Middle Archaic and Late Archaic/Woodland patch use in the Little Missouri Badlands, North Dakota

Greg L. Wermers

The University of Montana

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MIDDLE ARCHAIC AND LATE ARCHAIC/WOODLAND PATCH USE
IN THE LITTLE MISSOURI BADLANDS, NORTH DAKOTA

by
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B. A. University of North Dakota, 1987
presented in partial fulfillment of the requirements
for the degree of
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1999

Approved by:

Chairperson

Dean, Graduate School

Date 5-13-99
The Little Missouri Badlands in western North Dakota are a heavily dissected landscape resulting from erosional processes. These processes began during the Pleistocene and continue through the Holocene. A trend in the badlands archeological record involves a relationship between sites from known temporal periods and certain landforms. Previous explanations of site distribution in the badlands have focused on cultural preference or modification of the archeological record by erosional processes. This study examines the distribution of Middle Archaic McKean and Late Archaic/Woodland Besant sites within the badlands, but rather than concentrating on site location in relation to landform type it focuses on foraging behavior in an attempt to discern a difference between the two regarding site location.

The Marginal Value Theorem, a foraging theory patch use model developed to examine how optimal foragers use food resources in a patchy environment, was used as a framework to explain patterns of site distribution. It was predicted that during the Sub-Boreal climatic episode, when conditions were similar to the present, the McKean, being broad spectrum foragers, would allocate more foraging effort in patches characterized by diverse, abundant high ranked plant resources. Conversely, during the improved conditions of the subsequent Sub-Atlantic episode, resulting in better forage conditions for large herbivores, more Besant foraging time would be spent in patch types that contained an abundance of highly ranked animal resources.

The hypothesis was tested using archeological data from the Little Missouri Badlands in southwestern North Dakota. The pattern of McKean and Besant archeological sites and patch types appears to support the model. It must be cautioned that the data were not adequate for a true quantitative test of the MVT. A chi-square test of the data failed to reject the possibility of random factors being responsible for the observed distribution. However, it is felt that the data were sufficient to gain a preliminary understanding of McKean and Besant patch use in the badlands.
ACKNOWLEDGMENTS

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Words cannot express the gratitude Lisa and Markie, my wife and daughter, deserve. While I was absent from their lives, for two school years in Missoula and many nights upstairs in front of the computer, their support of me never waned. Without their strength and frequent reassurances it would not have been possible to complete this thesis. Finally, I wish to thank Donald and Verla Wermers, my parents, for instilling in me the importance of education.

glw
28 April 1999
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CHAPTER 1

INTRODUCTION

Optimal use of the Little Missouri Badlands by the McKean and Besant will be tested using the Marginal Value Theorem (Charnov 1976). This model, from foraging theory, was developed to investigate how an optimal predator (forager) uses a patchy environment. In an environment characterized by patchy resource distribution foragers encounter two interconnected problems: which set of patches to forage in, and how much foraging time will be spent in each (Smith 1983:630-631). The Marginal Value Theorem (MVT) takes as a given that the forager has already decided on the set of patches to utilize (Winterhalder 1981b:69) and examines the optimal pattern of time allocation to each patch within the set (Smith 1983:631). The MVT is designed to determine the forager’s pattern and rate of movement among patches selected for harvest (Winterhalder 1981a:28).

The Little Missouri Badlands in western North Dakota are a heavily eroded, dissected landscape. The downcutting and headward erosion of the Little Missouri River and its tributaries through Paleocene unconsolidated sediments is responsible for the badlands terrain. The erosional processes that shaped the badlands began during the early Pleistocene and continue today.

Two trends are apparent within the Little Missouri Badlands archeological record. First, there is little evidence for Paleoindian and Early Archaic, ca. 11,500-6000 B.P., occupation and use. Cultural materials are limited to a small number of
sites and projectile points identified in isolated surface contexts (Beckes and Keyser 1983:172-175; Simon and Keim 1983:25-27; Kuehn 1990:115-120). The reason for the lack of Paleoindian and Early Archaic sites is the erosional nature of the badlands. Most of the landscape surfaces that would have been available for occupation during these periods have been removed by erosion (State Historical Society of North Dakota 1990:1.48).

The second trend involves the correlation between site locations, specific prehistoric periods, and landforms (Kuehn 1990:162-164, 1993:313). The earliest components that regularly occur as intact deposits within the badlands are Middle Archaic McKean sites, ca. 5000-3000 B.P. (Kuehn 1990:120-121; State Historical Society of North Dakota 1990:1.50). These are predominantly situated on upland landforms, with some sites occurring on mid-level foothill landforms, and fewer in the lowlands (Beckes and Keyser 1983:177-178; Hill 1988; Kuehn 1990:162). This pattern changes through time with archeological sites attributed to subsequent periods distributed more evenly over upland, foothill, and lowland landforms (Hill 1988; Kuehn 1990:162-164, 1993:316-317).

The patterns evident in the badlands archeological record have received considerable attention in recent years. Many of these discussions have centered on prehistoric use of the landscape. For example, the work of Simon (1982; Simon et al. 1982; Simon and Keim 1983), and Beckes and Keyser (1983) represent early attempts at explaining site locations (Keuhn 1993:318). Simon’s research primarily concerned the northern badlands. Her work included archeological testing and mitigation projects
combined with site location information that existed at the time of the study. Results from her research indicated that prehistoric sites concentrated on upland ridgetops with fewer sites on stream terraces. She concluded that ridgetops were selected for more intensive occupation and use because they were natural travel routes and placed prehistoric groups in close proximity to key resources such as lithic materials, plants and animals, fuel, and water which occur along the ridges and in nearby drainages (Simon 1982:60; Simon et al. 1982:251-252; Simon and Keim 1983:516).

In Beckes and Keyser’s coverage of the Little Missouri Badlands, within their prehistoric overview of the Custer National Forest, they note “... a concentration of Middle Archaic sites on many of the extensive linear ridge systems which occur throughout the badlands” (1983:177). The authors, citing Simon’s findings (1982), attribute this pattern to travel routes. They, like Simon, also recognized the floral and faunal diversity, and the presence of fuel, shelter and the close proximity of reliable water sources available on ridgetops. The upland ridgetops were viewed as resource rich, favored by Middle Archaic groups because they were ecotonal contacts, segments of prairie extending into the badlands (Beckes and Keyser 1983:177-178). Beckes and Keyser also note the presence of few Middle Archaic sites on stream terraces and lowland settings within the badlands, or along the boundary separating the badlands and upland grasslands (1983:180).

When Beckes and Keyser wrote their overview (1983) there were few Late Archaic Besant sites, ca. 2100-1400 years B.P., recorded within the Little Missouri Grasslands as a whole. They thought
this reflected the Besant’s plains orientation, where these specialized bison hunters were believed to have spent the majority of their time. Beckes and Keyser felt that the small number of sites assigned to the Besant within the badlands possibly indicated a plains adapted people making only occasional trips into the badlands to procure certain needed resources (1983:190-191).

Beckes and Keyser also refrained from making definitive statements regarding Late Prehistoric-Protohistoric, ca. 1400-100 years B.P., use of the badlands because of a lack of data. However, they did note that Late Prehistoric groups used the boundary area between the badlands and the plains, and major streams more intensively than did earlier groups (Beckes and Keyser 1983:203).

Root (1985:91-119) believed the placement of the Olsen Ranch Site (a low density, multi-component cultural material scatter on a ridge top) conformed to the typical badlands settlement patterns. Root examined site function using Binford’s (1980) settlement scheme ideas (1985:92) that prehistoric groups in the Northwestern Plains practiced more of a collector strategy. He hypothesized that sites located on ridge tops in the northern badlands are predominantly hunting stations and field camps with hunting being the primary activity and plant gathering and stone material procurement secondary activities.

Hill (1988) discussed settlement patterns and site distribution in the Little Missouri Grasslands. He coded the geographic location, landform placement, and environmental setting for archeological sites of known cultural affiliation within the
area. His coding for environmental setting consisted of general biotic zones with typical plants and animals thought to have been important to the prehistoric occupants.

From the results Hill noted the prevalence of Middle Archaic sites on upland ridges but also observed a higher proportion of sites attributed to Late Archaic and Plains Village groups in the lowlands. Associated with this shift through time was a corresponding decrease of later sites on the ridges. His explanation for the variation in settlement pattern between Middle and Late Archaic groups was a change to a drier climate. He states, "Increased aridity would have resulted in a decreased reliability of resources within the study area, requiring ... a reliance on a broader range of resources and environments" (1988:16).

Kuehn, in his article concerning Little Missouri Badlands archeological site distribution and landforms, states:

... previous explanations for apparent landform patterns in badlands site distribution have centered on cultural preferences and settlement system characteristics rather than natural processes. These explanations are based on the premise that the extant archaeological record is an accurate reflection of prehistoric settlement patterns. Approaches of this nature fail to take into consideration postdepositional site disturbance and landscape modification, ... [1993:314].

Kuehn has conducted extensive research within the Little Missouri Badlands, including a multi-year archeological survey project within the Theodore Roosevelt National Park (1990), and numerous survey and testing projects outside of the Park. This research, coupled with earlier geomorphological work conducted in the badlands, is leading to the development of a stratigraphic
framework, or dating of late Quaternary landforms present within the badlands (Kuehn 1993:319, 1997:322-325). Kuehn uses principles from geoarcheology in his investigation of prehistoric site distribution in the badlands.

Results from radiocarbon dating performed on samples recovered from lowland fluvial landforms along the Little Missouri River and streams in the badlands, and from upland exposures (Table 1) indicate the dichotomy in ages between upland and lowland settings (Kuehn 1990:73-112, 1991:37-42, 1993:321-329). Dates from the fluvial lowland landforms show a range from 6600 years B.P. to recent and the majority of dates ranged from 3370 years B.P. to 100 years B.P. Two significantly older dates, 6600 years B.P. and 5900 B.P., were from samples recovered from an upper terrace within a large stream basin. The large size of this basin may account for the older dates. Dates of sediments within the majority of badlands stream valleys are within the younger date range, indicating a lack of older terrace materials (Kuehn 1993:321-327).

Many upland landform surfaces in the badlands are capped by eolian sediments. Dates from upland sediment samples cover the last 13,000 years. Kuehn (1993:329) notes from his work and previous geoarcheological work conducted in the badlands (East et al. 1985) that although Late Pleistocene and early Holocene sediments exist, they are uncommon and only occur in basins and swales on the top of upland landforms. In contrast, sediments dating to 5000 years B.P. are prevalent in the uplands (Kuehn 1993:329, 1997:323).
Table 1. Summary of Badlands Landforms and Radiocarbon Dates (Adapted from Kuehn 1993:323).

