BISON JUMP SITES IN THE NORTHWESTERN PLAINS OF NORTH AMERICA: A LOCATIONAL ANALYSIS

By

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ABSTRACT

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This study is a locational analysis of bison jump sites in the northwestern plains of North America. One hundred forty-six sites from Alberta, Montana and Wyoming were examined in an attempt to identify cultural preferences and environmental constraints which affected the site location decisions of prehistoric hunters.

Bison jump site data and associated environmental information including various soil types, geology, topography, vegetation and water source associations were partitioned into a set of quantified variables and subjected to a series of statistical procedures. The most critical environmental and cultural variables identified for site location through various tests for degrees of significance were water source association and jump face direction.

An interpretive framework provides evidence that jump face direction is strongly associated with prevailing wind direction. This knowledge may provide information relevant to seasonal site use, subsistence strategies and population movements. It is suggested that site proximity to permanent water sources reflects the use of

associated broken topography for bison jumping, or the water needs of human groups and/or bison herds.

ACKNOWLEDGMENTS

The research and writing of this thesis was carried out over a period of years from 1975 to 1979. It was originally conceived and initial background research begun while I was a graduate student at Idaho State University. Under the direction of the late Dr. Earl Swanson, a literature search was made and a research trip undertaken to the Universities of Wyoming, Montana and Calgary and to the Saskatchewan Natural History Museum to obtain site data. Additional site information was obtained from various sources during the period of analysis and write-up at Michigan State University. During my tenure at Michigan State, the College of Social Science and Department of Anthropology graciously provided computer time for this project. A large number of persons contributed to this effort and I acknowledge a debt of thanks to them all.

The help provided by my committee members is particularly appreciated. Dr. William A. Lovis, Chairman of my committee, gave much needed advice on statistical problems and provided a critical, yet patient, sounding board for both good and bad ideas. Dr. Charles Cleland, as a member of my committee, gave very generously of his time to fully discuss with me his appraisal of each chapter.

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TABLE OF CONTENTS

LIST OF TABLES

Table		Page

Table | Page

LIST OF FIGURES

INTRODUCTION

Late prehistoric and protohistoric bison hunting techniques in the Northwestern Plains of North America have been the subject of increasing interest in anthropological studies. In part such interest stems from the extensive technological, social, and economic impact that a single resource, bison, had upon many Plains Indian groups in the area. For many historically known groups including the Crow, Blackfoot and Gros Ventre, the bison provided their most important food source. Archaeological evidence suggests such dependence was probably similarly shared by prehistoric groups in the Northwestern Plains for the last several thousand years.

The Problem

Traditionally, prehistoric bison procurement research has stressed descriptive studies or problem-oriented research structured by the culture-historical framework of the area. Most studies have been site specific or regionally specific even when attempting to identify and explain patterns of behavior covering a much broader area. Those which provided comparative sections covering a large area of the Northern Plains have done so either superficially or quite selectively. While a symposium and a synthesis of the literature of one procurement method--bison jumping--appeared in the early 1960s (Malouf and Conner 1962; Hurt 1963) they were largely pioneering studies identifying little more than the parameters of the subject and some of the areas in need of research. But in pursuit of answers to a variety of problems related to kill sites, archaeologists have overlooked or ignored a major research topic: the spatial patterning of bison kill sites over a broad geographic region. It has been perhaps overlooked because it is considered too obvious--the assumption is that conditions favorable for particular types of bison kills, particularly jumps, are self-evident. It is thought that the most important research task begins after sites are located. But not all "favorable" locations contain bison jumps while others, which seem less favorable sometimes do. This suggests that less obvious environmental and cultural variables or particular sets of variables may have contributed to a chosen location for a jump site. In the following study I intend to pursue the proposition that there was a particular identifiable set of variables which controlled the optimal locations available for one type of bison kill--bison jumps. For the purposes of this study a bison jump is defined as "the physical location of a buffalo jump including lines of rock piles, cliff and area where the animals landed and were slaughtered" (Conner 1962: 57).

This study focuses upon several questions all of which relate to the spatial distribution of known bison jump sites in the Northwestern Plains. The most important focus will be determining why the jumps were located where they were. Important here is identification of the cultural preferences and environmental constraints which affected site location decisions of prehistoric hunters. This study's analysis will also provide enough detailed spatial information to answer several corollary questions: (1) does the locational data provide significant patterning and, if so, is the pattern predictable? and (2) do the environmental and cultural characteristics of bison jumps remain consistent throughout the Northwestern Plains? Answers to these questions should suggest powerful behavioral explanations for aspects of prehistoric communal bison hunting. At this point it should be stated that the severely limited number of dated jump sites restricts speculation about temporal patterns which may result from comparisons of the few dated sites.

Hypotheses

This investigation will follow the lead of several recent studies which utilized spatial modeling to establish the existence of patterned relationships between archaeological sites and the environment and between sites and other sites (Martin 1977; Green 1973; Gumerman 1971; Holman 1978; Roper 1975). These studies which stem from geographic locational analysis (Haggett 1965) have clearly shown the utility of isolating characteristics of the natural and cultural environment to establish their relationship with archaeological site distribution. My study, however, differs from previous research in that I propose to analyze the locational pattern exhibited by only one type of special use site--bison jumps. A corollary goal of the analysis is the formulation of a predictive testable model of jump sites which can be projected into as yet unsurveyed areas. That is, establishing the correlation between sites and environmental features and projecting this knowledge into similar areas and even into previously surveyed areas to discover overlooked sites (Green 1973: 279).

Two propositions of locational theory are vital for analysis and model-building in this study:

1. Sites were located so as to minimize the effort expended in acquiring required quantities of critical resources.
2. Sites were located with respect to critical on site resources. (Plog and Hill 1971: 12)

The first proposition suggests that sites were located to gain access to a maximal number of needed resources with minimal effort. Since this analysis is concerned with a site type devoted exclusively to the exploitation of a single resource--bison, it might be assumed that those resources related to bison presence (soils, vegetation and possibly water) represented the most critical environmental variables in site location decisions. The fluctuating availability of bison in any one area and the fact that bison were driven from as far as 20 to 40 miles to a jump-off (MacGregor 1966; Schaeffer 1962; Forbis 1962: 63-64), however, weighs against such a conclusion. The bison resource was an uncertain quantity and so probably represented a strong contributory factor rather than a dominant one. The second proposition refers to both potential on-site resources, such as water, and the immediate natural and cultural setting of the site. It is suggested that these variables were most critical in site location decisions because of the special topographic features required for jump sites and the relative permanence they offer for repetitive use.

Thus, in light of the above propositions, it can be expected that this analysis will (1) show those variables most important to successful bison jumping (topography, geology and possibly water) to be <u>the</u> most critical to site location decisions and (2) show those variables most closely related to the bison resource (vegetation, soils) to be important, but dependent variables.

Hypotheses:

As a result of this study, it is expected that:

1. Bison jump sites will show a definite predictable pattern most closely associated with topographic and geologic variables and possibly with water. While such a correlation could be anticipated from cursory examination of jump sites, it is suggested that refined environmental parameters will be established which will provide vastly increased predictive potential.
2. Critical environmental and cultural characteristics of bison jump sites will remain relatively consistent over the entire Northwestern Plains suggesting that, all things being equal, a most effective and productive method of killing bison was known over a large geographic area.

CHAPTER I

ENVIRONMENT OF THE NORTHWESTERN PLAINS

Study Area

The Great Plains of North America is a very cohesive environmental region. Physiographic, climatic and, to a large extent, biotic features distinguish it from adjacent regions including the Rocky Mountains to the west, the Parkland to the north, the Gulf lowlands to the south and, to a lesser extent, the tall grass prairies and woodlands to the east.

Scientists have, for purposes of discussion, found it valuable to divide the Plains into several sub-regions. This study will concentrate on that portion of the Plains commonly identified as the Northwestern Plains. The Northwestern Plains (Fig. 1) have themselves been defined several different ways in the past (Wedel 1961; Conner 1968; Frison 1978). For the purposes of this study a modified version of Stuart Conner's division was found most appropriate since it effectively incorporates the greatest concentration of bison jump sites and is not pretentious (Conner 1968: 13). Conner states that the boundaries are primarily " . . . a basis for discussion and not a definition" (1968: 13). In this scheme the Northwestern Plains constitute that portion of the short grass plains which lie between the Northern Rocky Mountains and the mixed grass prairie to the east. Politically, it includes

Figure 1. Map of the Northwestern Plains.

" . . . the southern one-half of Alberta and Saskatchewan, the eastern two-thirds of Montana, and the northern third of Wyoming" (1968: 13). Additionally, the extreme western portions of North and South Dakota and the eastern flanks of the Northern and Central Rocky Mountains are included (Hunt 1974). The latter regions encompass the large river valleys west of the Continental Divide in Montana and the large basins and valleys in north-central Wyoming. These areas share many of the features of the Plains and, in fact, tend to blend imperceptibly into the Plains setting.

Paleoenvironment

Several models have been postulated which describe and explain Holocene environmental conditions in parts of western North America, two of which have gained particular attention.

Antevs (1955) has postulated a model of gradual climatic change for the region which has traditionally provided the paleoenvironmental model for western North American archaeologists. The most significant part of this reconstruction is a gradual warming trend thought to have climaxed about 6000 years ago. Because Antevs' supportive data was primarily from the Great Basin, however, the degree to which the model is applicable to the Plains is largely unknown.

Another more recent model of the Holocene climate postulates intermittent periods of environmental stability followed by rapid climatic shifts. Its principal advocate, Reid Bryson (Bryson and Wendland 1967; Bryson and others 1970) suggests that there is a correlation between particular climatic variables and biotic regions. When climatic variables shift, there appears to be a corresponding shift in biotic regions. A cause and effect relationship has not been demonstrated, however, and, as Bryson emphasizes, the model may be premature (1967: 296).

The time span of major interest to this study is the last 2500 to 2000 years, since the vast majority of dated jumps fall within this time period. Bryson and Wendland (1967) propose that this period, called the Sub-Atlantic, was a time when biotic conditions were similar to the present, with only minor fluctuations primarily affecting the boundaries of biotic regions. Antevs' model postulates a gradual moderation of climatic conditions from the peak of the Altithermal 6000 years ago to today. Other environmental studies, drawing on pollen samples from southern Alberta (Wormington and Forbis 1975: 121) and northern Wyoming (Haynes 1965: 209), suggest that these portions of the Northwestern Plains have enjoyed a relatively stable climatic period for the last nine to ten thousand years. Thus, the consensus of the present evidence suggests the existence of a relatively stable environment on the Northwestern Plains over at least the last 2500 years.

In light of the above discussion, it is suggested that a detailed study of modern environmental variables at jump sites will generally reflect conditions prevalent at the sites within at least the last 2500 years. Some increase or decrease in erosional activity, due to unusually severe local climatic conditions or relatively recent grazing or other land-use practices, may have altered topographic variables and water availability at some locales. The assumption is, however, that general site settings have remained intact over time.

Present Environment

Physiographic Considerations

Contrary to the reports of many observers who characterized the Northwestern Plains as a level, windswept expanse, its topography is actually quite diverse. While a large part of the area consists of level plains, the isolated mountain ranges, high ridges, eroded badlands and river valleys serve to break up the level topography and provide a variety of micro-environments (Figs. 2 and 3).

The Northwestern Plains lies within two major river drainages: the Saskatchewan and the Missouri. The Saskatchewan Drainage encompasses most of the Alberta and Saskatchewan Plains in Canada (Fig. 2). Lying at elevations between 2500 feet above sea level to 3500 feet a.s.l. and 1500 feet a.s.l. to 2000 feet a.s.l., respectively, these plains are characterized and modified by isolated mountain ranges, deeply incised river valleys (200 to 400 feet deep) and various glacial features such as drumlins, moraines, erratics and drainage channels (Hunt 1974: 328; Bostock 1976: 20). The Missouri Drainage is characterized by glacial features north of the Missouri River proper, and unglaciated terrain south of it. The unglaciated region consists of broadly terraced river valleys between which lie high, widely alluviated plains (Fenneman 1931: 63). The entire region, both north and south of the river, also contains a number of isolated mountain ranges, deeply incised river valleys, and eroded badlands. The mountains and river floodplains were often well-wooded in the past, providing diverse animal and plant resources for prehistoric inhabitants.

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Figure 2. Landform Map of Alberta and Saskatchewan--after Bostock, 1970. Scale 1: 5,000,000

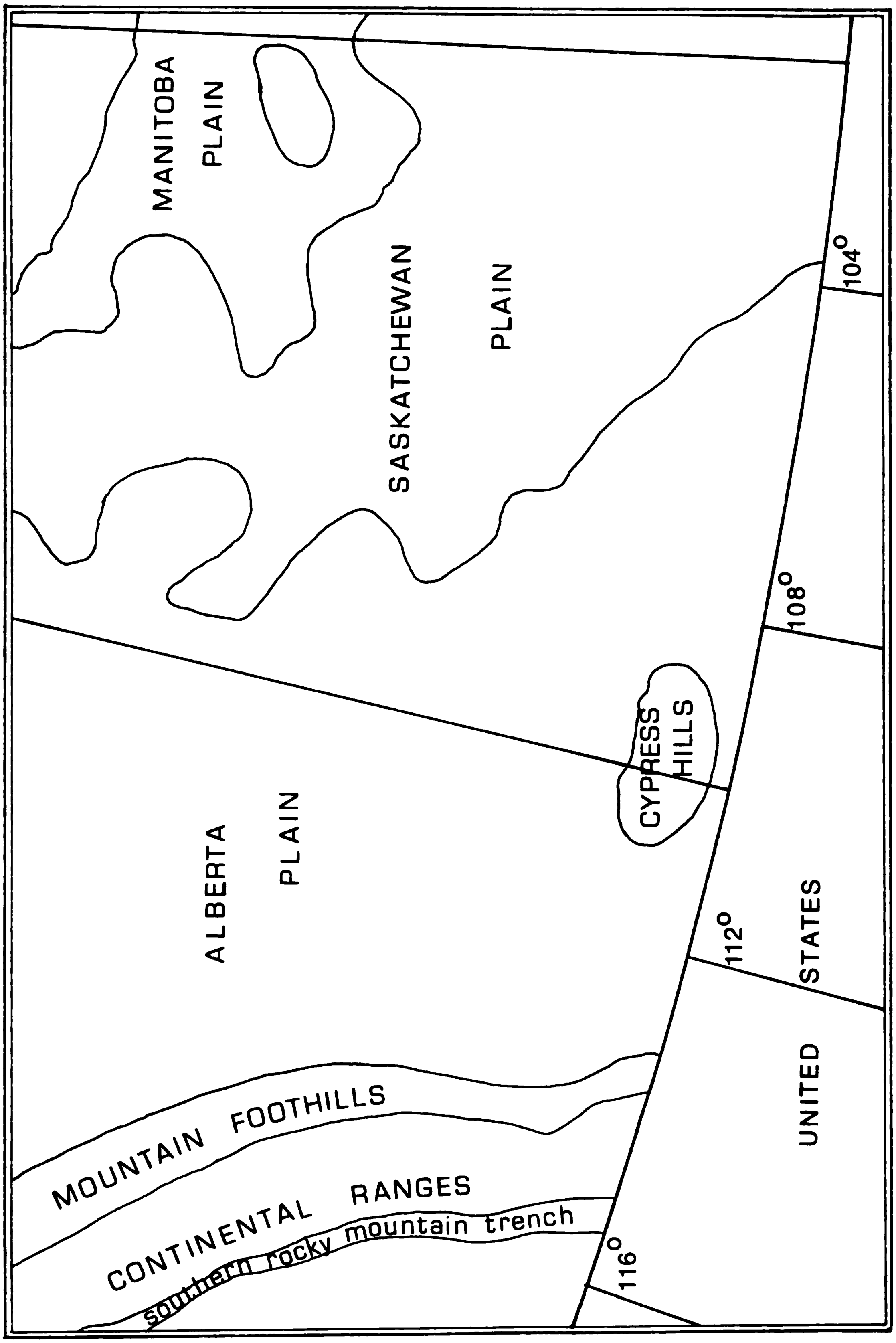
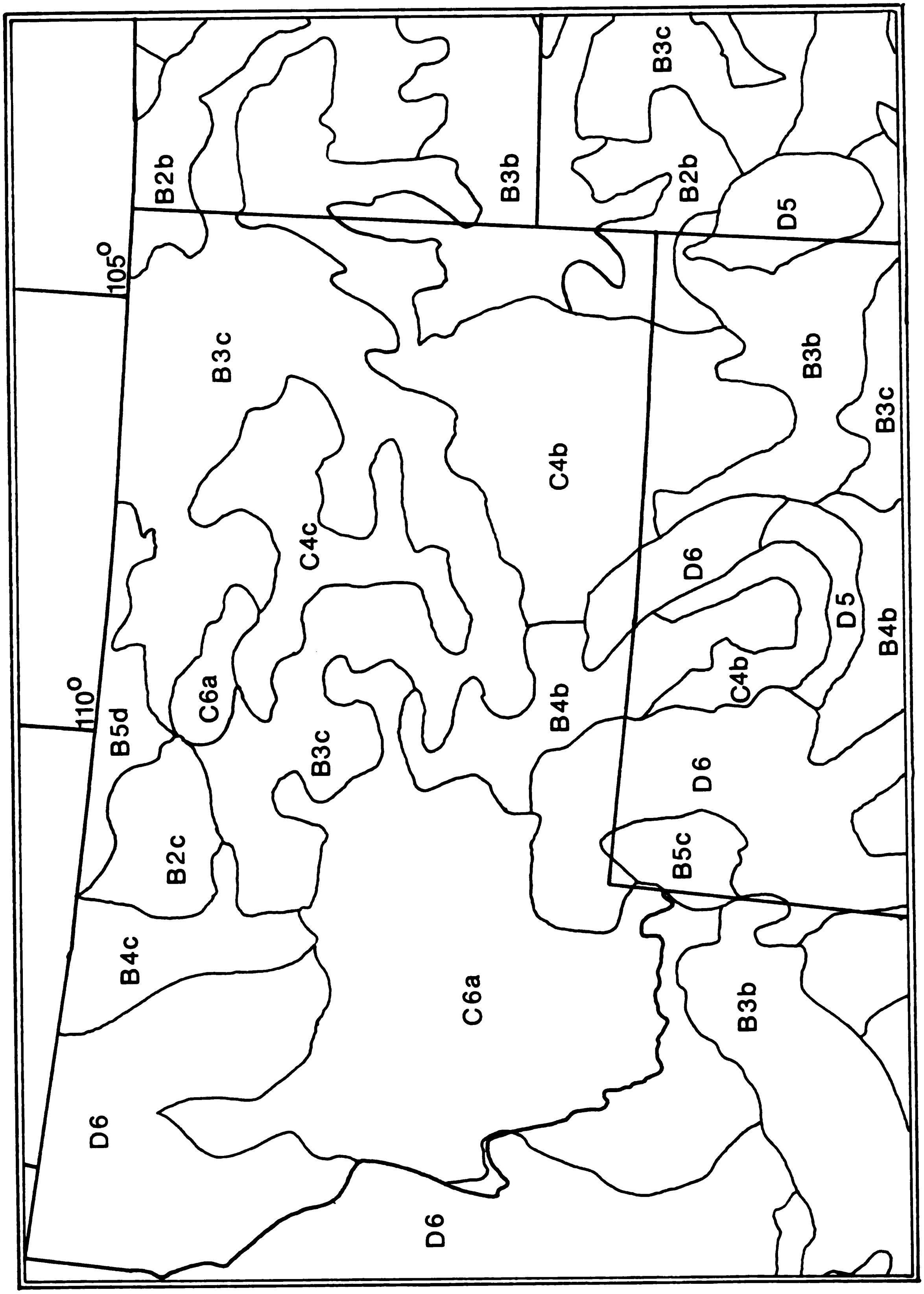

MANITOBA
PLAIN
SASKATCHEWAN
PLAIN
ALBERTA
PLAIN
CYPRESS
HILLS
MOUNTAIN FOOTHILLS
CONTINENTAL RANGES
southern rocky mountain trench
UNITED
STATES
104°
108°
112°
116°

Figure 3. Landform Map of Montana and Wyoming--after Hammond, 1964. Scale 1: 5,000,000

(See Appendix B for key to map symbols.)


105°
110°
B2b
B3b
B3c
B2b
D5
B3c
B3b
B3c
C4b
C4c
D6
D5
B4b
C6a
B5d
B3c
B4b
C4b
D6
B2c
B5c
B4c
C6a
B3b
D6
D6

A large portion of the Northwestern Plains is underlain by almost horizontal beds of sedimentary rocks of Paleozoic, Mesozoic and Cenozoic origin (Hunt 1974: 335; Bostock 1976: 19). These formations are predominately Cretaceous sandstones, shales and Paleozoic limestones. In much of southwestern Montana and northwestern Wyoming the predominate bedrock is Late Mesozoic and early Cenzoic igneous rock and Precambrian metamorphic formations (Love, Weitz, and Hose 1955; Ross and Witkind 1955). Most of the sedimentary formations are now overlain by deep alluvial and glacial drift deposits. Deeply incised watercourses and other eroded areas such as badlands and ridges often expose vertical and steep faces. These locations frequently served as prehistoric bison jump sites and habitation shelters.

Bedrock formations are also exposed on the Northwestern Plains in the form of isolated mountain masses. These ranges have a variety of origins including remnants of Tertiary formations such as the Cypress, Hand and Neutral Hills, domal uplifts such as the Black Hills and major laccolithic intrusions including the Sweetgrass Hills, and the Bearpaw, Little Rocky, Highwood, Moccasin and Judith Mountains (Hunt 1974: 338). Because of inadequate archaeological information, it is not known how frequently these formations served as jump locations.

Soils of the Northwestern Plains originated from and were later modified by, a variety of environmental factors including glacial deposits, bedrock, climate and vegetation. Soils of the glaciated portion of the Northwestern Plains developed on glacial till, while those to the south derived from a variety of parent materials including unconsolidated sediments, shale, sandstone and limestone. The glaciated portions of the Plains contain soils which are dominantly Brown, Chernozemic and Solonetzic, reflecting the subarid climatic conditions in these areas (Clayton and others 1977: 80). The unglaciated portion of the region reveals a more diverse series of soils. Predominate soils include bedrock derived Lithosols as well as Brown soils in the upland areas and dark-colored Chernozem soils in the uplands and along the eastern front of the Northern Rocky Mountains (Southard 1969). Alluvial soils predominate in the river valleys of the eastern flanks of the Northern Rocky Mountains and along many other large river valleys in the Northwestern Plains.

