8a). Based upon these features, and in comparison with bison skulls of known age in the MWAC faunal collection, the Fawn Creek skull represents an individual around five years of age.

Sexing of the skull was based on relative robustness of the skull and horn core morphology. Female skulls are smaller in size, and some features, such as horn cores and eye orbits, are less massive. Male horn cores have a distinct burr or rim at the dorsal base, while females show no distinct burr, and the horn core often blends with the neck and frontals (McDonald 1981a:44). The Fawn Creek skull illustrates rather massive features, such as protruding eye orbits and distinct burrs at the base of the horn cores, suggesting a male.

A less subjective means of assessing sex is the metric comparison of the Fawn Creek skull with other sexed skulls. Utilizing McDonald's (1981b) data for other western United States bison (Table 3), the greatest width of the frontals was plotted against spread of the horn cores and indicates the Fawn Creek skull to fall within the upper end of the chart with other males (Figure 9).

The horn cores in dorso-ventral view have an arched axis with straight growth, and in antero-posterior view have an arched axis with a concave margin and anterior rotation. The tip cross-section is circular, and the shape at the base of the horn cores is broadly triangular (isosceles).

Postmortem modifications were also noted. These include rodent gnawing on the inferior surface of the left eye orbit and on the lateral portion of the left frontal near the horn core.

In sum, the Fawn Creek bison represents a male of early maturation, probably about five years of age at the time of death. No evidence on the skull suggests the bison was killed by humans or other animals.

Preparation

As previously noted, the bison skull was recovered from the cutbank along Fawn Creek. The skull was found in an inverted position with the maxillary area exposed. The exposed area was bleached by the sun and had an extensive growth of moss. After its removal from the sediments, the skull was placed within a perforated plastic bag for transportation, and then it was slowly dried. The slow drying of the skull prevented the cracking and warping common for subfossil specimens.

The skull was initially shipped from the Salmon-Challis National Forest to PaleoResearch Laboratories in Golden, Colorado, where calculus and impacta

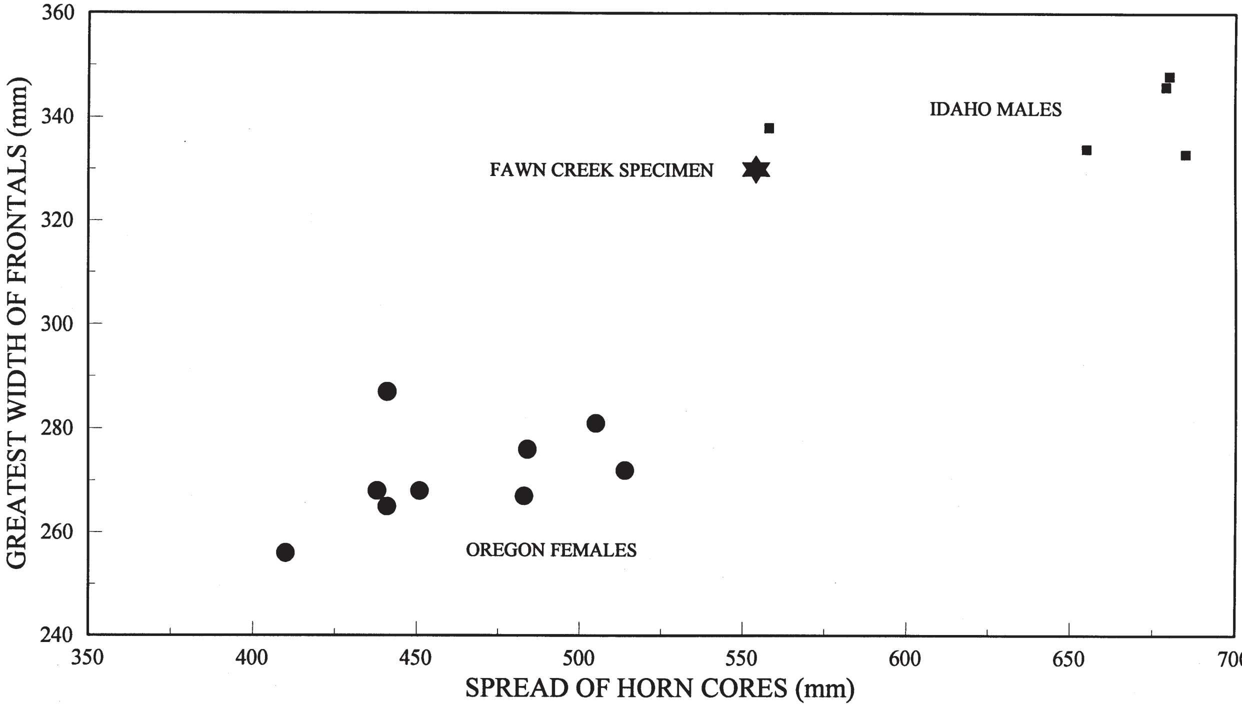

Figure 9. Plot of Fawn Creek skull measurements in relation to male and female bison skulls from the western United States. Data are from McDonald (1981b) and are presented in Table 3.

Table 3. Skull measurements following McDonald (1981a). All measurements presented in millimeters. McDonald's (1981b) Idaho and Oregon specimens are presented as means. The Idaho specimens (n=5) are from a number of locations on the Snake River Plain and are curated at the Idaho State Museum of Natural History. The Oregon specimens (n=9) are from Malheur Lake, Oregon, and are curated at the United States National Museum of Natural History. An asterisk indicates sample size is only four.

MEASUREMENT	FAWN CREEK	IDAHO MALES	OREGON FEMALES
Spread of horn core, tip to tip.	554	651.4	463
Horn core length, upper curve, tip to burr.	175	221.4	140.8
Straight line distance, tip to burr, dorsal horn core.	170	190.6	131.4
Dorso-ventral diameter, horn core base.	82.4	86.4	51.7
Minimum circumference, horn core base.	257	264	162.2
Width of occipital at auditory openings.	-	251.1*	202
Width of occipital condyles.	-	128*	116.1
Depth, nuchal line to dorsal margin of foramen magnum.	-	101.5*	87.6
Antero-posterior diameter, horn core base.	85.5	-	-
Least width of frontals, between horn cores and orbits.	270	283.6	216
Greatest width of frontals at orbits.	330	339.8	271.1
M^1-M^3, inclusive of alveolar length.	92.9	-	-
M^3, maximum width, anterior cusp.	22.8	-	-
Distance, nuchal line to tip of premaxillae.	-	-	493.4
Distance, nuchal line to nasal-frontal suture.	265	257.2	216.6
Angle of divergence of horn cores, forward from sagittal.	64 °	71.2°	65.2°
Angle between foramen magnum and occipital planes.	-	131°*	132.4°
Angle between foramen magnum and basioccipital planes	-	112.5*	110.8°

were removed from the cheek teeth by Dr. Linda Scott-Cummings (Cummings and Puseman 1996). At about this time, bone fragments from the interior of the skull were removed by Dr. Richard Marlar for DNA extraction and analysis (Appendix A). At MWAC, interior skull fragments were removed for radiocarbon assay and bone collagen analysis.

After all samples were collected from the skull, it was carefully dry-brushed to remove any adhering sediments. Compressed air was also used to remove sediments trapped within fossae. Modern rootlets were removed using tweezers and brushes. The maxillary area was cleaned of the moss with a 10-percent solution of Lysol and distilled water. This was applied with a small paint brush and cotton swabs.

About one week passed before final preparation was conducted. This time period allowed the skull to dry and also provided the time to collect additional samples if needed before final preparation. Fortunately, all samples submitted, with the exception of the DNA, were adequate.

A 30-percent solution of Acryloid B-72 and acetone was prepared as a consolidant. B-72 is an ethyl methacrylate copolymer that is used by preparers as both a glue and consolidant. It is distributed by Conservation Materials Ltd., of Sparks, Nevada. This solution was brushed on the inferior surfaces first, then allowed to dry overnight. The consolidant was then brushed on the superior surface. Only one coat was applied. A slight darkening of the skull occurred with the application of the consolidant.

Radiocarbon Dating Results

In order to accurately place the specimen within a historic context, a 20.7-gram sample was collected from the skull and submitted to Beta Analytic for radiocarbon assay. The sample consisted of portions of the hard palate, the vomer, and portions of the interior of the skull.

The sample was processed by Beta Analytic using the accelerated mass spectrometry technique. Standard procedures for bone dating include collagen extraction with alkali, graphization, and radiocarbon measurement. These procedures preceded normally and the $^{13}C/^{12}C$ ratio was measured at -20.3‰, which is within the expected range (-18 to -22‰) for ungulates. This measurement indicates that sufficient collagen was present for an accurate radiocarbon age (Hood 1996).

The radiocarbon age obtained is 170 ± 70 yr B.P. (Beta-93996). The radiocarbon years before present are referenced to A.D. 1950 and calculated using the Libby ^{14}C half life of 5568 years. The radiocarbon date was calibrated using the CALIB 3.0.3 program (Stuiver and Reimer 1993) to calendar years. At the one-sigma level (68.3 percent probability) the age of the skull ranges from cal A.D. 1660 to cal A.D. 1954, with multiple intercepts at cal A.D. 1680, 1753, 1804, and 1937. The greatest area under the probability distribution (0.54) occurs between cal A.D. 1717 and cal A.D. 1819, which implies that the age of the bison is statistically more likely to be of this age rather than the other calibrated ages.

Bison Taxonomy

Since the nineteenth century, when trappers, explorers, and zoologists first ventured into the Rocky Mountains, there has been controversy surrounding the species of bison occupying these regions. The earliest accounts are ripe with descriptions of the exploits of the "Woodland or Mountain Bison" (e.g., Christman 1971). Various historical accounts of the "mountain" bison indicate they "were more hardy, fleet, and wary, and had darker finer, curlier hair" than the Plains bison (Meagher 1973:14-15). Superintendent Norris (1880) describes the bison of Yellowstone National Park in the Superintendent's Annual Report:

> Bison or Mountain Buffalo...Bison, so called, in the Park, are somewhat smaller, of lighter color, less curly, and with horns smaller and less spreading than those of the bison formerly inhabitated the great parks of Colorado. They have also smaller shoulder humps, and larger, darker brisket wattles. They differ materially from the buffalo of the Great Plains, being more hardy, fleet, and intelligent; their hides also are more valuable for robes, as they are darker, finer, and more curly; and these animals are, in all probability, a cross between the two varieties just mentioned.