<table>
<thead>
<tr>
<th>Badlands Landform</th>
<th>Radiocarbon Date (Sample type)</th>
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<tbody>
<tr>
<td>L. Missouri River, modern floodplain</td>
<td>290 ± 80 yr B.P. (Bone collagen)</td>
</tr>
<tr>
<td>L. Missouri River, modern floodplain</td>
<td>380 ± 120 yr B.P. (Charcoal)</td>
</tr>
<tr>
<td>L. Missouri River, terrace</td>
<td>150 ± 60 yr B.P. (Charcoal)</td>
</tr>
<tr>
<td>L. Missouri River, terrace</td>
<td>290 + 80 yr B.P. (Bone collagen)</td>
</tr>
<tr>
<td>Knutson Creek, terrace</td>
<td>1210 ± 60 yr B.P. (Bulk soil)</td>
</tr>
<tr>
<td>Sand Creek, terrace</td>
<td>2400 ± 60 yr B.P. (Bulk soil)</td>
</tr>
<tr>
<td>Sheep Creek, terrace</td>
<td>1550 ± 50 yr B.P. (Charcoal)</td>
</tr>
<tr>
<td>Jules Creek, terrace</td>
<td>6660 ± 90 yr B.P. (Charcoal)</td>
</tr>
<tr>
<td>Upland ridge (Numerous buried soils)</td>
<td>880 ± 25 yr B.P. (Charcoal)</td>
</tr>
<tr>
<td></td>
<td>3370 ± 50 yr B.P. (Bulk soil)</td>
</tr>
<tr>
<td></td>
<td>300 ± 65 yr B.P. (Bone collagen)</td>
</tr>
<tr>
<td></td>
<td>100 ± 0.8% Modern (Bone collagen)</td>
</tr>
<tr>
<td></td>
<td>Upland ridge 13,070 ± 490 yr B.P. (Charcoal)</td>
</tr>
<tr>
<td></td>
<td>11,560 ± 110 yr B.P. (Bulk soil)</td>
</tr>
<tr>
<td></td>
<td>10,730 ± 460 yr B.P. (Bulk soil)</td>
</tr>
<tr>
<td></td>
<td>2160 ± 70 yr B.P. (Bulk soil)</td>
</tr>
<tr>
<td></td>
<td>Upland ridge 9200 ± 70 yr B.P.  (Bulk soil)</td>
</tr>
<tr>
<td></td>
<td>Upland ridge 10,740 ± 120 yr B.P. (Bulk soil)</td>
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The above work shows the difference in sediment age between upland and lowland contexts in the badlands. Older sediments are preserved in upland settings because the landforms on which they occur are subjected to less intensive types of erosional
processes, deflation from wind and hillslope lowering, in comparison to lowland landforms. In addition to deflation and hillslope lowering, lowland landforms are also impacted by downcutting and lateral migration of streams, slumping, piping, and gullying. As a result, the lowlands are virtually devoid of older sediments and are characterized by more recent sediments (Kuehn 1997:325).

Kuehn’s work illustrates the fact that natural processes have been acting on the badlands archeological record throughout the Holocene. He concludes that natural processes (i.e. erosion and stability) are responsible for variations in site distribution through time within the badlands, not changes in prehistoric preferences for certain landforms (Kuehn 1993). This position is similar to Reeves (1973) who believes erosional processes, along with sampling problems and misidentification of diagnostic artifacts, are partly responsible for the lack of Early Archaic sites on the Northwestern Plains, not a wholesale abandonment of this region for river valleys and mountain foothills during the dry conditions of the Atlantic climatic episode.

Badlands site location patterns attributed to earlier prehistoric groups have experienced more disturbance than the patterns of more recent groups. The reason for the apparent intensive use of the upland ridges by the Middle Archaic McKean, and less use of lowland settings, is due to the relative stability of the uplands and the more intensive erosional nature of the lowlands. Middle Archaic sites in the lowlands have been subjected to erosion longer than later period sites, hence there
are fewer of them in this setting when compared to sites dating to the Late Archaic and Late Prehistoric (Kuehn 1990:164, 1993:329).

Unlike McKean sites, Late Archaic Besant and Late Prehistoric sites are more evenly distributed over the uplands and lowlands. Land use patterns exhibited by these groups are believed to be more accurate as they have had less time to be disturbed by natural processes (Kuehn 1990:164, 1993:330). Kuehn also notes that settlement patterns among known prehistoric groups in the badlands appear to be homogenous, and that no clear differences in settlement patterns among the groups were apparent from geomorphological evidence (Kuehn 1990:164).

All of the above research on site location within the badlands primarily concerns site placement and landforms. The earlier discussions regarding prehistoric use of the badlands (Simon 1982; Simon et al. 1982; Simon and Keim 1983; Beckes and Keyser 1983) were general, focusing on broad factors (travel routes, closeness to natural resources, etc.) felt to be responsible for the relationship between site location and specific landforms.

In fairness to Simon and Beckes and Keyser, it must be understood that at the time of their work available data regarding the badlands archeological record was limited and biased. Although several archeological projects had been conducted in the badlands prior to the 1980's the number of archeological sites recorded was somewhat meager compared to the present. Also, most of their data was derived from projects related to oil and natural gas exploration on federally administered lands. At the time this exploration concentrated on ridge tops.
Root's analysis (1985) introduced Binford's concepts of settlement pattern (1980) to the study of badlands archaeology. This is an important contribution as it refined earlier ideas on why sites are located on ridge tops in the badlands. It explains the activities of prehistoric groups and how they relate to the occupation of ridge tops.

Hill's work (1988) considered environmental factors in more detail than did earlier efforts. He tried to explain why prehistoric people chose certain biotic communities. It should be noted that Hill's study was not limited to the badlands, but also included sites in the surrounding grasslands (Little Missouri National Grasslands).

Kuehn focused on geomorphological processes in his analysis of prehistoric settlement. By determining the age of landforms and taking into account subsequent deposition and erosion processes he has brought to light an obvious, but often unconsidered, factor in the badlands settlement studies. The dynamic nature of the badlands landscape, with cyclical periods of stability and erosion, has had a noticeable effect on the archeological record. Kuehn concludes that the differential use of the badlands by prehistoric groups through time is the result of natural, post-depositional disturbances and doesn't reflect any change in settlement pattern, with respect to certain landforms (Kuehn 1990:164, 1993:329).

The archeological remains within the badlands do not represent a complete record of hunter-gatherer movements, as demonstrated by Kuehn's work, but are rather the remnants of
settlement patterns (Dewar and McBride 1992). Stafford and Hajic comment:

The resolution of the archeological record is largely not at the scale of intraannual movements of hunter-gatherers. In addition, it is unlikely that the archeological record is the simple additive result of seasonal movements but is significantly more complex [1992:142].

According to Dewar and McBride (1992:228-229), the analysis of prehistoric land use in which the spatial distribution of cultural materials over an area is fitted into an ethnographic model of an annual subsistence round does not work. For this to be successful, specific sites associated with a particular annual round would need to be identified. This is of great importance to research concerning adaptation. Studies focusing on variations in subsistence-settlement systems as an indication of changes in adaptive behavior need to consider longer periods of time than an ethnographic year (Winterhalder 1994).

Smith (1991:254-255), in discussing implications raised by the Marginal Value Theorem recognizes that reasons other than subsistence are responsible for the movement of groups across the landscape. When considering the archeological record not all sites represent successful attempts at harvesting targeted food resources or are even related to subsistence pursuits (Bamforth 1988:27). However, it is believed that most sites resulting from people who survived in a hunting and gathering economy will be associated with food getting (Deaver and Deaver 1988:5).

The environment is often presented as being static in human ecology studies. When ecological factors are characterized in this normative fashion their dynamic, discontinuous, and
historical qualities cannot be fully appreciated (Winterhalder 1994:32). Hunter-gatherer mobility is affected to a certain degree by the kinds of resources that occur across the landscape. Any discussion regarding long-term changes in patterns of land use should take into account environmental variability. Variations in environmental characteristics over long time spans is significant to the study of adaptive behavior (Winterhalder 1980).

This study will test a foraging theory model to examine the relationship between the land use patterns of temporally distinct prehistoric hunter-gatherer groups and the characteristics of the badlands resources. The Middle Archaic McKean (5000 B.P. to 3000 B.P.) and the Besant of the Late Archaic/Woodland (2100 B.P. to 1000 B.P.) are considered in the study. The above approach will be used to determine whether changes in resources through time resulted in dissimilar use of the badlands landscape by the McKean and Besant.

This approach investigates the relationship between people and the natural environment in which they survive, focusing on specific characteristics of that environment and how they affect subsistence-settlement patterns. This is an area where resource occurrence can be used to predict where archeological sites are likely or least likely to be (Jochim 1976:9).

Two key assumptions of the approach are that (1) environmental factors have a significant effect on human adaptation and (2) they are conducive to scientific investigation. Following evolutionary biology, adaptation is linked to historical processes in natural ecosystems, with temporal variance and spatial heterogeneity of resources being significant factors
Winterhalder 1980:136). The environmental approach provides an avenue for beginning to understand the relationship between human behavioral and environmental variability (Smith and Winterhalder 1981:8).

The Little Missouri Badlands can be described as a heterogeneous, or patchy, environment, with an uneven distribution of diverse resources (flora, fauna, water, and stone). A patch is an ecologically defined area characterized by distinct resources. It is organism and problem defined, being related to the size, mobility, behavior, and perceptive abilities of the group being considered. Patches occur discontinuously across the landscape, having profound effects on the behavior of organisms that use them. Properties of patches that affect behavior include number of patch types, their size, quality, developmental dynamics of vegetation within patches, and distribution across the landscape. A concept related to patchiness is grain, referring to patterns of patch use by organisms. Grain can range from fine to coarse. Fine grain means the organism uses patches generally, in proportion to how they occur in the environment. The coarse grain designation is relevant to this study. A coarse grained response is characterized by selective patch use. The organism uses certain patches more than others (Winterhalder 1980:153-154, 1994:33).

Hill's (1988) analysis considered general biotic zones as a variable in explaining badlands site distribution. The current study will refine this somewhat, concentrating on a finer division of distinct vegetation patches present within the badlands. These vegetation patches vary in species composition and productivity,
influencing which kinds of game and the types and quantity of edible plant resources available for human consumption could be expected within them. The availability of plant and animal resources (in abundance and quality) to human groups changed through time in response to changing climatic conditions.

The McKean were present in the badlands during the Sub-Boreal climatic episode (Wendland 1978). During this episode conditions were moderating from the aridity of the preceding Atlantic episode. Cooler temperatures and increased precipitation led to environmental conditions similar to the present (Hoffman and Jones 1970:360-361). Patch productivity in the badlands during this time should have also been similar to today.

The Besant occupation of the region occurred primarily during the Sub-Atlantic episode, ending at the beginning of the subsequent Scandic episode (Wendland 1978). The Sub-Atlantic is characterized by continued cooling and increased precipitation in comparison to the Sub-Boreal. This difference in climate resulted in higher productivity of forage and game animals within patches. The Scandic episode marks the onset of warmer, drier conditions.

It has been observed that Plains foragers modified their strategies of food procurement to adjust for changes in ecological conditions (Greiser 1985; Bamforth 1988; Reeves 1990; Frison 1991). Therefore, I believe that changing environmental conditions led to a change in badlands resource structure. Due to resource structure alterations the McKean and Besant practiced different subsistence strategies that will be evident in their patterns of land use. This study will follow Kuehn (1990, 1993) in assuming that there is no difference in preference for certain
landforms between the two groups, and will concentrate on differential use of patches.

Assuming the McKeen and Besant had adapted to changes in badlands resource structure, I will show how by explaining patterns of site distribution using foraging theory from the field of evolutionary ecology. Evolutionary ecology applies natural selection theory in its study of adaptation and biological design in an ecological setting (Winterhalder 1981a:14; Smith 1991:34; Winterhalder and Smith 1992:5) and originated in the 1960’s from the work of population ecologists attempting to make ecology more rigorous. In its approach to ecological problems it uses a deductive orientation, usually constructs mathematical models, is frequently applied to behavioral aspects of ecology, and always follows the basic principles of natural selection (Smith and Winterhalder 1981:6).