Climate

The climate, perhaps more than any other aspect of the environment, has affected human use of the Plains. This has resulted as much from the severe nature of the climate as from its indirect effects upon subsistence resources. The Northwestern Plains has a continental climate with extreme temperature differences occurring from season to season. Winters are exceedingly cold and blizzards frequent. Temperatures as low as -30° to -40°F. are not uncommon. Summers are hot with temperatures regularly exceeding 100°F. Additionally, this region includes perhaps the most arid lands in the entire Great Plains. Precipitation is low, averaging less than 15 inches per year. This creates a semi-arid climate which contributes significantly to the predominant short grass vegetative cover (Hunt 1974: 345). Strong winds, often originating from great temperature changes, frequently sweep across the wide, level expanses on the Plains drying the land and creating unfavorable conditions for the growth of many types of vegetation (Wedel 1961: 30-33).

Flora and Fauna

A variety of grasses, forbs and shrubs provided the main dietary subsistence base for a large prehistoric grazing and browsing mammalian population in the Northwestern Plains. The vegetative cover is exceptionally important because of its influence on the distribution and abundance of game, especially the bison. Ecologists have biotically divided the Northern Great Plains several different ways. Two proposals which have gained most favor are outlined in Dice's Biotic Provinces of North America (1943) and Shelford's Ecology of North America (1963). Dice includes all of the Northern Plains within his "Saskatchewan Biotic Province," in which short and mid-height grasses form the climax vegetation (1943: 25). Portions of the present study areas, however, lying within the Northern and Central Rocky Mountains fall within a separate province called the "Montanian." Shelford (1963), on the other hand, includes almost the entire study area within a single biotic unit called the "short grass grassland." The only exception is a small area of southwestern Montana which is included in the "bunch grass grassland" (1963: 330). The short grass grassland includes the basins of north-central Wyoming and many of the wide river valleys in the Northern Rocky Mountains of southwestern Montana whose grass and sagebrush vegetation blend imperceptibly into the open plains. The dominant grasses of the short-grass grassland includes blue gramma (*Bouteloua gracilis*), hairy gramma (*Bouteloua hirsuta*), buffalo grass (*Buchloe dactyloides*) and galleta grass (*Hilaria jamesii*). Pasture sagebrush

(*Artemisia frigida*) constitutes the most dominant shrub (Shelford 1963: 344). The Northwestern Plains are not a homogeneous grassland, however, since isolated low mountain ranges provided favorable relief for local stands of deciduous or coniferous forests and deeply incised river valleys provided optimal conditions for the growth of plains cottonwood (*Populus sargentii*) and peachleaf willow (*Salix amygdaloides*).

The prehistoric faunal resources of the Northwestern Plains were both plentiful and diverse. Many species of fauna were relied upon at one time or another by Northern Plains Indians, including large and medium sized mammals such as Mule Deer (*Odocoileus hemionus*), Whitetail Deer (*Odocoileus virginianus*), Elk (*Cervus canadensis*), and Pronghorn Antelope (*Antilocapra americana*), smaller mammals and various types of birds and fish when available. It was the bison (*Bison bison bison*), the largest terrestrial animal, however, which represented the major subsistence resource, and which had the greatest affect upon the movements and organization of people.

Bison are very gregarious creatures, seldom found alone. In the eighteenth and early nineteenth centuries they almost always traveled in large herds numbering into the thousands (Allen 1877: 462). McHugh (1972: 157), who studied the habits of bison in Yellowstone National Park, noted that they tend to separate into sexually distinct groups composed of bulls and cows. The composition of these groups often altered, however, in response to intrusions of other groups, separation into smaller units, mating, or danger (Arthur 1975: 42-43).

The problem of migratory habits of the bison has incited intense debate among ethologists and other scientists. Bison were once thought to migrate in massive herds southward in the winter and northward in the summer. Critical appraisal of historic sources and recent studies of modern bison herds, however, suggest that bison movements tended to be limited to movements within a localized region (Roe 1970; Arthur 1975: 53-60; Soper 1941: 384). These movements were probably regular, patterned movements when possible, which may have been quite predictable within a given region, but were often altered by fire, climate and hunting activity (Arthur 1975: 54). Such disruptions in the pattern of bison movements were particularly important for the Indians who depended upon their presence in a certain locale at a particular time. For instance, during very mild winters which occasionally occurred during the early historic period, a herd might stay out on the open grasslands rather than move to sheltered forests or coulee areas as expected.

Bison behavior and movements during particular seasons represented one of the most important factors in developing exploitative strategies. The rutting season took place variously, from July into September (Roe 1970: 96-98; McHugh 1972; Soper 1941). During this season, large numbers of bison gathered together and considerable rivalry and activity occurred in the herd. Following the rut, during the fall and winter months, the herds tended to remain together and during the winter they usually remained within localized areas (Arthur 1975: 55-60; Soper 1941; Cahalane 1947: 75). Beginning in March and April calving season began and continued through the spring (Roe 1970: 98; Allen 1877: 463; McHugh 1972: 179). By late spring and into the summer the bison tended to disperse widely over the plains.

CHAPTER II

PREVIOUS INVESTIGATIONS

The following study of bison jump sites in the Northwestern Plains is in large part based upon prior surveys and published studies of the subject. Because of the importance of this prior research a review of the most important studies was deemed necessary. The intent of this review is to provide both historical and theoretical perspective. Due to the fact that this research addresses bison jumps only, it was not considered appropriate to consider prior research of bison pounds and traps. Nevertheless, it is recognized that investigations of such sites have contributed significantly to a better understanding of all prehistoric communally-initiated hunting endeavors on the Plains.

Early Research

Systematic investigation of bison jump sites in the Plains began late relative to most archaeological research in the United States. In fact, prior to the 1930s few archaeological investigations had been made in the Plains (Wedel 1961: viii). During the Depression era, however, proposed water-control projects in the Plains supported a flourishing salvage archaeology program. Although research increased even more dramatically in the 1940s and 50s, bison jump sites remained largely ignored. Several exceptions are notable, however.

Perhaps the earliest of these was Barnum Brown's assessment of the Emigrant Buffalo Jump site near Yellowstone National Park (1932). Though an amateur in archaeology, Brown made a remarkably perceptive study of the site incorporating ethnohistoric accounts in his analysis of the material requirements and level of organization needed for successful operation of the Emigrant Jump.

Also during the 1930s H. P. Lewis, a schoolteacher from Choteau, Montana, embarked upon an informal program of survey and excavation of bison jumps in Montana. Over a period of several years Lewis investigated 24 bison jumps. His manuscript (Lewis n.d.), an unusually insightful and resourceful work by an untrained amateur, is still considered an important source of information on bison jumps.

An additional study of particular note from this early period is Maynard Shumate's _The Archaeology of the Vicinity of Great Falls, Montana_ (Shumate 1950). His report, a descriptive study of bison kills and associated tipi rings and campsites in central Montana, reflects the sustained interest in systematic study of bison drive sites at a time when pothunters and fertilizer companies were rapidly destroying them.

Research Since 1960

The paucity of research prior to 1960 stands in sharp contrast to the proliferation of bison procurement studies in the 1960s and 70s. Immediately prior to this period of intensive study, however, two exceptionally important works were published which had a major impact upon subsequent archaeological research in the Northwestern Plains including those of bison drives. In 1958 William Mulloy, of the University of Wyoming, proposed a comprehensive scheme for identifying cultural development in the Northwestern Plains in a series of five successive periods based largely upon continuity and changes in material culture over time. His five periods: Early Prehistoric, Early Middle Prehistoric, Late Middle Prehistoric and Historic span the period from approximately 13,000 years ago to the present. The Late Middle Prehistoric Period (0 A.D. - 500 A.D.) and Late Prehistoric Period (A.D. 500 - A.D. 1800) are of particular interest to this study since, until recently, it was thought that bison traps first appeared during the Late Middle Prehistoric Period and that during the following Late Prehistoric Period, dependence upon this hunting method reached its peak. Recent research has confirmed use of traps as early as the Paleo Indian period (Wheat 1972; Frison 1974), but regular and widespread use of communal bison drives still appears to be limited to about the last 2000 years following the end of the Altithermal. More recent culture historical reconstructions of the Northwestern Plains have suggested modifications and deletions of portions of Mulloy's scheme (Wormington and Forbis 1965; Reeves 1970), but his basic period divisions and many associated technological traits have remained the standard nomenclature for Northwestern Plains Prehistory.

Another study of primary importance to later research of bison procurement is Kehoe and McCorquodale's detailed examination of the Avonlea Point as a horizon marker for the Northwestern Plains (1961). According to Kehoe and McCorquodale (1961: 179):

> Although they [Avonlea Points] have been assigned to the Late Prehistoric Period (Mulloy 1958: 163), and their association with communal bison hunting noted, they have been considered too generalized to be used in studies of ethnic or cultural affiliation.

In their detailed analysis they demonstrate that the Avonlea Point can indeed be used as a horizon marker delineating the emergence of the "Later Prehistoric Period" in the Northwestern Plains. Additionally, they add that the point " . . . can definitely be linked with the demonstration--possibly the emergence--of great herds of bison and communal bison hunting" (1961: 187). Leslie Davis in a later paper (1966) confirms the hypothesis that this point type introduced the "Late Prehistoric Period" in the Canadian Plains and in Montana, but questions its association with the emergence of communal bison hunting.

In the early 1960s substantive contributions by both professionals and amateurs concerning bison jumps first appeared in the literature. Although many of these studies remained descriptive, some problem-oriented research was also initiated. The 1961 Symposium on Buffalo Jumps (Malouf and Conner 1962) contains the first substantive contributions. The symposium, sponsored by the Montana Archaeological Society, was held in an effort to ascertain the present state of knowledge concerning buffalo jumps and the direction research was currently taking. Most of the papers are descriptive summaries of buffalo jumps in Montana and ethnographic descriptions of Blackfoot and Crow bison drive methods. Several of the papers provide particularly valuable data and interesting insights for a rapidly expanding subject field. A brief summary of these papers follows.

Conner (1962: 1-2), provides the first comprehensive published discussion of bison jumps and their component parts in a short introductory statement. In the second paper, Richard Forbis (1962a: 3-7) presents a summary of finds from the Old Woman's Buffalo Jump. This site is particularly significant since it was the first stratified jump site systematically excavated and recorded. The site's temporal span is almost 2000 years (extending up to 1600 A.D.) and reveals a series of projectile point changes from large, broad types such as Besant points (dated A.D. 300-400) (1962b: 106) to much smaller late prehistoric side-notched points. During the same year that he wrote this paper his monograph of the site was released (1962b). The following papers of the symposium of buffalo jumps feature descriptive summaries of the Keogh Buffalo Jump by Conner (1962: 8-11) and the Logan (Madison) Buffalo Jump by Carling Malouf (1962: 12-15). George Arthur's (1962: 16-27) paper The Emigrant Bison Drive of Paradise Valley, Montana provides descriptions of the two bison drive sites originally studied by Barnum Brown (1932) and attempts a chronology and point typology based upon limited test excavations and surface observations. In the following articles Claude Schaefer (1962: 28-34) discusses Blackfoot hunting drives and Joseph Medicine Crow (1962: 35-38) discusses Crow Buffalo Jump Legends. The last section, a panel discussion on buffalo jumps (1962: 40-56) represents a particularly valuable part of the symposium since it provided a professional forum for important hypotheses and speculation not yet tested in the field and published in written form.

Another comprehensive review of bison jumps in the Northern Plains was undertaken by the National Park Service in 1962 in which Wesley Hurt (1963) described 19 bison jumps in Montana and Wyoming and ranked them for their potential research and interpretive value. Seven of the sites were considered exceptionally valuable based largely upon their unusual characteristics and exceptional preservation qualities. While Hurt's study was not a product of original research, his summary discussion of the characteristics, distribution, chronology and cultural affiliation of bison jumps as well as summary descriptions of 19 sites helped to further clarify and emphasize present knowledge and to identify areas most in need of study.

Yet another 1962 article concerning a bison jump site was written by Bernard Hoffman. He described a bison jump in the Smith River drainage of the Montana Rockies and the artifacts recovered from one test pit. Diagnostic artifacts include small, unstemmed, side-notched points suggesting the site is probably late prehistoric. Hoffman indicates that no cultural affiliation is known, though he suggests it may be Blackfoot (1962: 200).

George Arthur contributed a major portion of a 1966 survey report on the Upper Yellowstone Drainage to bison drives. He describes ten kill sites from the Upper Yellowstone Valley, eight of which are jump sites. Also discussed are several interpretational problems posed by jump sites, the most important of which concern the absence of bone deposits at four otherwise completely intact bison jump sites. Similar sites have been identified elsewhere in the northern Plains. Thus the three alternative explanations offered by Arthur have potentially wide applicability. Arthur suggests that:

1. drive lanes were constructed for a specific bison herd that moved out of the area before the animals could be lured into the drive lane,

2. the bone deposits washed away and either disappeared or remain to be located away from the jump,

3. other variables, such as wind direction proved unfavorable and necessitated abandonment of the site (1966: 54-56).

Arthur adds a brief discussion of protohistoric population movements in the upper Yellowstone Valley area, concluding that bison jumps in the area were probably used primarily by the Shoshoni and Crow (1966: 54-56).

Several bison jump site reports published in 1967 revealed a growing interest in communal bison procurement studies and increasing evidence that the bison drive complex represented a crucial component in prehistoric northern Plains socio-economic systems. A particularly good example is Thomas Kehoe's monograph on the Boarding School Bison Drive Site, a jump-pound in north-central Montana near Browning (Kehoe 1967). Extensive sampling excavation of the site was undertaken in 1952 and 1958-59 both above and below the steep embankment which lies near Cut Bank River. Kehoe established the existence of four cultural zones and identified three successive kills at the site all occurring after about A.D. 1600. Diagnostic artifacts include Plains side-notched points and Prairie side-notched points. Kehoe's careful excavation, recording of features and detailed analysis establishes this site as one of the few which can adequately be used for comparative purposes.

Also contributing to the growing literature of Montana bison drives is Maynard Shumate's report on the Taft Hill Buffalo Jump (Shumate 1967). The report includes a discussion of the significance of the Taft Hill jump and an associated campsite. Unfortunately, most of the bone layers at the jump were removed for conversion to fertilizer in the late 1940s, thus seriously impairing interpretation of site remains. The campsite was not disturbed, however, so it should have provided more accurate artifact provenience. Unfortunately, methods of collection are not specified in the report. Comparing point types from the upper levels of the jump and from the campsite with that of the upper level of the Old Woman's Buffalo Jump, Shumate estimates that the Taft Hill Buffalo Jump was initially used about A.D. 900 and last used about A.D. 1600 (1967:30).

The year 1967 also saw the publication of results of a major bison jump research project in Wyoming (Frison 1965; 1967). The Piney Creek Sites in Northeastern Wyoming, consisting of a jump site (48 JO 312) and an associated campsite (48 JO 311), were excavated in 1964 and 1965. George Frison made a detailed analysis of the sites establishing that both probably represent a single year's operation. An extensive bone deposit mixed with a variety of cultural debris was found at the base of the jump site (1967). Over one-hundred small side-notched projectile points found in the deposit suggest that the site dates to the Late Prehistoric Period. Among the most important contributions in Frison's report are his analysis of butchering and processing techniques of bison bone, lithic analysis and the discussion of buffalo handling techniques. These aspects have become particularly important in more recent bison jump research.

In 1970 George Frison published the results of excavations at two additional bison jumps in the Northwestern Plains (Frison 1970a, 1970b). The Kobold site (Frison 1970b), a bison jump in southeastern Montana, is particularly important because it shows considerable time depth. Bison jumping at the site spans 3500 to 4000 years from the Early Middle Prehistoric Period to the Late Prehistoric Period, an exceptionally long record (1970b: 32-33). Particularly significant is the evidence from the earliest levels which suggests that complex communal bison driving was practiced as early as the Early Middle Prehistoric Period. This contradicts Frison's previous hypothesis that there was a general increase in the complexity of bison procurement techniques over time (1970b: 1).

Frison's subsequent bison jump paper in 1970 was on the Glenrock Buffalo Jump in eastern Wyoming which was excavated in 1968 and 1969 (1970a). Three different bone deposits (the upper two of which were undisturbed) were excavated in bone filled arroyos. The uppermost deposit is estimated to be 450 to 750 years old. The two undisturbed bone deposits contained Plains Side-notched Points, while a late basal-notched type was found in the top layer. A detailed discussion of site seasonality is made in which Frison suggests that the fall was the preferred time to drive bison. Perhaps the most important section is his detailed discussion of butchering processes. A minimum of 195 individuals are analyzed from a 20 percent sample.

Yet another 1970 study provided results of research on one of the few known bison jump sites in Manitoba. The Harris Sites (Hlady 1970), located in extreme southwestern Manitoba, were excavated in 1966. Two bison jumps are represented of which the oldest is estimated to date to 540 B.C. and the youngest to A.D. 1500 (1970: 179).

Only a few bison jump site reports have appeared since 1970, possibly due to the recent increased interest in bison pound and trap research. In 1974, Brian Reeves delivered a most important paper to the Plains Conference in Laramie, Wyoming, detailing progress on analysis of the Head-Smashed-In Buffalo Jump (Reeves 1974). This site, the largest known bison jump in the Northern Plains, has deposits reaching a depth of 35 feet (Kehoe 1973: 165). The earliest levels date to about 3600 B.C. (Mummy Cave Complex) in which the diagnostic points are Bitterroot-Salmon River Side-Notched atlatl points. Above this level, however, there is a 1000 year break in the cultural sequence during which time the jump was apparently abandoned. Subsequently, the site was reused and there appears an unbroken sequence from the Pelican Lake Phase (ca. 900 B.C. - A.D. 100/300) to historic times (Reeves 1974: 15-17). A most important aspect of the Head-Smashed-In site is the extremely complex system of 8 drive lanes it incorporates. If only a portion of the system was operative during the earliest occupation it corroborates Frison's hypothesis for an early development of a communal bison procurement complex.

A study of the Risley Bison Kill (24 LC 1003) in west-central Montana represents one of the most recently published bison jump studies in the Northwestern Plains (Keyser and Knight 1976). The site was test excavated in 1974, but it had been severely damaged by collectors prior to this time limiting the information obtainable from excavations. At least four kill occurrences are known for the site and although no dates are available, the points found are entirely side-notched suggesting a Late Prehistoric Period date (1976: 300).

The most recently published study of a bison jump site is that of the Vore Site, a large sinkhole jump in northeastern Wyoming (Reher 1977; Reher and Frison, in press). Diagnostic cultural material and radiocarbon dates of 1580± 140 years A.D. and 1750± 90 years A.D. suggest the site falls within the Late Prehistoric Period (Reher 1977: 16). In Reher's paper, he does not provide a detailed description of the site, but rather outlines an interpretive model of the site from which he derives an explanation of the " . . . role of the large, cooperative buffalo kill in adaptive process and cultural evolution on the shortgrass Plains" (1977: 13). Reher predicts the carrying capacity of the environment surrounding the site for bison based on the climatic indications of local varves and tree ring sequences. An estimate is then made of the critical number of bison needed to make jumping economically feasible for the Indians and it is determined that a necessary herd size was not continually present. Upon comparison of the frequency of requisite herd size with the frequency of jumps reflected in the site stratigraphy, a high correlation is found to exist. Reher then postulates a series of potential behavioral responses that humans in the area would find necessary to cope with these changing conditions. Reher's article provides an explanation of an important aspect of Vore Site prehistory as well as a general statement of causality for bison drive sites throughout the northern Plains.

Bison Jump Sites in Other Areas

While most known bison jump sites occur within the Northwestern Plains region, a number of others have been identified from the Central and Southern Plains and from west of the Continental Divide in Idaho and Utah.

The oldest known bison jump in North America, Bonfire Shelter, lies in the Southern Plains at the foot of a canyon in southwestern Texas (Dibble and Lorrain 1968). The stratified deposits of the site yielded a small number of points in the lower bed comparable to Paleo Indian Plainview Points. This evidence is corroborated by a radiocarbon date of 10,230± 160 years B.P. and identification of the bone layer as extinct Bison antiquus or Bison Occidentalis forms. At a higher level of the shelter deposits a layer of modern bison bones were found associated with Late Archaic point forms (1968: 9). The authors contend that the bone layers from both the lower and upper beds resulted from deliberate driving of the animals over the cliff above the shelter. While such may be the case, comparable evidence is not known for the Southern Plains.

Bison jumps have also been reported in the Central Plains, though not in large numbers. One of these sites, the Roberts Buffalo Jump, located in extreme Northern Colorado, was excavated in the late 1960s and reported on by Max Witkind in 1971 (Witkind 1971). Three contiguous areas of the site were identified: a kill-butchering location, a meat processing area and habitation site. The undifferentiated stratigraphy of the bison bone layer suggests that the site was only used once. Though the antiquity of the site is unclear, the similarity of points found at the Roberts Jump and those recovered from the Piney Creek sites in Wyoming and in the Dismal River area of Nebraska suggests a Late Prehistoric Period date (1971: 47-48). A most interesting aspect of the report is the caloric value estimation for the 18 bison identified at the site. This measurement, coupled with estimated daily caloric needs for humans, allowed Witkind to estimate that the available meat (in dried form) could support a small band for at least four months (1971: 93).

West of the Continental Divide several jump sites have recently been reported. Though not a common phenomena, the sites often contain all features normally associated with classic Plains bison jumps.

The first reported jump in the region was the Woodruff Bison Kill in extreme Northeastern Utah (Shields 1966). This site consists of a large concentration of bison bone at the base of a high talus slope and cliff. The lack of stratigraphy at the site suggests that the jump was used only once. Although some artifacts were recovered, the absence of diagnostic tools precludes assigning temporal or cultural affiliation.

North of this site in the Upper Salmon River region of eastern Idaho lies the Challis Bison Jump (Butler 1971). This jump contains the classic vertical cliff face and remnants of drive lanes near the cliff edge. Though the site possesses two stratigraphic layers, it appears that the kill lies entirely within the upper level and represents a single event in which 20-30 animals were driven over the cliff (1971: 6). Many small side-notched points typical of the late prehistoric and early historic period in eastern Idaho were recovered from the kill as well as 19 small glass beads strongly suggesting a recent date (1971: 6).

More recently, Agenbroad (1974; 1976) made a case for two bison jumping complexes (10 OE 229, 10 OE 232) in southeastern Idaho. Agenbroad describes elaborate stone fences and drive lanes and indicates that bison remains occurred below several steep embankments though only a minimal discussion of the faunal remains is provided. A succession of point types at the site suggests that the jumps were used from at least 7,000 years ago up to the acquisition of the horse (1976: 23). Because of the rugged topography north of and east of this area, Agenbroad suggests that bison entered the region through Nevada from the Salt Lake area (1976: 4). While this is a possibility, southwestern Idaho would have provided only marginal support for even moderate-sized bison herds. As a result, construction of such elaborate drive lanes predominately for bison is questionable.

The history of bison jump research outlined in this chapter indicates that studies have tended to emphasize description and, with notable exceptions, have focused upon individual sites with only token regard for regional comparisons and syntheses. To some degree this is the result of the paucity of site information available, but it also indicates a deficiency in research priorities. In support of the present effort, previous studies offer primarily descriptive information, rather than to suggest potential avenues for research.