In fact, considering the geographic range of bison in North America, some authors have suggested there may have been several distinct geographic forms. However, with the near extinction of the bison in North America, a comprehensive study of its geographic variation has been precluded (van Zyll de Jong 1986:1). In the latter part of the nineteenth century, biologists recognized a distinct form of bison in northern Canada, formally described as the subspecies *B. b. athabascae* by Rhoads (1897) based on a single specimen he did not directly observe (van Zyll de Jong 1986:1). While most biologist agreed with Rhoads designation of *B. b. athabascae* being at least subspecifically distinct (e.g., Skinner and Kaisen 1947; McDonald 1981a), some felt that the differences in the two subspecies, *B. b. athabascae* and *B. b. bison*, were of little consequence (van Zyll de Jong 1986:1).

According to van Zyll de Jong (1986:1), the decimation of the bison herds prior to first-hand study and the small number of specimens available for study contributed to the diversity of opinions. In one of the first quantitative studies of museum specimens—primarily crania— Skinner and Kaisen (1947) argued for an overlap in distribution of the two subspecies—*B. b. athabascae* and *B. b. bison*—along the eastern slopes of the Rocky Mountains (Figure 10). However, their argument was unconvincing due to the lack of cranial and postcranial specimens for comparison.

More recently, McDonald (1981a) presented metric data from a limited sample that shows evidence that the *B. bison athabascae* range was limited to the northern Rocky Mountains and the boreal forests of Canada (Figure 11). This model refutes Skinner and Kaisen's earlier model. He suggests a phylogenesis of modern North American bison from an indigenous Nearctic line (*B. b. antiquus)*, with *B. b. athabascae* evolving directly from the ancestral *B. b. antiquus*, or a more recent adaptive differentiation from *B. b. bison*, as suggested by the larger body size of *B. b. athabascae*. However, van Zyll de Jong (1986), studying presumed pure *B. b. athabascae* specimens from northwestern Canada and comparing them to other North American fossil and modern bison, suggests that body size is just one of a number of presumably genetic characteristics that differentiates the two modern species. According to his analyses, *B. b. athabascae* is more probably "a direct and little differentiated descendant of [Beringian] *B. b. occidentalis*" (van Zyll de Jong 1986:54). His analysis found that *B. b. bison* shows a marked difference in horn core measurements, reflecting a general reduction in horn core size in comparison to *B. b. occidentalis*, whereas with *B. b. athabascae* there is only a reduction in horn core length (van Zyll de Jong 1986:18 [Figure 12]).

Arguing for genetic variation, as opposed to ecophenotypic, van Zyll de Jong (1986:54-55) illustrates how the interaction of ecological and behavioral factors, gene flow, and natural selection can account

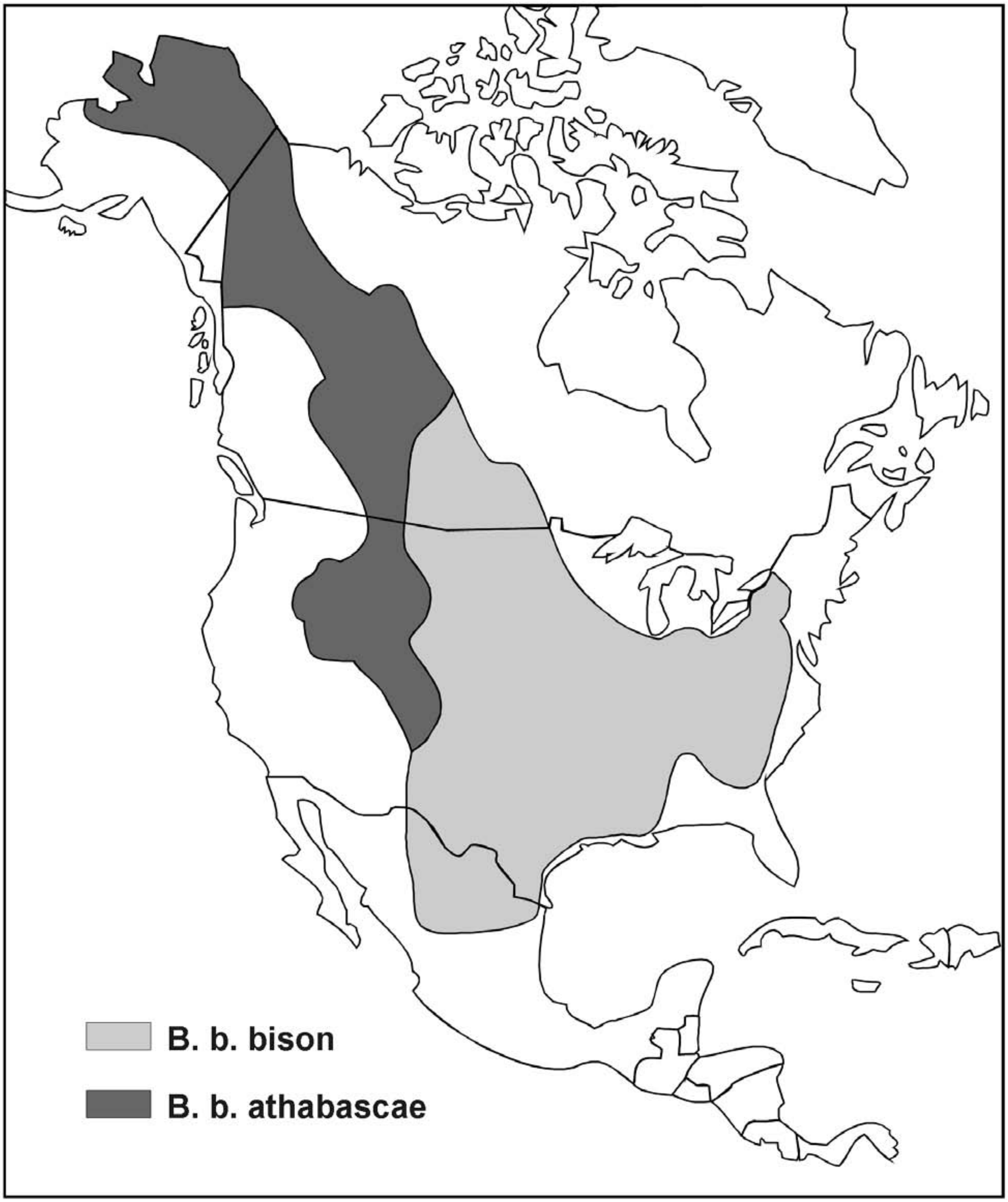

Figure 10. North American range of *Bison bison athabascae* and *Bison bison bison* according to Skinner and Kaisen (1947).

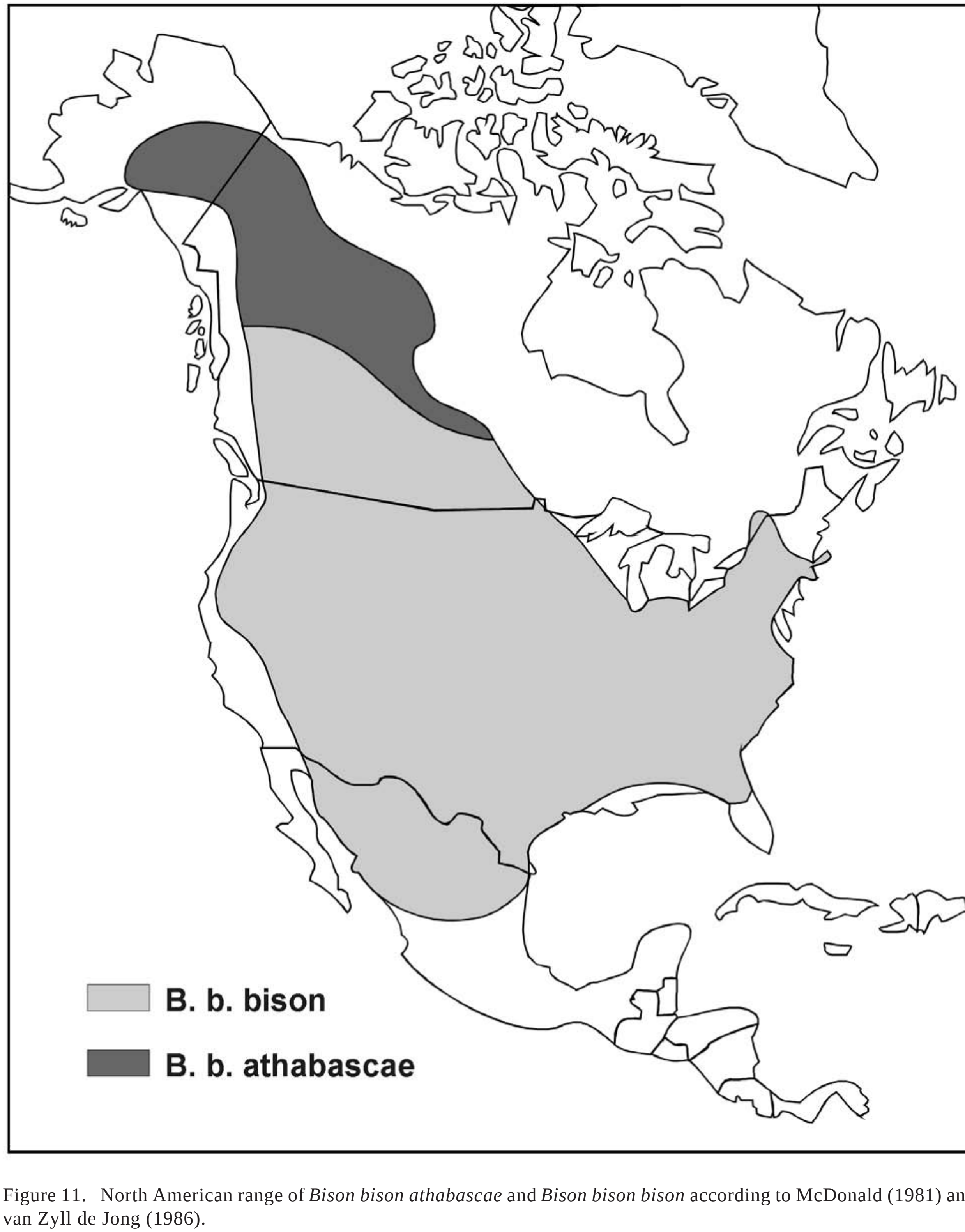

Figure 11. North American range of *Bison bison athabascae* and *Bison bison bison* according to McDonald (1981) and van Zyll de Jong (1986).