A fundamental assumption of evolutionary ecology is that the relative frequency of traits in a population is the result of differential fitness among the individuals in that population (Kohler 1988:46). Underlying strategies, shaped by selection, are responsible for behavior that on average makes a larger contribution to the fitness of an individual than do other strategies, social learning as opposed to individual trial and error learning (Smith 1991:20, 35). Fitness is difficult to measure so correlates (e.g. net rate of energy capture, predator detection rates) are often employed (Kohler 1988:46; Smith 1991:35). Genetic causation of behavioral variability is not assumed, instead a capacity for adaptive decision making is proposed. Behavioral and environmental variability are stressed
in evolutionary ecology, making it well suited to the study of human adaptation (Smith and Winterhalder 1981:6-7).

Evolutionary ecology will guide this study of subsistence-settlement variations between the McKean and Besant in the Little Missouri Badlands. Both participated in hunting and gathering economies. As this study is attempting to discern and explain changes occurring over time between the two it is important to adhere to evolutionary concepts. Since evolutionary ecology is concerned with behavioral and environmental processes which relate to individual fitness, its basic principles provide a means for understanding changes in subsistence practices because these changes will probably bear directly on the reproductive and cultural fitness of those who forage for a living (Smith 1991:21-22). It allows for a focus on environmental conditions within the badlands and how McKean and Besant responded behaviorally to variations in resources over time.

This study does not directly test whether the McKean or the Besant are maximizing Darwinian fitness, because it is conducted within a space-like framework concerned with energy exchange and not with the differential survival of any genealogical entities. However, it is still important that it be conducted within an evolutionary framework. As Simms noted:

... subsistence is essential and basic and these characteristics make it a good starting point for working toward an understanding of human behavior in evolutionary terms. The link between the actual models and the theory of Darwinian evolution remains necessary even when important issues about Darwinian evolution itself are not tested. Such a link enables the empirical results to be compared to predictions from specified variables and constraints that are consistent within a larger theoretical framework [1987:100].
Foraging theory, based on the principles of evolutionary ecology, has developed over the last 30 years and provides a set of general models which produce testable explanations concerning the range of foraging behaviors practiced by animal species in different environmental conditions (Winterhalder 1981a:13; Smith 1983:626, 1991:41). The use of these models has increased because a significant portion of an animal’s life is devoted to feeding as compared to the time spent mating, fighting, or fleeing from predators (Krebs and McCleery 1984:95). The models center on patterns of foraging behavior which are expected to result in high net rates of energy acquisition. Foraging models examine optimal strategies in three fundamental areas: (1) food choice and diet breadth; (2) group organization; and (3) settlement pattern and patch use (Keene 1983:139). These features of foraging theory are a main reason for its use in hunter-gatherer research (Winterhalder 1981a:13).

Foraging theory, being a branch of evolutionary ecology, relies on assumptions from views of adaptation in natural selection theory. In particular, natural selection and competition are the inevitable outgrowths of reproduction in a finite environment (Pianka 1978:12) and foraging behavior has been "designed" to respond to changes in local conditions in a manner that enables the forager to acquire energy and nutrients, survive, and contribute to the following generation (Winterhalder 1981a:15; Smith 1983:626, 1991:42).

Genes are coded instructions, information, in DNA. Culture consists of information, symbols, beliefs, values, and ideals, and includes material expressions resulting from this information.
The information within genes and culture is inherited from previous generations. Cultural inheritance results from social learning, genetic inheritance from sexual reproduction. Phenotypes are arrived at by the interaction of genetic and cultural information, either separately or together, with the environment (Boyd and Richerson 1985). Foraging theory, being couched in evolutionary ecology, holds genetics and culture constant. This allows foraging studies to investigate how environmental variables affect foraging behavior (Smith 1991:20).

Foraging theory uses principles from formal optimization models to explain different foraging behaviors. Optimization models, used in decision theory, economics, and engineering, as well as evolutionary ecology, were primarily developed and used in economic theory (MacArthur and Pianka 1966:603; Bettinger 1980:208; Smith 1991:36). The optimization assumption underlying foraging theory is:

... under specified conditions selection is likely to favor from among the set of available strategies and choices those that maximize the net rate of energy capture while foraging [Smith and Winterhalder 1985:646].

The use of optimization analysis in evolutionary ecology to address evolutionary processes has received considerable debate (see Sahlins 1979; Krebs and McCleery 1984:91-121; Oster and Wilson 1984:271-288; Stephens and Krebs 1986). The link between optimization analysis and evolutionary processes generally follows three views. The first view is that evolution through natural selection is an optimizing process in itself (Sahlins 1979:71-72; Smith 1991:36; Smith and Winterhalder 1992:51). This view is characteristic of early ecological optimization studies, an
example being "... natural selection is defined and operates as a mechanism that maximizes fitness" (Cody 1974:1156). This view is no longer viable. In addition to natural selection other forces, including random genetic drift, gene flow (including isolation), and pleiotropy (Irons 1979; Sober 1987:108-116), exist which have an effect on evolutionary processes. Results from the effects of these other forces may not always be optimal. Also, the connection between selection and optimization is not precise. Selection deals in relative advantages. It favors higher fitness in existing variants, which is not always the best possible variant (Smith and Winterhalder 1992:52).

The second view proceeds from the first and implies that there is no place for optimization analysis in evolutionary theory. Critics (e.g. Gould and Lewontin 1979; Lewontin 1979, 1987; Martin 1983) argue that selection does not always favor optimal outcomes but often results in inefficiency (Stephens and Krebs 1986:213; Smith 1991:32; Smith and Winterhalder 1992:52). Another criticism is that organisms are faced with several adaptive problems and compromises must be made. Optimal decisions relating to one behavior may cause less than optimal decisions in another (Smith and Winterhalder 1992:52).

Proponents counter by arguing that an organism's traits are interconnected and that the optimal strategy for any trait is considered as one within a feasible set which is responsible for the greatest fitness, given the other traits an organism has and that each is optimal in the same context. In the research of specific adaptive problems this introduces extreme complexity because to comprehend one trait, the researcher needs to know all.
Little work is being conducted on whole-organism adaptation using optimality models due to this complexity. Instead research is concentrating on a single optimization problem at a time, considering them separate from other problems (Smith and Winterhalder 1992:52).

The third view is characteristic of the position held by most researchers using optimization models in evolutionary ecology. The models provide a methodology for ecological analysis (Smith and Winterhalder 1992:53) which serves to generate new explanations, provide researchers with testable hypotheses, and provide a bridge connecting abstract principles of natural selection theory to the diversity of behavior observed in the real world (Smith 1983:626, 1987:202, 1991:37). Optimization models, in evolutionary ecology, have been viewed more as an analytical tool rather than a theory. Smith (1987:202) notes that optimality models, "... are not complete explanations for any complex phenomena ... ". They are not meant to describe every aspect of real life foraging behavior or processes of adaptation by natural selection (Smith and Winterhalder 1992:50-51).

Researchers in evolutionary ecology who use principles of optimization in their analysis are not suggesting that natural selection is goal oriented (Smith 1987:223). However, they do acknowledge that it is persistent and cumulative. A trajectory can be thought optimal, if there is enough genetic variation and consistent selective pressures (Smith and Winterhalder 1992:53).

Three main components common to foraging and optimality models are listed below from Stephens and Krebs (1986:5):
1. Decision Assumptions. Which of the forager’s problems (or choices) are to be analyzed?

2. Currency Assumptions. How are various choices evaluated?

3. Constraint Assumptions. What limits the forager’s feasible choices, and what limits the currency that may be obtained?

The decision component relates to the foraging problem to be analyzed and consists of the decisions available to the forager. Decisions may be restricted to a few alternatives or encompass many. Optimization models often aid in choosing which decisions to analyze (Smith and Winterhalder 1992:54). This is accomplished by separating foraging problems into distinct choice categories. Examples include what to eat, where to look for food, and what route to take in looking for food. Rather than concentrating on specific foraging tactics they consider broad strategies, making models and data easier to manage (Krebs 1978:24; Smith 1983:626, 1991:41).

The currency component measures the costs and benefits of alternative choices. Currencies are used to rank preferences. The model predicts that a forager will choose the highest valued preference. Two general currencies are often employed, fitness and utility (Smith 1983:626, 1991:45-46; Smith and Winterhalder 1992:55). The generality of these currencies has proved troublesome as they are not precise in measuring choices (Smith and Winterhalder 1992:55). The fitness effects of foraging choices are difficult or impossible to quantify (Smith 1983:626, 1991:46) and utility cannot be reliably discerned from the choices made by a forager (Smith and Winterhalder 1992:56). Correlates,
or proxy currencies, that are less general and more operationally useful (Smith and Winterhalder 1992:56) are used instead.

The majority of foraging models use a currency referred to as net rate of energy gain, or energy efficiency (Winterhalder 1981a:20; Smith 1983:626, 1991:46; Stephens and Krebs 1986:8). Smith (1991:46) defines net rate of energy gain as "... a measure of the net metabolic energy (edible calories minus labor energy expended) acquired over some unit of foraging time". Net rate of energy gain, or net return rate, is frequently used as a currency because time and energy are easy to measure. Costs, energy used while foraging, and benefits, energy gained while foraging, are both measures of energy (Stephens and Krebs 1986:8). Time is an important element when using energy as a currency. It is an opportunity cost as time spent foraging cannot be used for different foraging and non-foraging activities (Smith 1991:50).

The use of energy efficiency as a currency has led some to believe that energy must be in short supply. This is not necessarily the case. Three conditions under which the maximization of energy efficiency can occur are presented below (Smith 1983:626, 1991:50).

1. Available energy is scarce or limiting; increased efficiency allows an increase in total energy gained.

2. Time for non-foraging activities is scarce or limiting; increased efficiency allows for energy to be gained in less time, allowing time for other activities.

3. Foraging exposes the forager to risk (predation, accident, etc.); increased efficiency allows for energy to be gained in less time, lowering the risk factor.
A forager who has a surplus of energy meets metabolic requirements and has energy left to devote to non-foraging activities (Stephens and Krebs 1986:8) such as the manufacture of tools and shelter, social interaction, status pursuits, defense, and leisure (Winterhalder 1981a:21). A forager need not be faced with starvation in order to realize the benefits of efficient foraging behavior (Smith 1983:626).

Stephens and Krebs (1986:9) consider constraints to be “… all those factors that limit and define the relationship between the currency and the decision variable(s)”. Variables not subject to the choice of the forager are constraints. Constraints are divided into two different types, extrinsic and intrinsic. Extrinsic constraints are limitations placed on the forager by the social or natural environment. Intrinsic constraints are limitations placed on the forager by phenotypical characteristics (Smith and Winterhalder 1992:56). Intrinsic constraints can be separated into two categories, factors limiting a forager’s requirements and factors which limit a forager’s abilities (Stephens and Krebs 1982:10; Smith 1991:57-58; Smith and Winterhalder 1992:56). Requirement limitations involve physiological and nutritional factors, among others. An example would be a forager needs X amount of nutrients to meet metabolic requirements in order to survive.