Regional syntheses and explanatory models are only beginning to appear concerning communal subsistence strategies in the northwestern Plains and, as a result, existing literature sorely lacks predictive research potential. The goal of this study is to initiate more explanatory research which will possess limited predictive potential and possibly stimulate other research efforts in this direction.

CHAPTER III

METHODOLOGY

The primary objective of this study is to establish a locational model of bison jump sites within the Northwestern Plains. To achieve this end bison jump site data and associated environmental information were collected from within the study area, partitioned into a set of quantified variables, and subjected to a series of statistical procedures. Following is a detailed summary of the methods used in carrying out this research.

The entire Northwestern Plains was chosen as a research area, but the actual study area was more restricted. Southern Saskatchewan and the western Dakotas were deleted from the analysis because of the absence of adequate comparative environmental data in those areas. However, all possible variations in environment and most, if not all, cultural manifestations within the Northwestern Plains are found within the immediate study area. It is thus suggested that the few deleted known sites from Saskatchewan and the western Dakotas will be favorably accommodated within the environmental and cultural range exhibited by cases in Montana, Alberta and Wyoming.

Locational and descriptive information on sites within the study area were gathered from published and unpublished site reports and from various site files maintained by universities and museums, including the University of Montana, University of Calgary, and the University of Wyoming. While a large number of cases were collected from these sources, not all recorded bison jumps were included in the present analysis for reasons discussed below.

Data analyzed in this study were initially placed on punch cards for use with programs of the Statistical Package for the Social Sciences (SPSS) (Nie and others 1975). All data was processed through the Michigan State University's CDC 6500 Computer System.

Site Selection Criteria

Bison jumps are often loosely designated in site forms so that other types of kill sites such as impoundments or natural traps are sometimes designated as "jumps." This problem may be due to the physical similarities sometimes exhibited by different types of bison kills, or a lack of sufficient physical remains for precise identification. It does, however, illustrate the difficulty of attempting to clearly define bison jumps as a site type, and also points to a lack of consensus about the particular characteristics of bison jump sites. In the present study, there was a need for a precise, standardized definition with which to identify jumps. As a result, a set of criteria was established for this purpose. The criteria include all components of a jump normally included, but in some instances arbitrary decisions were necessary for practical reasons. It is also recognized that this set of criteria may have unintentionally excluded some jumps and included some other types of kills, but the need for standardization was paramount. Thus, for the purposes of this analysis, an identified site possessing two or more of the following components will be considered a bison jump:

1. presence of bison bones at the base of a cliff or slope, or on a slope
2. slope of at least 45 degrees (when a measurement is given)
3. presence of a fall of at least 15 feet or five meters
4. presence of identifiable drive lanes above site deposits
5. presence of a corral below a cliff at least 15 feet in height or a 45 degree or greater slope.

The above criteria were waived in the event a professional archaeologist indicated the probable presence of a jump site even in the absence of most identifiable components.

Additional deletions of cases (sites) occurred in this study when they were found to have erroneous, contradictory, unknown or improbable locations or locational information. Cases were also eliminated if their legal descriptions were not sufficiently complete to indicate at least the section in which a case was located. An accurate legal description was, for some cases, deduced from additional locational information provided by site descriptions.

A total of 146 sites were included in the study. Fifty-one of these lie within Alberta, 91 within Montana, and 4 within Wyoming. A list of the cases with their Smithsonian numbers or Borden System numbers and names (if any), and known published or unpublished sources are listed in Table 1.

Additional Considerations

This analysis primarily concerns the environmental conditions present at bison jumps, but it was recognized that the location and successful operation of these jumps also depended upon the type of

TABLE 1

LIST OF SITES USED IN ANALYSIS

Case Number	Site Number or County	Site Name	Reference
001	DgOv-26	Verdigris Coulee Jump	
002	DgOv-41		
003	DgOw-2		
004	DgOw-10		
005	DgOn-108		
006	DgPe-102		
007	DgPj-11		Quigg (1974)
008	DiPh-1		
009	DjPf-4		
010	DjPk-3	Shaver Jump	
011	DkPj-1	Head-Smashed-In Buffalo Jump	Reeves (1974b)
012	DlPk-1		
013	EaPk-76b		
014	EaPk-111b	Jenkins Bison Jump	Byrne (1973)
015	EaPk-125		
016	EaPk-133a		
017	EbPk-4	Pine Coulee Buffalo Kill	
018	EbPl-1	Nanton Jump	Forbis (n.d.)
019	EcPc-1	Old Woman's Buffalo Jump/ Cayley Kill	Forbis (1962a, 1962b)
020	EcPl-4		
021	EcPl-5		
022	EcPl-6		
023	EbPn-3		
024	EdPn-15		
025	EePk-81		
026	EePm-88		

TABLE 1 (Cont't.)

Case Number	Site Number or County	Site Name	References
028	EePn-19		
029	EePn-27		
030	EePn-50		
031	EfPg-2		
032	EfPk-2		
033	EfPl-33		
034	EfPl-43		
035	EfPp-1	Bragg Creek Bison Run	
036	EgPg-1	Risseeuw	
037	EgPn-15		
038	EgPp-1	Jumping Pound Jump	
039	EhPo-4		
040	EiPh-1		
041	EiPh-2		
042	EiPn-1		
043	EjPc-1		
044	EkPf-7		
045	EkPk-1		
046	EkPk-43b		
047	ElPf-1		
048	FbOv-1		
049	FbPi-1		
050	FbPl-100		
051	DjPp-5		Reeves (1974a)
052	DjPp-23		Reeves (1974a)
056	24 BH 261	Grapevine Buffalo Jumps	Conner (n.d.), Medicine Crow (1962)
057	24 BH 262	Grapevine Buffalo Jumps	Conner (n.d.)
058	24 BH 263	Grapevine Buffalo Jumps	Conner (n.d.)

TABLE 1 (Cont'd.)

Case Number	Site Number or County	Site Name	References
059	24 BH 264	Grapevine Buffalo Jumps	Conner (n.d.)
060	24 BH 265	Grapevine Buffalo Jumps	Conner (n.d.)
061	24 BH 1047		
062	24 BH 1729		
063	24 BH 406	Kobold Buffalo Jump	Frison (1970)
064	Big Horn	Dryhead Buffalo Jump	
065	24 CB 608 and 24 CB 803	Overlook Buffalo Jump	Conner (n.d.); Edwards and Krause (1969)
066	24 CT 1003	Blowout Kill Site	
067	24 CT 1004	Ralph Bison Jump	
068	24 CA 17		
069	24 CA 19		
070	24 CA 33		
071	24 CA 41		
072	24 LC 203 and 24 CA 1007		
073	24 CA 1012	Ulm Buffalo Jump	Shumate (1967); Lewis (n.d) Hurt (1963); Dicus (n.d.)
074	Cascade	Simms Buffalo Jump	Lewis (n.d.)
075	24 CH 234		
076	24 CH 1002		
077	24 DW 1007		
078	24 FR 601		
079	24 ME 1	Deep Creek/White Sulpher Springs Jump	Hoffman (1961); Barz (1967)
080	24 GA 104/314	Madison Buffalo Jump	Malouf (1962); Hurt (1963); Lewis (n.d.); Conner (n.d.)
081	24 GA 305	Hardy-Kistner Dam Buffalo Jump	

TABLE 1 (Cont'd.)

Case Number	Site Number or County	Site Name	Reference
082	24 GA 658	Eukes Bison Kill	Napton (1966): Forbis (1960)
083	24 GA 1223	Accola Jump	
084	Glacier	Schultz Buffalo Jump	Hurt (1963)
085	Glacier	Landslide Butte Kill	Lewis (n.d.)
086	24 HL 40		Keyser (1977)
087	24 HL 46	English Bison Kill	Keyser (1977)
088	24 HL 55		Keyser (1977)
089	24 HL 58		Keyser (1977)
090	24 HL 70		Keyser (1977)
091	24 HL 80		Keyser (1977)
092	24 HL 88/79		Keyser (1977)
093	24 HL 109		Keyser (1977)
094	24 JF 65		
095	24 JF 12	Whitehall Buffalo Jump	
096	24 JF 13	Ridder Buffalo Jump	
097	24 LC 12	Williams Kill	Lewis (n.d.)
098	24 LC 14	Eder's Kill	Lewis (n.d.)
099	24 LC 1004		
100	24 LC 1006	Kelly Ranch Buffalo Jump (probably)	Hurt (1963)
101	24 LC 1003	Risley Bison Kill	Keyser and Knight (1976); Lewis (n.d.)
103	Lewis and Clark	Spring Creek Buffalo Jump/ Marsh Kill	Hurt (1963); Lewis (n.d.)
104	24 MA 75		
105	24 MA 1032		Thompson and Hand (1950)
106	24 MA 1041	Sweetwater Jump	
107	Madison	Wigwam Creek Buffalo Jump	Hurt (1963)

TABLE 1 (Cont'd.)

Case Number	Site Number or County	Site Name	References
108	Madison	Indian Creek Buffalo Jump	Hurt (1963)
109	24 ME 12		
110	24 PA 314	Strickland Creek Rock Lines	Arthur (1966)
111	24 PA 334	Peterson Jump	Arthur (1966)
112	24 ME 66		
113	24 ME 201/30/72	Bingham Buffalo Jump	
114	24 ME 662	Birch Creek Jump	
115	24 ME 404		
116	24 ME 405	Voldseth Buffalo Jump	
*117	24 ML 1027	Eiselein Buffalo Jump	
*118	24 ML 1028	Sawmill Creek Buffalo Jump	
119	24 PA 304	Merrill Buffalo Kill	Arthur (1966)
120	24 PA 308	Emigrant Buffalo Jump	Brackett (1893); Arthur (1962, 1966); Napton (1966) Brown (1932); Hurt (1963); Mulloy (1958)
121	24 PA 318/313	Long Ridge Jump	Medicine Crow (1962); Arthur (1966)
122	24 PA 332	Hepburn Mesa Buffalo Jump	
123	24 PA 333		
124	24 PH 35	Whitewater Kill	
125	24 PH 72	Prestage Kill	
126	24 PH 405		
127	24 PH 1018		Hoy (1973)
128	24 PH 1019	Salsbury Bison Kill	Hoy (1973)
129	24 RL 518	Garden Coulee Kill	
130	24 RL 1007		
131	24 RV 101		

*These two sites are actually within Fergus County (FR)

TABLE 1 (Cont'd.)

Case Number	Site Number or County	Site Name	References
132	24 ST 401	Keogh Buffalo Jump	Conner (1962c, 1967, 1968)
133	24 SW 408	Buffalo Jump Ranch Jump	Arthur (1966)
134	24 SW 402	Six Shooter Buffalo Kill	Hagen (1968)
135	24 SW 552	Cummins Buffalo Kill	
136	24 SW 1001	Big Timber Creek Jump	
138	Teton	McDonald Creek Buffalo Jump #2	Hurt (1963)
139	Teton	Cashman Kill	Lewis (n.d.)
140	Teton	Chouteau Buffalo Jump/ Deep Creek Kill	Lewis (n.d.); Hurt (1963)
141	24 VL 15	Hinsdale Bison Kill	Davis (1975)
142	24 VL 18		Davis (1975)
143	24 WL 552	Big Elk Buffalo Jump	
144	24 WL 556		
145	24 WL 559	Sage Basin Buffalo Jump	
146	24 BL 102		
147	24 BL 104		
148	24 BL 1001	Peoples Creek Bison Jump	
149	48 CO 304	Glenrock Buffalo Jump	Frison (1970)
150	48 JO 312	Piney Creek Site	Frison (1965, 1967b)
151	48 SH 313	Big Goose Creek Kill	Frison (1967a, 1978); Frison and others (n.d.)
152	48 CK 302	Vore Site	Reher (1977): Frison and Reher (n.d.); Frison (1978)

microenvironment surrounding the site; that is, the types and conditions of the surrounding soil, topography, vegetation and water which strongly influenced the location and features of each site. This assumption is based partially upon prior locational studies which used a spatial analysis technique concerned with microenvironmental conditions surrounding sites known as site catchment analysis (Vita-Finzi and Higgs 1970; Higgs 1975). Largely, however, it is based upon knowledge of observed cases.

Since this study is exclusively concerned with sites whose purpose was for the exploitation of a single resource, it is likely that few available resources in close proximity to the sites would significantly affect its location. On the other hand, it is probable that particular microenvironmental conditions were critically important to where sites were established, since the driving and jumping of bison depend upon particular sets of topographic, geologic and erosional land patterns. As such, the microenvironmental conditions surrounding jumps were focused upon in this study in order to accurately quantify and evaluate their importance to site location.

A 5000 meter radius was chosen for the size of the standard area around each site (equalling 78.5 square kilometers). This distance was chosen primarily to encompass all of the area intensively used by bison hunters at the majority of known jump sites. Many drive sites retain identifiable drive lane remnants. In most cases these lanes extend outward from the fall less than 5000 meters. It is likely that many drive lane markers have been obliterated, but of those remaining, few reach beyond 5000 meters, and those few that do, so extend far beyond that limit. A major drawback of this approach is the probability that only a small portion of the standard area was used for the purposes of driving bison. Although many drive lanes and jump locations were repeatedly used, it was not possible to identify the exact locations of runways and jumps within each standard area. Nevertheless, it is maintained that the extraneous variability created by some data will be filtered out by the large sample size used in the analysis.

Cultural and Environmental Variables

The 146 sites chosen for analysis in this study were measured on 36 variables covering a range of information categories and measurement scales. A list of acronyms used for each variable is presented in Appendix A while Appendix B contains a list of the values used to code variable information on each case. The following presents a discussion of each variable and the manner by which each was selected and refined.

The variables were divided into three major groups based on their scale of measurement and their use in analysis. A wide variety of information classes are covered by the variables, but most reflect various aspects of the natural environment within the standard area surrounding each bison jump. This emphasis upon environmental variables reflects the exceptional importance they were deemed to have played in choice of site location and site form. Environmental sources also provided a much larger and more complete data base than site source materials (Table 2). Many topographic, soil, vegetation and geologic maps were found covering most of the area, often at several scales. Site source materials, on the other hand, were spotty and often offered quite limited information.

TABLE 2

LIST OF ENVIRONMENTAL MAP SOURCES AND SCALES

Category	Map Name	Scale	Source
Vegetation	Potential Natural Vegetation of the Conterminous United States	1:3,168,000	Kuchler (1964)
Vegetation	The Vegetation of Alberta	1:3,200,000	Lewis and others (1928)
Vegetation	The Vegetation of Alberta	1:4.245,120	Moss (1932)
Soils	Soils of Gallatin Valley, Montana	1:63,360	DeYoung and Smith (1931)
Soils	Soils of Johnson County, Wyoming	1:126,720	Dunnewald and others (1931)
Soils	Soils of Richland County, Montana	1:253,440	Geiseker (1955)
Soils	Soils of Sweetgrass County, Montana	1:253,440	Geiseker (1956)
Soils	Soils of Stillwater County, Montana	1:253,440	Geiseker (1957)
Soils	Soils of Central Montana	1:253,440	Geiseker and others (1953)
Soils	Soils of the Northern Plains of Montana	1:500,000	Geiseker and others (1929)
Soils	Soils of Dawson County, Montana	1:24,000 and 1:380,000	Holder and Pescador (1976)
Soils	Soils of Big Horn County, Montana	1:24,000 and 1:506,880	Meshneck and others (1977)

TABLE 2 (Cont'd.)

Category	Map Name	Scale	Source
Soils	Soils of Carbon County Area, Montana	1:24,000 and 1:506,880	Parker and others (1975)
Soils	Soils of Sheridan County, Wyoming	1:63,360	Thorp and others (1939)
Soils	Soils of the McLeod Sheet, Alberta	1:190,080	Wyatt (1924)
Soils	Soils of the Lethbridge and Pincher Sheets, Alberta	1:190,080	Wyatt and others (1939)
Soils	Soils of the Rainy Hills Sheet, Alberta	1:190,080	Wyatt and others (1937)
Soils	Soils of the Milk River Sheet, Alberta	1:190,080	Wyatt and others (1941)
Soils	Soils of the Blackfoot and Calgary Sheets, Alberta	1:190,080	Wyatt and others (1942)
Soils	Soils of the Rosebud and Banff Sheets, Alberta	1:190,080	Wyatt and others (1943)
Soils	Soils of the Red Deer Sheet, Alberta	1:190,080	Bowser and others (1951)
Topography	Physiography and Glacial Geology of Eastern Montana and Adjacent Areas	1:500,000	Alden (1932)
Topography	Physiography and Glacial Geology of Western Montana and Adjacent Areas	1:500,000	Alden (1953)
Landform	Physiographic Regions of Canada	1:5,000,000	Bostock (1970)

TABLE 2 (Cont'd.)

Category	Map Scale	Scale	Source
Landform	Classes of Land-Surface Form in the Forty-Eight States, U. S. A.	1:5,000,000	Hammond (1964)
Surficial Geology	Surficial Geology, Beiseker, Alberta	1:253,440	Stalker (1956)
Surficial Geology	Surficial Geology, High River, Alberta	1:253,440	Stalker (1957)
Surficial Geology	Surficial Geology, Fort MacLeod, Alberta	1:253,440	Stalker (1959)
Surficial Geology	Surficial Geology, Red Deer-Stettler, Alberta	1:253,440	Stalker (1960)
Surficial Geology	Surficial Geology, Lethbridge, Alberta	1:253,440	Stalker (1962)
Surficial Geology	Surficial Geology, Foremost-Cypress Hills	1:250,000	Westgate (1968)
Bedrock Geology	Geology of Pincher Creek, Alberta	1:40,000	Douglas (1951)
Bedrock Geology	Geology of Turner Valley Sheet	1:63,360	Hume (1931)
Bedrock Geology	Geology of Bragg Creek	1:63,360	Hume (1941)
Bedrock Geology	Geology of Stimson Creek	1:63,360	Hume (1949)
Bedrock Geology	Geology, Lethbridge	1:253,440	Irish (1967)
Bedrock Geology	Geology, Foremost	1:253,440	Irish (1968a)

TABLE 2 (Cont'd.)

Category	Map Name	Scale	Source
Bedrock Geology	Geology, Gleichen	1:253,440	Irish (1968b)
Bedrock Geology	Geology of Wyoming	1:500,000	Love and others (1955)
Bedrock Geology	Geologic Map of Montana	1:500,000	Ross and Witkind (1955)

Group One includes 12 nominal and ordinal scale variables. A portion of these served the purpose of record keeping and data standardization, while the remainder are cultural and site specific variables. All of the data for these variables were derived from site source materials, thus representing second-hand information provided by a large number of different individuals. Group Two includes 16 dichotomous and multistate nominal scale variables providing information on a number of environmental variables related to bison kill sites. These variables serve to eliminate extraneous information from the data and identify important variable trends. They also provide the primary data for case comparison and the identification of critical variables through cross-tabulation and statistical procedures. Group Three included eight interval scale environmental variables which provide the finest measure with which to compare cases and identify critical variables. Together with Group Two variables, they provide the information upon which the predictive statements rest.

Group One variables were gathered almost entirely from site forms, unpublished manuscripts and published reports. In some instances, additional information was obtained from appropriate maps. These variables include STATE, denoting the state or province where the case was located, and COUNTY, indicating the county in the United States where the case was found. Cases from Alberta were excluded from this category and instead were given the designation 99. PRESEARCH denoted whether a site had been previously researched and TYPEPR indicated the type of previous research known. Previous research was not indicated unless the site was recorded as part of a systematic survey or other project for which a manuscript was written or for which literature review was later given. SOURCE indicated where the information was derived for each case. LOCRELY denoted a measure of locational preciseness for each case. This variable was used to test the relationship between progressively finer locational measurements and bison jump site settings.

The next 6 Group One variables represent a range of identifiable cultural and site specific manifestations extant at bison jump sites. These variables were treated with caution since they are obtained from a wide variety of sources which contain some indirect measurements. Additionally, many of the site record sources did not identify all variables. Nevertheless, some trends were identified among these important aspects of jumps. The AGE acronym referred to the cultural period(s) of each case. While the age of only a minority of cases were known, those so identified were directly or indirectly measured by radiocarbon dating, geochronology or associated diagnostic artifacts. Thus, unlike other cultural variables, AGE represents a relatively reliable measurement. It was decided to group ages into the widely accepted culture-historical chronology suggested by Mulloy (1958) due to both the small number of dated cases and the broad time frames provided for many of the sites. Important modifications to this scheme based on more complete data have been recently suggested (Reeves 1970). For the purposes of this study the modifications would not be significant since they refer largely to the Middle Prehistoric Period, for which few cases are known.

ASSOCAMP and DRIVLANE are presence-absence variables denoting the presence of a prehistoric campsite near a jump and drive lanes above the base of the fall. Campsites may or may not be directly associated with the jumps they are near. In most cases an association is impossible to prove without excavation. Thus, the variable merely measures the degree of association between habitation sites and jump sites. Drive lanes provide a much clearer measure of direct association since the only Plains sites known to contain converging linear ground configurations are animal kills. For this reason, the existence of drive lanes alone, without an associated kill deposit, is sufficient to warrant a site's inclusion as a case.

The remaining three Group One variables all concern the jumpoff location of sites. TYPEFALL identifies the type of fall represented. JUMPFACE denotes the direction in which the jump faced and hence the direction the bison were run in the final moments of the drive. JUMPHEIT refers to the height of the jumpoff. This variable was usually estimated so it was considered most appropriate to use grouped distances. The fall distance denoted the vertical distance for cliffs and cutbanks (as opposed to the combined vertical drop and steep incline following the drop, if any) and the incline distance for steep slopes. This decision was made to include the largest number of cases possible. Sources on most cases identifying cliffs and cutbanks provided a measurement of vertical drop, not the entire fall length.

Group Two variables form the bulk of environmental identifiers, comprising 16 nominal scale variables. The variables represent five major environmental groupings including water resources, vegetation, soils, surficial land formations and bedrock formations, all gathered from a wide variety of environmental sources. Five of the variables concern water resources. Data for water variables was derived from 15 and 7½ minute U.S. Geological Survey Quadrangle maps and topographic maps of the Canadian Department of Energy, Mines and Resources (Scale 1:50,000 and some 1:125,000). WATERONE AND WATERTWO variables denote the nearest water source to each case and the next nearest water source to each case. PERMWATER concerns the nearest available permanent water source and WATERDIS AND DISTPERM refer to the distance to the nearest water and the distance to the nearest permanent water, respectively. It would have been preferable to provide exact distances from site to water sources, but this was precluded because only approximate locations were given for most sites. Thus, all distances to water were measured from the center of the most precisely given location for the site. For instance, for a site located within a ¼ section, distances to water were measured from the center of the ¼ section. The use of this procedure prompted grouping distance measurements into 400 meter and larger increments.

The VEG variable denoted the natural vegetation type which occurs at each site. For cases within the United States Kuchler's Potential Natural Vegetation of the Coterminous United States (1964) was used while information on Canadian cases was derived from Lewis, Dowdling and Moss' The Vegetation of Alberta, II (1928) and Moss' The Vegetation of Alberta, IV (1932).