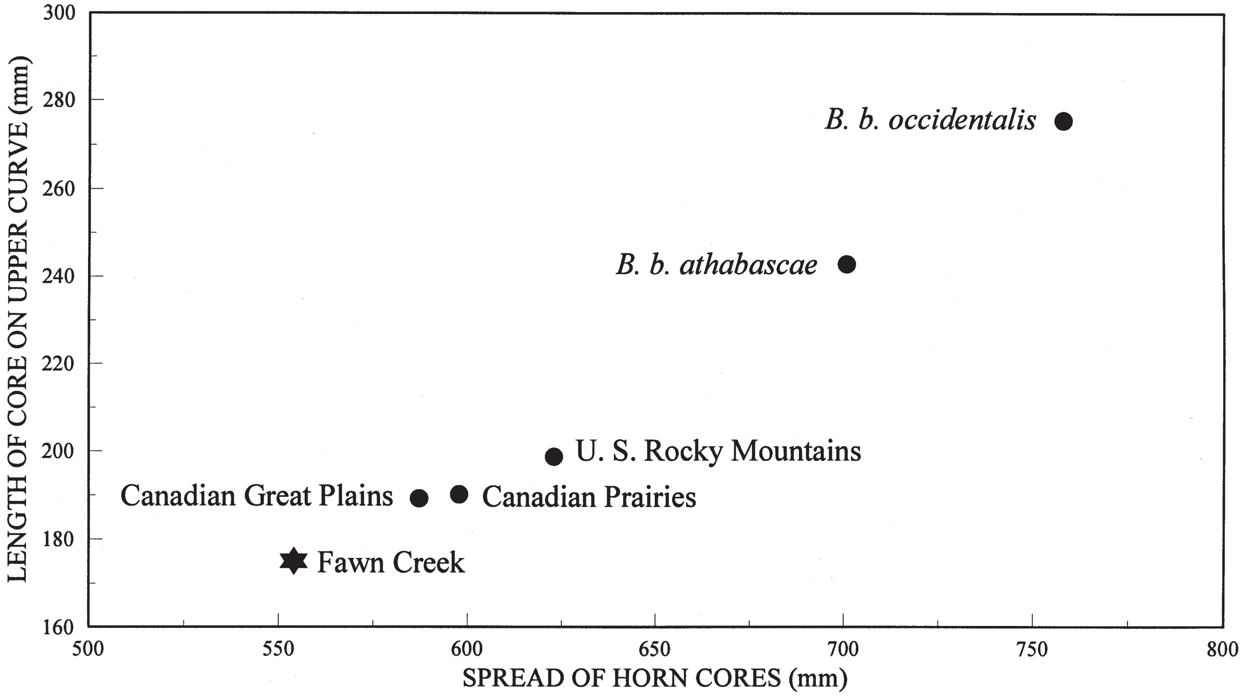

Figure 12. Plot of mean horn core measurements of five historical, Holocene, and Late Pleistocene groups in comparison to Fawn Creek specimen. Plot illustrates reduction in horn core size from ancestral *B .b. occidentalis* to modern *B. b. bison* as discussed in text. Data are from van Zyll de Jong (1986:Table 1).

for the maintenance of the distinctiveness of the two modern species. Specifically, the boreal forest ecotone acted as a natural barrier to contact with *B. b. bison* in the grasslands to the south. Interbreeding was also minimized due to the limited seasonal movement of the two populations within their respective home ranges. The diverse habitats occupied by the two populations may also have promoted "differential directional selection" of a specific allele frequency or phenotype that provided them with a greater degree of fitness for surviving in their respective environments.

Dr. Curtis Strobeck has recently conducted a molecular study of DNA from several populations of wood and plains bison in Canada and the United States in an attempt to genetically determine the status of the two subspecies. Based on this study, Strobeck concluded that wood and plains bison "do not form distinct phylogenetic groups and are not genetically distinct subspecies" (Strobeck 1992:15). With the similarity in mtDNA types from both "wood" and "plains," the possibility that they may have been distinct subspecies in the past is also refuted, Strobeck asserts.

Geographic isolation of populations may have the effect of creating different genotype frequencies in different herds. Strobeck (1992:15-16) contends from his study that "each population represents a geographical genetic isolate of a once vast population of bison." This genetic isolation may provide some clues to the morphological variability we see in bison populations. This observation is similar to what van Zyll de Jong (1986:55) found in his morphometric analysis. He goes on to suggest that similar mechanisms are still in operation among ungulates (e.g., caribou) today and can be studied.

In order to address the issue of the genetic relationship of the Fawn Creek bison to other genetically sequenced bison populations, samples from the interior of the skull were extracted by Dr. Richard Marlar, director of the Special Coagulation Laboratory of the Denver Veterans Administration Medical Center. Unfortunately, Dr. Marlar and his associates were not able to extract bison DNA from the sample. Several different techniques were attempted without success. Dr. Marlar thought that the adhering moss was preventing the extraction and replication of bison DNA (Appendix A).

Results of Phytolith and Macrofossil Analysis of Bison Teeth

Introduction

The study of bison diet by biologists usually involves the painstaking task of observation or the collection of feces remains in order to extract plant remains. However, when attempting to reconstruct the diet of past animal populations and ecosystems, direct observation is not possible; so other techniques must be developed.

Guthrie (1980; 1990:175-176) has noted that modern bison are eclectic foragers, but despite this versatility they are adaptive specialists who prefer low-growth herbs, particularly grasses. Studies of modern bison indicate that grasses comprise 80 to 90 percent of their diet (Meagher 1973; Olsen and Hanson 1977; Van Vuren 1984), with forbs and woody browse of less importance (Soper 1941). However, significant consumption of sedges and browse have been identified among bison occupying riverine and woodland habitats (Borowski et al. 1967).

The bison that were introduced to Alaska in the 1930s, which are confined to riverine areas within, or adjacent to, mountain passes, illustrate a very different diet in comparison to grassland bison. Several populations of these bison have been studied. The *Fairwell herd* eat grasses and sedges through the winter, with browse contributing a little more than one percent (Campbell and Hinkes 1983). The *Delta herd* subsist on river bar grasses and farmers' barley, as well as browse and *Equisetum* (Gipson and McKendrick 1981). Limited sampling of fecal remains from two smaller herds revealed considerable use of browse in the summer (50 percent willow and 50 percent graminoid), and the winter diet consisted of 75 percent browse with the remaining percentage graminoids (Miquelle 1985).

Meagher's (1973:90-95) study of Yellowstone bison rumen, which may be the most relevant to our study, indicates grass and grasslike plants were by far the predominant elements of the bison's diet throughout the year (Table 4). Sedge was the main source of forage in all seasons, averaging more than half the diet. Seasonal shifts in the quantity of sedge correlate well with bison seasonal use of the landscape. For example, in winter, sedge is represented at 56 percent and is reflective of the bison's winter use of river valleys and exposed stream banks where nearly all plant growth is sedge (Meagher 1973:91, Figure 45).

Grass is second in quantity in all seasons except the fall. In the spring, grasses are selected in the highest proportion (46 percent), reflecting its greater palatability, availability, and nutrition. Wire rush was another important element of the diet, representing about one-third of the fall diet.

Forbs and browse are also represented throughout the year in the bison diet. Meagher (1973:94) suggests that while forbs represent a small portion of the diet they may be of nutritional importance. Browse is of least importance quantitatively. Six species are represented, but only in trace amounts.

Armitage (1975) applied the botanical technique of phytolith analysis to the teeth of archeological cattle from Roman and Medieval sites, as well as recent cattle, in order to understand diet. Opal phytoliths were extracted from residual food material found on the cusps of their teeth (calculus) and subjected to analysis. Festucoid grass phytoliths, including *Dactylis glomerata* and *Festuca ovina*, were identified.

In another attempt to develop an understanding of ungulate diet, Guthrie (1990:176-178) had plant fragments recovered from the infundibula analyzed by range managers and wildlife biologists (Figure 13). The material extracted from these specimens included the waxy cuticles that cover the plant epidermis. Plant cuticles are readily identifiable in the laboratory and are characteristic of each plant group. The results indicate that grass fragments were the predominant food found in the teeth of steppe bison, horses, and woolly rhinos.

Table 4. Seasonal food habits of Yellowstone bison as determined by rumen sample analysis*. Data are from Meagher (1973:Table 17). Samples were collected in the mid-1960s.