Often, few or no constraints are placed on foragers abilities in conventional foraging models (Stephens and Krebs 1982:10). The models employ the concept of complete information (Stephens and Krebs 1982:11; Smith 1991:59). Complete information does not mean
the forager is aware of the results of decisions before they are made. Stephens and Krebs state:

We call this complete information rather than perfect information because it does not imply that the forager is omniscient. A completely informed forager is like a gambler who knows the odds but cannot predict exactly what number will come up on the next spin of the wheel [1986:11].

In reality, foragers do not behave exactly according to the rules put forth by foraging models, but often appear to be. This is probably due to their use of rules of thumb. General rules of thumb were probably inherited through cultural and genetic evolution because they allow a forager to find low cost, optimal solutions to problems which may not be possible through rational choice or may be too costly by trial and error (Smith 1991:20; Smith and Winterhalder 1992:57-58). Also, it is probable that humans reach optimal solutions to complex decision problems because they have access, through conversation, cultural tradition, and lore, to the accumulated experiences of others who have faced the same or similar problems (Smith 1991:60-61; Smith and Winterhalder 1992:58).

The Marginal Value Theorem, a model from Foraging Theory, will be used to test for optimal use of the Little Missouri Badlands by the McKean and Besant. The MVT makes four distinct assumptions (Smith 1983:631, 1991:253; Stephens and Krebs 1986:25-28; Kaplan and Hill 1992:180). These assumptions are: (1) time spent foraging includes travel time (between patches) and hunting time (within selected patches); (2) encounters with patches are sequential and follow a Poisson process; (3) return rates within any patch are negatively accelerated and gradual depletion of
resources within patches results from foraging activities; and (4) the forager has complete information regarding patches (e.g. patch identity, productivity, and availability).

Several predictions are generated by this model. The following two Smith 1983:631, 1991:253; Kaplan and Hill 1992:180) are relevant to this study. The first prediction holds that the optimal forager should leave a selected patch when the marginal return rate is equal to the average of all patches within a set or the entire habitat. When resources within a patch are depleted to the point where foraging in another patch will result in higher returns, it is predicted that the forager will leave. The second is that the time spent in a selected patch will increase if a decline in the return rate for all other patches occurs. Less time is spent in selected patches if there is an increase in the overall return rate for all patches. This is because the average yields from all patches used by the forager directly bears on how much time is devoted to any one patch.

Smith (1991:253-255) discusses further implications raised by the MVT. First, decisions concerning which patch to use and how much time should be spent foraging within a patch cannot be made without considering the return rates from other patches. Choice and use of a resource patch depends on the quality of other patches. According to the MVT, even if a patch is characterized by a steady return rate its use, or nonuse, by foragers remains relative to other patches. If the return rate for other patches increases, less time will be spent within the consistent patch, or it will be abandoned. On the other hand, if the quality of other
patches decreases the consistent patch will be chosen for use with a corresponding increase in foraging time devoted to it.

According to Smith (1991:254-255) another implication involves hunter-gatherer mobility. There are several reasons, not all related to subsistence, for the movement of groups. However, ecological circumstances often play a significant role in these decisions. A widely held view in hunter-gatherer studies is that groups in unproductive environments move frequently due to the easy depletion of limited resources. The MVT supports this idea. Patches with low returns should experience shorter use time, but with the MVT it is possible that frequent moves and shorter time spent within patches are also possible in productive environments. The reasoning is that as the overall productivity of an environment increases foragers may experience higher returns by moving from a partially depleted patch to an adjacent patch unaffected by foraging. Conversely, the opposite may occur in unproductive environments.

Smith recognizes (1991:255) that not all forager movement hinges on subsistence needs. Movement, or extended stays, can often result because of social reasons, conflict and competition with neighboring groups, etc.

The final implication discussed by Smith (1991:255-256) concerns conservation, resource management, and prey extinction. According to the MVT patches will not be completely depleted of resources as the optimal forager will depart for patches which will provide a positive return rate. The MVT is not designed to determine whether foragers practice planned conservation or game management. The avoidance of resource depletion is predicted by
the MVT under specific conditions, but is only an incidental result of optimal foraging behavior.

Testing the MVT has proven difficult due to the extensive amount of data required, including information on marginal return rates for all patches over short periods of time and travel time between patches (Stephens and Krebs 1986; Smith 1991:257). The problem is compounded as the archeological record presents us with incomplete data over a broad time span. For this reason a simple test of the MVT, originally devised by Smith (1991:256-259) for his research of monthly and seasonal Inujiuamiut foraging behavior, will be used. According to Smith’s test (1991:258), the MVT predicts that "... foraging effort will correlate directly with the efficiency rank order, such that higher ranked patches will receive greater total allocations of foraging time".

Studies of patch use must also consider efficiency rankings of food resources, or diet breadth. These rankings allow for discussions concerning the order that food items within patches will be added or dropped. The primary proposition of optimal diet model is:

... a forager chooses from an available set of resources on the basis of their abundance and efficiency rank. Efficiency rank is measured as a function of the handling (post encounter) costs over the energy yield of the resource. Handling cost is composed of pursuit and processing which together equal handling time. Another type of cost is search time, which helps understand the proportions of resources in the diet [Simms 1987:15].

Many diet breadth studies use units of calories as a measure of yield. Search time is defined as being the time it takes for a forager to travel to and locate a resource patch or a resource within a patch with multiple resources. Pursuit time is the time
it takes for a forager to pursue or collect a resource after it is encountered. Processing time equals time required to process the resource item into useable form and handling time is the total of pursuit and processing times (Simms 1987:15-16).

Three important predictions from the diet breadth model are presented below (from Simms 1987:16-17):

1. High ranking (relatively inexpensive considering handling costs) resources will always be taken when they are encountered.

2. The inclusion of lower ranked resources in the diet will depend not only on their own abundance, but also on the abundance of higher ranked items.

3. As the abundance of higher ranked items decreases, lower ranked items will be included in the diet.

Patch productivity during the McKean occupation of the badlands region is expected to have been similar to the present as a result of the Sub-Boreal climatic episode. The Besant were present in the badlands primarily during the improved conditions of the Sub-Atlantic episode. The model predicts that changes in patch productivity in response to variations in climate will result in differential use of the badlands landscape by the McKean and Besant.

The environmental conditions of the Sub-Boreal episode were similar to today. Much of the archeological evidence concerning the McKean indicates that they participated in a broad spectrum subsistence system (Frison 1991, Keyser 1986). This would have included a significant amount of foraging effort devoted to plant foods. Numbers of large, aggregated, game animals would not have
been as high as during the favorable conditions of the Sub-Atlantic, resulting in higher search and pursuit costs for big game and lower return rates. The McKean did participate in the hunting of large animals when the opportunity presented itself, but big game hunting was not their primary focus. The gathering and processing of plant foods, which rank lower than animals when considering net return rates (Simms 1987), figured prominently in their subsistence strategies. Due to the somewhat prohibitive search and pursuit costs of big game hunting, lower ranking resources, such as plants and smaller animals, would have made up a significant portion of their diet. This should be reflected in McKean patch use, with patches ranking high in edible plants being intensively used.

Improved environmental conditions during the Sub-Atlantic episode would have increased forage production, supporting larger numbers of big game animals that would more frequently be aggregated. Search and pursuit costs for big game would be reduced with increased return rates in comparison to the Middle Plains Archaic. Thus, the Besant should allocate more of their foraging effort within patches favored by big game when compared to the McKean. This is not to say that the Besant did not expend foraging effort and time acquiring plant foods, only that, because of improved big game numbers, it was economically feasible to spend more foraging time in patches with large numbers of higher ranked big game.

For the model to be accepted, it must be shown that there is a change in behavior between the two with respect to patches emphasized during foraging. A change of this nature will be
evident in the archeological record for the McKean and the Besant. If the model is accurate McKean site location should reflect more foraging effort expended in patches that contained edible plant resources while Besant sites will indicate more intensive use of patches that had high large animal numbers.

There are important implications for badlands archeology if it can be demonstrated by using foraging theory that significant changes in foraging behavior occurred between the McKean and the Besant. Differences between McKean and Besant subsistence-settlement behavior indicate that they adapted their food getting strategies to variations in food resources in the Little Missouri Badlands. Variations in food resources were the result of changes in environmental conditions over time. This is important as previous archeological work in the Little Missouri Badlands concerning settlement behavior has not devoted much attention to subsistence adaptations, usually taking as a given that it occurred without investigating the "how" and "why" questions. Hill's (1988) research considering differences in prehistoric site location with changes in badlands food resources over time is an exception.

Although the archeological record within the Little Missouri Badlands, as well as other badlands settings, has definitely been impacted to a great degree by natural erosional processes, it still contains valuable information concerning changes in prehistoric lifeways. The archeological record is probably not capable of detecting fine-scale variability in prehistoric use of badlands resources. However, when considering the record from a more general perspective, visible patterns can reflect important
variations in subsistence behavior which "... are likely to be adaptively meaningful" (Broughton and Grayson 1993:133).

The use of models from foraging theory can be useful in identifying differences and evaluating changes in the foraging economies of hunting and gathering societies over time. For this study the MVT provided the methodology for examining changes in the use of the badlands environment. This is important to badlands archeology because past discussions concerning changes in subsistence-settlement behavior in the badlands have been somewhat intuitive, save for a few. Also, and probably most significantly, by using the MVT from foraging theory evidence for adaptations in prehistoric foraging behavior from the badlands can be considered within an evolutionary perspective.
CHAPTER 2
BACKGROUND INFORMATION

Study Area

The Little Missouri Badlands form a unique topographic region within the Missouri Plateau area of the Great Plains physiographic province (Fenneman 1931). The badlands are located on both sides of the Little Missouri River and range from 3.2 km to 24 km in width. The river flows within an approximately 960 km long channel which originates near the Missouri Buttes in northwestern Wyoming and terminates at its confluence with the Missouri River in west-central North Dakota (Simon and Kuehn 1982). The Little Missouri drainage is present within the Williston basin, a large structural and sedimentary basin, covering 520,000 km² in western North Dakota, eastern Montana, northwestern South Dakota, southwestern Manitoba, and southern Saskatchewan (Bluemle 1975:2). The Williston Basin contains a sedimentary rock sequence ranging in age from the Tertiary to the Cambrian overlaying a complex of pre-Cambrian igneous and metamorphic rock (Lau 1981:12; Bluemle 1977:1-2).

The steep, heavily dissected topography which characterizes the Little Missouri Badlands is the result of natural erosional processes which began during the Pleistocene and continued through the Holocene. These forces are dynamic and remain active at the present time. The formation of the badlands is due to headward erosion and rapid downcutting of the Little Missouri River and its tributaries through the unconsolidated sediments of the Fort Union
Group, deposited during the Paleocene Epoch of the Tertiary Period. Late Cretaceous Period formations are exposed in the lower Little Missouri drainage in the extreme southwestern corner of North Dakota (Bluemle 1991a:153-154; Kuehn 1982:44).

The Fort Union Members exposed along the Little Missouri River include, from youngest to oldest, the Sentinel Butte, Bullion Creek, Slope, and Ludlow. The marine, deltaic, and fluvial sediments of these units are lithologically similar, with clay, sandstone, shale, and lignite predominating (Clayton 1980). Deposition continued in the area throughout the Tertiary Period, as represented by the Golden Valley Formation (Eocene epoch) and the White River Group (Oligocene and Miocene epochs). These sediments were subsequently eroded and today are present only on the tops of isolated buttes in western North Dakota (Bluemle 1991a:154).