Four environmental variables concerned soil classification. Soil information was derived from reports and maps of the U.S. Soil Conservation Service, several Bulletins of the Montana Experiment Station, and soil survey Bulletins of the University of Alberta, College of Agriculture. SITESOL denotes the soil type predominant at the site while AREASOL indicates the soil type within the standard area around the site. Logistical problems posed by the wide variety of soil survey reports used resulted in inclusion of only the most basic soil texture classes which appear in all reports. CORSESOL and STONISOL are two dependent variables denoting the relative coarseness of the predominant soil in each standard area and the relative stoniness of the soil in each standard area, respectively. CORSESOL and STONISOL were chosen for the purpose of exploring possible relationships with vegetation types.

LANDFORM denotes the major geographic landform for each case as designated by Hammond (1964) in his Classes of Land-Surface Form in the Forty-eight States, U.S.A. (Fig. 2) and Bostock (1970) in Physiographic Regions of Canada (Fig. 3). This variable served to sort out major landform trends associated with bison jump sites. Following LANDFORM were three related topographic variables SITETOPO, PRSRTOPO and AREATOPO. SITETOPO refers to the surficial geologic features at each site, PRSRTOPO denotes the predominant surficial geologic feature at the site and AREATOPO identifies the predominant surficial geologic feature within the standard area. For sites in the United States William C. Alden's Physiography and Glacial Geology of Eastern Montana and Adjacent Areas (1932) and Physiography and Glacial Geology of Western Montana and Adjacent Regions (1953) were used, while in Alberta a series of surficial geologic maps produced by the Geological Survey of Canada and the Research Council of Alberta were used.

The final two Group Two variables concern bedrock geology. SITEROCK denotes the predominant bedrock type occurring at each site and AREAROCK refers to the predominant bedrock type occurring within the standard area. The U.S. Geological Survey geology map of Montana (Ross and Witkind 1955) and of Wyoming (Love, Weitz and Hose 1955) were used to plot cases within the United States. A series of Geological

Survey of Canada bedrock geology maps were used for cases in Alberta.

Group Three data includes eight interval scale variables covering three major environmental areas. NUMWASH and NUMSTRM refer to counts of intermittent watercourses and perennial watercourses, respectively, over three kilometers in length within each standard area. These variables were established to test for a potential relationship between stream density and bison jump location. The three kilometer length requirement for each watercourse was an attempt to reduce distortion in the data. In this case the distortion was frequently due to the existence of dozens of very short streamlets within a standard area. These streamlets drain minimal surface area and thus, if measured with longer watercourses, would distort the potentially greater effect longer streams have on topography and water resources within the standard area around each site.

NUMSOL AND PERCTSOL denote aspects of soil type. The NUMSOL variable refers to a count of soil classes in the standard area around each case. This count was made to establish the density of different soil types within a standard area. PERCTSOL is the percentage of the standard area around a site occupied by the predominant soil type. This percentage, similar to that measured for surficial geologic features (see below), were obtained by overlaying gridded paper on appropriate maps and counting squares located within the desired soil class. Counts were made using 10 millimeter to the centimeter mesh graph paper.

The remaining four interval scale variables concern some aspect of surficial topography. ELEV denotes the elevation of each site in feet. The high and low measurements for each case were averaged to arrive at the given figure. NUMTOPO was a count made of the number of surficial geologic features within each standard area. AROCTOPO is the percentage of each standard area occupied by the dominant surficial geologic feature and STOCTOPO is the percentage of the standard area occupied by the surficial geologic feature predominant at the site.

TABLE 3

LIST OF COUNTIES AND NUMBER OF SITES
INVESTIGATED IN MONTANA AND WYOMING

County	State	Smithsonian Number	Number of Sites
Big Horn	Montana	24 BH	9
Big Horn	Wyoming	48 BH	0
Blaine	Montana	24 BL	3
Broadwater	Montana	24 BW	0
Campbell	Wyoming	48 CA	0
Carbon	Montana	24 CB	1
Carter	Montana	24 CT	2
Cascade	Montana	24 CA	7
Chouteau	Montana	24 CH	2
Converse	Wyoming	48 CO	1
Crook	Wyoming	48 CK	1
Custer	Montana	24 CR	0
Daniels	Montana	24 DN	0
Dawson	Montana	24 DW	1
Fallon	Montana	24 FA	0
Fergus	Montana	24 FR	1
Fremont	Wyoming	48 FR	0
Gallatin	Montana	24 GA	4
Garfield	Montana	24 GF	0
Glacier	Montana	24 GL	2
Golden Valley	Montana	24 GV	0
Hill	Montana	24 HL	8
Hot Springs	Wyoming	48 HO	0
Jefferson	Montana	24 JF	3
Johnson	Wyoming	48 JO	1
Judith Basin	Montana	24 JT	0
Lewis and Clark	Montana	24 LC	6
Liberty	Montana	24 LT	0
McCone	Montana	24 MC	0
Madison	Montana	24 MA	5
Meagher	Montana	24 ME	7
Musselshell	Montana	24 ML	2*
Natrona	Wyoming	48 NA	0
Niobrara	Wyoming	48 NO	0
Park	Montana	24 PA	7
Park	Wyoming	48 PA	0
Petroleum	Montana	24 PT	0
Phillips	Montana	24 PH	5
Pondera	Montana	24 PN	0
Powder River	Montana	24 PR	0

*These two sites are actually in Fergus County

TABLE 3 (Cont'd.)

County	State	Smithsonian Number	Number of Sites
Prairie	Montana	24 PE	0
Richland	Montana	24 RL	1
Roosevelt	Montana	24 RV	1
Rosebud	Montana	24 RB	0
Sheridan	Montana	24 SH	0
Sheridan	Wyoming	48 SH	1
Stillwater	Montana	24 ST	1
Sweetgrass	Montana	24 SW	4
Teton	Montana	24 TT	3
Toole	Montana	24 TL	0
Treasure	Montana	24 TE	0
Valley	Montana	24 VL	2
Washakie	Wyoming	48 WA	0
Weston	Wyoming	48 WE	0
Wheatland	Montana	24 WL	3
Wibaux	Montana	24 WX	0
Yellowstone	Montana	24 YL	0
Yellowstone National Park	Montana	24 YE	0
Yellowstone National Park	Wyoming	48 YE	0

CHAPTER IV

LOCATIONAL ANALYSIS: SITES AND THEIR ENVIRONMENTAL SETTINGS

The thirty environmental and cultural variables used in this study were subjected to a series of univariate and multivariate tests in order to determine their value as predictors of site location. Several SPSS subprograms (Nie and others 1975) were used to determine the distribution of individual variables and to explore the behavioral characteristics of sets of variables. Following is a discussion and interpretation of the results of those tests.

Nominal and Ordinal Scale Variables

Frequency Distributions

The SPSS subprogram FREQUENCIES was generated to determine the degree of correspondence between case locations and various values of cultural and environmental variables. Absolute and adjusted frequency distributions were computed for all 146 cases on the nominal scale dichotomous and multistate variables and ordinal scale multistate variables. These variables included AGE, ASSOCAMP, DRIVLANE, TYPEFALL, JUMPFACE, JUMPHEIT, WATERONE, WATERTWO, VEG, SITESOL, AREASOL, CORSESOL, STONISOL, LANDFORM, SITETOPO, AREATOPO, SITEROCK, AREAROCK, PRSRTOPO, WATERDIS, PERMWATR AND DISTPERM (See Appendices A and B for a description of these variables and their relevant values). Frequency distributions of most of these variables are displayed in Tables 4 through 15. Prominent frequencies and percentages are underlined.

Inspection of the frequency distributions indicate that the variables exhibit a wide range of variability. Cases frequently associate with two or more different values in some variables and with only one in others. Among the Group One variables this pattern is clearly evident. Cases overwhelmingly associate with the Late Prehistoric Period value in the AGE variable and the bluff or cliff value in the TYPEFALL variable (Tables 4 and 5). On the other hand, cases frequently occur in association with several values of the JUMPHEIT and JUMPFACE variables (Tables 6 and 7). The strong association of cases with the Late Prehistoric Period appears to reflect the actual temporal distribution of sites, but their overwhelming association with bluffs and cliffs is partially the result of researcher error. Information pertaining to the type of fall for each site and all other descriptive information concerning sites were obtained from site records and other written sources. Written observations concerning the type of fall present were not standardized; rather, they varied with the knowledge and background of each observer. As a result, the terms "bluff" and "cliff" may refer to a wider variety of topographic situations than is actually the case. The data for other variables AGE, ASSOCAMP, DRIVLANE, JUMPHEIT and JUMPFACE was derived from the same sources as that for TYPEFALL. But these variables have considerably more credibility because they are not subject to interpretation, i.e., they are quantifiable.

The variable ASSOCAMP, which measured the presence or absence of campsites associated with jump site locations, and the variable DRIVLANE,

TABLE 4

FREQUENCY DISTRIBUTION OF AGE VALUES

Cultural Period of Site	Frequencies	%
Late Prehistoric	15	50.0
Late Prehistoric/Historic	6	20.0
Late Middle Prehistoric	2	1.4
Late Middle Prehis./Late Prehistoric	2	1.4
Late Middle Prehis./Late Preshis./Historic	1	.7
Early Middle Prehistoric/Historic	1	.7
Early Middle Prehistoric/Late Middle Prehis.	1	.7
Early Middle Prehis./Late Mid. Pre./Late Pre.	2	1.4
SUB-TOTAL (valid cases)	30	100.0
MISSING CASES	116	
TOTAL	146	100.0

TABLE 5

FREQUENCY DISTRIBUTION OF TYPEFALL VALUES

Type of Fall At Site	Frequencies	%
bluff/talus slope	15	11.6
bluff/steep embankment/river cut	3	2.3
bluff and steep embankment	2	1.6
bluff and cutbank	3	2.3
bluff or cliff	72	55.8
talus slope/steep embankment	1	.8
talus slope	1	.8
steep embankment/river cut	1	.8
steep embankment	16	12.4
river or creek bank	12	9.3
other	3	2.3
SUB-TOTAL (valid cases)	129	100.0
MISSING CASES	17	
TOTAL	146	100.0

TABLE 6

FREQUENCY DISTRIBUTION OF JUMPFACE VALUES: 1

Direction Jumpoff Faces	Frequencies	%
Southwest	5	5.6
Southeast	3	3.3
Northwest	3	3.3
Northeast	11	12.2
West	5	5.6
South	16	17.8
South-southeast	1	1.1
East	12	13.3
North	30	33.3
North-northwest	3	3.3
North-northeast	1	1.1
SUB-TOTAL (valid cases)	90	100.0
MISSING CASES	56	
TOTAL	146	100.0

TABLE 7

FREQUENCY DISTRIBUTION OF JUMPHEIT VALUES

Height of Jumpoff	Frequencies	%
over 50 meters	4	5.6
40 to 50 meters	2	2.8
30 to 40 meters	3	4.2
20 to 30 meters	9	12.5
10 to 20 meters	31	43.1
under 10 meters	23	31.9
SUB-TOTAL (valid cases)	72	100.0
MISSING CASES	74	
TOTAL	146	100.0

which measured the presence or absence of drive lanes, are potentially important for understanding the environmental and cultural context of jump site locations. Unfortunately, the site sample at hand does not provide a reliable measurement of the distribution of these features. While the present study established the existence of 34 campsites adjacent to jump sites and 46 sets of drive lanes, many more of these features may have gone unrecorded at known jump sites for a number of reasons. For instance, there may have been historic disturbance which obliterated the features or there may not have been thorough surveys made of the sites. It is also possible that the features never existed at many sites. The failure to accurately establish the presence or absence of these features at many sites, therefore, precludes formal use of existing information in the generation of a predictive site locational model.

Of the remaining Group One variables, AGE, JUMPFACE, and JUMPHEIT appear to be the most reliable for purposes of this study. The JUMPFACE variable has the greatest potential for contributing to an understanding of site location. Cases frequently associate with several different values on this variable revealing a pattern which is not entirely compatible with existing literature on this aspect of jump sites. Limited observations have led to the conclusion that the vast majority of bison jump sites face either north or east; seldom west and almost never south (Malouf and Conner 1962: 44-45; Lewis n.d.). The distribution of facings derived from this study (Table 7), indicate that most jumps face north (33.3%), and a lesser number face east or northeast (27.6%). Contrary to previous statements, however, a large number of sites also face south (17.8%). It is impossible to know to what extent this distribution is reflective of all jump sites in the Northwestern Plains since the cases evaluated in this study were non-randomly collected. Nevertheless, this distribution suggests that more variability may exist than formerly thought.

In order to more clearly identify the diversity in the JUMPFACE variable, two additional frequency distributions were generated in which selected values of the PRSRTOPO and ELEV variables were controlled for. In the first analysis, site altitudes (ELEV) were divided into nine 500-foot interval groups and frequency distributions of the JUMPFACE variable then generated for each group. The results were inconclusive due to the paucity of cases generated for each distribution. In contrast, when controlling for the surficial geologic features ground moraine and unglaciated terrain (PRSRTOPO variable), enough cases were generated to reveal significant variability in the JUMPFACE distribution (Table 8). When controlling for unglaciated terrain, however, the results were mixed with a significant percentage of sites facing either south, north or northeast.

An inspection of frequency distributions of the 16 Group 2 environmental variables revealed that, similar to Group 1 variables, some have greater potential for identifying site locations than others. For instance, for several reasons the variables WATERTWO, CORSESOL and STONISOL provided little information relevant to site placement. The WATERTWO variable, which identified the secondary water source of each case, was not accompanied by a distance measurement. In the absence of known distances to case locations the variable measures only the occurrence of secondary water sources within the study area, not their relation to the sample population. Additionally, the CORSESOL and

TABLE 8

FREQUENCY DISTRIBUTION OF JUMPFACE VALUES: 2

Direction Jumpoff Faces	Frequencies*	%	Frequencies**	%
North	14	58.3	4	17.4
East	3	12.5	3	13.0
South	2	8.3	6	26.1
West	1	4.2		
Northeast	3	12.5	5	21.7
Northwest			1	4.3
Southeast			2	8.7
South-southeast			1	4.3
Southwest	1	4.2	1	4.3
SUB-TOTALS (valid cases)	24	100.0	23	100.0
MISSING CASES	10		17	
TOTALS	34	100.0	40	100.0

*of sites in ground moraine
**of sites in unglaciated terrain

TABLE 9

FREQUENCY DISTRIBUTION OF WATERONE VALUES

Nearest Water Source	Frequencies	%
lake	5	4.1
river	14	11.6
river/spring/ lake	1	.8
wash	41	33.9
wash/ spring	2	1.7
wash/river	6	5.0
perennial stream	34	28.1
perennial stream/ lake	1	.8
perennial stream/ river	2	1.7
perennial stream/ wash	14	11.6
perennial stream/ wash/ lake	1	.8
SUB-TOTAL (valid cases)	121	100.0
MISSING CASES	25	
TOTAL	146	100.0

STONISOL variables, which measure the relative coarseness and stoniness of predominant soils in each site's standard area, provided minimal information due to problems which developed during collection of the data. After inspecting a number of site soils for these features, it became clear that different proportions of coarseness and stoniness frequently occurred in the same soil type within a given standard area. Several of the COARSESOL and STONISOL values were combined within their respective variables in an attempt to rectify this problem. Unfortunately, this procedure resulted in a display of the variation, rather than the predominance, of soil coarseness and stoniness. Consequently, the two variables were eliminated from additional analysis.

The SITETOPO variable, although it revealed considerable information relevant to site location, did not provide meaningful and comparative statistical results largely because it was not highly discriminating, i.e., it evaluated all surficial geologic features present at a site location rather than the predominant ones. Thus, SITETOPO was not readily comparable with other variables which identify predominant environmental features. The PRSRTOPO variable provided an appropriate evaluation of this aspect of the environment by identifying only predominant surficial geologic features at a site location.

The remainder of the Group 2 variables consist of a series of concise assessments of vegetation, soils, landform, geology and water features and their association with case locations. Cases tend to associate with few values within each of these variables and in some, they largely associate with only one value. For example, cases measured on the SITESOL and AREASOL soil variables occur exceptionally often with loam and cases evaluated on the SITEROCK and AREAROCK variables overwhelmingly associate with shale/sandstone. The strength of these values is undoubtedly a reflection of the Northwestern Plains environment, i.e., loams are the predominant soil type and shale, sandstone, and related rocks are the most commonly occurring bedrock formation in this part of the Plains.

The WATERDIS variable, which measures the distance from a site to the nearest water source, and the DISTPERM variable, which measures the distance to the nearest permanent water source, also strongly associate with only one value (Tables 10 and 12). In both instances, cases most frequently associate with a water source (WATERDIS) within 400 meters of a site or a permanent water source (DISTPERM) within 800 meters of a site.

The balance of the Group 2 environmental variables tend to display more variability than those discussed above, i.e., two or more values share a significant percentage of the total valid case population. Frequency distributions of these variables are displayed in Table 9 and Tables 11 through 16.

Frequency Cross-tabulation

Two-by-two contingency tables were generated by the SPSS subprogram CROSSTABS in order to determine if particular sets of variables co-occur with case locations. A large number of cross-tabulations were generated, but only a few revealed significant associations. All variable combinations which were analyzed will be discussed, but only those tables which suggest the existence of important associations will be illustrated. Prominent frequencies are underlined in the displayed tables. Chi-square significance tests were made for each of the

TABLE 10

FREQUENCY DISTRIBUTION OF WATERDIS VALUES

Distance to Nearest Water	Frequencies	%
within 400 meters	101	84.2
within 800 meters	14	11.7
within 1600 meters	4	3.3
within 2400 meters	1	.8
SUB-TOTAL (valid cases)	120	100.0
MISSING CASES	26	
TOTAL	146	100.0

TABLE 11

FREQUENCY DISTRIBUTION OF PERMWATR VALUES

Nearest Permanent Water	Frequencies	%
lake	7	5.8
spring	5	4.2
river	34	28.3
perennial stream	68	56.7
perennial stream/lake	2	1.7
perennial stream/spring	2	1.7
perennial stream/river	2	1.7
SUB-TOTAL (valid cases)	120	100.0
MISSING CASES	26	
TOTAL	146	100.0

TABLE 12

FREQUENCY DISTRIBUTION OF DISTPERM VALUES

Distance to Permanent Water	Frequencies	%
within 400 meters	73	59.4
within 800 meters	24	19.5
within 1600 meters	8	6.5
within 2400 meters	11	8.9
within 3200 meters	5	4.1
within 5000 meters	1	.8
beyond 5000 meters	1	.8
SUB-TOTAL (valid cases)	123	100.0
MISSING CASES	23	
TOTAL	146	100.0

TABLE 13

FREQUENCY DISTRIBUTION OF VEG VALUES

Vegetation Type	Frequencies	%
K64/Southern Prairie	48	32.9
Cordilleran Forest	2	1.4
Parkland	5	3.4
Northern Prairie	31	21.2
Northern Prairie/Parkland	4	2.7
Northern Prairie/Southern Prairie	1	.7
K98	1	.7
K66	6	4.1
K64/K66	1	.7
K63	20	13.7
K63/K64	2	1.4
K55	4	2.7
K16	3	2.1
K16/K64	2	1.4
K15	2	1.4
K12	10	6.9
K12/K55	1	.7
K12/K15	3	2.1
TOTAL (valid cases)	146	100.0

TABLE 14

FREQUENCY DISTRIBUTION OF LANDFORM VALUES

Landform Class	Frequencies	%
Mountains	2	1.4
Mountain Foothills	4	2.7
Alberta Plain	40	27.4
Alberta Plain/Mountain Foothills	5	3.4
D6	12	8.2
C6a	19	13.0
C6a/D6	1	.7
C4b	7	5.0
B5d	9	6.2
B5b	1	.7
B4c	12	8.2
B4c/D6	1	.7
B4b	4	2.7
B3c	20	13.7
B3c/C6a	2	1.4
B3c/B4b	1	.7
B3b	5	3.4
B3b/D5	1	.7
TOTAL (valid cases)	146	100.0

TABLE 15

FREQUENCY DISTRIBUTION OF AREATOPO VALUES

Surficial Geologic Features	Frequencies	%
unglaciated terrain	43	33.3
dissected mountains	11	8.5
alluvium	1	.8
remnant stream terrace	5	3.9
glacial lake bed	14	10.9
glacial channels/ alluvium	2	1.6
ground moraine	50	38.8
moraine	1	.8
moraine/ground moraine	2	1.6
SUB-TOTAL (valid cases)	129	100.0
MISSING CASES	17	
TOTAL	146	100.0

TABLE 16

FREQUENCY DISTRIBUTION OF PRSRTOPO VALUES

Surficial Geologic Features	Frequencies	%
unglaciated terrain	40	30.8
dissected mountains	10	7.7
bedrock	9	6.9
gravel	1	.8
alluvium	9	6.9
remnant stream terrace	8	6.2
glacial lake bed	10	7.7
glacial channels/alluvium	7	5.4
ground moraine	34	26.2
moraine	1	.8
ground moraine/moraine	1	.8
SUB-TOTAL (valid cases)	130	100.0
MISSING CASES	16	
TOTAL	146	100.0

contingency tables to determine the statistical significance of each cross-tabulation. Those measuring to at least the .05 level were deemed acceptable.

Initially, the AGE and JUMPFACE variables were cross-tabulated with several environmental variables: AGE with LANDFORM, JUMPFACE, JUMPHEIT and PRSRTOPO and JUMPFACE with LANDFORM and JUMPHEIT. Significant associations were not demonstrated between any of these sets of variables. The negative associations which occurred with the AGE variable probably resulted from both the limited number of dated sites in the study population (30) and the lack of variability present in the sample. Half of the dated sites fall within the Late Prehistoric Period and more than 86 percent contain at least one Late Prehistoric Period component. Probable causes for the lack of association with the JUMPFACE variable are not clear.

The cross-tabulation of the LANDFORM variable with a series of other environmental variables represented one of the most important segments of this analysis. The landform classes proposed by Hammond (1964) and Bostock (1970) divide the study area into a number of geographically bounded areas with distinct topographic characteristics and altitudes (Figs. 2 and 3). Case locations within each of these regions share broad environmental characteristics. As a result, cross-tabulation of landform units with other environmental variables has considerable potential for identifying important differences between these cohesive groups of jump sites. Only sites located within Montana and Wyoming were used in analysis of the LANDFORM variable because of the incompatibility of Canadian and United States landform units. Classes proposed by Hammond (1964) for the United States provide more quantifiable and comparable physical descriptions of the separate units than those recently established for Canada (Bostock 1970). Thus, comparison between the two schemes was not possible without severely compromising the information content of the Hammond classes.