	WINTER (N=11)		SPRING (N=4)		SUMMER (N=4)		FALL (N=3)		TOTAL (N=22)	
SPECIES	%FRQ	%CMP	%FRQ	%CMP	%FRQ	%CMP	%FRQ	%CMP	%FRQ	%CMP
Grasses and Grass-like Plants	100	99	100	96	100	91	100	99	100	96
Sedge	100	56	100	49	100	50	100	37	100	51
Grasses	100	34	100	46	100	32	100	30	100	35
Wire Rush	100	9	50	1	100	8	100	32	91	10
Spike-sedge	-	-	-	-	50	1	-	-	9	trace
Forbs	45	trace	100	3	100	6	67	trace	68	2
Phlox	18	trace	75	2	25	trace	-	-	27	1
Northwest cinquefoil	-	-	25	trace	100	6	-	-	23	1
Sulfur eriogonum	9	trace	100	trace	75	trace	33	trace	36	trace
Dandelion	73	trace	-	-	75	trace	33	trace	32	trace
Pussytoes	-	-	75	trace	-	-	-	-	14	trace
Groundsel	-	-	-	-	75	trace	-	-	14	trace
Shrubby cinquefoil	18	trace	-	-	-	-	-	-	9	trace
Clover	-	-	-	-	50	trace	-	-	9	trace
Onion	-	-	-	-	25	trace	-	-	5	trace

Table 4. (concluded).

	WINTER (N=11)		SPRING (N=4)		SUMMER (N=4)		FALL (N=3)		TOTAL (N=22)	
SPECIES	%FRQ	%CMP	%FRQ	%CMP	%FRQ	%CMP	%FRQ	%CMP	%FRQ	%CMP
Blue-eyed Mary	-	-	-	-	-	-	33	trace	5	trace
Unidentified	-	-	25	trace	75	trace	33	trace	23	trace
Onion	-	-	-	-	25	trace	-	-	5	trace
Browse	82	1	75	trace	50	2	67	trace	73	1
Big sagebrush	36	1	50	trace	-	-	-	-	27	1
Red dogwood	45	trace	-	-	-	-	-	-	23	trace
Raspberry	9	trace	-	-	25	trace	-	-	9	trace
Dwarf huckleberry	-	-	-	-	25	2	-	-	5	trace
Serviceberry	-	-	-	-	-	-	25	trace	5	trace
Fringed sagebrush	9	trace	-	-	-	-	-	-	5	trace
Unidentified	45	trace	25	trace	-	-	67	trace	36	trace
Lodgepole pine	18	trace	75	trace	50	trace	33	trace	36	trace
Horsetail	18	trace	25	trace	25	trace	-	-	18	trace
Moss	9	trace	-	-	25	trace	33	trace	14	trace
Lichen	-	-	25	trace	-	-	-	-	5	trace
Unidentified	36	36	75	trace	50	trace	33	trace	46	trace

*Trace indicates less than 1 percent composition. Material is ranked according to composition by volume, in the total diet. Composition totals of less than 100 percent are the result of rounding to the nearest percent.

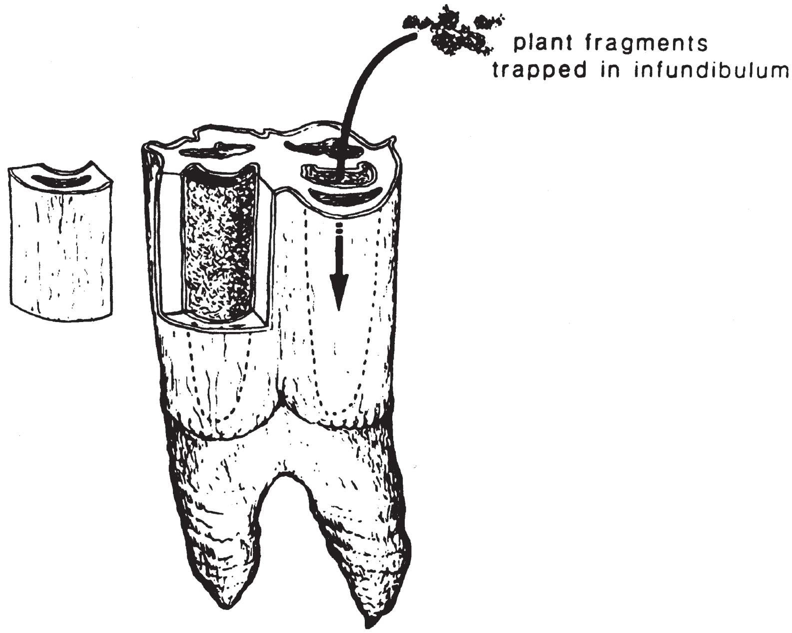

Figure 13. Plant fragments trapped in molar infundibula were extracted and identified in the lab. This information was used in the reconstruction of the bison's diet and habitat. Modified from Guthrie (1990:Figure 7.2).

Table 5. Provenience of phytolith and macrofloral samples removed from bison teeth.

Sample No.	Tooth	Analysis	Phytoliths Counted
1	Right 2nd molar, impacta	Macrofloral, Phytolith	10
2	Left 2nd molar, calculus	Phytolith	100
3	Right 3rd premolar, calculus	Phytolith	109
4	Left 2nd molar, impacta	Macrofloral	-

In our study, calculus or impacta contents were examined for three cheek teeth from the skull by PaleoResearch Laboratories. The following section is modified from this report (Cummings and Puseman 1996), which will hereafter not be referenced. This study was undertaken to identify diet and possible ecology of the area in which this bison ranged. The bison is of relatively recent age (170 ± 50 B.P.), representing the Late Holocene. Phytolith and macrofloral analyses of impacta contents, as well as phytolith analysis of calculus, provide a partial record of diet.

Methods

Impacta contents were removed from the second right and second left upper molars using a dental pick. Only a very small quantity of impacta was removed from the left molar, while a larger sample was available from the right molar (Table 5). Calculus was removed from these same teeth, as well as from the third upper premolar on the right side. Each sample was placed in a separate conical polypropylene tube. Dilute hydrochloric acid (seven percent) was added to each sample, which softened the impacts and the calculus. The softened calculus was scraped from the small pieces of tooth that broke off when removing the calculus from the tooth. The samples were rinsed with distilled water and centrifuged. Each sample received a 60-minute acetylation to remove as much organic matter as possible without seriously damaging it to the point where identification would be impossible. A portion of the impacta contents were examined prior to acetylation. All remains appeared fibrous, but no identification of any remains could be made. No seeds were observed at this time. Following acetylation, all samples were rinsed in distilled water. The macrofloral samples were examined wet at a magnification varying between 7x and 70x and yielded only fibers. The phytolith sample was mounted in cinnamaldehyde and examined at a magnification of 400x.

Discussion

Phytoliths are silica bodies produced by plants when soluble silica in the ground water is absorbed by the roots and carried up into the plant via the vascular system. Evaporation and metabolism of this water result in precipitation of the silica in and around the cellular walls. The general term phytoliths, while strictly applied to opal phytoliths, may also be used to refer to calcium oxylate crystals produced by a variety of plants, including *Opuntia* (prickly pear cactus). Opal phytoliths, which are distinct and decay-resistant plant remains, are deposited in the soil as the plant or plant parts die and break down. They are, however, subject to mechanical breakage, erosion, and deterioration in high pH soils. Phytoliths are usually introduced directly into the soils in which the plants decay. Transportation of phytoliths occurs primarily by animal consumption, the gathering of plants by humans, or by erosion or transportation of the soil by wind, water, or ice. Grazing animals deposit phytoliths in their calculus as a result of chewing grasses. In addition, any dirt ingested has the opportunity to contribute to the phytolith record contained in dental calculus.

The major divisions of grass short cell phytoliths recovered include festucoid, chloridoid, and panicoid. Smooth elongate phytoliths are currently of no aid in interpreting either paleoenvironmental conditions or the subsistence record because they are produced by a large number of grasses. Phytoliths tabulated to represent "total phytoliths" include all forms representing plants. Frequencies for all other bodies recovered are calculated by dividing the number of each type recovered by the *total phytoliths*.

The festucoid class of phytoliths is ascribed primarily to the subfamily Pooideae, which occurs most abundantly in cool, moist climates. However, Brown (1984) notes that festucoid phytoliths are produced in small quantity by nearly all grasses. Therefore, while the typical phytoliths are produced by the subfamily Pooideae, they are not exclusive to this subfamily. Chloridoid phytoliths are found primarily in the subfamily Chloridoideae, a warm-season grass that grows in arid to semi-arid areas and requires less available soil moisture. Chloridoid grasses are most abundant in the American Southwest (Gould and Shaw 1983:120). Panicoid phytoliths occur in warm-season or tall grasses that frequently thrive in humid conditions. Twiss (1987:181) also notes that some members of the subfamily Chloridoideae produce both bilobate (panicoid) and festucoid phytoliths. “According to Gould and Shaw (1983:110) more than 97 percent of the native US grass species (1,026 or 1,053) are divided equally among three subfamilies Pooideae, Chloridoideae, and Panicoideae” (Twiss 1987:181).

Bulliform phytoliths are produced by grasses in response to wet conditions (Irwin Rovner, personal communication to Linda Cummings, 1991), and are to be expected in wet habitats of floodplains and other places. Phytoliths referred to as “pillows” are the same as those reported by Rovner (1971). While these phytoliths are described, no taxonomic or environmental significance has been assigned. They most probably represent grasses. Trichomes and papilla represent epidermal hairs on grasses and/or sedges. Epidermal forms represent epidermal grass cells.

Diatoms also were observed, indicating wet conditions. Volcanic ash fragments are noted to be widely dispersed in sediments across the North American continent in quantities varying from mere presence to dominance of the record. At present, volcanic ash fragments are interpreted to represent tiny fragments present in the upper atmosphere that fall to the earth, rather than any specific volcanic event.

Phytolith analyses of the impacta of the right second molar and of the calculus of the left second molar are very similar to one another. These records are dominated by festucoid forms composed primarily of crenate platform and crescent forms (Figure 14). Crenate platforms are common in, but not limited to, such grasses as brome grass (*Bromus*). Crescent forms are noted in, but not limited to, wheat grasses (*Agropyron*), ricegrass (*Oryzopsis*), squirrel tail grass (*Sitanion*), and needle grasses (*Stipa*). Festucoid forms represent cool-season grasses that grow in the cooler weather of spring and fall or that are dominant in northern latitudes. Two common forage grasses from the region include *Festuca idahoensis* and *Agropyron spicatum* (Daubenmire 1952:7). *Agropyron* spp. is noted as an important forage species for bison in northern-latitude mixed prairies (Plumb and Dodd 1983).