Pleistocene glaciation and preadvance stream piracy were major factors in the development of the Little Missouri Badlands. Before the onset of the episodic glacial advances and retreats the Missouri River and its tributaries, including the Little Missouri River, flowed north and eastward over a gently rolling peneplain before draining into Hudson Bay (Bluemle 1977:5). These watercourses were diverted along the southern glacial margins during major advances, being forced to occupy new channels. Eventually the Missouri River and its tributaries became part of the Mississippi River drainage network. Diversion of the Little Missouri River triggered the extreme erosional processes responsible for the badlands (Wykoff and Kuehn:139).
Tributary streams cut across drainage divides. At this point the river’s course was shortened and its gradient increased. This, combined with increased precipitation associated with the Kansan-Illinoisan glacial advances, resulted in the rapid downcutting and mass wasting of unconsolidated Fort Union group sediments (Bluemle 1977:11). Rejuvenation processes are believed to have originated at the mouth of the current river and moved upstream. This process of deepening and headward erosion also affected the valleys of the major tributaries emptying into the river (Kuehn 1990:18-19).

The subsequent Wisconsin ice sheets retreated at the end of the Pleistocene. It was during the period immediately following the withdrawal of the Wisconsin glaciers that the Little Missouri Badlands experienced the most extreme episode of erosion. Intensified mass wasting and slopewash of valley sideslopes occurred as a result of sparse vegetative cover, thin soils, and unstable hill slopes (Kuehn 1982:47; Moran et al. 1976:153).

Badlands terrain formation has been greatly affected by climatic fluctuations during the Holocene. Due to varying climatic conditions during the last 11,000 years slopes, upland surfaces, and drainages in the badlands have experienced several episodes of erosion and deposition. Periods of adequate moisture increased the density of vegetative cover, reducing erosion. However, as a result of preceding dry periods slopes were sparsely vegetated. Initial increases in precipitation caused slopewash and mass wasting, resulting in valley cutting and filling. These processes continued until vegetation was adequate and slopes became stabilized (Kuehn 1990:19-20).
The dynamic erosional forces responsible for the badlands have created a diverse landscape. Badlands settings are characterized by several different landform types. Kuehn (1990:24-25) devised a framework of landform types and descriptions for badlands terrain. This was done to aid in interpreting site locational data from an archeological inventory of the North and South Units of the Theodore Roosevelt National Park, present within the Little Missouri Badlands. This framework is presented below to familiarize the reader with landform types present within the badlands.

1. **Upland Grasslands**: The uneroded Missouri Plateau. The grasslands occur along the periphery of the badlands. They are also present on the tops of large ridges which extend into the badlands.

2. **The Little Missouri Escarpment**: The abrupt slope and eroding edge of the Missouri Plateau, marking the transition between the Upland Grasslands and the Little Missouri Badlands.

3. **Ridges**: Linear upland remnants which either extend into the badlands from the Missouri Plateau, or which have been detached from the Plateau by erosion. Ridges generally have a length:width ratio of at least 2:1.

4. **Buttes**: Isolated upland remnants which are not linear in shape and which are more severely eroded and hence smaller than ridges. Buttes generally have a length:width ratio of less than 2:1.

5. **Knobs**: Small, highly eroded and rounded buttes.

6. **Foothills**: Eroded remnants at the base or foot of ridges, buttes, escarpments or other uplands which remain articulated to
the more elevated landform. They are intermediate in elevation between uplands and lowlands.

7. Slopes: The sides of ridges, buttes, knobs, foothills, the Little Missouri Escarpment, and drainages. These slopes are steep (often over 45%) and lack soil and vegetation. Some slopes are less steep and are covered by grasses, trees, and shrubs.

8. Toe Slopes: Occur at the base of slopes and consist of colluvially deposited sediments.

9. Colluvial flats: Flat accumulations of slopewash materials present below the base of slopes. These flats commonly grade into terrace deposits.

10. Terraces: Occur adjacent to streams. Flat lowlands formed of alluvial sediments or flat benches that have been cut by stream action into Tertiary sediments.

11. Drainages: All drainage channels and active floodplains.

The Little Missouri River and its tributaries form a dendritic drainage system. The river is a perennial, slow flowing water course which empties into the Missouri River in west-central North Dakota. During the fall and dry years the surface flow is reduced to near zero along some stretches of the river. It freezes solid during extremely cold winters. Numerous permanent and intermittent, low yielding, streams drain the badlands into the Little Missouri River. Their greatest discharge is in the spring during snowmelt. High discharges can also occur during the summer months in response to locally heavy precipitation. The drainage basin sizes of these tributaries varies from small to large throughout the badlands (Kuehn and Gregg 1985:192; Kuehn 1991:8-9; United States Department of Agriculture, Custer National
Climate is an important factor in studying human subsistence behavior. It influences which plant and animal communities will exist in an area, vegetation productivity, and animal carrying capacity. Changes in climate affect plant and animal communities. Current climatic conditions for the study area are presented below. Awareness of current climate allows a reader to understand how paleoclimatic conditions, to be discussed later, affected badlands plants and animals.

The modern climate in the Little Missouri Badlands is semi-arid and is effected by four major air masses. The Continental-Polar air mass, originating to the north, is dry and cool. The Maritime-Polar air mass, from the Pacific Ocean, is moisture laden. By the time this air mass reaches the study area its moisture content is greatly reduced from crossing over the Rocky Mountains. The following two air masses have their greatest impact on the study area during the summer months. The Maritime-Tropical air mass is composed of moist, warm air and originates in the Gulf of Mexico, while the Continental-Tropical air mass is of dry, warm air heated in the center of the United States (Stewart and Stewart 1973:13).

The unsettled weather during the spring months results from the movement, at irregular intervals, of all major air masses with Continental-Polar and Maritime-Polar masses being dominant. The Maritime-Tropical from the south reaches the study area occasionally and joins with western fronts to produce significant precipitation. The summer and fall months are dominated by the
Maritime-Polar masses, with southern fronts intruding sporadically. These southern fronts often bring with them large amounts of moisture in the form of rain showers. The Continental-Tropical mass is responsible for periods of extremely hot and dry conditions during the summer. The winter months, like most of the year, is primarily affected by the Maritime-Polar air mass, bringing fronts and winds from the west. Bitterly cold temperatures and dangerous wind chill factors are the result of the Continental-Polar air mass dropping out of the north (Deaver and Deaver 1988a:15).

The study area experiences extreme seasonal and yearly fluctuations in temperature and precipitation. Extreme temperatures vary from -37° C to 38° C. Monthly temperature averages range from -11° C in January to 22° C in July, with winters being long and cold, and summers hot and dry. The average length of the frost-free period is around 120 days, running from May 10-20 to September 15-25. Annual mean precipitation is 38 cm. Around 70% of this precipitation is received from May through September. The majority of the summer rainfall occurs as localized thunderstorms characterized by high intensity and short duration. Frequently, spectacular hail is produced by these thunderstorms. Drought conditions, resulting from consecutive years with inadequate moisture, occur in southwestern North Dakota about 40% of the time. Average mean snowfall is 76 cm with the mean number of days with a snow depth of 15 cm or more being around 22 days. The prevailing wind direction is from the west-northwest (USDA, CNF and USDI, BLM 1995:III-8; United States
Soils in the badlands, influenced by erosion and recent sediment age, generally do not have well developed pedogenic horizons. They are classified as Entisols (Ruhe 1984:13). Kuehn (1991:7) observed "... soils in the upland areas are older and have more strongly developed pedogenic horizons than do soils in the lowlands". This is attributed to the relative stability of upland landforms in comparison to the erosional nature of lowland settings (Kuehn 1993:329-330). Prominent soils in the upland and lowland settings are well drained loams, silty loams, clay loams, and sandy loams. These soils are present in areas characterized by level to rolling surfaces. Soils on steep slopes have a thin surface layer and outcrops of sedimentary rock are prevalent. These steep slopes have little or no vegetation; their soils are well to excessively drained and susceptible to water erosion. Mass wasting is common (Stewart and Stewart 1973:91).

The development of soils in the study area has been in response to several different factors including parent material, topography, climate, and vegetation. In western North Dakota soils are predominantly light brown in color. This is due to their relatively low organic material content, 2%-3% on average, a result of the semiarid climate in this region. The annual production of plant biomass per unit area is low, contributing to slow soil development (Bluemle 1991a:91). This is relevant to the study as percentage of organic material, along with other soil characteristics including texture, thickness of organic layer, and calcium carbonate depth (Tisdale and Bramble-Brohdahl 1983; USDA,
SCS 1998a), are used to determine which types of vegetation grow in different soils. This can be used to estimate vegetation patterns in the past (Deaver and Deaver 1988b:2).

Plant communities are the primary producers in ecosystems (Winterhalder 1980:153). Their composition and productivity is determined primarily by soil, climate, and topography (USDA, SCS 1998b). Disturbance and succession are also major contributors to composition and productivity (Winterhalder 1981b:78). The distribution of individual plant species within the badlands is varied. Some species are only present in certain soils and landscape positions. Of course, the distribution of animal species is generally correlated with vegetation communities (USDA, CNF and USDI, BLM 1995:III-4).

Vegetation communities and associated animal species can be retrodicted for soil types in which archeological sites are located. Knowing this, subsistence behavior can be investigated for prehistoric groups who used resources in the badlands.

The Little Missouri Badlands are characterized by greater floral diversity than the surrounding plains. This diversity is the result of different elevations, geology, soils, slope, and exposure. The dominant floral community in the badlands is the western wheatgrass-sagebrush. Characteristic vegetation in the lowland areas include several varieties of sagebrush, buckbrush, perennial mixed grasses, and prickly pear cactus. Large dense groves of hardwoods, including cottonwood, green ash, box elder, and American elm, are present along portions of the Little Missouri River and larger tributaries. Willow thickets are also found along the river. Fruit-bearing shrubs and plants, including
chokecherry, American plum, serviceberry, currents, and gooseberry, are also found along waterways. Vegetation on badlands slopes is responsive to exposure to the sun. South-facing slopes generally support very sparse or no vegetation. Exposure to temperature extremes and desiccation from wind and sun result in erosion, and consequently little plant growth. Vegetation hardy enough to survive these conditions include yucca, rabbitbrush, and sagebrush. North-facing slopes and foothills, being somewhat protected from these extremes, have dense growths of Rocky Mountain juniper, green ash, sage, buffaloberry bushes, buckbrush, prickly pear cactus, and perennial mixed grasses. In the vicinity of springs and seeps stands of Quaking aspen will occur occasionally. The upland ridgetops are generally densely covered by mixed grasses. Other plant types include sage, buckbrush, prickly pear cactus, various wildflowers, wild onions, and prairie turnip (Stewart and Stewart 1973:34; Simon and Kuehn 1982:8; Ritterbush 1983:616; State Historical Society of North Dakota 1990:1.5; Kuehn 1991:9).

Undoubtedly, this diversity of vegetation within the badlands influenced the subsistence activities and movements of prehistoric groups. Seasonality and location of edible plants, and types and abundance of game animals using different vegetation patches factored into decisions of where people went to procure food resources in the badlands.
Paleoclimate

The productivity of vegetation communities within the badlands is believed to have changed through time in response to environmental conditions. These changes in productivity affected prehistoric groups who relied on edible plants and game species present in certain communities. Climate is a primary factor when considering the availability of natural resources to prehistoric groups through time. Three paleoclimatic episodes are relevant to this study, the Sub-Boreal, Sub-Atlantic, and the Scandic (Bryson et al. 1970; Wendland and Bryson 1974; Wendland 1978).