Using the 95 case sample from Montana and Wyoming, LANDFORM was cross-tabulated with VEG, SITESOL, AREASOL, PRSRTOPO, AREATOPO, SITEROCK, AREAROCK, WATERONE and PERMWATR to determine if sets of these variables co-occur with case locations. Sites associated with the five LANDFORM values B5d, B4c, B3c, C4b and C6a occurred frequently and consistently in association with a limited number of values on each of the other nine values. The LANDFORM values fall into two major groups: (1) B5d, B4c, and B3c, tablelands with moderate to high relief and (2) C4b, open high hills, and D6 and C6a, high mountains and open high mountains with extreme local relief (Hammond 1964). In all contingency tables except one (AREASOL) chi-square tests confirmed significance to the .05 level.

The cross-tabulation of landform classes with vegetation types revealed associations between tableland sites (B3c, B4c and B5d) and the short grass Plains vegetation (K64) and between open high mountain sites (C6a) and prairie grasses (K63) (Table 17).

Contingency table analysis of the LANDFORM variable with SITESOL and with AREASOL revealed that loam soils most frequently occur in association with open high mountain and tableland sites (Tables 18 and 19). Specifically, loam soils occur with sites in the C6a, B4d and B3c landform classes on the AREASOL variable. The chi-square significance test of the AREASOL and LANDFORM contingency table, however, revealed that an unacceptably high level exists for this combination of variables. While this is true for the entire contingency table, the

TABLE 17

FREQUENCY CROSS-TABULATION:
LANDFORM CLASS BY VEGETATION TYPE

LANDFORM \ VEG	K98	K66	K64	K64/K66	K63	K63/K64	K55	K16	K16/K64	K15	K12	K12/K55	K12/K15	TOTAL
D6	0	0	0	0	2	0	0	0	0	2	5	0	3	12
C6a	0	0	4	0	6	1	3	0	0	0	4	1	0	19
C6a/D6	0	0	0	0	1	0	0	0	0	0	0	0	0	1
C4b	0	0	1	0	4	0	1	1	0	0	0	0	0	7
B5d	0	0	9	0	0	0	0	0	0	0	0	0	0	9
B5b	0	0	0	0	1	0	0	0	0	0	0	0	0	1
B4c	0	0	10	0	1	1	1	0	0	0	0	0	0	13
B4c/D6	0	0	1	0	0	0	0	0	0	0	0	0	0	1
B4b	0	0	0	0	4	0	0	0	0	0	0	0	0	4
B3c	1	3	12	1	0	0	0	0	2	0	1	0	0	20
B3c/C6a	0	0	0	0	0	0	0	2	0	0	0	0	0	2
B3c/B4b	0	0	1	0	0	0	0	0	0	0	0	0	0	1
B3b	0	2	2	0	1	0	0	0	0	0	0	0	0	5
B2b/D5	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	1	7	40	1	20	2	5	3	2	2	10	1	3	96

TABLE 18

FREQUENCY CROSS-TABULATION:
LANDFORM CLASS* BY PREDOMINANT SOIL TYPE*

LANDFORM	SITESOL alluvium	eroded soil	clay	clay loam	clay loam/ clay	silt loam	loam	loam/silt loam	sand loam	TOTAL
D6	1	0	0	0	0	0	2	0	1	4
C6a	1	0	0	0	0	1	8	0	0	10
C4b	0	0	0	1	1	0	5	0	0	7
B5d	2	2	0	0	0	0	5	0	0	9
B5b	0	0	0	0	0	0	1	0	0	1
B4c	1	0	0	3	0	0	8	0	0	12
B4c/D6	1	0	0	0	0	0	0	0	0	1
B4b	1	0	0	0	0	0	1	2	0	4
B3c	3	1	1	1	0	0	10	0	2	18
B3c/C6a	0	0	0	0	0	0	2	0	0	2
B3c/B4b	0	0	1	0	0	0	0	0	0	1
B3b	0	0	0	0	0	0	2	0	0	2
TOTAL	10	3	2	4	1	2	44	2	3	71

*at site

TABLE 19

FREQUENCY CROSS-TABULATION:
LANDFORM CLASS* BY PREDOMINANT SOIL TYPE*

LANDFORM	AREASOL: alluvium	clay loam	silt loam	silt loam/ clay loam	loam	loam/ clay loam	loam/silt loam/ clay loam	sandy loam	TOTAL
D6	1	1	0	0	1	1	0	0	4
C6a	0	0	1	0	_7_	0	0	1	9
C4b	0	1	0	0	1	0	0	0	2
B5d	0	0	0	0	_9_	0	0	0	9
B5b	0	0	0	0	1	0	0	0	1
B4c	0	2	0	0	_10_	0	0	0	12
B4c/D6	0	0	0	0	1	0	0	0	1
B4b	0	0	0	0	2	0	1	0	3
B3c	1	1	0	1	_11_	0	0	1	15
B3c/C6a	0	0	0	0	2	0	0	0	2
B3c/B4b	0	0	0	0	1	0	0	0	1
B3b	0	0	0	0	1	0	0	1	2
TOTAL	2	5	1	1	47	1	1	3	61

*in standard area around site

large size of the table (13 by 8 cells) and the high proportion of empty cells within it would tend to mask a small number of paired associations.

Frequent associations occur between a limited number of bedrock geologic features and sites in high mountains and tablelands. The sandstone/shale bedrock feature occurs overwhelmingly with cases in tablelands of moderate and high relief (B3c and B5d) in both the SITESOL and AREASOL variables. Other sedimentary rock formations occur in open high mountain sites (C6a) in both the SITEROCK and AREAROCK variables and in tableland sites having considerable relief (B4c) in the AREAROCK variable. The possible significance of site association with other sedimentary rocks is impossible to determine since the category includes a variety of rock types.

Surficial geologic features vary in association with landform characteristics (Tables 20 and 21). Cross-tabulation of landform classes with predominant geologic features (PRSRTOPO and AREATOPO) reveal that tableland sites in areas of moderate and high relief (B3c and B5d) most frequently occur with ground moraine surficial formations while those sites in open high mountains (C6a), in tablelands with considerable relief (B4c) and in open high hills (C6a) occur with unglaciated terrain. Sites in high mountains (D6) are most frequently associated with dissected mountain terrain.

Ephemeral and perennial water features also appear to vary with respect to landform class (Tables 22 and 23). High mountain sites (D6) are frequently associated with perennial streams in the WATERONE and PERMWATR variables. Sites in open high mountains (C6a) and open high hills (C4b) also occur with perennial streams when dry washes are

TABLE 20

FREQUENCY CROSS-TABULATION:
LANDFORM CLASS BY PREDOMINANT SURFICIAL GEOLOGIC FEATURE*

LANDFORM / PRSRTOPO	unglaciated terrain	dissected mountains	bedrock	remnant stream terrace	glacial lake bed	glacial channel/ alluvium	ground moraine	moraine	ground moraine/ moraine	TOTAL
D6	1	8	1	1	0	1	0	0	0	12
C6a	8	2	0	4	1	4	0	0	0	19
C6a/D6	0	0	0	1	0	0	0	0	0	1
C4b	7	0	0	0	0	0	0	0	0	7
B5d	0	0	0	0	0	0	9	0	0	9
B5b	1	0	0	0	0	0	0	0	0	1
B4c	7	0	0	2	2	0	0	0	1	12
B4c/D6	0	0	0	0	0	0	0	1	0	1
B4b	4	0	0	0	0	0	0	0	0	4
B3c	5	0	0	0	3	2	8	0	0	18
B3c/C6a	2	0	0	0	0	0	0	0	0	2
B3c/B4b	1	0	0	0	0	0	0	0	0	1
B3b	3	0	0	0	2	0	0	0	0	5
B2b/D5	1	0	0	0	0	0	0	0	0	1
TOTAL	40	10	1	8	6	7	17	1	1	91

*at site

TABLE 21

FREQUENCY CROSS-TABULATION:
LANDFORM CLASS BY PREDOMINANT SURFICIAL GEOLOGIC FEATURE*

LANDFORM \ AREATOPO	unglaciated terrain	dissected mountains	remnant stream terrace	glac. lake bed	glac. channel/ alluvium	ground moraine	moraine	ground moraine/ moraine	TOTAL
D6	1	9	2	0	0	0	0	0	12
C6a	11	2	1	4	1	0	0	0	19
C6a/D6	0	0	1	0	0	0	0	0	1
C4b	7	0	0	0	0	0	0	0	7
B5d	0	0	0	0	0	9	0	0	9
B5b	1	0	0	0	0	0	0	0	1
B4c	9	0	0	2	0	0	0	1	12
B4c/D6	0	0	0	0	0	0	1	0	1
B4b	4	0	0	0	0	0	0	0	4
B3c	3	0	1	3	1	11	0	0	19
B3c/C6a	2	0	0	0	0	0	0	0	2
B3c/B4b	1	0	0	0	0	0	0	0	1
B3b	3	0	0	2	0	0	0	0	5
B2b/D5	1	0	0	0	0	0	0	0	1
TOTAL	43	11	5	11	2	20	1	1	84

*in standard area around site

TABLE 22

FREQUENCY CROSS-TABULATION:
LANDFORM CLASS BY NEAREST WATER SOURCE

LANDFORM \ WATERONE	lake	river	river/spring/ lake	wash	wash/spring	wash/river	perennial stream	perennial stream/wash	perennial stream/wash/lake	TOTAL
D6	1	0	1	3	0	0	6	1	0	12
C6a	0	0	0	7	0	1	3	5	1	17
C6a/D6	0	0	0	1	0	0	0	0	0	1
C4b	0	0	0	3	0	0	2	2	0	7
B5d	0	5	0	1	0	1	0	1	0	8
B5b	0	0	0	0	1	0	0	0	0	1
B4c	0	0	0	7	0	3	2	0	0	12
B4c/D6	0	1	0	0	0	0	0	0	0	1
B4b	0	0	0	0	0	0	2	1	0	3
B3c	1	1	0	10	1	0	2	1	0	16
B3b	0	0	0	0	0	0	1	1	0	2
B2b/D5	0	0	0	1	0	0	0	0	0	1
TOTAL	2	7	1	33	2	5	18	12	1	78

TABLE 22

FREQUENCY CROSS-TABULATION:
LANDFORM CLASS BY NEAREST WATER SOURCE

LANDFORM \ WATERONE	lake	river	river/spring/ lake	wash	wash/spring	wash/river	perennial stream	perennial stream/wash	perennial stream/wash/lake	TOTAL
D6	1	0	1	3	0	0	6	1	0	12
C6a	0	0	0	7	0	1	3	5	1	17
C6a/D6	0	0	0	1	0	0	0	0	0	1
C4b	0	0	0	3	0	0	2	2	0	7
B5d	0	5	0	1	0	1	0	1	0	8
B5b	0	0	0	0	1	0	0	0	0	1
B4c	0	0	0	7	0	3	2	0	0	12
B4c/D6	0	1	0	0	0	0	0	0	0	1
B4b	0	0	0	0	0	0	2	1	0	3
B3c	1	1	0	10	1	0	2	1	0	16
B3b	0	0	0	0	0	0	1	1	0	2
B2b/D5	0	0	0	1	0	0	0	0	0	1
TOTAL	2	7	1	33	2	5	18	12	1	78

TABLE 22

FREQUENCY CROSS-TABULATION:
LANDFORM CLASS BY NEAREST WATER SOURCE

LANDFORM \ WATERONE	lake	river	river/spring/ lake	wash	wash/spring	wash/river	perennial stream	perennial stream/wash	perennial stream/wash/lake	TOTAL
D6	1	0	1	3	0	0	__6__	1	0	12
C6a	0	0	0	__7__	0	1	3	5	1	17
C6a/D6	0	0	0	1	0	0	0	0	0	1
C4b	0	0	0	3	0	0	2	2	0	7
B5d	0	5	0	1	0	1	0	1	0	8
B5b	0	0	0	0	1	0	0	0	0	1
B4c	0	0	0	__7__	0	3	2	0	0	12
B4c/D6	0	1	0	0	0	0	0	0	0	1
B4b	0	0	0	0	0	0	2	1	0	3
B3c	1	1	0	__10__	1	0	2	1	0	16
B3b	0	0	0	0	0	0	1	1	0	2
B2b/D5	0	0	0	1	0	0	0	0	0	1
TOTAL	2	7	1	33	2	5	18	12	1	78

TABLE 23

FREQUENCY CROSS-TABULATION:
LANDFORM CLASS BY NEAREST PERMANENT WATER SOURCE

LANDFORM \ PERMWATR	lake	spring	river	perennial stream	perennial stream/lake	perennial stream/spring	perennial stream/river	TOTAL
D6	1	0	1	10	0	0	0	12
C6a	0	0	2	12	2	1	0	17
C6a/D6	0	0	0	1	0	0	0	1
C4b	0	0	0	7	0	0	0	7
B5d	0	0	8	0	0	0	0	8
B5b	0	1	0	0	0	0	0	1
B4c	0	1	7	4	0	0	0	12
B4c/D6	0	0	1	0	0	0	0	1
B4b	0	0	0	2	0	1	0	3
B3c	3	2	4	5	0	0	1	15
B3b	0	0	0	2	0	0	0	2
B2b/D5	0	0	0	1	0	0	0	1
TOTAL	4	4	23	44	2	2	1	80

eliminated as a category (in PERMWATR variable). Tableland sites with considerable or high relief (B4c and B5d) most frequently occur near rivers in the PERMWATR variable, but when washes are included as a category (in the WATERONE variable) rivers drop from importance and are replaced by washes. Tableland sites with moderate to considerable relief (B4c and B3c) and sites in open high mountains (C6a) also most frequently occur with washes.

Additional cross-tabulations were made between landform classes and the SITETOPO, AREATOPO and AREASOL variables selecting for environmentally distinct regions of the study area which might serve to differentiate sets of cases. One set of tables were generated for cases within unglaciated areas, a second for those in glaciated regions and yet another for all cases lying above 4500 feet in altitude. In all analyses, the cells within the tables produced too few cases that were too widely dispersed to identify significant trends.

The remainder of cross tabulations encompassed the entire sample population and focused upon case associations with soils and vegetation. In one analysis the site soil type (SITESOL) was compared with predominant site surficial features (PRSRTOPO) (Table 24). Sites in unglaciated terrain most frequently occur with loam soils while sites in ground moraine areas (glaciated) were found to associate with loams and, to a lesser extent, with eroded soils. A cross-tabulation between AREASOL and AREATOPO revealed case associations similar to that between SITESOL and PRSRTOPO, except that eroded soils did not even occur as a AREASOL category. The comparison between AREASOL and AREATOPO variables resulted in an unacceptably high chi-square level of probability. This was probably due to the large number of empty contingency table cells

TABLE 24

FREQUENCY CROSS-TABULATION:
PREDOMINANT SOIL TYPE* BY PREDOMINANT SURFICIAL GEOLOGIC FEATURE*

SITESOL \ PRSRTOPO	unglaciated terrain	dissected mountains	bedrock	gravel	alluvium	remnant stream terrace	glacial lake bed	glacial channel/ alluvium	ground moraine	moraine	ground moraine/ moraine	TOTAL
alluvium	5	0	0	0	0	0	0	1	2	1	0	9
eroded soil	0	0	4	0	3	0	0	0	9	0	0	16
clay	1	0	0	0	1	0	2	0	0	0	0	4
clay loam	3	0	0	0	1	1	0	0	3	0	0	8
clay loam/ clay	1	0	0	0	0	0	0	0	0	0	0	1
silt loam	0	0	0	0	0	0	0	1	0	0	0	1
loam	21	4	2	1	2	2	5	1	16	0	1	55
loam/ silt loam	2	0	0	0	0	0	0	0	0	0	0	2
sand loam	1	1	0	0	0	0	1	0	0	0	0	3
sand	0	0	0	0	1	0	0	0	0	0	0	1
TOTAL	34	5	6	1	8	3	8	3	30	1	1	100

*at site

and the table's large size (8 by 9 cells), both of which tended to mask the paired value associations.

A cross-tabulation of the VEG AND AREASOL variables revealed that loam soil is associated with sites located in several different vegetation zones (Table 25). The most frequent occurrence is with sites in the K64/Southern Prairie vegetation type. Loam occurs with less intensity with sites in Northern Prairie and K63 vegetation types.

In contrast to this pattern, analysis of the VEG and SITETOPO variables suggests that site soil type tends to vary in association with vegetation types (Table 26). Loam frequently occurs with sites in the K64/Southern Prairie, Northern Prairie and K63 vegetation types while eroded and alluvial soils often occur with sites in the K64/Southern Prairie type. Eroded soils are also often associated with sites in Northern Prairie vegetation. The greater variability exhibited in soil and vegetation types at site locales (SITESOL) than in their surrounding area (AREASOL) may, in part, be due to the different localized topographic settings. Sites are often located on high, steep cutbanks above rivers and washes which frequently produce eroded soils and, depending upon conditions, alluvial soils. These conditions are usually localized, however, and so tend to occur most often at site locations rather than in the surrounding area.

Surficial geologic features of sites and surrounding vicinity (PRSRTOPO and AREATOPO) also appear to vary in association with vegetation type (Tables 27 and 28). Sites in unglaciated terrain frequently occur with the K63 vegetation type while those in both unglaciated terrain and ground moraine areas are often associated with the K64/Southern Prairie type. Sites located in areas where ground moraine,

TABLE 25

FREQUENCY CROSS-TABULATION:
VEGETATION TYPE BY PREDOMINANT SOIL TYPE*

VEG \ AREASOL	alluvium	eroded soil	clay	clay loam	silt loam	silt loam/ clay loam	loam	loam/ clay loam	loam/silt loam/ clay loam	sandy loam	TOTAL
K64/Southern Prairie	1	0	0	3	0	0	37	0	0	1	42
Cordilleran Forest	0	0	0	0	0	0	2	0	0	0	2
Parkland	0	1	0	2	0	0	2	0	0	0	5
N. Prairie	0	0	4	0	0	2	13	0	0	0	19
N. Pr./Pkld.	0	0	0	2	0	0	1	0	0	0	3
N. Pr./S. Pr.	0	0	0	0	0	0	1	0	0	0	1
K98	0	0	0	0	0	0	0	0	0	1	1
K66	0	0	0	0	0	1	1	0	0	0	2
K64/K66	0	0	0	0	0	0	1	0	0	0	1
K63	0	0	0	4	1	0	8	0	1	2	16
K63/K64	0	0	0	0	0	0	2	0	0	0	2
K55	0	0	0	0	0	0	1	1	0	0	2
K16	0	0	0	1	0	0	2	0	0	0	3
K12	1	0	0	1	0	0	1	1	0	0	4
TOTAL	2	1	4	13	1	3	72	2	1	4	103

*in standard area around site

TABLE 26

FREQUENCY CROSS-TABULATION:
VEGETATION TYPE BY PREDOMINANT SOIL TYPE*

VEG \ SITESOL	alluvium	eroded soil	clay	clay loam	clay loam/ clay	silt loam	loam	loam/ silt loam	sandy loam	sand	TOTAL
K64/Southern Prairie	7	6	2	4	0	0	23	0	1	0	43
Cordilleran Forest	0	0	0	0	0	0	2	0	0	0	2
Parkland	0	2	0	1	0	0	2	0	0	0	5
No. Prairie	0	9	4	2	0	0	10	0	0	1	26
N. Pr./Pkld.	0	0	0	1	0	1	1	0	0	0	3
N. Pr./S. Pr.	0	0	0	0	0	0	1	0	0	0	1
K98	0	0	0	0	0	0	0	0	1	0	1
K66	1	0	0	0	0	0	2	0	0	0	3
K64/K66	0	0	0	0	0	0	1	0	0	0	1
K63	1	0	0	1	0	1	10	2	0	0	15
K63/K64	0	0	0	0	0	2	0	0	0	0	2
K55	0	0	0	1	1	1	0	0	0	0	3
K16	0	0	0	0	0	0	3	0	0	0	3
K16/K64	0	0	0	0	0	0	0	0	1	0	1
K12	1	0	0	0	0	0	5	0	1	0	7
TOTAL	10	17	6	10	1	5	60	2	4	1	116

*at site

TABLE 27

FREQUENCY CROSS-TABULATION:
VEGETATION TYPE BY PREDOMINANT SURFICIAL GEOLOGIC FEATURE*

	PRSRTOPO											
VEG	unglaciated terrain	dissected mountains	bedrock	gravel	alluvium	remnant stream terrace	glacial lake bed	glacial channel/ alluvium	ground moraine	moraine	ground moraine/ moraine	TOTAL
K64/Southern Prairie	12	0	0	0	0	5	3	2	21	1	0	46
Parkland	0	0	2	0	0	0	0	0	0	0	0	2
No. Prairie	0	0	6	1	9	0	2	0	9	0	0	27
N. Pr./Parkld.	0	0	0	0	0	0	0	0	2	0	0	2
N. Pr./S. Pr.	0	0	0	0	0	0	0	0	1	0	0	1
K98	0	0	0	0	0	0	1	0	0	0	0	1
K66	4	0	0	0	0	0	0	0	1	0	0	5
K64/K66	0	0	0	0	0	0	1	0	0	0	0	1
K63	11	2	0	0	0	2	1	3	0	0	1	20
K63/K64	1	0	0	0	0	0	1	0	0	0	0	2
K55	2	0	0	0	0	0	1	1	0	0	0	4
K16	3	0	0	0	0	0	0	0	0	0	0	3
K16/K64	2	0	0	0	0	0	0	0	0	0	0	2
K15	0	2	0	0	0	0	0	0	0	0	0	2
K12	4	4	0	0	0	1	0	1	0	0	0	10
K12/K55	1	0	0	0	0	0	0	0	0	0	0	1
K12/K15	0	2	1	0	0	0	0	0	0	0	0	3
TOTAL	40	10	9	1	9	8	10	7	34	1	1	121

*at site

TABLE 27

FREQUENCY CROSS-TABULATION:
VEGETATION TYPE BY PREDOMINANT SURFICIAL GEOLOGIC FEATURE*

VEG \ PRSRTOPO	unglaciated terrain	dissected mountains	bedrock	gravel	alluvium	remnant stream terrace	glacial lake bed	glacial channel/ alluvium	ground moraine	moraine	ground moraine/ moraine	TOTAL
K64/Southern Prairie	12	0	0	0	0	5	3	2	21	1	0	46
Parkland	0	0	2	0	0	0	0	0	0	0	0	2
No. Prairie	0	0	6	1	9	0	2	0	9	0	0	27
N. Pr./Parkld.	0	0	0	0	0	0	0	0	2	0	0	2
N. Pr./S. Pr.	0	0	0	0	0	0	0	0	1	0	0	1
K98	0	0	0	0	0	0	1	0	0	0	0	1
K66	4	0	0	0	0	0	0	0	1	0	0	5
K64/K66	0	0	0	0	0	0	1	0	0	0	0	1
K63	11	2	0	0	0	2	1	3	0	0	1	20
K63/K64	1	0	0	0	0	0	1	0	0	0	0	2
K55	2	0	0	0	0	0	1	1	0	0	0	4
K16	3	0	0	0	0	0	0	0	0	0	0	3
K16/K64	2	0	0	0	0	0	0	0	0	0	0	2
K15	0	2	0	0	0	0	0	0	0	0	0	2
K12	4	4	0	0	0	1	0	1	0	0	0	10
K12/K55	1	0	0	0	0	0	0	0	0	0	0	1
K12/K15	0	2	1	0	0	0	0	0	0	0	0	3
TOTAL	40	10	9	1	9	8	10	7	34	1	1	121

*at site

TABLE 28

FREQUENCY CROSS-TABULATION:
VEGETATION TYPE BY PREDOMINANT SURFICIAL GEOLOGIC FEATURE*

VEG \ AREATOPO	unglaciated terrain	dissected mountains	alluvium	remnant stream terraces	glacial lake bed	glacial channel/ alluvium	ground moraine	ground moraine/ moraine	moraine	TOTAL
K64/Southern Prairie	14	0	0	1	4	1	23	0	1	44
Parkland	0	0	0	0	0	0	2	0	0	2
N. Prairie	0	0	0	0	3	0	21	1	0	25
N. Pr./Pkld.	0	0	0	0	0	0	2	0	0	2
N. Pr./S.Pr.	0	0	1	0	0	0	0	0	0	1
K98	0	0	0	0	1	0	0	0	0	1
K66	4	0	0	0	0	0	2	0	0	6
K64/K66	0	0	0	0	1	1	0	0	0	2
K63	12	2	0	2	2	0	0	1	0	19
K63/K64	1	0	0	0	1	0	0	0	0	2
K55	2	0	0	0	2	0	0	0	0	4
K16	3	0	0	0	0	0	0	0	0	3
K16/K64	2	0	0	0	0	0	0	0	0	2
K15	0	2	0	0	0	0	0	0	0	2
K12	4	4	0	2	0	0	0	0	0	10
K12/K55	1	0	0	0	0	0	0	0	0	1
K12/K15	0	3	0	0	0	0	0	0	0	3
TOTAL	43	11	1	5	14	2	50	2	1	129

*in standard area around site

bedrock or alluvium is predominant are often associated with Northern Prairie vegetation. This association only extends to the area surrounding the site (AREATOPO), however, for cases in ground moraine areas. Bedrock and alluvium features are usually too limited in extent to predominate within the broad contiguous standard area surrounding a site.