A small quantity of chloridoid saddle forms was noted in sample 1, representing the impacta. These forms represent short grasses such as buffalograss, blue grama, and others. Bilobate, cross, and polylobate forms were recorded in these samples. Generally these forms are ascribed to panicoid grasses. However, some grasses in the festucoid group also produce these forms. At present, the phytoliths recovered belonging to this group cannot be assigned to any particular genus of grass.

Both samples 1 and 2 exhibit moderate frequencies of smooth elongate forms, which are common in many grasses and are not considered to be diagnostic of any. Small quantities of spiny elongate, ridged elongate, trichome, and bulk forms were noted in both samples. Small quantities of pillow, dendritic elongate, wavy epidermal, and papilla were noted in one sample or the other. All these forms represent grasses, and none are considered diagnostic.

Pollen (Figure 15) recorded in these samples included *Pinus* (pine) and *Pseudotsuga* (Douglas fir). These pollen types probably represent trees present in the area while this bison lived and fed. Each of these two samples contained a starch granule that represents grass seeds, although the form of the starch granules was not identical. Fibers were noted in both the impacta and calculus sample (Figure 16). Microscopic examination indicates they are not bison hair (Figure 17), but rather plant material. At present, these fibers remain unidentified.

Remains observed in the two phytolith samples that did not represent plants include volcanic ash fragments and probable microscopic silica flakes.

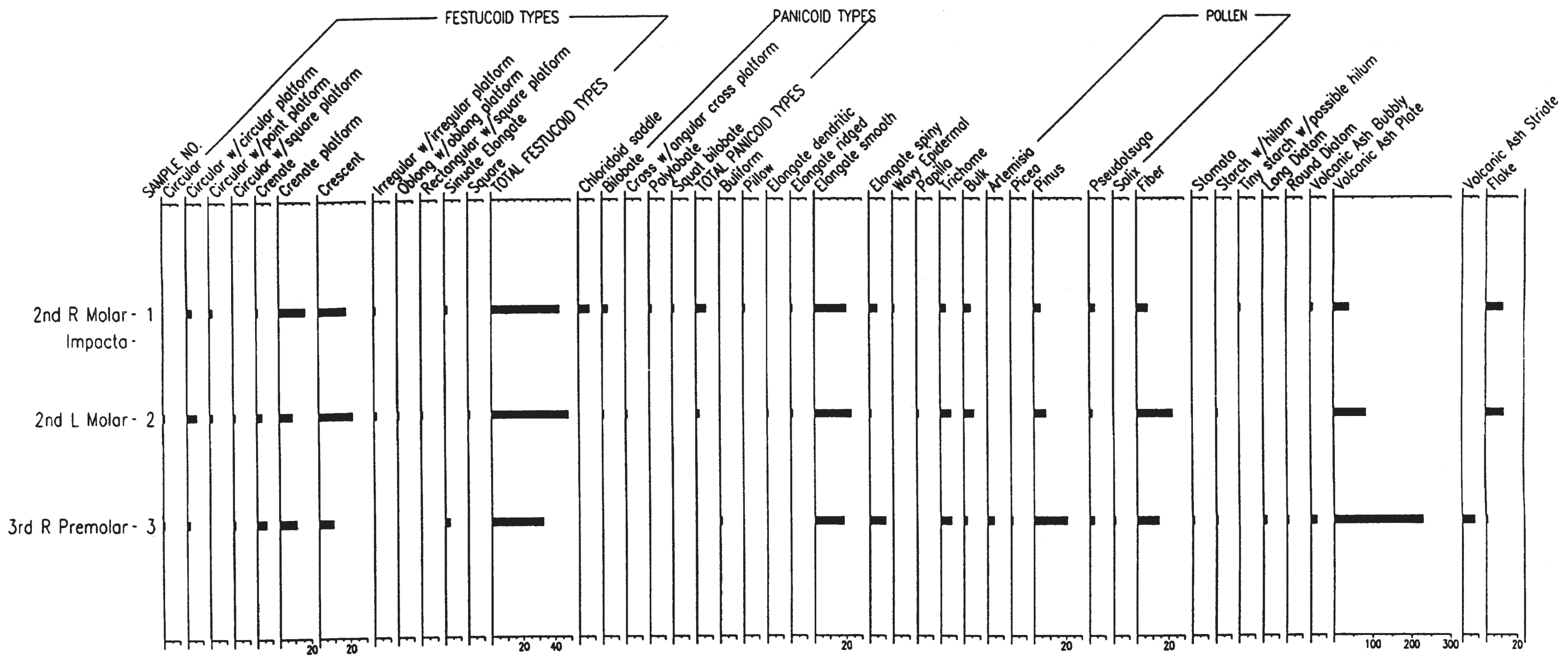

Figure 14. Phytolith diagram based on results of analysis of Fawn Creek bison molar teeth tartar.

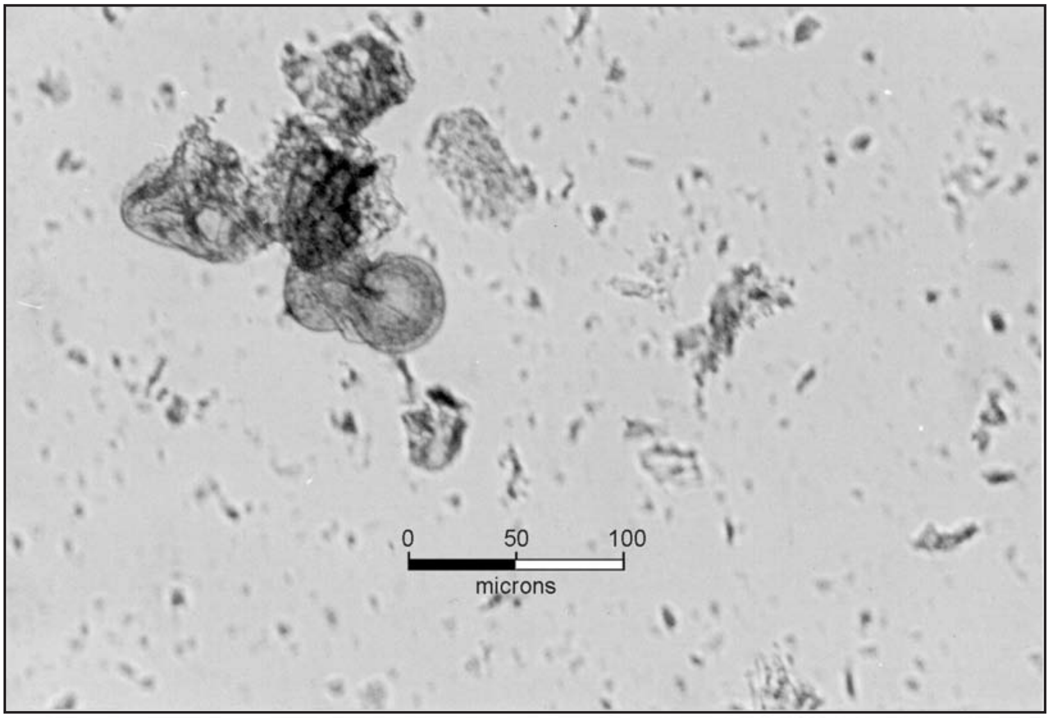

Figure 15. Photograph of *Pinus* pollen extracted from Fawn Creek bison molar teeth tartar.

Figure 16. Photograph of plant fiber recovered from Fawn Creek bison molar.

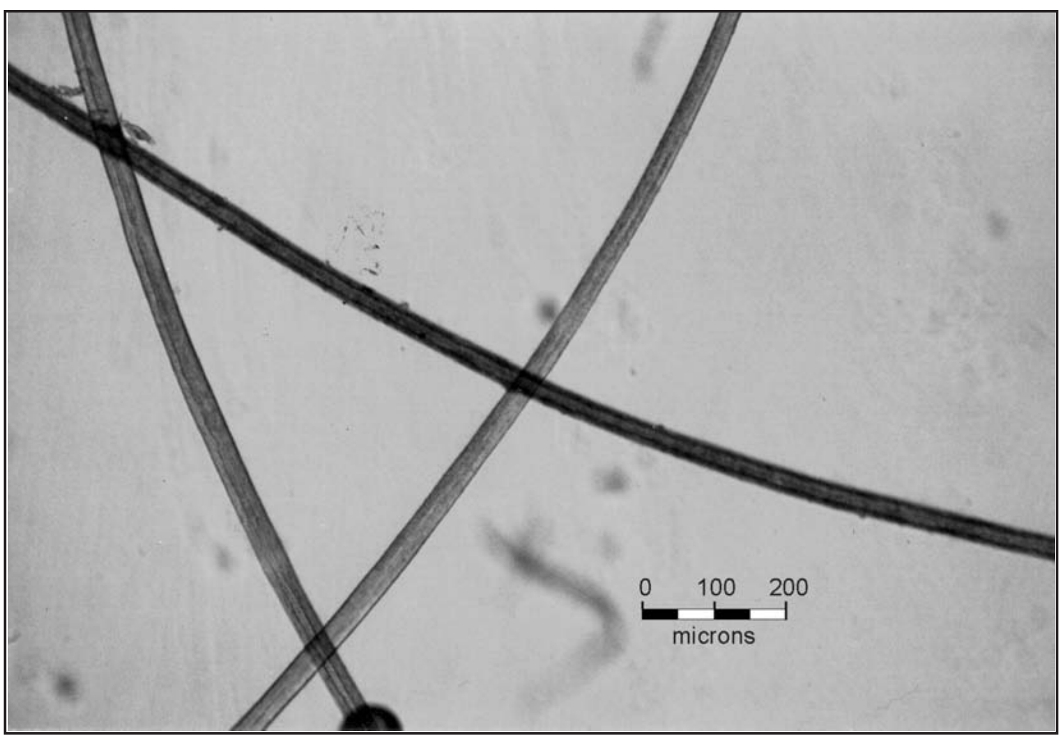

Figure 17. Photograph of reference bison hair. Compare to plant fiber in Figure 16.