The Sub-Boreal episode occurred between approximately 5000 and 3000 B.P. and corresponds with the presence of the McKean. This climatic episode is characterized by a trend towards cooler temperatures and an increase in precipitation, in comparison to the preceding Atlantic episode. During this time the southern edge of the northern boreal forest moved southward to its approximate present location (Burley et al. 1982:51). Stratigraphic pollen and phytolith analysis conducted at sites 32BI317 (Scott and Lewis 1983a) and 32DU285 (Scott and Lewis 1983b) in western North Dakota indicate that after 5000 B.P. vegetation similar to the present became established. Little change in species composition was evident in pollen profiles from then till now. The pollen records from two lakes in the northern plains of Montana also indicate the onset of cooler and moister conditions during this period (Barnosky 1989).

In North Dakota, the lower Thompson paleosol, within the Riverdale Member of the Oahe Formation, correlates with the
beginning of the Sub-Boreal episode, evidence for increased precipitation and landform stabilization (Gregg and Davidson 1985:6). Modern faunal species are represented in the archeological record by the early part of the Sub-Boreal (Greiser 1985:22). As the climate moderated during the Sub-Boreal episode, from the arid conditions of the preceding Atlantic episode, conditions became similar to the present (Hoffman and Jones 1970:360-361). The productivity of vegetation communities within the Little Missouri Badlands during this time is expected to be comparable to modern.

The Besant were present in the badlands during the latter part of the Sub-Atlantic episode, 3000 to 1600 B.P., and into the early Scandic episode. The Sub-Atlantic episode, is characterized by continued cooling and increased moisture. Precipitation increased during this time to higher than modern levels (Bryson and Wendland 1967; Wendland and Bryson 1974; Wigand 1987). Glaciers in the Rocky Mountains advanced during this period (Richmond 1965; Fall et al. 1995). Pollen evidence from the Great Basin in eastern Oregon (Miller and Wigand 1994) and the Wind River Range in western Wyoming (Fall et al. 1995) indicate an expansion of pine forests downslope. Miller and Wigand (1994:467) also note a rise in regional water tables and an increase of grass pollen over sagebrush. The upper Thompson paleosol formed at the end of the Sub-Boreal and the beginning of the Sub-Atlantic episode in North Dakota (Gregg and Davidson 1985:6). It is probable that vegetation production in the badlands would be above normal standards, supporting large numbers of game species.
The end of the Sub-Atlantic is marked by the onset of warmer and drier climatic conditions, the Scandic episode (Reeves 1969; Wendland and Bryson 1974). During the Scandic, alpine glaciation moderated (Richmond 1965), water tables lowered, pine forests retreated upslope (Wigand 1987) and sagebrush pollen increased in relation to grass (Miller and Wigand 1994:468; Markgraf and Lennon 1986). Badlands vegetation productivity would gradually decline as the Scandic episode progressed.

Devils Lake, in northeastern North Dakota, is located within a basin that has a closed and nonintegrated drainage, when lake levels are normal. When lake levels rise water flows into neighboring Stump Lake. If the water continues to rise it overflows into the Sheyenne River. Work on the sedimentary history of the lake (Callender 1968:246-258) and radiocarbon dating of buried soils overlain by beach deposits (Bluemle 1991b:10) show that lake levels have fluctuated throughout the Holocene due to changes in annual precipitation. Gregg (1994:2.3-2.4) correlated lake levels with prehistoric cultures on the Northern Plains. During McKean times, lake levels were normal to slightly below normal. Lake levels were high to the point of overflow during the time the Besant would have been present.

Toom's (1992) research of climate and the origin of Plains Village culture provides a detailed view of paleoclimatic conditions in the Middle Missouri subarea. He examined stratigraphic sequences from several archeological sites in the Lake Sharpe area along the Missouri River in central South Dakota. Observations of geomorphic stability and instability, and soil classification (considering how certain soil types are associated
with prevailing environmental conditions) allowed for interpretations of paleoclimate (1992:319).

Data correlating to the Sub-Boreal episode from the Lake Sharpe area agree with the paleoclimate models considered above. Data for the Sub-Atlantic and Scandic vary slightly from the above proposed conditions for these episodes. Evidence from soil formation and low sedimentation rates indicates that the end of the Sub-Atlantic and the Scandic were warm and moist (Toom 1992:347-349).

If these conditions existed in the Little Missouri Badlands during Sub-Atlantic and Scandic episodes, they do not alter my predictions concerning Besant subsistence practices. The Besant presence in the badlands still coincides with what can be interpreted as favorable climatic conditions.

The above discussion concerning climatic change is somewhat broad and relies on proxy data from a large area to infer paleoenvironmental conditions. It is understood that paleoclimatic conditions were variable within episodes and in different regions of North America. However, these general paleoclimatic trends are felt to be applicable to the Little Missouri Badlands (Kuehn 1990; Gregg and Davidson 1985). The small body of paleoenvironmental data recovered from the badlands correspond with the above mentioned paleoclimatic models.

**Study Populations**

The McKean and the Besant are considered in this study of prehistoric land use in the Little Missouri Badlands. McKean
sites date from ca. 5000 B.P. to 3100 B.P., within the Middle Archaic Tradition, and have a wide geographic distribution in central North America. The name is from the McKean type site located along the Belle Fourche River in northeastern Wyoming (Mulloy 1954).

The McKean complex includes three stylistically similar lanceolate dart points; McKean, Duncan, and Hanna. Wheeler (1952, 1954) originally defined the three as separate point types. The three types have been considered as the McKean complex after all were discovered together at the McKean site (Mulloy 1954). Other projectile point types are also within the McKean complex including Mallory (Gregg 1985:108), and other unnamed types (Frison 1978:50). The McKean complex represents a number of different point types recovered separately or together in various combinations from sites with varying dates.

This has led to a discussion of whether the different point styles changed sequentially through time (Frison 1978) or that the McKean complex is composed of related, contemporaneous cultural groups with generally similar adaptive strategies (Beckes and Keyser 1983:177; Gregg 1985:108). Reeves (1983) uses the variation noted in the McKean complex to define the first two of four sequential phases of the TUNAXA cultural tradition. This analysis will consider the McKean complex as representing contemporaneous cultural groups who participated in similar lifeways and refer to them as McKean. McKean, Duncan, and Hanna point varieties are the most frequent in the badlands archeological record.
The McKean occupied several different ecological areas within the Northwestern Plains (Frison 1991:89) and used a variety of resources for subsistence. The diversity in resources used is evident in the materials recovered from McKean sites. Examples include bison, antelope, and mountain sheep remains from the Lightning Spring Site (Keyser and Davis 1984) in northwestern South Dakota, mountain sheep and mule deer remains being well represented at the Dead Indian Creek Site (Frison 1978:54) in northwestern Wyoming, and antelope bone at the Crooks Site (McKern 1987) in central Wyoming. The Scoggin Site (Lobdell 1973) in south-central Wyoming, a bison jump and trap, shows that the McKean also communally hunted big game, although this is not a common McKean site type.

Manos, milling stones, roasting pit hearths, and floral remains recovered from several sites in the southern portion of the Northwestern Plains indicate that plant resources were an important aspect of the McKean diet (Keyser 1986:225-226). Evidence for the processing of plant materials is rare in the northern portion of the Northwestern Plains. Brumley (1975:85) feels that McKean subsistence strategies focused on bison in this region.

Another important characteristic of the McKean is their use of residential structures. In Wyoming several sites, including the Crooks Site (McKern 1987) and the Bald Knob Site (Reust et al. 1993), contain the remains of pit house structures. Stone circles, associated with the use of conical, hide-covered tipi superstructures, increase in number during the Middle Archaic (Frison 1991:92; Larson 1997:364). A subsurface stone circle was
excavated at the Cactus Flower Site (Brumley 1975:85) in southern Alberta.

Within the majority of the Northwestern Plains the McKean complex is characterized by a broad spectrum subsistence strategy. They used a wide variety of floral and faunal resources implying relatively small residential groups and short, but frequent moves to seasonally available resources. This mobility and land-use pattern places them towards the forager end of Binford’s (1980:5-10, 15) forager-collector continuum.

Evidence of focused bison use by the McKean in the northern portions of the Northwest Plains indicates a shift in subsistence behavior from broad spectrum foraging to more intensive big game hunting. This shift could be regional in that vegetation composition and productivity in this area favored large numbers of bison compared to other areas of the Northwestern Plains. Or temporal, the cool-moist trend of the Sub-Boreal climatic episode culminated in high productivity of grasslands forage species and increased bison numbers by the end of the Middle Archaic. Regardless, it implies that the McKean in this area werelogistically mobile placing them towards the collector end of the forager-collector continuum (Binford 1980:13).

The question concerning the relationship between the "Besant" and the "Sonota" has been raised several times in the past (Neuman 1975; Sym 1977; Dyck 1983; Reeves 1983; Root 1983; Gregg 1985). The question relates to whether they should be considered as a single taxonomic unit or two (Root 1983:994). The Sonota were first described by Nueman (1975) and are contemporaneous with the Besant (ca. 2100 B.P. to 1400 B.P.), except that their presence
lasted 600 years longer than the Besant (1000 B.P.). Sonota sites are generally limited to the Middle Missouri subarea from central South Dakota to central North Dakota. They also extend into northeastern North Dakota.

The Sonota are characterized by the use of burial mounds and cord-marked, conoidal ceramics. Sonota burial mounds are present only in the Middle Missouri subarea and the ceramics are rarely recovered outside of this area (Root 1983:994). However, ceramics and mounds do occur at Besant sites further to the west (Johnson 1977; Dyck 1983). Projectile points recovered from Sonota sites are no different than Besant dart points (described below). The remains of a dwelling structure, consisting of an oval arrangement of post holes, a center fire hearth, and associated ceramics, bone, mussel shell, and fire cracked rock just outside the exterior, was unearthed at the La Roche Site in South Dakota and is similar to structures excavated at Early Woodland sites to the east (Dyck 1983:113). A structure affiliated with a Besant occupation, which was partially excavated, was also present at the Mortlach Site. However, there is some question to its exact function (Wettlaufer 1955:41-43).

Besant sites date from ca. 2100 B.P. to 1400 B.P. and overlap the end of the Late Archaic and the Early Woodland. The Besant are known for their "extreme degree of specialization in upland living and upland game (bison) hunting using specialized communal techniques" (Deaver and Deaver 1988a:98). They used the pound method, constructing complex corrals, as evidenced at the Ruby Site (Frison 1971) and Muddy Creek Site in Wyoming (Frison 1978:221-222). At the Ruby Site, the alignment of post holes and
associated timbers, indicate the presence of a structure adjacent to the pound corral. Some believe this possibly represents a religious structure (Frison 1978:220-221). Bison jumps were also used, the Old Women’s Buffalo Jump Site being an example (Forbis 1962). Large stone circle (tipi ring) sites are also a common feature of the Besant. They are frequently associated with Besant kill sites

The Besant used large, side-notched, dart-type projectile points (Frison 1978:59). Another projectile point associated with Besant sites is termed Samantha (Kehoe and Kehoe 1968). These points are smaller but resemble the Besant dart point. Samantha points are not common at Besant sites and are thought to represent early bow and arrow technology (Reeves 1970:162; Deaver and Deaver 1988a:101).