Interval Scale Variables

The eight interval scale environmental variables investigated in this study which reflect aspects of soil, water, topography and altitude associated with case locations, were all subjected to multivariate analysis. In part, this method of analysis was chosen to supplement information on associations previously discovered during the frequency and cross-tabulation tests of Group 1 and 2 variables and site locations. More importantly, however, it will provide a more encompassing view of the patterns of relationships exhibited by variables than was possible in the more cumbersome nominal scale analyses. The analytic results are enhanced by the much greater information potential possessed by interval scale variables. In addition to the multivariate analysis, a frequency distribution test was performed on the altitude variable ELEV.

The multivariate analysis procedure, SPSS subprogram FACTOR, was performed on all of the interval scale variables in order to gain maximum associational information. Prior to this analysis, however, a series of univariate statistics were produced of each variable by SPSS sub-program CONDESCRIPTIVE in order to establish the degree to which the data approximate a normal distribution. Near normal data distributions are necessary to insure the reliability of the multivariate analyses. An examination of measures of kirtosis and skewness of each variable revealed that none even approached three standard deviation units, thus indicating a near normal distribution.

Inspection of correlation coefficients of the eight variables produced by SPSS sub-program PEARSON CORR revealed one set of multi-collinear variables and several that were moderately intercorrelated. All of these coefficients were significant to the .001 level. Only three, however, equaled or exceeded the Pearson's r level of .74.

The R-Mode factor analysis generated included all cases and all eight variables. The SPSS PA/2 method of factoring (Principal Factoring with iteration) was used in which communality estimates are automatically given and iteration employed to improve the estimates. Three factors were revealed accounting for 100 percent of the total variance present in the three eigenvalues (Table 30). Varimax rotation of the factor matrix was made following extraction of appropriate eigenvalues resulting in significant factor loadings on several variables. The rotated factor matrix is displayed in Table 29. Significant loadings are underlined.

Factor 1 is characterized by three variables: positively by AROCTOPO and STOCTOPO and negatively by NUMTOPO. These variables exhibit two strong relationships: (1) an association between the proportion of surficial geologic features at a site location and within a standard area; and (2) an inverse relationship between the percentage of area occupied by a predominant surficial feature at or around a site and the number of types of features present. These associations suggest that when a single predominant surficial feature occupies a large proportion of a site or area surrounding a site, multiple surficial

TABLE 29

VARIMAX ROTATED MATRIX OF FACTOR LOADINGS:
ALL VARIABLES

Variable	1	2	3
NUMWASH	-.07	-.08	.997
NUMSTRM	-.02	.44	-.23
NUMSOL	-.19	.50	.05
PERCTSOL	.22	- .88	.14
ELEV	.13	.36	.20
NUMTOPO	-.82	.07	.01
AROCTOPO	.96	-.16	-.08
STOCTOPO	.88	-.06	.05

TABLE 30

SPSS PA/2 ANALYSIS (R-MODE):
FACTORS, EIGENVALUES AND PERCENT VARIANCE

Factor	Eigenvalue	Percent Variance
1	2.66	53.5
2	1.35	27.3
3	.95	19.2
		100 = Cumulative Percentage

features will not tend to occur. Conversely, when the percentage of the predominant feature is low, there will tend to be a diversity of surficial features.

Factor 2 is characterized by four variables: positively by NUMSTRM, NUMSOL and ELEV and negatively by PERCTSOL. Two relationships characterize this factor: (1) a positive association between altitude, stream density and the diversity of soil types within a site's standard area; and (2) an inverse relationship between, on the one hand, altitude, perennial stream density and diversity of soil types, and, on the other hand, the percentage of area occupied by a predominate soil type within a site's standard area. These associations suggest that when sites are high in altitude they tend to have a high density of perennial streams and a diversity of soil types in the site's standard area. The opposite would also be true. Also, when sites are high in altitude and there is a density of perennial streams and diversity of soil types in a site's standard area, the percentage of the predominant soil type will tend to be low. Conversely, when sites are low in altitude and there are low numbers of streams and few soil types, the predominant soil will occupy a relatively large percentage of the standard area.

Factor 3 is characterized by only one variable: NUMWASH. It appears to have a tightly clustered, independent nature because it loads extremely high on the factor and does not display significant relationships with other variables.

Results of the statistical test performed on the altitude variable ELEV were inconclusive. A frequency distribution was generated by SPSS sub-program FREQUENCIES revealing 121 valid cases having an elevational range of 2020 feet to 8400 feet above sea level. The sample represents an almost continuous distribution so that potential site grouping are not discernible within particular elevational ranges. This suggests that elevation may not have been an important selective factor in site location.

Nominal, Ordinal and Interval Scale Variables: Statistical Comparisons

The univariate and multivariate analyses described in the previous section revealed several significant associations between environmental features and site locations. These analyses, however, did not provide the means to compare the nominal and ordinal scale variables with interval scale variables. To explore the information potential of such comparisons it was decided to implement SPSS sub-program BREAKDOWN. This program sub-divided the means, standard deviations, and variances of selected interval scale variables among value categories of one or two nominal or ordinal scale variables in order to establish the degree of correspondence between them. The measures of central tendency and dispersion of the NUMWASH, NUMSTRM, PERCTSOL, AROCTOPO and STOCTOPO variables were examined among values of eleven nominal and ordinal scale variables. The most significant values of the analyses discussed are displayed in Tables 30 through 38.

A one-way analysis of variance was produced for each procedure to test whether the means of the population sub-samples were significantly different from one another. This test is intended for paired variables, so that only the first two were analyzed even when additional variables were included in the same analysis. All analyses were measured at the .05 level of significance.

The initial analysis was made on the NUMWASH variable, which measures the number of intermittent watercourses within a site's standard area. It was broken into sub-populations by the VEG, AREATOPO and PRSRTOPO variables. The comparison with the AREATOPO and PRSRTOPO variables are of particular interest (Tables 31 and 32). Both showed a strong association between unglaciated terrain sites and a relatively large number of washes and between ground moraine sites and a small number of washes. Several alternative explanations can be suggested for these associations. One is that site location was significantly influenced by different stream densities in the two areas. It is most likely, however, that because Pleistocene ice advances obliterated or altered former stream drainage patterns in ground morainic areas, there has not been sufficient time for stream patterns to fully mature. The result has been a low density of intermittent streams.

The analysis of the NUMWASH and VEG variables revealed a pattern of stream density associations similar to that discussed above. This pair of variables is deleted from discussion, however, because the standard deviations of the values were very large and the sample sizes quite disparate. The result was a highly skewed association pattern.

The NUMSTRM variable was statistically broken down by PRSRTOPO and AREATOPO revealing very similar patterns of association (Tables 33 and 34). Unglaciated terrain sites tend to occur in areas with slightly higher stream densities than do ground moraine sites. The standard deviations for these values are so large, however, that the mean differences must be considered negligible.

Mixed results were yielded when the PERCTSOL variable, measuring the percentage of area occupied by a predominant soil type in a site's

TABLE 31

BREAKDOWN ANALYSIS:
NUMBER OF WASHES* BY PREDOMINANT SURFICIAL GEOLOGIC FEATURE*

AREATOPO Value	Mean	Standard Dev.	Cases
For entire population	6.27	4.39	98
1. unglaciated terrain	8.79	3.53	33
7. ground moraine	3.87	3.47	37

*in standard area around site

TABLE 32

BREAKDOWN ANALYSIS:
NUMBER OF WASHES* BY PREDOMINANT SURFICIAL GEOLOGIC FEATURE**

PRSRTOPO Value	Mean	Standard Dev.	Cases
For entire population	6.24	4.41	97
1. unglaciated terrain	8.48	2.90	29
9. glaciated terrain	4.24	3.32	25

*in standard area around site/ **at site

TABLE 33

BREAKDOWN ANALYSIS:
NUMBER OF STREAMS* BY PREDOMINANT SURFICIAL GEOLOGIC FEATURE*

AREATOPO Value	Mean	Standard Dev.	Cases
For entire population	3.33	2.43	99
1. unglaciated terrain	3.46	1.89	33
7. ground moraine	2.71	2.63	38

*In standard area around site

TABLE 34

BREAKDOWN ANALYSIS:
NUMBER OF STREAMS* BY PREDOMINANT SURFICIAL GEOLOGIC FEATURE**

PRSRTOPO Value	Mean	Standard Dev.	Cases
For entire population	3.37	2.42	98
1. unglaciated terrain	3.41	1.78	29
9. glaciated terrain	2.35	2.65	26

*in standard area around site/**at site

standard area, was statistically broken down by AREASOL and VEG and by SITESOL and PRSRTOPO. The first analysis, a three-way breakdown between PERCTSOL and AREASOL and VEG, suggests that there are only slight differences between the areal soil percentage means of sites located in K64/Southern Prairie vegetation and those located in the Northern Prairie type (Table 35). The 6 percent difference in means may be due to the non-random nature of the data base or possibly to the better adaptation of K64/Southern Prairie vegetation to loam soils.

The analysis of the PERCTSOL variable with SITESOL and PRSRTOPO reveals stronger associations than those described above. Within the loam value, sites associated with ground moraine and unglaciated terrain display a 10 percent mean difference in the predominant soil type percentage figure (Table 36). The difference may stem, in part, from the non-random data base, small sample size, overlap of the standard deviation figures, or from a combination of these factors. It is also possible, however, that it stems from the surficial terrain differences between the two areas. Stream dissected areas (unglaciated terrain) exhibit a greater diversity of microenvironments than do the topographically more uniform ground moraine areas. As a result, it is expected that soils would also exhibit greater diversity. Thus, soil types would tend to occupy smaller contiguous parcels than those found in ground moraine areas. Alternatively, there may have been a locational preference for establishing ground moraine sites in largely uniform soils and locating sites in unglaciated terrain in areas with some soil type diversity for as yet unknown reasons. In any case, the mean percentage difference between these values is not excessive. Comparisons of sites associated with eroded soils and those associated

TABLE 35

BREAKDOWN ANALYSIS:
PERCENTAGE AREA OCCUPIED BY PREDOMINANT SOIL TYPE* BY
PREDOMINANT SOIL TYPE* BY VEGETATION TYPE

AREASOL Value	VEG Value	Mean	Stan. Dev.	Cases
For entire population		57.54	18.78	84
7. loam		63.23	16.51	66
	1. K64/Southern Prarie	66.71	16.05	35
	5. Northern Prarie	60.46	18.17	13

*in standard area around site

TABLE 36

BREAKDOWN ANALYSIS:
PERCENTAGE AREA OCCUPIED BY PREDOMINANT SOIL TYPE* BY
PREDOMINANT SITE SOIL TYPE BY PREDOMINANT SURFICIAL GEOL. FEATURE**

SITESOL Value	VEG Value	Mean	Stan. Dev.	Cases
For entire population.		60.0	18.97	69
2. eroded soil		56.58	14.90	12
	9. ground moraine	59.44	14.43	9
7. loam		67.66	16.97	38
	1. unglaciated terrain	64.67	12.83	9
	9. ground moraine	74.67	18.57	15

*in standard area around site/ ** at site with loam soils reveals an even greater disparity in the predominant soil percentage. The mean standard deviations are considerable, but it is likely that much of the disparity in means stems from the contrasting topographic settings of the two soil types. Eroded soils tend to occur along river and stream courses while loams are most often found in broad, contiguous zones between watercourses and in undissected plains.

AROCTOPO wa broken down by AREATOPO and SITESOL and resulted in a disparity in the mean AROCTOPO percentage of eroded and loam soils similar to that above (Table 37). The high standard deviations show considerable dispersal of the percentages which, to some degree, negate the mean differences. Nevertheless, the difference may also be attributable to the contrasting topographic settings in which the soils occur.

The analysis of both AROCTOPO and STOCTOPO by the LANDFORM variables resulted in several associations which, in mean percentage difference, far exceed any of those discussed above. The associated values in the STOCTOPO analysis, however, have exceptionally high standard deviations which indicate that the value means are not necessarily the focus of percentage distribution. Rather, they represent the mid-point in a series of widely dispersed STOCTOPO percentages. As a result, the value associations are minimally significant. The breakdown of the AROCTOPO variable by the LANDFORM and AREAROCK variables resulted in much more significant percentages (Table 38). The two AREAROCK sandstone/shale values moderately deviate from the mean, but their respective ranges only overlap by 4 percent. This distributional pattern strongly suggests that sites associated with sandstone/shale bedrock in the Alberta Plain tend to occur in more surficially diversified settings than do tableland sites of moderate relief (B3c) which

TABLE 37

BREAKDOWN ANALYSIS:
PERCENTAGE AREA OCCUPIED BY DOMINANT SURFICIAL FEATURE* BY
PREDOMINANT SOIL TYPE* BY PREDOMINANT SITE SOIL TYPE

AREATOPO Value	SITESOL Value	Mean	Stan. Dev.	Cases
For entire population		77.14	19.31	98
1. unglaciated terrain		80.86	18.46	35
	7. loam	81.50	18.46	22
7. ground moraine		75.76	19.44	42
	2. eroded soil	68.86	17.03	14
	7. loam	81.94	18.46	18

*in standard area around site

TABLE 38

BREAKDOWN ANALYSIS:
PERCENTAGE AREA OCCUPIED BY DOMINANT SURFICIAL FEATURE* BY
LANDFORM TYPE* BY PREDOMINANT TYPE OF BEDROCK*

LANDFORM Value	AREAROCK Value	Mean	Stan. Dev.	Cases
For entire population		76.70	19.96	125
17. Alberta Plain		63.86	12.14	28
	6. shale/sandstone	65.40	11.69	25
5. D6		83.58	21.59	12
6. C6a		71.47	22.34	19
11. B4c		73.75	15.98	12
14. B3c		84.58	21.36	19
	6. shale/sandstone	89.06	15.93	16

*in standard area around site

occur with sandstone/shale bedrock. These sites tend to occur in more surficially uniform settings. While the cause of the difference is not clear, it cannot be attributed to dissimilar landforms since both regions have comparable topography. It is possible, however, that the difference stems from dissimilar map scales. The surficial geologic maps used for Alberta were to a scale of at least 1:253,440 while those in Montana and Wyoming were all at a scale of 1:500,000. Thus, the larger scale maps for areas in Alberta would tend to more finely partition surficial features than would the Montana maps which are tiwce that size. The result might be a higher number of surficial geologic features and a correspondingly lower percentage of area occupied by the predominant feature within the standard area surrounding each jump site in Alberta, the exact pattern displayed by the BREAKDOWN analysis of AROCTOPO BY LANDFORM BY AREAROCK.

Chapter Summary

The results of the univariate and multivariate analyses provide evidence of both regional and sub-regional site locational patterning in the study area which is summarized in the following paragraphs.

The analyses suggest that, regardless of sub-regional assignation, jump sites tend to date to the Late Prehistoric Period and occur with cliffs or steep slopes measuring up to 20 meters high. Sites also tend to be associated with loam soils and sandstone and shale bedrock, though bedrock formations are not always surficial. Most importantly, however, are indications that jump sites:

1. tend to face either in a north, northeast, east or south direction;

2. usually lie within 400 meters of a water source, most often a wash or perennial stream; and

3. often lie within 400 meters of and most frequently within 800 meters of a permanent water source, almost invariably a perennial stream or river.

The analyses also suggest that there exists sub-regional variation in site location. While differences focus upon several environmental features, the most prominent and important are the ground moraine and unglaciated terrain. In large part, surficial geologic assignation depends upon whether the site is to the north of the Missouri River (entirely glaciated) or south of it (largely unglaciated). Sites in glaciated terrain tend to be association with a more diversified vegetation pattern than those in ground moraine areas. Those in both types of terrain strongly associate with short grass vegetation, but only sites in unglaciated terrain occur frequently with the denser grasses of the mountain foothills. Ground moraine sites also tend to associate with higher densities of intermittent streams (washes) and a higher percentage of loam soils than do sites in unglaciated terrain. On the other hand, there is a negligible difference between the two in perennial stream density. Most importantly in this site variation, however, are suggestions that:

1. while sites in both glaciated and unglaciated terrain are strongly associated with perennial streams and washes, those in ground moraine areas (primarily in Alberta) also frequently occur with rivers; and

2. that jump sites in ground moraine most often face north while those in unglaciated terrain frequently face either north, northeast or south.

Site locational variation is also apparent within the sub-regional landform units of Montana and Wyoming. Case locations, regardless of their location in those two states, are strongly associated with loam soils, but bedrock type varies with topographic setting. Plains (tableland) sites in areas of moderate and high relief most frequently occur with sandstone and shale bedrock formations (though formations may not be surficial), while Plains sites with considerable local relief and those in open high mountains are most often associated with a variety of sedimentary rocks. Water features, however, appear to have perhaps the most striking amount of site diversity. The nearest water source to Plains and open high mountain sites tends to be washes, whereas sites in high mountains more frequently occur near perennial streams. When permanent sources of water are considered separately, there is a tendency for sites in both open high mountains, high mountains, and open high hills to occur near perennial streams, and Plains (tableland) sites near rivers.

CHAPTER V

CONCLUSIONS

The analysis of prehistoric bison jump site locations in relation to cultural and environmental variables performed in this study has revealed several important site location patterns. These results provide evidence for immediate interpretation and speculation and possess considerable predictive potential and research value for future investigations. In this final chapter an interpretive framework will be suggested for the critical variable relationships identified in Chapter IV, followed by a discussion and revision of the general hypotheses outlined in the Introduction in relation to the results of the analysis. Finally, there will be a discussion of the significance of the study in relation to its practical applicability for future research.

The 146 prehistoric jump sites considered in this study were evaluated on variables reflecting various cultural and environmental features. The cultural variables focused upon the age and selected topographic feature options available at site locations while the environmental variables evaluated specific aspects of: water association, geologic feature association, vegetation association, soil association, and topography. Of these seven major feature associations, two reveal close associations with sites, suggesting strong site distributional patterns and providing predictability in site location. Given the results of the statistical analyses, supplemented by archaeologically and ethnographically available evidence, the most critically important variables to occur in association with site locations are (1) the direction in which jump sites face, and (2) water features. The strong patterning observed in the JUMPFACE variable strongly suggests a single cause, while several factors probably contribute to the close association between sites and water features. Following is a discussion of each of these associations.

Several alternative causes for the association of water features with jump sites are suggested by the fact that the nearest water source to most sites is either a wash, perennial stream or river (Tables 9 and 11). One explanation suggests that the sample case population is skewed toward areas associated with watercourses, especially permanent ones. While all of the areas surveyed by field workers who recorded the bison jump sites used in this study are not known, it is likely that at least some of the surveys were entirely carried out along watercourses with no attempt to cover adjacent regions where there may have been additional sites. If many of the surveys were carried out in this way it could partially explain why most jump sites appear to occur along watercourses.

Nevertheless, site proximity to water sources may represent a strong site locational pattern despite some distortion in the data base. Assuming that this is an accurate tendency, the case associations can be explained in other ways. For instance, it is possible that the dissected terrain often created by permanent (and ephemeral) watercourses provided the required topographic setting to effectively operate bison drives. Steep slopes or sheer cliffs were needed for jump locations and the partial impediment which watercourses often created to bison movements may have helped funnel them to particular locations.

It can also be argued that jump sites are frequently in close proximity to permanent water (within 800 meters) because of a human need for water itself. Camps were often established at jump sites where people remained for weeks at a time subsisting on the killed animals. A dependable local water source would have been necessary to sustain such a group. Thus, the availability of water may have been an important consideration in the decision of where to construct a jump.

Jumps may also have been constructed near permanent water sources to take advantage of bison movements to such sources or at least to take advantage of the bison's protracted presence within a limited area surrounding a permanent water source.

In contrast to the numerous causation hypotheses proposed for the above association, considerably fewer potential explanations appear available concerning the direction in which jumps face. Statistical analyses of this variable indicate that jumps tend to face north, northeast, east or south and that there is a decided preference for north facing sites in glaciated locations. One explanation for this might be that the site sample is skewed, caused by over-selection of sites with one or another facing direction. Because the sample was non-randomly collected the validity of this argument is, of course, unknown. If one assumes, however, that the sample accurately reflects the total site population in the region, at least two alternative explanations of the situation are possible.

First, it is possible that the directions in which jumps face are a natural result of the particular orientation of the surficial topography, i.e., the direction in which watercourses flow and cliff rock breaks off. This was probably a limiting factor in the directional choices available, although because of the meandering nature of many watercourses in the Northwestern Plains, depending upon one's location, it is possible to find sufficiently lethal cliff drops and steep slopes facing in any or all direction. Thus to fully explain these patterned facings yet another explanation must be sought.

One which may, in large part, help explain this patterning are seasonal prevailing wind patterns. A slight digression is necessary to fully explain this hypothesis which emanates in modified form from ideas suggested earlier by H. P. Lewis (n.d.) and several members of the 1961 Symposium on Buffalo Jumps (Malouf and Conner 1962: 44-45).