The volcanic ash fragments probably were introduced into the calculus and impacta as a result of being contained in local sediments. Alternatively, the presence of small quantities of volcanic ash fragments high in the atmosphere produces a very small amount of volcanic ash rain that increases during the few years following a major volcanic eruption. These volcanic ash fragments may be present on vegetation consumed by the bison.

The calculus sample from the right third premolar yielded different frequencies of generally the same phytolith types that were recorded in the other two samples examined. Festucoid forms still dominate the record, although not as heavily. Chloridoid and possible panicoid forms are absent. Other, nonspecific phytolith forms that indicate the presence of grasses include bulliform, smooth and spiny elongates, trichome, and bulk. More pollen types were recovered from this calculus than from either the second molar calculus or the impacta. Pollen observed include *Artemisia* (sagebrush), *Picea* (spruce), *Pinus* (pine), *Pseudotsuga* (Douglas fir), and *Salix* (willow). These pollen indicate not only forest vegetation, but also a member of the upland vegetation community (sagebrush) and a member of the riparian or stream-side vegetation community (willow). Fibers identical to those in the previous two samples were present and a single stomata was recovered. A single starch granule also was present, representing grass seeds.

Non-plant remains recovered from this sample of calculus included both long and round diatoms, as well as volcanic ash fragments and a single microscopic silica flake. The diatoms probably were introduced while eating grasses (for the long diatom) or perhaps while drinking water (for the round diatom). Long diatoms represent algae that do not require a large or regular amount of water to live, while round diatoms usually are found in water or puddles.

Macrofloral analysis of impacta samples yielded no seeds. The only potentially identifiable remains were the abundant fibers. These fibers were examined using a binocular microscope at a magnification of 400x. They were compared with bison hair, and did not match. Their structure is clearly that of plant fibers. At present, these fibers remain unidentified.

Summary and Conclusions

Phytolith and macrofloral analyses of impacta and calculus from the Fawn Creek skull provide a look at potential diet for this animal. Three different teeth were examined for phytoliths. The phytolith record was very similar for the impacta and calculus examined from teeth of the same age (second upper molars). It was somewhat different for the tooth of a different age (the third upper premolar). This difference points to the potential for examining different teeth from the same individual to obtain more information. Macrofloral analysis of the impacta yielded only fibers, which were examined microscopically.

The phytolith record, which includes pollen, fibers, and starch granules as well, points to a diet of cool-season grasses, as well as at least one non-grass plant, represented by the fibers. Clear dominance of the phytolith record by festucoid grasses indicates that this bison lived its life at a latitude similar to that of the present Salmon-Challis National Forest. There is no evidence of a significant migration to the south nor any evidence for a migration into more open, dry areas. Either of these migrations would be expected to produce an elevated chloridoid phytolith signature. This bison appears to have lived primarily in a forested area. The forest appears to have been a mosaic, rather than a dense canopy of trees. The presence of a small quantity of chloridoid phytoliths, as well as sagebrush pollen, supports this interpretation. At the time the bison lived, the forest included at least pine, spruce, and Douglas fir. Willow was available along Fawn Creek and in other wet areas. This is consistent with the community structure of the modern drainage (refer to the Environment section, pp. 3-6, for details).

Results of Stable-Isotope Analysis

Introduction

As was mentioned in the introduction, an important reason for addressing issues of ecology and seasonal movement of prey species is to provide a better understanding of past human use of these resources. In areas of the Plains this is even more crucial since bison were the predominant resource of Plains groups. In the Intermountain West, the role of bison in the economy is not well understood and may have been more important during certain time periods (e.g., Butler 1978). However, this should not diminish the need or importance of understanding their seasonal movements.

One way of approaching this problem is by applying analyses of diet to the study of foraging patterns. If bison are moving through various ecosystems during annual migrations, and if these environments have different food resources, we should expect this to be evident in the bison's diet (Chisholm et al. 1986:193). Stable-carbon-isotope analysis has been applied to populations of modern ungulates in South Africa (e.g., Tieszen et al. 1979; Vogel 1978), prehistoric bison on the Northern Plains (Chisholm et al. 1986), as well as to other fossil vertebrates (e.g., Bocherens et al. 1994; Heaton 1995) in order to understand their dietary selection.

The usefulness of carbon-isotope analysis to ecological studies became apparent with the publication of an article by Bender (1968) that described a systematic relationship between the photosynthetic pathways (C_3 and C_4) and the stable-isotopic ratios of carbon in grasses (Tieszen 1994:261). The dietary application of carbon-isotope studies involves the quantification of ratios of $^{13}C/^{12}C$ isotopic abundances in bone collagen, which is linked through the food web to the primary producers—photosynthetic plants (Bocherens et al. 1994:214). In terrestrial environments, two main categories of plants are recognized by their carbon-fixation pathways, which are clearly distinguished by their stable-carbon-isotope ratios. The C_3 plants include all trees and herbaceous plants from cold and temperate climates. Their $\delta^{13}C$ values range between -23 and -32‰, with an average of about -26‰. Warm weather and tropical herbaceous plants, such as maize, sugar cane, and millet, are classified as C_4 and have a $\delta^{13}C$ value between -9 and -16‰, averaging around -13‰ (Smith and Brown 1973:505; Bocherens et al. 1994:214). With this understanding of the $\delta^{13}C$ values the amount of C_3 and C_4 plants consumed by herbivores can be quantified and applied to various biogeographic questions.

An important aspect in using carbon isotope analysis in reconstructing diets is that variation in atmospheric values of $\delta^{13}C$ have varied in predictable ways through time, due to different environmental conditions. In systems where the respiratory release of CO_2 does not mix freely with the atmosphere, such as in closed canopy forests, the ambient CO_2 can become depleted, resulting in higher negative values for both C_3 and C_4 plants (Tieszen 1994:264). An example from the Amazonian forests measured $\delta^{13}C$ values as negative as -37‰. In comparison, open habitats of C_3 grasses average about -26.5‰ (van der Merwe and Medina 1991:250). This depletion is transferred to other trophic levels and must be taken into account when considering diet for forest-dwelling herbivores as well as humans (Tieszen 1994:264).

The anthropogenic addition of CO_2 to the atmosphere over the past two centuries through the burning of fossil fuels has depleted atmospheric CO_2 of $\delta^{13}C$. This input has also enhanced decomposition associated with agriculture and deforestation. Preindustrial $\delta^{13}C$ values of -6.45‰ have been measured from Antarctica ice cores, compared with modern conservative estimates at -8.0‰. Based on this knowledge, significant adjustments must be made in the reconstruction of past diets and in paleoecological interpretations. Therefore, an adjustment of about 1.5‰ must be made to Holocene samples dating to before A.D. 1800 in comparison to modern values (Tieszen 1994:264).

The distribution of C_3 and C_4 plants in the environment is not random, but related to environmental factors, specifically temperature. With increasing latitude and longitude there is a corresponding increase in C_3 species. An example from Kenya illustrates this point—within low-altitude, open savannahs all grasses are C_4 and nearly all trees and shrubs are C_3; above 1,800 m, C_4 grasses begin to be replaced by C_3 grasses; and at 3,000 m, nearly all grasses are C_3 (Tieszen 1994:265).

In a study from southeast Wyoming, Boutton et al. (1980, as cited by Tieszen 1994:265) showed that the percentage of C_3 biomass increased with elevation. Regressions of relative biomass abundance of C_3 and C_4 plants on climatic variables illustrated that both mean annual temperature and annual precipitation were equally reliable predictors. Temperature was also a factor the authors felt strongly influenced the ratios.

On the Great Plains, increases in C_3 grasses are correlated with increasing latitude. In south and southwest Texas, C_4 grasses are represented at 68 and 82 percent, respectively, decreasing to 35 percent in South Dakota. Browse species, such as the sedges, do not show as clear a temperature-dependent distribution as grasses. *Carex*, a common genus of sedge in the mountains, is C_3 (Tieszen 1994:265). Grass composition for Idaho is estimated at about 18 percent C_4 species (Teeri and Stowe 1976:Table 2).

It is therefore expected that generalist consumers of grass biomass should have a modern isotopic signal that reflects the mixture of C_3 and C_4 species in the utilized environment. However, since climatic changes have been demonstrated for various periods during the course of the Holocene, vegetation values should be expected to reflect these climatic shifts. This temporal variable is another complicating factor involved in the interpretation of isotopic signals from paleo-samples (Tieszen 1994:166).

The Fawn Creek Sample

A bone sample consisting of the zygomatic arch from the Fawn Creek bison skull was submitted to Drs. Larry Tieszen and Michael Chapman of the Biology Department of Augustana College for stable-isotope analysis. The sample consisted of a portion of the left zygomatic arch and weighed 14.2 grams. Analyses preceded normally and the collagen pseudomorph extracted was given a rank of 3 based on a scale from 1 to 5, with 5 being the highest quality. In order for analysis to proceed, the following criteria must be met: rank >1, percent of yield >3.0, percent of carbon > 15, and the carbon/nitrogen ratio must be between 3.6 and 2.9. All these criteria were met (Table 6).

The $\delta^{13}C$ value for the sample is -19.6‰. Adjusting for modern anthropomorphic alteration of atmospheric CO_2 the $\delta^{13}C$ value is -21.1‰. This value is similar to values for those of modern bison (-23.4‰) in Yellowstone National Park that occupy a similar latitude and elevation to that of the Fawn Creek bison (Tieszen et al. 1996), as well as to values for other high-altitude/high-latitude specimens (Figure 18). Although bison in Yellowstone are considered free-roaming and their diets are not supplemented, they are limited in their range to the park boundaries of the Yellowstone Plateau (Meagher 1973). The high negative value measured for the Yellowstone bison was not unanticipated, since C_4 plants are not available on the Yellowstone Plateau (Tieszen et al. 1996, quoting Turner et al. 1994).