An interesting feature of Besant lithic technology was the intensive use of chalcedony, from the Knife River Flint Quarries in western North Dakota, for the manufacture of projectile points and other stone tools. A widespread exchange system is suggested because the material type is present in Besant sites located great distances from the quarries (Clark 1984).

There is evidence for the participation of the Besant and Sonota in the Hopewell Interaction Sphere (HIS). Artifacts of Knife River flint and stylistic similarities between dart points exist in mortuary offerings recovered from Middle Woodland sites in the upper Mississippi Valley (Braun et al. 1982:86). Burial mounds appear in the Middle Missouri subarea at the time the HIS was operating and Sonota burial offerings consisted of materials
obtainable through the HIS including copper and conch shell (Gregg
1985:121).

The above evidence indicates that the Sonota share many
similarities with the Besant, including projectile point style, a
preference for Knife River flint, ceramics, mounds, and the
intensive use of bison. These similarities are considered to be
more significant than any differences that may be noted. I will
treat the two as a single population, referred to as Besant.

The Besant presence in the badlands correlates with the
latter portion of the Sub-Atlantic climatic episode, characterized
by increased precipitation. These conditions are associated with
increased forage and high, concentrated numbers of large game
(Bamforth 1988). The focus on bison hunting indicates that the
Besant, and the McKean in the northern Northwestern Plains, were
logistically organized (Binford 1980:10-12). However, Bamforth
(1997:19-20) suggests that hunter-gatherer groups practicing
communal bison hunting may grade more towards the forager end of
the forager-collector continuum because entire social units were
moved to the bison for communal harvests rather than special task
groups.
CHAPTER 3
DATA COLLECTION

The marginal value theorem tests for the optimal pattern of time allocation to patches within a set, which results in the highest rate of energy capture (Smith 1983:630). Patches are ranked according to energy return rates. Efficient foragers should dedicate most of their foraging effort within higher ranked patches. The environment, e.g. climatic conditions, has an affect on the return rates of resources within patches. A change in the environment over time can affect the return rates of patches, altering patch rankings. In response, foragers should adjust subsistence strategies, patterns of patch use, to continue gaining high rates of energy.

From this, it follows that differences in patch use intensity over time indicate changes in subsistence-settlement strategies resulting from changes in the return rates of patches. Foraging strategies can be identified by examining the archeological record and its relationship to resource patches. As observed in Chapter 1, it is assumed that visible patterns in the archeological record "... are likely to be adaptively meaningful" (Broughton and Grayson 1993:133).

To investigate for changes in subsistence-settlement behavior between the McKean and the Besant, recorded archeological sites attributed to the two were drawn from the Little Missouri Badlands region in North Dakota (Figure 1). The study area includes the badlands areas within Billings, McKenzie, Slope, Golden Valley,
Figure 1. Location map of the study area.
and Bowman Counties. The Little Missouri River flows through all of the counties and each has extensive badlands within its boundaries.

A large number of cultural resources inventory projects have been conducted in the badlands within North Dakota. Much of this work was associated with oil and natural gas exploration and development projects occurring on federally managed U.S. Forest Service and Bureau of Land Management lands (State Historical Society of North Dakota 1990:1.6). A variety of different survey types have been conducted including numerous 4 and 16 ha well pad surveys, sample surveys of large blocks (Kuehn 1990, 1991), surveys focusing on specific landforms (Loendorf et al. 1982), long transects for pipelines crossing the badlands (Root and Gregg 1983; Gregg et al. 1985; Artz et al. 1987), and several short transects for access roads, county roads, short pipelines, and various other small projects. As a result, a large number of archaeological sites have been recorded.

Several archaeological test excavation projects have been conducted in the badlands. Again, these were the result of oil and natural gas exploration and development. In contrast to the large number of test excavations very few major excavation (mitigation) projects have been conducted. This is because developers and federal managing agencies try to avoid construction related impacts to potentially significant and significant sites (State Historical Society of North Dakota 1990:1.39-1.45).

Data concerning McKean and Besant sites were retrieved from North Dakota Cultural Resources Survey Archeological Site Forms and relevant archeological contract reports. The site forms and
reports were stored at the offices of University of North Dakota Archeological Research (UNDAR)-West, Belfield and at the State Historical Society of North Dakota in Bismarck. I reviewed all site forms within the sample area, identifying all McKean and Besant sites within the badlands and recording all information pertinent to the current study. In addition, I consulted contract reports to further assess site information.

Data gathered for each site included legal location, topographical location (on U.S.G.S. quadrangle maps) and artifact content. All sites consisted of sparse to dense cultural material scatters. Only sites with diagnostic artifacts (identifiable projectile points) were considered for this study. Typological cross-dating has been used extensively in the badlands, as in other regions, to determine the temporal and cultural affiliation of recorded sites. Sites assigned to broad temporal periods (e.g. Middle Archaic and Late Archaic) solely on the basis of radiocarbon dating were not included because they could not be associated with specific cultural complexes.

The above information for McKean and Besant archeological sites was compared with data from the relevant County Soil Survey Manuals (USDA, SCS 1975, 1978, 1989, 1998a, 1998b). This was done to associate the above archeological sites with range sites. The Soil Survey Manuals for Billings and McKenzie counties are currently being updated as the original manuals were completed in the 1940’s and are antiquated. As a result much of the this work for both counties was conducted by going to the respective United States Department of Agriculture, Soil Conservation Service Office’s in Dickinson and Watford City, North Dakota.
This process involved translating archeological site topographic location to corresponding aerial photos. The aerial photos contained the boundaries of mapped soil types. From this it was determined which soil types the archeological sites were associated with. Next, Range Site Descriptions and Rangeland Productivity and Characteristic Plant Communities Tables (USDA, SCS 1975, 1978, 1989, 1998a, 1998b) for the badlands were consulted for each county. The Range Site Descriptions link individual soil types with range sites. For this study range sites are used to define patches, as they delineate the boundaries of specific vegetation communities. Vegetation is often used to distinguish different patch types in studies of foraging strategy (Winterhalder 1980:153, 1981:75; Smith 1991:262). Winterhalder (1980:153) observes, “Vegetation provides an obvious landscape element for establishing patchiness”.

Included within the Range Site Descriptions is a discussion regarding kinds of wildlife species that utilize each range site. This information will be considered in the study because prehistoric groups were well aware that game species preferred certain patches. Unfortunately, only species currently inhabiting the badlands were listed. Species that were important resources for prehistoric groups, bison, elk, and bighorn sheep were not accounted for. These species were exterminated from the region following European settlement in the 1800’s. Suitability of range sites for domestic livestock grazing was used as a proxy for bison (with the understanding that there are slight differences in grazing behavior between bison and domestic cows).
According to the Range Site Descriptions some game species are capable of using forage in several different patches. An example is the potential presence of white-tailed and mule deer in all defined patch types within the badlands. It is important to note that the presence and abundance of game species within these patches is related to forage productivity. Hence, game species are more likely to be present in patches with higher productivity values for the forage they subsist on. All species potentially used by the McKean and Besant are not represented, only general species appearing in the Range Site Descriptions for each county (USDA, SCS 1975, 1978, 1989, 1998a, 1998b) are listed.

From the Rangeland Productivity and Characteristic Plant Communities Tables total production values for vegetation were considered for range sites included in the study. Total production lists the vegetation dry weight (lb/acre) for each range site. Values for dry weight are presented by kind of year, or growing conditions. Kind of year is divided into three categories, favorable, normal, and unfavorable. Production values for a range site vary slightly depending on soil characteristics and topographical position. Forage production is greatly affected by climate. Favorable production years, mainly resulting from higher precipitation, provide better forage conditions and higher densities of large herbivores (Coe et al. 1976; Sims and Singh 1978; Bamforth 1987:31-39). Characteristics of patch types (range sites) that contain recorded McKean and/or Besant sites are presented in Table 2.
Table 2. Forage and Faunal Characteristics of Little Missouri Badlands Patch Types Containing McKean and Besant Archaeological Sites (Adapted from USDA, SCS 1998a, 1998b).

<table>
<thead>
<tr>
<th>Patch Type</th>
<th>Total Production (lb/acre)</th>
<th>Associated Fauna (deer in all)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overflow</td>
<td>Favorable: 3000 Normal: 2600</td>
<td>Bison, cottontail rabbit, sharp-tailed grouse</td>
</tr>
<tr>
<td>Sandy</td>
<td>Favorable: 2400 Normal: 2000</td>
<td>Bison, antelope, jackrabbit, sharp-tailed grouse</td>
</tr>
<tr>
<td>Silty</td>
<td>Favorable: 2100 Normal: 1800</td>
<td>Bison, antelope, jackrabbit, sharp-tailed grouse</td>
</tr>
<tr>
<td>Clayey</td>
<td>Favorable: 2000 Normal: 1700</td>
<td>Bison, jackrabbit, sharp-tailed grouse</td>
</tr>
<tr>
<td>Shallow</td>
<td>Favorable: 1700 Normal: 1400</td>
<td>Bison, sharp-tailed grouse</td>
</tr>
<tr>
<td>Claypan</td>
<td>Favorable: 1300 Normal: 1100</td>
<td>Bison, antelope, jackrabbit</td>
</tr>
<tr>
<td>Thin</td>
<td>Favorable: 700 Normal: 500</td>
<td>Antelope, jackrabbit</td>
</tr>
</tbody>
</table>

Edible plant resources are considered because plant gathering played a prominent role in the subsistence strategies of hunter-gatherers (Simms 1987; Frison 1991). Evidence recovered from several McKean sites on the Northwestern Plains, including plant processing tools, roasting pit hearths, and floral remains, indicates that plant resources were important items in the McKean diet (Keyser 1986:225-226). Common edible plant types within the patch types (range sites) included in this study are presented in Table 3.

The use of the plant species listed in Table 3 have been documented in ethnographic research of Northwestern Plains groups (Gilmore 1977; Rogers 1980; Latady and Dueholm 1985:82-83). Obviously, not all edible plants used by prehistoric groups living in the Little Missouri Badlands are accounted for in the table. However, the species listed represent potential resources for
Table 3. Common Edible Plant Resources Within Little Missouri Badlands Patch Types Containing McKean and Besant Archeological Sites (Adapted from Deaver and Deaver 1988b:12-15; USDA, SCS 1998a, 1998b).