It is well-known that bison possess an exceptionally well-developed sense of smell (Hornaday 1889: 418; McHugh 1972: 149; Garretson 1938: 46). As such, prehistoric hunters of bison would have found it necessary to remain upwind of the animals most of the time to avoid detection during drives. This could be accomplished by moving the bison with the wind so that during a drive the animals would not sense hunters ahead and to the sides of them (possibly hiding behind rock cairns); rather, they would tend to flee from a few hunters or "runners" they sensed moving up behind them gently urging them on. If a jump was repeatedly used, this technique might also keep the animals from balking at the scent from rotting carcasses of other bison driven over the same jump one or more seasons before.

The importance of wind direction in driving bison has been historically documented for the Northern Plains Indians. Several descriptions of Assiniboine drives stress the point that a favorable wind was required before the drive could begin (Henry and Thompson 1965: 519; De Smet 1905: 1029-1030). When blowing from this direction runners could slowly start the bison moving by setting small dung or grass fires which would drift toward the animals and cause them to slowly move away from the smoke and toward the enclosure (Henry and Thompson 1965: 519; Weekes 1948: 16). The smoke may have also helped mask the human scent of the runners which could be even more frightening to the bison than smoke. The same technique was described by McDougall (1896: 278) for the Cree Indians in Saskatchewan. The need for favorable wind direction to successfully drive bison was also documented among the Blackfoot (Henry and Thompson 1965: 577). In this case, the Indians made several attempts to drive the animals toward the pound, but were not successful until the wind shifted to a more favorable direction.

Depending upon the location in the Northwestern Plains, prevailing winds may or may not tend to shift with the change of seasons. For instance, in Sheridan, Wyoming prevailing winds are consistently from the northwest year around whereas in Great Falls, Montana they are consistently from the southwest and in Helena from the west year around (Cordell 1971; Lowers 1960). In contrast, in Havre, Billings and Miles City, Montana prevailing winds tend to shift from season to season and even month to month. In light of these examples of Plains wind patterns, it would have been desirable to change the direction of the bison drives in areas where seasonal wind patterns shifted, if bison were jumped during more than one season of the year. The site data displayed in Table 6 suggests that such seasonal adjustments may have been made in certain areas. Such changes might take the form of several different sites in one area with different facing directions. At the same time, if jumps were only used during one season or in an area where the prevailing winds were constant year around, there would be little reason to have sites with different directional facings. If the data displayed in Table 6 represent accurate population tendencies, it suggests a powerful predictive method for determining site seasonality. As an example of this, it could be predicted that jump sites located in the Miles City area having north to northwest facings would probably represent either summer or late fall kills since prevailing wind patterns at those times are from the southeast and south-southeast. Similarly, those sites having south to southeast facings would probably represent winter or late summer kills since at these times the prevailing wind direction is from the northwest. Ideally, after compiling wind direction information for all sites, the information could be plotted on maps with seasonal use areas delimited. If this variable represents a true tendency in seasonal site use, such a map could have considerable research value, not only in its own right, but also by providing an independent test of other seasonal data.

It is recognized that this hypothesis is highly speculative and that jump facing and wind direction were only some of the many considerations in choosing a site location and season for jumping bison. Nevertheless, it suggests a potentially useful method for establishing site seasonality and differences in seasonal population movements in the Northwestern Plains.

Only one substantive objection to the idea can be immediately discerned: the fact that some drive lanes are circuitous and thus would not always follow prevailing wind directions. The effects of local topographic conditions, which may change wind patterns, could account for some directional differences in drive lanes. Regardless, however, the site data at hand reveal relatively few sites at which drive lane patterns are described at all and even fewer with circuitous or angled turns. Unless there exists substantial archaeological and environment data to prove this idea untenable, only additional seasonality determinations from faunal material in jump site deposits will suffice to verify its potential worth as a predictor of site seasonality.

Hypotheses

The results of this analysis made only partially confirm (or partially reject) the two hypotheses proposed in the introductory statement of this thesis. As such, they require modification to accurately reflect the probable site locational information discovered during the variable analysis. Following is a restatement of those hypotheses incorporating the new information.

As a result of detailed statistical analysis of bison jump sites in the Northwestern Plains it has been demonstrated, and it is expected that additional research will confirm, that:

1. Bison jump site locations show a definite, predictable pattern most closely and importantly associated with water features. Landform units and surficial geologic features provide modifying, but secondarily important, influences upon water feature association.

2. Critical environmental and cultural characteristics of bison jump sites do not tend to remain consistent over the entire Northwestern Plains.

    a) Types of water features nearest jump sites vary from area to area (although close proximity to water sources is constant throughout the region).

b) Jump site facing directions tend to vary from area to area.

In light of these modifications it is clear that there are fewer identifiable environmental features critical for jump site location than originally proposed. As a result, future investigators should be able to more closely examine the few critical variables identified in this study and explore additional features not yet considered.

Significance for Future Research

The mass of detail produced by a study of this magnitude often makes it difficult to step back and properly assess its practical significance. Nevertheless, several aspects can be singled out which have value for future research efforts.

First, and most importantly, this study provides a testable predictive model of bison jump locations in the Northwestern Plains. While only a few environmental variables were identified as most crucial for site location, the combination of variables covering soil type, vegetation type, surficial geologic feature type, bedrock type, and water type can effectively delimit general conditions under which sites are most likely to be found. Through field tests the model can be refined to make it a most valuable predictive tool. In the process, it can also provide an important source from which to interpret site distribution in terms of subsistence strategies, site seasonality, seasonal population movements and the place of communal bison jump sites within the larger socio-economic systems of prehistoric cultures.

The study also indicates considerable deficiencies in the jump site data base throughout the Plains. Additional site information and especially improved quality of the information are necessary to allow development of a more solid framework upon which to formulate more refined testable hypotheses and to speculate about socio-economic patterning. There is a particular need for more temporal information on jump sites. Currently, a very small number of sites are dated providing only a very general time frame for the use of this bison procurement method in the Northwestern Plains. Changes which occurred in the form or function of this method over time are documented at only a few individual sites and are so little known regionally that even speculation is difficult.

Finally, this study points to the need for additional locational analyses of sites in the Northwestern Plains. Regional efforts such as Loendorf's analysis of campsite selection patterns in the Prior Mountains of Montana (1970) are an invaluable means of establishing site to environment and site to site relationships as well as identifying associations with which to speculate about the subsistence strategies and other socio-economic aspects of resident prehistoric and protohistoric cultures.

APPENDICES

APPENDIX A

IDENTIFICATION OF VARIABLES

APPENDIX A

IDENTIFICATION OF VARIABLES

Acronym	Definition
ID	case number
STATE	state or province
COUNTY	county in U.S.A. site is in
PRESEARCH	previous research known
TYPEPR	type of previous research
SOURCE	source of information about site
LOCRELY	locational reliability of site
AGE	cultural period of site
ASSOCAMP	associated campsite
DRIVLANE	associated drive lanes
TYPEFALL	type of fall at site
JUMPFACE	direction jumpoff faces
JUMPHEIT	height of jumpoff
WATERONE	nearest water source to site
WATERTWO	secondary water source to site
VEG	type of vegetation at site
SITESOL	soil type predominant at site
AREASOL	soil type predominant within standard area
CORSESOL	relative coarseness of predominant soil in standard area
STONISOL	relative stoniness of predominant soil in standard area
LANDFORM	major landform designation for site
SITETOPO	surficial geologic formation at site
AREATOPO	surficial geologic formation within standard area
SITEROCK	predominant bedrock type at site
AREAROCK	predominant bedrock type within standard area
PRSRTOPO	predominant surficial geologic feature at site
WATERDIS	distance to nearest water source
PERMWATR	nearest permanent water source
DISTPERM	distance to nearest permanent water source

Acronym	Definition
NUMWASH	count of intermittent watercourses over three kilometers in length within standard area
NUMSTRM	count of perennial watercourses over three kilometers in length within standard area
NUMSOL	count of soil classes in standard area
PERCTSOL	percentage of standard area occupied by predominant soil type
ELEV	elevation of site in feet
NUMTOPO	count of surficial geologic features in standard area
AROCTOPO	percentage of standard area occupied by dominant surficial feature
STOCTOPO	percentage of standard area occupied by surficial geologic feature predominant at site

APPENDIX B

LIST OF VARIABLE CODES

APPENDIX B

LIST OF VARIABLE CODES

STATE
1. Wyoming
2. Montana
3. Alberta

COUNTY
2. Big Horn, Montana
4. Blaine
7. Carbon
8. Carter
9. Cascade
10. Chouteau
11. Converse
12. Crook
15. Dawson
17. Fergus
19. Gallatin
21. Glacier
23. Hill
25. Jefferson
26. Johnson
28. Lewis and Clark
31. Madison
32. Meagher
36. Park, Montana
39. Phillips
43. Richland
44. Roosevelt
47. Sheridan, Wyoming
48. Stillwater
49. Sweetgrass
50. Teton
53. Valley
56. Wheatland
99. Alberta

PRESEARCH
1. known
2. unknown

TYPEPR
1. survey
2. test excavation
3. excavation
4. documentary research
5. none
6. 1 and 2
7. 1 and 3
8. 1 and 4
12. 2, 3 and 4
15. all

SOURCE
1. Site Form
2. Published Report
3. Unpublished Report
4. 1 and 2
5. 2 and 3
6. 1 and 3
7. All

LOCRELY
1. Within ½ secion
2. Precisely located
3. Within ¼ of ¼ section
4. Located within ¼ section
5. Located within section

AGE
1. Late Prehistoric
2. Late Prehistoric and Historic
3. Late Middle Prehistoric
4. Late Middle and Late Prehistoric
5. Late Middle, Late and Historic
6. Early Middle and Historic
7. Early Middle and Late Middle
8. Early Middle, Late Middle and Late Prehistoric

ASSOCAMP
1. Known
0. Unknown

DRIVLANE
1. Known
0. Unknown

TYPEFALL
1. Other
2. River or Creek Bank
3. Steep Embankment

TYPEFALL continued
4. Steep Embankment and River Cutbank
5. Talus Slope
6. Talus and Steep Embankment
7. Bluff or Cliff
8. Bluff and Cutbank
9. Bluff and Steep Embankment
10. Bluff, Steep Embankment and Cutback
11. Bluff and Talus

JUMPFACE
1. SW
2. SE
3. NW
4. NE
5. W
6. S
7. S, SE
8. E
9. N
10. N, NW
11. N, NE

JUMPHEIT
1. Over 50 meters
2. 40 to 50 meters
3. 30 to 40 meters
4. 20 to 30 meters
5. 10 to 20 meters
6. Under 10 meters

WATERONE
1. Lake
2. River
3. River, Spring, Lake
4. Wash
5. Wash, Spring
6. Wash, River
7. Perennial Stream
8. Perennial Stream, Lake
9. Perennial Stream, River
10. Perennial Stream, Wash
11. Perennial Stream, Wash, Lake

WATERTWO
1. Marsh
2. Lake
3. Spring
4. River
5. Wash
6. Wash, Spring

WATERTWO continued

7. Wash, River
8. Wash, River, Lake
9. Perennial Stream
10. Perennial Stream, Lake
11. Perennial Stream, Spring
12. Perennial Stream, Wash

VEG

1. K64/Southern Prairie = grama-needlegrass-wheatgrass
2. Cordilleran Forest
3. Parkland
5. Northern Prairie
6. N. Prairie, Parkland
7. N. Prairie, S. Prairie
8. K98 = Northern Floodplain Forest
9. K66 = wheatgrass-needlegrass
10. K64, K66 = grama-needlegrass-wheatgrass/wheatgrass-needlegrass
11. K63 = Foothills Prairie
12. K63, 64 = Foothills Prairie/grama-needlegrass-wheatgrass
13. K55 = Sagebrush Steppe
14. K16 = Eastern Ponderosa Forest
15. K16, K64 = Eastern Ponderosa Forest/grama-needlegrass-wheatgrass
16. K15 = Western Spruce-Fir forest
17. K12 = Douglas Fir Forest
18. K12, K55 = Douglas Fir Forest/Sagebrush Steppe
19. K12, K15 = Douglas Fir Forest/Western Spruce - Fir Forest

SITESOL

1. Alluvial
2. Eroded
3. Clay
4. Clay Loam
5. Clay Loam, Clay
6. Silt Loam
7. Loam
8. Loam, Silt Loam
9. Sandy Loam
10. Sand

AREASOL

1. Alluvial
2. Eroded
3. Clay
4. Clay Loam
5. Silt Loam
6. Silt Loam, Clay Loam
7. Loam
8. Loam, Clay Loam
9. Loam, Silt Loam, Clay Loam
10. Sandy Loam

CORSESOL
1. Gravelly
2. Coarse, Medium, Fine
3. Coarse, Medium, Fine, Stony
4. Coarse, Medium, Fine, Cobbly
5. Coarse, Medium, Fine, Cobbly, Stony
6. Coarse, Medium, Fine, Gravelly
7. Coarse, Medium, Fine, Gravelly, Stony

STONISOL
1. Rockland
2. Stony
3. Stony, Rockland
4. Not Stony
5. Not Stony, Rockland
6. Not Stony, Stony
7. Not Stony, Stony, Very Stony

LANDFORM
1. Mountains (Alberta)
2. Mountain Foothills (Alberta)
3. Alberta Plain (Alberta)
4. Alberta Plain, Mountain Foothills (Alberta)
5. D6 - High Mountains (3000-5000 feet local relief, less than 20% of area gently sloping)
6. C6a - Open High Mountains (3000-5000 feet local relief, 20-50% of area gently sloping, more than 75% of gentle slope is in lowland)
7. C6a, D6 - Open High Mountains/High Mountains
8. C4b - Open High Hills (500-1000 feet local relief, 20-50% of area gently sloping, 50 to 75% of gentle slope is in lowland)
9. B5d - Tablelands, high relief (1000-3000 feet local relief, 50-80% of area gently sloping, more than 75% of gentle slope is an upland)
10. B5b - Plains with low mountains (1000-3000 feet local relief, 50-80% of area gently sloping, 50 to 75% of gentle slope is in lowland)
11. B4c - Tablelands, considerable relief (500-1000 feet local relief, 50-80% of area gently sloping, 50 to 75% of gentle slope is on upland)
12. B4c, D6
13. B4b - Open High Hills (500-1000 feet local relief, 20-50% of area gently sloping, 50 to 75% of gentle slope is in lowland)
14. B3c - Tablelands, moderate relief (300-500 feet local relief, 50-80% of area gently sloping, 50 to 75% of gentle slope is an upland)
15. B3c, C6a
16. B3c, B4b
17. B3b
18. B3b, D5

SITETOPO
1. Unglaciated
2. Dissected mountains
3. Bedrock
4. Alluvium
5. Alluvium, Bedrock
6. Remnant stream terrace bench and alluvial fan
7. Glacial lake bed
8. Glacial lake bed, Alluvium
9. Glacial and outwash channels
10. Glacial and outwash channels, Remnant stream terrace bench
11. Glacial channels, Glacial Lake Bed
12. Glacial channels, Lake bed, Alluvium
13. Ground Moraine
14. Ground Moraine, Bedrock
15. Ground Moraine, Stream Gravel
16. Ground Moraine, Alluvium
17. Ground Moraine, Alluvium, Bedrock
18. Ground Moraine, Glacial and outwash channels
19. Ground Moraine, Channels, Alluvium
20. Unglaciated, Remnant stream terrace bench and alluvial fan
21. Unglaciated, Glacial lake bed
22. Unglaciated, Glacial lake bed, Remnant stream terrace bench and alluvial fan
23. Unglaciated, Glacial channels, Alluvium
24. Moraine
25. Moraine, Ground Moraine

AREATOPO
1. Unglaciated
2. Dissected mountains
3. Alluvium
4. Remnant stream terrace bench and alluvial fan
5. Glacial Lake bed
6. Glacial channels, Alluvium
7. Ground Moraine
8. Moraine
9. Moraine, Ground Moraine

SITEROCK
1. Alluvium
2. Stream terrace bench and alluvial fan
3. Quartzite
4. Other sedimentary rock
5. Glacial deposits
6. Sandstone, Shale
7. Shale, Alluvium
8. Shale, Sandstone, Conglomerate
10. Limestone, Quartzite
11. Limestone, Quartzite, Shale, Sandstone, Other sedimentary rock
12. Limestone, Shale, Sandstone
13. Limestone, Shale, Sandstone, Conglomerate

SITEROCK continued
14. Extrusive fragmental rock, Other igneous rock
15. Andesite
16. Andesite, Alluvium

AREAROCK
1. Alluvium
3. Other sedimentary rock
4. Other sedimentary rock, Terrace deposits
5. Glacial deposits
6. Shale, Sandstone
7. Shale, Other sedimentary rock
8. Shale, Sandstone, Conglomerate
10. Limestone, Quartzite
11. Limestone, Quartzite, Shale, Sandstone
12. Limestone, Shale, Sandstone
13. Limestone, Shale, Sandstone, Conglomerate
14. Other igneous rock
15. Other igneous, Limestone, Shale, Sandstone
16. Extrusive fragmental rock, Other igneous rock
17. Andesite
18. Extrusive fragmental rock, Other igneous rock, Limestone, Shale, Sandstone
19. Extrusive fragmental rock, Slate

PRSRTOPO
1. Unglaciated
2. Dissected mountains
3. Bedrock
4. Gravel
5. Alluvium
6. Remnant stream terrace bench and alluvial fan
7. Glacial lake bed
8. Glacial channels, Alluvium
9. Ground Moraine
10. Moraine
11. Ground Moraine, Moraine

WATERDIS
1. Within 2400 meters of the site
2. Within 1600 meters
3. Within 800 meters
4. Within 400 meters

PERMWATR
1. Lake
2. Spring
3. River
4. Perennial stream
5. Perennial stream, Lake

PERMWATR continued

6. Perennial stream, Spring
7. Perennial stream, River

DISTPERM

1. Beyond 5000 meters of the site
2. Within 5000 meters
3. Within 3200 meters
4. Within 2400 meters
5. Within 1600 meters
6. Within 800 meters
7. Within 400 meters

APPENDIX C

COMPUTER PRINTOUT OF SITE AND ENVIRONMENTAL DATA

APPENDIX C

COMPUTER PRINTOUT OF SITE AND ENVIRONMENTAL DATA

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DATA LIST      FIXED(2)/1,ID1,1-3,STATE,6,COUNTY,8-9,PRESEARCH,11,TYPEPR,13-14,
               SOURCE,16,LOCRELY,18,AGE,20,ASSOCAMP,22,DRIVLANE,24,TYPEFALL,
               26-27,JUMPFACE,29-30,JUMPHEIT,32,WATERONE,34-35,WATERTWO,37-38,
               VEG,42-43,SITESOL,45-46,AREASOL,48-49,CORSESOL,51,
               STONISOL,53,LANDFORM,55-56,SITETOPO,58-59,AREATOPO,61,SITEROCK,
               63-64,AREAROCK,66-67,PRSRTOPO,69-70,WATERDIS,72,PERMWATR,74,
               DISTPERM,76/2,ID2,1-3,NUMWASH,6-7,NUMSTRM,9-10,NUMSOL,12-13,
               PERCTSOL,15-17,ELEV,19-22,NUMTOPO,24,AROCTOPO,26-28,STOCTOPO,
               30-32
MISSING VALUES PRESEARCH,TYPEPR,AGE TO STRMORDR,SITESOL TO STONISOL,SITETOPO TO
               DISTPERM(0)/NUMWASH TO NUMSTRM(99)/NUMSOL(88)/PERCTSOL,
               AROCTOPO,STOCTOPO(H88)/ELEV(9999)/NUMTOPO(8,9)
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11	3	99	0	0	1	3	0	0	0	3	9	0	4	0	0	1	7	7	2	2	3	13	7	6	6	9	4	4	6
12	5	3	3	55	3100	4	68	68																					
21	3	99	0	0	1	3	0	0	0	3	4	0	4	4	0	1	2	7	2	2	3	18	7	6	6	9	4	3	6
22	7	3	4	53	3213	3	61	61																					
31	3	99	0	0	1	5	0	0	0	7	9	0	2	9	0	1	2	7	2	2	3	18	7	6	6	9	4	3	7
32	4	3	3	56	3237	2	59	59																					
41	3	99	0	0	1	4	0	0	0	3	9	0	4	9	0	1	2	7	2	2	3	13	7	6	6	9	4	4	6
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52	0	12	88	888	3325	2	98	98																					
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62	5	3	4	73	4162	6	43	6																					
71	3	99	1	7	4	3	4	1	0	7	0	0	2	5	0	5	4	6	2	2	2	8	7	6	6	5	4	3	7
72	0	1	6	50	3800	4	46	9																					
81	3	99	0	0	1	4	0	0	0	2	8	0	6	9	0	5	3	6	2	1	3	8	5	12	12	5	4	3	7
82	8	3	4	17	3312	4	42	31																					
91	3	99	0	0	1	5	0	0	0	0	6	0	7	1	0	5	3	3	2	2	3	7	5	6	6	7	1	4	4
92	0	9	3	24	3100	3	59	59																					
101	3	99	0	0	1	5	3	0	1	7	6	0	4	2	0	6	4	4	2	1	2	13	7	6	6	9	2	1	4
102	0	0	4	36	4300	4	69	69																					
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112	4	3	88	888	3725	4	69	69																					
121	3	99	0	0	1	3	2	1	0	7	9	0	7	1	0	5	0	0	0	0	3	16	7	6	6	5	4	4	7
122	6	4	88	888	3425	6	45	25																					
131	3	99	0	0	1	3	0	0	0	2	0	6	7	10	0	5	2	0	0	0	3	4	7	6	6	5	4	4	7
132	1	5	88	888	3400	3	77	9																					
141	3	99	1	2	1	3	0	0	0	7	0	0	7	9	0	5	2	0	0	0	3	5	7	6	6	5	4	4	7
142	2	5	88	888	3425	4	64	8																					
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152	1	6	88	888	3425	4	70	70																					
161	3	99	0	0	1	1	0	0	1	3	8	0	7	2	0	5	2	0	0	0	3	17	7	6	6	3	4	4	7
162	1	4	88	888	3375	3	70	9																					
171	3	99	0	0	1	3	0	0	0	7	8	3	4	9	0	5	0	0	0	0	3	3	7	6	6	3	4	4	6
172	3	3	88	888	3512	3	71	13																					
181	3	99	0	1	1	4	2	0	0	7	8	1	7	9	0	5	0	0	0	0	3	14	7	6	6	9	4	4	7
182	0	8	88	888	3930	4	61	61																					
191	3	99	1	15	7	3	4	1	0	7	9	6	7	9	0	5	2	7	2	2	3	14	0	6	6	9	4	4	7
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202	0	7	88	888	3297	3	52	27																					
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212	99	99	2	73	3444	4	77	80																					

221	3	99	0	0	1	3	0	1	0	2	9	0	7	1	0	5	7	0	0	0	3	4	7	6	6	5	4	4	7
222	0		7	88	888		3362		5	69		28																	
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262	2		5	4	38		3650		8	888		888																	
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322	99		99	4	78		9999		3	69		28																	
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372	1		4	3	53		3562		8	888		888																	
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401	3	99	1	8	6	4	2	0	0	10	9	0	0	0	0	5	7	0	0	0	3	14	7	0	0	9	0	0	0
402	99		99	88	888		9999		8	888		888																	
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432	99		99	5	37		2775		2	36		36																	

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441  3 99 0  0 1 4 0 0 0   3  5 5    4  4 0  5 4  7 2 4  3 14 7  0  0  9 4 3 5
442   4  1  5  52 2650 3  79   79
451  3 99 0  0 1 3 0 0 0   2 10 0    0  0 0  5 2  0 0 0  3 14 7  0  0  3 0 0 0
452 99 99 88 888 9999 3   59   15
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REFERENCES CITED

REFERENCES CITED

Adams, Gary

1973 The Bakken-Wright Site DiOa-1. Manuscript on file at the University of Saskatchewan, Saskatoon, Saskatchewan.

Agenbroad, Larry D.