Analysis of seasonal food habits of Yellowstone bison from rumen samples indicates a diet consisting exclusively of C_3 plants (Table 4; photosynthetic pathways confirmed by L. Tieszen, personal communication 1996). The major forage species identified as potentially being within the adjacent environments in which the skull was found are generally C_3 plants. These include Idaho fescue and bluebunch wheatgrass in the forested uplands, and bluegrass, Stipa, and oatgrass in the canyon (photosynthetic pathway data from Boutton et al. 1980:Table 1).

Table 6. Results of stable-isotope analysis of Fawn Creek and other modern North American bison specimens. Alaska data from Bocherens et al. (1994:Table 4), Konza, Niobrara, Wood Buffalo, and Yellowstone data from Tieszen et al. (1996), and Wind Cave data from Tieszen (1994:Table 5).

SPECIMEN	MEASUREMENT							
	COLLAGEN RANK	PERCENT YIELD	PERCENT NITROGEN	PERCENT CARBON	CARBON/ NITROGEN	$\delta^{13}C$	$\delta^{15}N$	APATITE $\delta^{13}C$
FAWN CREEK	3	25.9	14.8	41.5	3.3	-19.6‰	6.5‰	-10.8‰
ALASKA	-	-	-	-	-	-20.5‰	4.4‰	-
KONZA, KS	-	-	-	-	-	-13.8‰	5.5‰	-
NIOBRARA, NE	-	-	-	-	-	-15.9‰	2.9‰	-
WIND CAVE, SD	-	6.5	-	-	3.22	-18.7 ± 0.2‰	6.4 ± 0.23‰	-
WOOD BUFFALO, NWT	-	-	-	-	-	-23.9‰	6.6‰	-
YELLOWSTONE, WY	-	-	-	-	-	-23.4‰	6.9‰	-

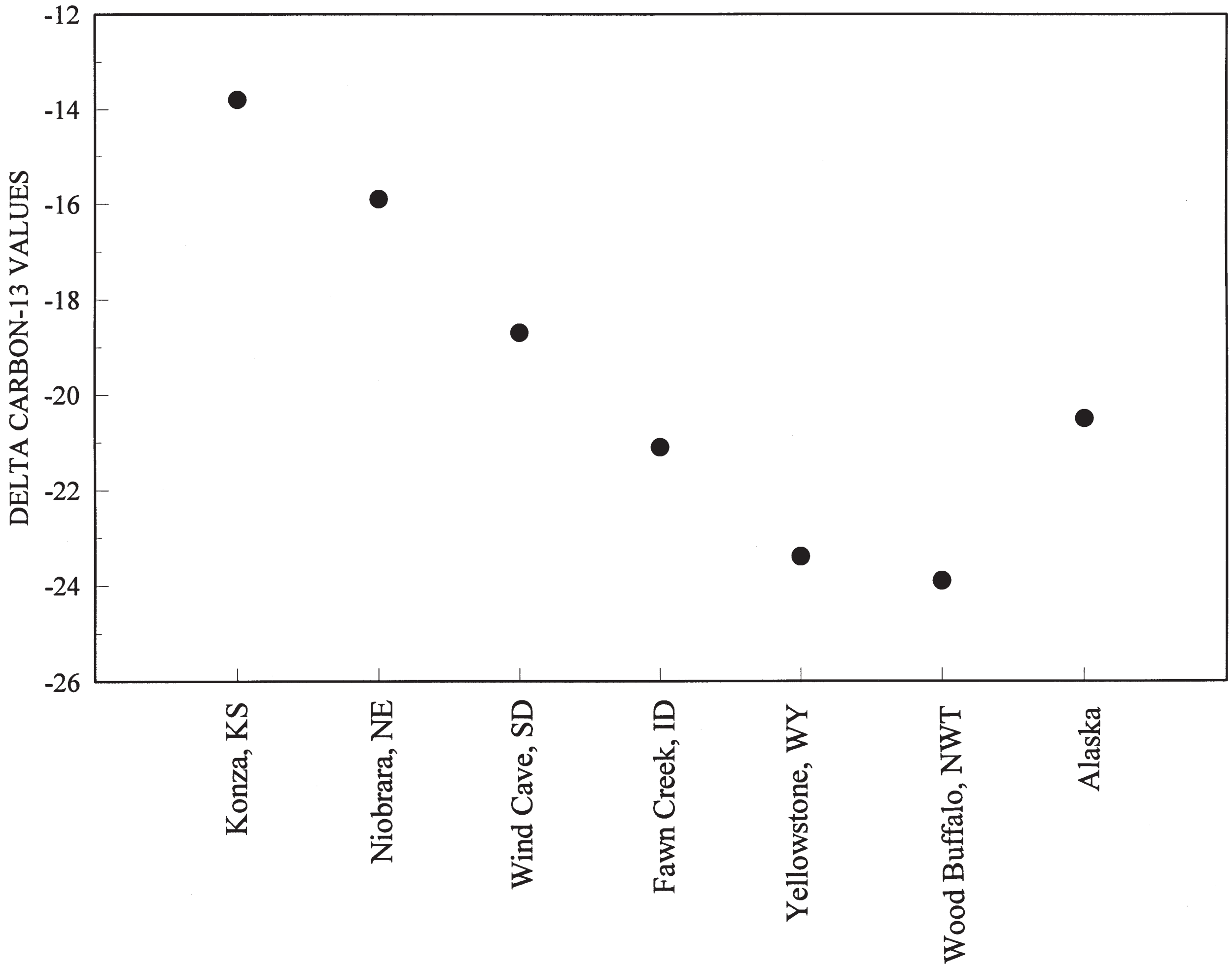

Figure 18. Comparison of $\delta^{13}C$ for North American bison populations. Data from Bocherens et al. (1994), Tieszen (1994), and Tieszen et al. (1996). Percentage of C_4 increases as $\delta^{13}C$ value becomes more positive.

The stable-isotope analysis suggests the Fawn Creek bison probably did not migrate any great distances during its lifetime, especially into the grassland valleys where C_4 plants would be accessible. The negative value is similar to that of modern bison inhabiting mountainous terrain in Yellowstone National Park and suggests an almost exclusive diet of C_3 plants. For Yellowstone bison, the stable-isotope results are supported by the analysis of rumen (Meagher 1973) and may provide an analogue for the Fawn Creek bison.

Some C_4 plants may have been eaten during the latter part of the year. Boutton et al. (1980) found that C_4 biomass increased at all elevations during the late summer. Tieszen (1994:275) found that bison in South Dakota rely on C_3 plants until early June. During July and early August, fecal values indicate a 45-percent reliance on C_4 vegetation. Seasonal migrations between the uplands and the Salmon River canyon to partake of ripening grasses, as well as not-long-distance migrations between the wide valleys to the south, may account for the results of the $\delta^{13}C$ tests. During the winter, bison will seek out the warmest and driest part of their range. It may be during these months that C_4 plants become a component of the diet (Tieszen et al. 1996). Without a larger sample and more complete analysis of the local plant communities, a more definitive explanation is not possible.

Another stable isotope examined in the study of diet is $\delta^{15}N$, which is linked to trophic level. As $\delta^{15}N$ values increase 2-5‰, a corresponding increase in the trophic level occurs (Bocherens et al. 1994:214). The potential of dietary stress can also be assessed by examining $\delta^{15}N$ values. In examining horn sheath annuli of bison from the Central Plains, Tieszen et al. (1996) identified a change in $\delta^{13}C$ values accompanied by changes in $\delta^{15}N$ that they interpreted as a large degree of stress undergone by these individuals with shifts in diet. The exact cause of stress may have been from illness or water stress. The Fawn Creek $\delta^{15}N$ value is within the range of normal bison $\delta^{15}N$ values (Figure 19), implying that this individual did not undergo significant dietary stress.

Summary

The stable-isotope analysis of the Fawn Creek skull indicates a significant portion of its diet consisted of C_3 plants. These cool-weather grasses, which would include such species as *Festuca* and *Agropyron*, are common at this altitude and latitude. An area of similar altitude and latitude is Yellowstone National Park, and plant surveys indicate only C_3 species are available to bison for grazing (Turner et al. 1994, as cited in Tieszen et al. 1996). This data implies that the bison probably did not migrate long distances over the course of its life, but survived within the mountainous terrain of the Salmon River Mountains.