1974 Buffalo Jump Complexes in Owyhee County, Idaho, 10-OE-229 and 10-OE-232. Paper presented at the 32nd Plains Conference, held at Laramie, Wyoming, November 7-9, 1974.

__________.

1976 Buffalo Jump Complexes in Owyhee County, Idaho. Tebiwa: Miscellaneous Papers of the Idaho State University, Museum of Natural History, No. 1.

Alden, William C.

1932 Physiography and Glacial Geology of Eastern Montana and Adjacent Areas. U.S. Geological Survey, Professional Paper 174.

__________.

1953 Physiography and Glacial Geology of Western Montana and Adjacent Areas. U.S. Geological Survey, Professional Paper 231.

Allen, J. A.

1877 History of the American Bison, Bison Americanus. Ninth Annual Report of the U.S. Geological and Geographical Survey, Part III: Zoology, 443-587.

Antevs, Ernst

1955 Geologic-Climatic Dating in the West. American Antiquity 20(4): 317-355.

Arthur, George W.

1962 The Emigrant Bison Drives of Paradise Valley, Montana. In: Symposium on Buffalo Jumps, Montana Archaeological Society, Memoir No. 1. Carling Malouf and Stuart Conner, eds., pp. 16-27.

__________.

1966 An Archaeological Survey of the Upper Yellowstone Drainage, Montana. Agricultural Economics Research Report, No. 26, Dept. of Agricultural Economics and Rural Sociology, Montana Agricultural Experiment Station, Bozeman, Montana.

__________.
1975 An Introduction to the Ecology of Early Historic Communal Bison Hunting Among the Northern Plains Indians. Archaeological Survey of Canada, Mercury Series, Paper No. 37.

Barz, Carl
1967 White Sulfer Springs Buffalo Jump. Trowel and Screen 8(9): 3.

Bostock, H. S.
1970 Physiographic Regions of Canada. (Map) In: Geology and Economic Minerals of Canada, Part B., Geological Survey of Canada, Economic Geology Report No. 1. R. J. W. Douglas, ed.

__________.
1976 Physiographic Subdivisions of Canada. In: Geology and Economic Minerals of Canada, Part A, Chapter II. Geological Survey of Canada, Economic Geology Report No. 1. R. J. W. Douglas, ed., pp. 9-30.

Bowser, W. E., T. W. Peters and J. D. Newton
1951 Soil Survey of Red Deer Sheet. University of Alberta, College of Agriculture, Bulletin No. 51.

Brackett, William S.
1893 Indian Remains on the Upper Yellowstone. Annual Report of the Smithsonian Institution for 1892, pp. 577-581.

Brown, Barnum
1932 The Buffalo Drive. Natural History 32(1): 75-82.

Bryson, R. A., D. A. Baerreis and W. M. Wendland
1970 The Character of Late-Glacial and Post-Glacial Climatic Changes. Pleistocene and Recent Environments on the Central Plains. W. Dort, Jr. and J. K. Jones, Jr., eds., pp. 53-74. University of Kansas. Lawrence.

Bryson, R. A. and W. M. Wendland
1967 Tentative Climatic Patterns for Some Late-Glacial and Post-Glacial Episodes in Central North America. Life, Land and Water. W. M. Mayer-Oakes, ed., pp. 271-298. University of Manitoba Press. Winnipeg.

Butler, B. Robert
1971 A Bison Jump in the Upper Salmon River Valley of Eastern Idaho. Tebiwa, Vol. 14, No. 1, pp. 4-32.

Byrne, William J.
1973 The Archaeology and Prehistory of Southern Alberta as Reflected by Ceramics. Archaeological Survey of Canada, Mercury Series Paper No. 14.

Cahalane, Victor H.
1947 Mammals of North America. The MacMillan Company. New York.

Clayton, J. S., W. A. Ehrlich, D. B. Cann, J. H. Day and I. B. Marshall
1977 Soils of Canada. 2 volumes. Canada Dept. of Agriculture, Research Branch. Ottawa.

Conner, Stuart
1962a Glossary. In: Symposium on Buffalo Jumps, Montana Archaeological Society, Memoir No. 1. Carling Malouf and Stuart Conner, eds., pp. 57-58.

__________.
1962b Introduction to Buffalo Jumps. In: Symposium on Buffalo Jumps, Montana Archaeological Society, Memoir No. 1. Carling Malouf and Stuart Conner, eds., pp. 1-2.

__________.
1962c Unusual Characteristics of the Keogh Buffalo Jump. In: Symposium on Buffalo Jumps, Montana Archaeological Society, Memoir No. 1. Carling Malouf and Stuart Conner, eds., pp. 8-10.

__________.
n.d. Letter transmittals describing bison jumps in Big Horn. Carbon and Gallatin Counties. University of Montana, Site Files.

Cordell, Grayson, V. Jr.
1971 Climate of Montana. Climatography of the United States No. 60-24 (Revised), U.S. Dept. of Commerce.

Davis, Leslie B.
1966 Avonlea Point Occurrence in Northern Montana and Canada. Plains Anthropologist 11(2): 100-116.

__________.
1975 The Prehistory of the Whitewater-Frenchman Creek/Milk River Locality, Northeastern Montana: An Introduction. Report to the Bureau of Land Management, Malta District.

DeSmet, Father Pierre-Jean, S.J.
1905 Life, Letters and Travels of Father Pierre-Jean DeSmet, S.J. 1801-1873. 4 Volumes. Francis P. Harper. New York.

DeYoung, William and L. H. Smith
1931 Soil Survey of the Gallatin Valley Area, Montana. U.S. Dept. of Agriculture, Bureau of Chemistry and Soils, Series 1931, No. 16.

Dibble, David S. and Dessamae Lorrain
1968 Bonfire Shelter: A Stratified Bison Kill Site, Val Verde County, Texas. Texas Memorial Museum, Miscellaneous Papers No. 1. Austin.

Dice, Lee Raymond
1943 The Biotic Provinces of North America. University of Michigan Press. Ann Arbor. Third Printing, 1956.

Dicus, William
n.d. Statewide Archaeological Survey of Cascade County. Manuscript on file with the Department of Anthropology, University of Montana, Missoula.

Douglas, R. J. W.
1951 Pincher Creek, Alberta (Geology). Geological Survey of Canada, Preliminary Map 51-22.

Dunnewald, Theodore J., Orel Tikkaner and Wesley Roath
1939 Soil Survey of Johnson County, Wyoming. U.S. Dept. of Agriculture, Bureau of Chemistry and Soils, Series 1933, No. 28.

Edwards, Everett and O. V. Krause
1969 The Ice Cave Buffalo Jump. Trowel and Screen 10(3): 5-7.

Fenneman, Nevin M.
1931 Physiography of the Western United States. McGraw-Hill Book Company, Inc. New York.

Forbis, Richard G.
1962a The Old Woman's Buffalo Jump, Alberta. Natural Museum of Canada Bulletin No. 180. Contributions to Anthropology 1960, Part I, pp. 56-123.

__________.
1962b A Stratified Buffalo Kill in Alberta. In: Symposium on Buffalo Jumps, Montana Archaeological Society, Memoir No. 1. Carling Malouf and Stuart Conner, eds., pp. 3-7.

__________.
n.d. Description of Nanton Jump (Eb-Pl-1). University of Calgary, Site Files.

Frison, George C.
1965 A Preliminary Report on Two Sites at Piney Creek, Wyoming 48JO311 and 48JO312. Plains Anthropologist 10(30): 240-246.

__________.
1967a. Archaeological Evidence of the Crow Indians in Northern Wyoming: A Study of a Late Prehistoric Buffalo Economy. Ph.D. Dissertation, University of Michigan, Ann Arbor.

__________.
1967b The Piney Creek Sites, Wyoming. University of Wyoming Publications XXXIII (1).

__________.
1970a The Glenrock Buffalo Jump, 48CO304: Late Prehistoric Period Buffalo Procurement and Butchering. Plains Anthropologist, Memoir, No. 7.

__________.
1970b. The Kobold Site, 24BH406: A Post-Altithermal Record of Buffalo-Jumping for the Northwestern Plains. Plains Anthropologist 15(47): 1-35.

Frison, George C.
1978 Prehistoric Hunters of the High Plains. Academic Press. New York.

Frison, George C., Michael Wilson and Danny N. Walker
n.d. The Big Goose Creek Site, Wyoming: Bison Procurement and Faunal Analysis. Manuscript on file at the Dept. of Anthropology, University of Wyoming, Laramie.

Garretson, Martin S.
1938 The American Bison. New York Zoological Society. New York.

Geiseker, L. F.
1955 Soils of Richland County, Preliminary Report. Montana Experiment Station Bulletin 515.

__________.
1956 Soils of Sweetgrass County, Preliminary Report. Montana Experiment Station Bulletin 519.

__________.
1957 Soils of Stillwater County, Preliminary Report. Montana Experiment Station Bulletin 529.

Geiseker, L. F., C. F. Maniford, A. T. Strahorn, and O. F. Bartholomew
1953 Soil Survey (Reconnaissance) of Central Montana. U.S. Dept. of Agriculture, Soil Conservation Service, Series 1940, No. 9.

Geiseker, L. F., E. R. Morris, A. T. Strahorn and C. B. Maniford
1929 Soil Survey (Reconnaissance) of the Northern Plains of Montana. U.S. Dept. of Agriculture, Bureau of Chemistry and Soils, Series 1929, No. 21.

Green, Ernestene L.
1973 Location Analysis of Prehistoric Maya Sites in Northern British Honduras. American Antiquity 38(3): 279-293.

Gumerman, George J., ed.
1971 The Distribution of Prehistoric Population Aggregates. Prescott College Anthropological Reports, No. 1. Prescott, Arizona.

Haggett, Peter
1965 Locational Analysis in Human Geography. Edward Arnold. London.

Hammond, Edwin H.
1964 Classes of Land-Surface Form in the Forty-Eight States, U.S.A. Map Supplement No. 4, Annals of the Association of American Geographers 51(1).

Haynes, C. Vance, Jr.
1965 Preliminary Palyntological Investigation of the Sisters' Hall Site, Wyoming. Plains Anthropologist 10(29).

Henry, Alexander and David Thompson
1897 New Light on the Early History of the Greater Northwest. The Manuscript Journals of Alexander Henry and David Thompson, 1799-1814. 2 volumes, Elliot Coues, ed. Reprinted (1965) by Ross and Haines, Inc., Minneapolis.

Higgs, E. S., ed.
1975 Paleoeconomy. Cambridge University Press. Cambridge.

Hlady, Walter M.
1970 The Harris Bison Runs Near Brandon. Ten Thousand Years: Archaeology in Manitoba, Walter M. Hlady, ed., pp. 175-179. Manitoba Archaeological Society.

Hoffman, B.
1962 A Buffalo Kill Site in the Montana Rockies. Plains Anthropologist 7(17): 196-201.

Holder, Tommie J. and Pedro Pescador, Jr.
1976 Soil Survey of Dawson County, Montana. U.S. Dept. of Agriculture, Soil Service.

Holman, Margaret B.
1978 The Settlement System of the Mackinac Phase. Ph.D. Dissertation, Michigan State University, East Lansing.

Hornaday, William T.
1889 The Extermination of the American Bison, with a Sketch of its Discovery and Life History. Annual Report of the U.S. National Museum for 1886-87, pp. 367-548. Washington.

Hoy, Judy
1973 Six Bison Kill Sites in Phillips County, Montana. Archaeology in Montana, 14(3): 1-34.

Hume, G. S.
1931 Turner Valley Sheet (Geology). Geological Survey of Canada, Map 257A.

__________.
1941 Bragg Creek (Geology). Geological Survey of Canada, Map 654A.

__________.
1949 Stimson Creek (Geology). Geological Survey of Canada, Map 934A.

Hunt, Charles B.
1974 Natural Regions of the United States and Canada. W. H. Freeman and Company, San Francisco.

Hurt, Wesley
1963 A Survey of Buffalo Jumps in the Northern Plains. Dept. of the Interior, National Park Service, Omaha.

Irish, E. J. W.
1967 Geology, Lethbridge. Geological Survey of Canada, Preliminary Series, Map 20-1967.

__________.
1968a Geology, Foremost. Geological Survey of Canada, Preliminary Series, Map 22-1967.

__________.
1968b Geology, Gleichen. Geological Survey of Canada, Preliminary Series, Map 19-1967.

Kehoe, Thomas F.
1967 Boarding School Bison Drive. Plains Anthropologist 12(35): 1-165. Memoir No. 4.

__________.
1973 The Gull Lake Site: A Prehistoric Bison Drive Site in Southwestern Saskatchewan. Milwaukee Public Museum Publications in Anthropology and History, No. 1.

Kehoe, Thomas F. and Bruce A. McCorquodale
1961 The Avonlea Point--Horizon Marker for the Northwestern Plains. Plains Anthropologist 6(13): 179-188.

Keyser, James
1977 The Role of Seasonal Bison Procurement in the Prehistoric Economic Systems of the Indians of North-Central Montana. Ph.D. Dissertation, University of Oregon. University Microfilms. Ann Arbor.

Keyser, James D. and George C. Knight
1976 The Risley Bison Kill: West-Central Montana. Plains Anthropologist 21(74): 291-300.

Küchler, August Wilhelm
1964 Potential Natural Vegetation of the Conterminous United States. American Geographical Society, Special Publication No. 36.

Lee, Richard B.
1966 What Hunters Do for a Living. Man the Hunter, R. R. Lee and I. DeVore, eds., pp. 30-48. Aldine. Chicago.

Lewis, Francis J., Eleanor S. Dowdling and E. H. Moss
1928 The vegetation of Alberta, II. Journal of Ecology 16(1): 19-102.

Lewis, H. P.
n.d. Copy of an Unpublished Manuscript About the Buffalo Kills of Montana. Copied from a Copy on File at the Midwest Archaeological Center, National Park Service, Omaha.

Loendorf, Lawrence L.
1970 Prehistoric Patterns of Campsite Selection in the Prior Mountains, Montana. Archaeology in Montana II(1): 17-44.

Love, J. D., J. L. Weitz and R. K. Hose
1955 Geology of Wyoming. U.S. Geological Survey, Special Geologic Map, Mono 55-4.

Lowers, A. R.
1960 Climates of the States: Wyoming. Climatography of the United States No. 60-48, U.S. Dept. of Commerce.

MacDougall, John
1896 Saddle, Sled and Snowshoe. Curts and Jennings. Cincinnati.

MacGregor, J. G.
1966 Peter Fidler: Canada's Forgotten Surveyor 1769-1822. McClelland and Steward, Ltd. Toronto.

McHugh, Tom
1972 Time of the Buffalo. Alfred Knopf. New York.

Malouf, Carling and Stuart Conner, eds.
1962 Symposium on Buffalo Jumps. Montana Archaeological Society, Memoir No. 1.

Martin, Susan R.
1977 A Preliminary Cultural Resource Management Study of the Hiawatha National Forest, Michigan. 2 volumes. Michigan State University Museum, Archaeological Survey Report, No. 20. East Lansing.

Medicine Crow, Joseph
1962 Crow Indian Buffalo Legends. In: Symposium on Buffalo Jumps, Montana Archaeological Society, Memoir No. 1. Carling Malouf and Stuart Conner, eds., pp. 35-39.

Meshneck, James C., James H. Smith, and Laverne G. Gray
1977 Soil Survey of Big Horn County Area, Montana. U.S. Dept. of Agriculture, Soil Conservation Service and U.S. Dept. of the Interior, Bureau of Indian Affairs.

Moss, E. H.
1932 The vegetation of Alberta, IV. Journal of Ecology 20(2): 380-405.

Mulloy, William
1958 A Preliminary Historical Outline for the Northwestern Plains. University of Wyoming Publications 22 (1).

Napton, Lewis K.
1966 Canyon and Valley Preliminary Archaeological Survey in the Gallatin Area, Montana. M.A. Thesis, Dept. of Anthropology, University of Montana.

Nie, Norman H., C. Hadlai Hull, Jean G. Jenkins, Karin Steinbrenner and Dale H. Bent
1975 SPSS: Statistical Package for the Social Sciences. 2nd edition. McGraw-Hill Book Company.

Parker, John L., Gordon L. Decker and Laverne Gray
1975 Soil Survey of Carbon County Area, Montana. U.S. Dept. of Agriculture, Soil Conservation Service and Forest Service.

Plog, Fred and James N. Hill
1971 Explaining Variability in the Distribution of Sites. In: The Distribution of Prehistoric Population Aggregates, Prescott College Anthropological Papers, No. 1, George J. Gumerman, ed., pp. 7-36. Prescott, Arizona.

Quigg, J. Michael
1974 The Belly River: Prehistoric Population Dynamics in a Northwestern Plains Transitional Zone. Archaeological Survey of Canada, Mercury Series, Paper No. 23.

Reeves, B. O. K.
1970 Culture Change in the Northern Plains: 1000 B.C. - A.D. 1000. 2 volumes, Ph.D. Dissertation, University of Calgary.

__________.
1974a Crowsnest Pass Archaeological Project, 1973 Salvage Excavations and Survey Paper No. 2. Preliminary Report. Archaeological Survey of Canada, Mercury Series, Paper No. 24.

__________.
1974b Head-Smashed-In: 5500 Years of Bison Jumping in the Alberta Plains. Paper Presented at the 32nd Plains Conference Held at Laramie, Wyoming, November 7-9, 1974.

Reher, Charles A.
1977 Adaptive Process on the Shortgrass Plains. For Theory Building in Archaeology, Lewis R. Binford, Ed., pp. 13-40. Academic Press. New York.

Reher, Charles A. and G. C. Frison
(In Press) The Vore Site 48CK302: A Stratified Buffalo Jump in the Black Hills of Northeastern Wyoming. Plains Anthropologist Memoir.

Roe, Frank Gilbert
1970 The North American Buffalo: A Critical Study of the Species in its Wild State. University of Toronto Press. Toronto, Canada.

Roper, D. C.
1975 Archaeological Survey and Settlement Pattern Models in Central Illinois. University Microfilms. Ann Arbor.

Ross, C. P. and I. J. Witkind
1955 Geologic Map of Montana. U.S. Geological Survey, Special Geologic Map, Mono 55-7.

Schaeffer, Claude E.
1962 The Bison Drive of the Blackfeet Indians. In: Symposium on Buffalo Jumps, Montana Archaeological Society, Memoir No. 1. Carling Malouf and Stuart Conner, eds., pp. 28-34.

Shelford, Victor E.
1963 The Ecology of North America. University of Illinois Press, Urbana.

Shields, Wayne F.
1966 The Woodruff Bison Kill. Manuscript in Author's possession, Dickson Mounds, Lewistown, Illinois.

Shumate, Maynard
1950 The Archaeology of the Vicinity of Great Falls, Montana. Montana State University, Anthropology and Sociology Papers, No. 2.

__________.
1967 The Taft Hill Buffalo Jump. Archaeology in Montana 8(4): 12-34.

Soper, J. Dewey
1941 History, Range, and Home Life of the Northern Bison. Ecological Monographs 11(4): 347-412.

Southard, A. R.
1969 Soils of Montana. Montana State University, Montana Agricultural Experiment Station, Bulletin 621.

Stalker, A. M.
1956 Surficial Geology, Beiseker, Alberta. Geological Survey of Canada Paper 55-7.

__________.
1957 Surficial Geology, High River, Alberta. Geological Survey of Canada Preliminary Series Map 14-1957.

__________.
1959 Surficial Geology, Fort MacLeod, Alberta. Geological Survey of Canada, Preliminary Series Map 21-1958.

__________.
1960 Surficial Geology, Red Deer-Stettler, Alberta. Geological Survey of Canada Map 1081A.

__________.
1962 Surficial Geology, Lethbridge, Alberta. Geological Survey of Canada, Preliminary Series Map 41-62.

Thompson, Otto and Susan Hand
1950 Archaeological Notes on the Madison and Jefferson Rivers. Montana State University, Anthropology and Sociology Papers, No. 3. Missoula.

Thorp, James, T. W. Glassey, T. J. Dunnewald and B. L. Parsons
1939 Soil Survey of Sheridan County, Wyoming. U.S. Dept. of Agriculture, Bureau of Chemistry and Soils, Series 1932, No. 33.

Vita-Finzi, C. and E. S. Higgs
1970 Prehistoric Economy in the Mount Carmel Area of Palestine: Site Catchment Analysis. Proceedings of the Prehistoric Society 36: 1-37.

Wedel, Waldo R.
1961 Prehistoric Man on the Great Plains. University of Oklahoma Press. Norman.

Weekes, Mary
1948 An Indian's Description of the Making of a Buffalo Pound. Saskatchewan History 3(1): 14-17.

Westgate, J. A.
1968 Surficial Geology, Foremost-Cypress Hills (Map). Research Council of Alberta Bulletin No. 22.

Witkind, Max
1971 An Archaeological Interpretation of the Roberts Buffalo Jump Site, Larimer County, Colorado. M.A. Thesis, Colorado State University, Fort Collins.

Wormington, H. M. and R. G. Forbis
1965 An Introduction to the Archaeology of Alberta, Canada. Denver Museum of Natural History Proceedings, No. 11.

Wyatt, F. A.
1924 Survey of the McLeod Sheet. University of Alberta, College of Agriculture, Bulletin No. 11.

Wyatt, F. A., W. E. Bowser, and W. Odynsky
1939 Soil Survey of Lethbridge and Pincher Creek Sheets. University of Alberta, College of Agriculture, Bulletin No. 32.

Wyatt, F. A., J. D. Newton, W. E. Bowser and W. Odynsky
1937 Soil Survey of Rainy Hills Sheet. University of Alberta, College of Agriculture, Bulletin No. 28.

__________.
1941 Soil Survey of Milk River Sheet. University of Alberta, College of Agriculture, Bulletin No. 36.

__________.
1942 Soil Survey of Blackfoot and Calgary Sheets. University of Alberta, College of Agriculture, Bulletin No. 39.

__________.
1943 Soil Survey of Rosebud and Banff Sheets. University of Alberta, College of Agriculture, Bulletin No. 40.