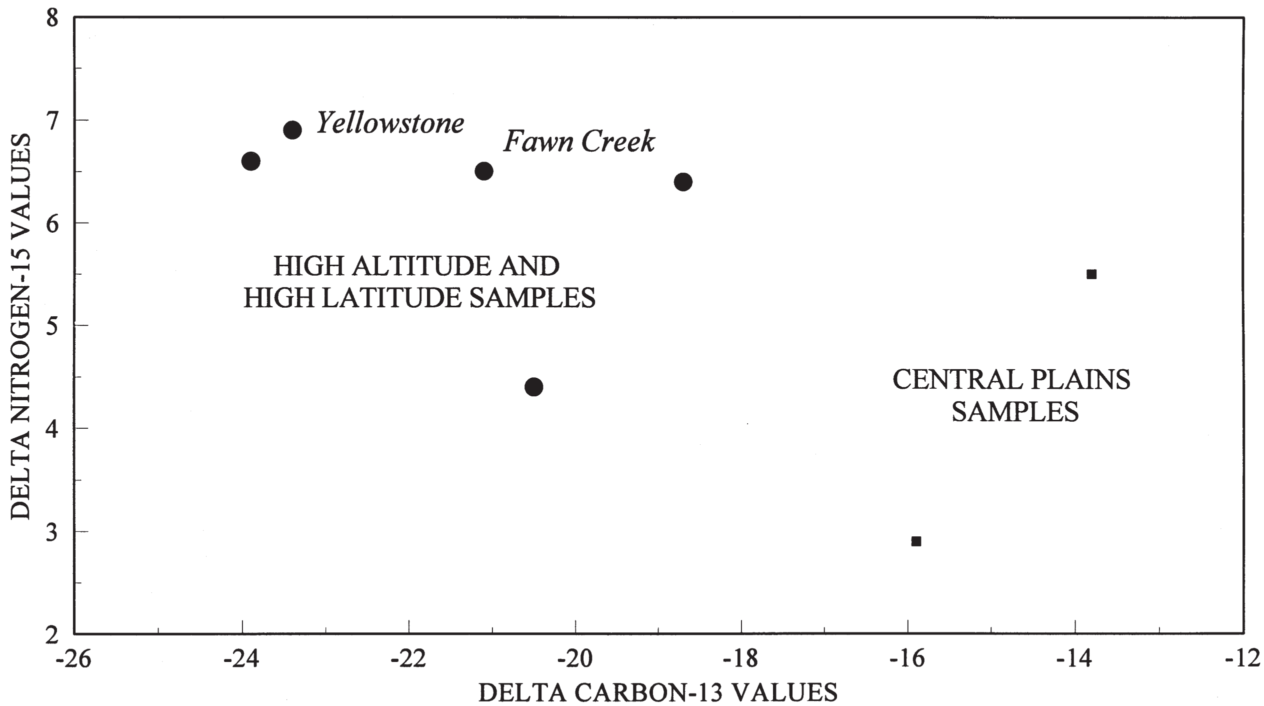

Figure 19. Plot of $\delta^{15}N$ against $\delta^{13}C$ values for North American bison specimens from high altitude (e.g., Yellowstone), and high latitude (e.g., Wood Buffalo), and from the Central Plains. Data from Bocherens et al. (1994), Tieszen (1994), and Tieszen et al. (1996).

Conclusions

In 1995 a bison skull was recovered from the bank of Fawn Creek, a steep, narrow drainage that flows into Panther Creek, a major tributary of the Salmon River in Lemhi County, central Idaho. Vegetation of Douglas fir, interspersed with a few open sage/grass communities on the southern and western slopes, does not intuitively present itself as prime bison habitat, and the faunal evidence bears this out. Due to the paucity of historic bison in these mountain settings, as well as from the local archeological record, the Salmon-Challis Forest entered into a cooperative agreement with the Midwest Archeological Center to study the bison in order to understand its ecology. The skull was prepared at MWAC for display on the Forest. And, a review of the prehistoric and historic record of bison in central and eastern Idaho is also presented.

Several analytical techniques were applied to the skull in order to understand its age of deposition and ecology. Radiocarbon dating revealed a recent age of 170 ± 70 yr B.P., which calibrates to about the late eighteenth to early nineteenth century. Identification of macrobotanical remains recovered from the infundibulum of the molars, in association with the analysis of pollen and phytoliths extracted from tooth tartar, indicate this bison subsisted on festucoid grasses and other cool-season grasses in an open forest setting. The stable-carbon-isotope analysis is consistent with the plant data—this particular bison lived its life in the mountainous region of the Salmon River. There is no indication of long-distance migrations. The stable-isotope results are also consistent with Yellowstone National Park modern bison studies. These bison exist at a similar altitude and latitude as the Fawn Creek bison and are restricted to the uplands of the Yellowstone Plateau.

While this study provides an important first step towards understanding bison ecology in the intermountain west, analysis of a number of bison from various sites in the region would provide a more definitive model. Bison have existed in the intermountain west since at least the Late Pleistocene, with populations fluctuating in response to fluctuations in the biome's carrying capacity, a probable effect of climatic conditions. During the nineteenth century, the introduction of the horse, firearms, and Euroamerican trappers and settlers had a devastating effect upon the bison from which they never recovered. With the near extinction of bison from almost all of its former range, the task of understanding their ecology, behavior, and taxonomic relationships falls to the study of managed or isolated herds.

Understanding bison ecology and migration patterns through the study of sub-fossil bison is one of the few ways we have in the reconstruction of past conditions. Bison today are confined to small, isolated herds that are not allowed to range freely within their historic ranges. If we are to truly manage the few surviving undisturbed areas in a meaningful way, we must be willing to expend the effort to study how ecosystems have developed through time. Today ungulate management is a very politically charged issue, and much of the information used to make the management decisions is based on modern studies of herds under confined situations (e.g., Berger and Cunningham 1994). Few, if any, studies incorporate long-term data such as that available from paleostudies. Studies, such as stable-isotope analysis, provide a means to decipher paleoenvironment conditions to model future changes and the restoration of habitats.

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Appendix A

Analysis of DNA from the Skull of an American Bison Recovered from the Salmon-Challis National Forest in North Central Idaho

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Sample

The sample was an intact complete bison skull reported to be from the Late Holocene. The skull was not cleaned after excavation and contained dirt and modern living and dead plant material.

Obtaining Material

Using sterile instruments, approximately 30 gm of "spongy" bone material was removed from the occipital region of the skull surrounding the spinal cord entrance. The material removed contained little visible dirt and plant material, and it was stored in a sterile plastic tube at -20°C until processed. All sterile instruments and containers were treated with 1 N HCl to destroy all contaminating DNA.

DNA Extraction

The extraction process of the bone was performed to isolate both genomic DNA and mitochondrial DNA in a process that is termed "total DNA."

The extraction process was carried out in an enclosed DNA processing box that had been sterilized with UV light to destroy any contaminated DNA within the working area of the box. All equipment and supplies used in the extraction process were sterile and decontaminated with 1 N HCl. All reagents were formulated or processed to remove all contaminating DNA. Sterile gloves and sterile technique were used throughout the processing.

All outside surfaces of the bone were cleaned prior to processing to attempt to remove extraneous contaminating DNA from the organisms in the dirt and the plant material on the outside of the bone sample.

The bone tissue was submerged in liquid nitrogen for 20 min and pulverized by mortar and pestle to a powder. The bone powder was added to 5 ml of extraction buffer: 10 mM Tris-HCl (pH 8.0), 2 mM EDTA, 10 mM NaCl, 1% (w/v) sodium dodecyl sulfate, 10 mg/ml dithiothreitol, and 0.5 mg/ml proteinase K. The mixture was incubated with gentle agitation at 37°C for 20 hours. An equal volume of phenol (equilibrated with 1 M Tris-HCl, pH 8.0) was added. The mixture was allowed to separate and the phenol removed. The sample was extracted twice with phenol followed by a standard chloroform extraction procedure. The aqueous phase after the three extractions was concentrated with a micro concentrator to about 3 ml. The sample was stored in 6 aliquots at -20°C. To visualize the DNA for size, an aliquot of the extracted DNA was separated on agarose gel electrophoresis and stained with ethidium bromide.

PCR Amplification and DNA Sequencing

Polymerase chain reaction (PCR) was carried out using standard methods with 25-30 µl reaction mixtures: 67 mM Tris (pH 8.8), 2 mM $MgCl_2$, 20 mg/ml bovine serum albumin, 1 mM of each deoxynucleotide triphosphate (dNTP), 1µM of each primer, isolated genomic or mitochondrial DNA (10-100 ng) and AmpliTaq "Gold" polymerase (2 units). Multiple primers were utilized in an attempt to determine the presence of bison genomic or mitochondrial DNA, or mammal and vertebrate mitochondrial DNA. The following reaction protocol was used: initial incubation at 94°C for 10 min, followed by 30 cycles of the following temperature changes, melt for 15 sec at 94°C, anneal for 15 sec at 40°C and extend for 1 min at 72°C. After the 30 cycles, the final extension was at 72°C for 7 min. Two controls were always run with each assay: 1) a blank extract control to control for contamination during isolation, and 2) reagent controls to control for contamination during reagent preparation. The PCR product was analyzed by agarose gel electrophoresis and stained with ethidium bromide. Double-stranded DNA sequencing was performed by standard methods using a Pharmacia ALF express automated sequencer.

Results

Amount and Fragmentation of DNA

The amount of DNA obtained from 25 gm of bone material was only 6 μg total in 3 ml. Upon analysis on agarose electrophoresis, the majority of the DNA was fragmented. About 80-90% of the DNA had a molecular weight of 200-300 daltons and the remaining material was larger in size. The small size of the isolated DNA is typical of ancient DNA.

PCR Products

To attempt to identify the DNA of *Bison bison*, we tested for five known genomic sequences of bison or bovine and a region in the D-loop of the bison mitochondrial DNA. This was accomplished using primer oligonucleotides for the following genomic genes: hemoglobin, albumin, myoglobin, microsatellites and *Alu* repeats. The D-loop of bison mitochondria was also amplified to identify bison species. We were not able to obtain amplified products from any of the mammalian genomic or mitochondrial sequences. The DNA was either too degraded or was from only plant or bacterial sources.

Discussion

The bison skull obtained from the site in the Salmon-Challis National Forest in north central Idaho was buried and contained considerable amounts of dirt and plant debris in terms of molecular biology contamination. Samples were taken for DNA analysis from the external occipital region of the skull. The skull would have had to be destroyed to obtain good clean uncontaminated DNA from the inside of the skull.

DNA was isolated from the sample removed from the skull and was fragmented as expected from ancient DNA. However, because the DNA did not amplify, it must be concluded that the DNA was not of mammalian origin but was from bacteria or plants. The other possible cause for the lack of amplification of the mammalian DNA was that the DNA regions tested were degraded and not available for amplification. A third possible reason for non-amplification is that time-induced inhibitors of the ancient mammalian DNA may be present that interfered with reactions, but this is only a remote possibility.

The use of DNA analysis to determine the species and potentially the sub-species or the genetic population from which an animal is obtained is possible and of significant importance. Based on work in man and other species, it is possible to determine the population from which a species may have come. This would be important in archeological specimens since we may be able to study migration patterns and possibly the interaction of a species with man. Unfortunately, with the work done on this specimen, we have not been able to identify the DNA as to bison or even to mammal/vertebrate. Further work on this material will continue.