<table>
<thead>
<tr>
<th>Patch Type</th>
<th>Edible Plant Resources ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overflow</td>
<td>Grasses: Bluegrass</td>
</tr>
<tr>
<td></td>
<td>Forbs: Scurfpea, Sunflower</td>
</tr>
<tr>
<td></td>
<td>Shrubs²: Western Snowberry, Juneberry</td>
</tr>
<tr>
<td>Sandy</td>
<td>Grasses: Indian Ricegrass, Bluegrass</td>
</tr>
<tr>
<td></td>
<td>Forbs: Scurfpea</td>
</tr>
<tr>
<td></td>
<td>Shrubs: Western Snowberry</td>
</tr>
<tr>
<td>Silty</td>
<td>Grasses: Bluegrass</td>
</tr>
<tr>
<td></td>
<td>Forbs: Scurfpea, Biscuitroot</td>
</tr>
<tr>
<td></td>
<td>Shrubs²: Western Snowberry</td>
</tr>
<tr>
<td>Clayey</td>
<td>Grasses: Bluegrass</td>
</tr>
<tr>
<td></td>
<td>Forbs: Biscuitroot, Onion</td>
</tr>
<tr>
<td></td>
<td>Shrubs: Nuttall Saltbush, Western Snowberry</td>
</tr>
<tr>
<td>Shallow</td>
<td>Grasses: Bluegrass</td>
</tr>
<tr>
<td></td>
<td>Forbs: Scurfpea</td>
</tr>
<tr>
<td></td>
<td>Shrubs²: Western Snowberry</td>
</tr>
<tr>
<td>Claypan</td>
<td>Grasses: Bluegrass, Saltgrass</td>
</tr>
<tr>
<td></td>
<td>Forbs: -</td>
</tr>
<tr>
<td></td>
<td>Shrubs: Nuttall Saltbush</td>
</tr>
<tr>
<td>Thin</td>
<td>Grasses: Saltgrass</td>
</tr>
<tr>
<td></td>
<td>Forbs: -</td>
</tr>
<tr>
<td></td>
<td>Shrubs: -</td>
</tr>
</tbody>
</table>

¹ Sedges occur in all above patch types
² Has at least one of these: Chokecherry, Plum, Bullberry, Gooseberry, or Current

prehistoric groups and should reflect patterns of foraging behavior involving plants.

Efficiency rankings of food resources, diet breadth, must be considered in studies of patch use. These rankings allow for discussions concerning the order that food items within patches will be added or dropped (Simms 1987:15; Smith 1991:204-208). The optimal diet model predicts that "... change in the abundance of high ranked resources should affect the remainder of the diet" (Simms 1987:38). This is important for the current study because changes in resources over time will alter patch use intensity.
Table 4. Rankings of Plant and Animal Resources.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Resource</th>
<th>Mean Return Rate (calories per hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Male Bison</td>
<td>315,525</td>
</tr>
<tr>
<td>2</td>
<td>Female Bison</td>
<td>140,233</td>
</tr>
<tr>
<td>3</td>
<td>Elk</td>
<td>122,704</td>
</tr>
<tr>
<td>4</td>
<td>Deer/Bighorn Sheep</td>
<td>24,711</td>
</tr>
<tr>
<td>5</td>
<td>Pronghorn Antelope</td>
<td>23,588</td>
</tr>
<tr>
<td>6</td>
<td>Jackrabbit</td>
<td>14,438</td>
</tr>
<tr>
<td>7</td>
<td>Gophers</td>
<td>9,882</td>
</tr>
<tr>
<td>8</td>
<td>Cottontail Rabbit</td>
<td>9,392</td>
</tr>
<tr>
<td>9</td>
<td>Ground Squirrel</td>
<td>5,866</td>
</tr>
<tr>
<td>10</td>
<td>Lined Ground Squirrel</td>
<td>4,634</td>
</tr>
<tr>
<td>11</td>
<td>Ducks</td>
<td>2,342</td>
</tr>
<tr>
<td>12</td>
<td>Bitterroot</td>
<td>1,237</td>
</tr>
<tr>
<td>13</td>
<td>Nuttall Saltbush Seeds</td>
<td>1,200</td>
</tr>
<tr>
<td>14</td>
<td>Shadscale Seeds</td>
<td>1,033</td>
</tr>
<tr>
<td>15</td>
<td>Peppergrass</td>
<td>537</td>
</tr>
<tr>
<td>16</td>
<td>Basin Wild Rye Seeds</td>
<td>370</td>
</tr>
<tr>
<td>17</td>
<td>Indian Ricegrass Seeds</td>
<td>347</td>
</tr>
<tr>
<td>18</td>
<td>Dropseed Seeds</td>
<td>228</td>
</tr>
<tr>
<td>19</td>
<td>Foxtail Barley Seeds</td>
<td>206</td>
</tr>
<tr>
<td>20</td>
<td>Sedge Seeds</td>
<td>202</td>
</tr>
<tr>
<td>21</td>
<td>Cattail Seeds</td>
<td>198</td>
</tr>
<tr>
<td>22</td>
<td>Saltgrass Seeds</td>
<td>153</td>
</tr>
<tr>
<td>23</td>
<td>Squirreltail Grass Seeds</td>
<td>91</td>
</tr>
</tbody>
</table>

Knowing the rankings of potential food items will provide a clear understanding of changes in prey choice and in consequent patch use.

Table 4 presents the resource rankings for plants and animals based partially on resource rankings devised by Simms (1987) for the Great Basin, and Prentiss and Welch (1996) for the Northwestern Plains. Regarding floral resources, some of the plants listed in Table 2 are not present, and some of the ranked species may not occur in the study area. However, from the rankings it appears that edible roots (e.g. scurfpea) should rank highest, shrub seeds next, and grass seeds lowest in terms of cost/benefit value. No energy return rates could be located for berries, but they probably would be positioned in the upper
ranks for plant resources.

It should be noted that patch rankings are not expected to remain the same between the Sub-Boreal and Sub-Atlantic climatic episodes. The Sub-Atlantic episode is characterized by increased moisture over the Sub-Boreal. This is expected to have improved forage conditions resulting in increased numbers of big game animals. Aggregating behavior among bison is also expected to increase during this episode (Bamforth 1987, 1988). Search, pursuit, and handling costs for big game resources would have been reduced resulting in higher net returns. During the Sub-Atlantic episode patches containing high numbers and a diversity of accessible highly ranked (mean return rate) large game animals will be among the upper ranked patches.

Forage conditions during the Sub-Boreal episode are believed to have been not so productive. Search, pursuit, and handling costs for large game animals would have been higher due to a reduction in their numbers, more mobility in search of food, and less time spent in large aggregations (bison). Lower ranked plant resources would be added to the diet as access to big game animals lessened. As this occurred, patch rankings are expected to shift favoring patches with more abundant edible plant resources.
A total of 37 McKean sites and 31 Besant sites were identified for inclusion in the study. These sites were retrieved from the North Dakota Cultural Resources Site Forms at the offices of UNDAR-West, Belfield, and the State Historical Society of North Dakota, Bismarck. Five multi-component sites, having both McKean and Besant cultural materials, were present. These sites are 32BI548, 32BI614, 32MZ258, 32GV17, and 32GV37. Sites 32MZ946, 32MZ954, and 32MZ957 are all within 30 meters of each other and for this study are considered a single site. This also applies for sites 32MZ988 and 32MZ1000.

As the Soil Survey Manuals for Billings and McKenzie Counties are in the process of being updated (to be published in 1998) soil survey fieldwork had not been completed in some areas of the badlands at the time of this study. Archeological sites that lacked information concerning the particular range sites they are located within were not included in the study.

Table 5 lists the archeological sites (using the Smithsonian Institution Trinomial System) by cultural affiliation and the patch types (Range Sites) they are present within. A few of the archeological sites occur within Range Site complexes. These are areas that have more than one Range Site which grade into one another with no distinct boundary. In these instances the Range Site with the highest production value was listed.
Table 5. Tabulation of McKean and Besant Archeological Sites and Patch Types (Range Sites).

<table>
<thead>
<tr>
<th>McKean Sites</th>
<th>Patch Type</th>
<th>Besant Sites</th>
<th>Patch Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>32BI22</td>
<td>Silty</td>
<td>32BI110</td>
<td>Clayey</td>
</tr>
<tr>
<td>32BI40</td>
<td>Silty</td>
<td>32BI269</td>
<td>Sandy</td>
</tr>
<tr>
<td>32BI103</td>
<td>Silty</td>
<td>32BI275</td>
<td>Sandy</td>
</tr>
<tr>
<td>32BI205</td>
<td>Overflow</td>
<td>32BI353</td>
<td>Shallow</td>
</tr>
<tr>
<td>32BI265</td>
<td>Silty</td>
<td>32BI379</td>
<td>Overflow</td>
</tr>
<tr>
<td>32BI419</td>
<td>Silty</td>
<td>32BI441</td>
<td>Silty</td>
</tr>
<tr>
<td>32BI426</td>
<td>Shallow</td>
<td>32BI459</td>
<td>Sandy</td>
</tr>
<tr>
<td>32BI429</td>
<td>Sandy</td>
<td>32BI548</td>
<td>Silty</td>
</tr>
<tr>
<td>32BI438</td>
<td>Clayey</td>
<td>32BI575</td>
<td>Silty</td>
</tr>
<tr>
<td>32BI451</td>
<td>Claypan</td>
<td>32BI614</td>
<td>Sandy</td>
</tr>
<tr>
<td>32BI520</td>
<td>Silty</td>
<td>32BI706</td>
<td>Sandy</td>
</tr>
<tr>
<td>32BI522</td>
<td>Silty</td>
<td>32MZ213</td>
<td>Silty</td>
</tr>
<tr>
<td>32BI548</td>
<td>Silty</td>
<td>32MZ258</td>
<td>Silty</td>
</tr>
<tr>
<td>32BI614</td>
<td>Sandy</td>
<td>32MZ292</td>
<td>Silty</td>
</tr>
<tr>
<td>32BI788</td>
<td>Silty</td>
<td>32MZ397</td>
<td>Shallow</td>
</tr>
<tr>
<td>32BI824</td>
<td>Silty</td>
<td>32MZ838</td>
<td>Shallow</td>
</tr>
<tr>
<td>32MZ258</td>
<td>Silty</td>
<td>32MZ946, 954, and 957</td>
<td>Sandy</td>
</tr>
<tr>
<td>32MZ319</td>
<td>Sandy</td>
<td>32MZ984</td>
<td>Silty</td>
</tr>
<tr>
<td>32MZ487</td>
<td>Silty</td>
<td>32MZ988 and 1000</td>
<td>Shallow</td>
</tr>
<tr>
<td>32MZ535</td>
<td>Sandy</td>
<td>32MZ996</td>
<td>Silty</td>
</tr>
<tr>
<td>32MZ591</td>
<td>Silty</td>
<td>32MZ1022</td>
<td>Sandy</td>
</tr>
<tr>
<td>32MZ606</td>
<td>Silty</td>
<td>32MZ1082</td>
<td>Shallow</td>
</tr>
<tr>
<td>32MZ752</td>
<td>Silty</td>
<td>32MZ1086</td>
<td>Shallow</td>
</tr>
<tr>
<td>32MZ912</td>
<td>Silty</td>
<td>32MZ1090</td>
<td>Sandy</td>
</tr>
<tr>
<td>32MZ935</td>
<td>Silty</td>
<td>32GV17</td>
<td>Shallow</td>
</tr>
<tr>
<td>32MZ1211</td>
<td>Sandy</td>
<td>32GV37</td>
<td>Sandy</td>
</tr>
<tr>
<td>32GV17</td>
<td>Shallow</td>
<td>32SL219</td>
<td>Silty</td>
</tr>
<tr>
<td>32GV37</td>
<td>Sandy</td>
<td>32SL224</td>
<td>Shallow</td>
</tr>
<tr>
<td>32GV44</td>
<td>Silty</td>
<td>32BO64</td>
<td>Silty</td>
</tr>
<tr>
<td>32GV147</td>
<td>Silty</td>
<td>32BO222</td>
<td>Sandy</td>
</tr>
<tr>
<td>32GV158</td>
<td>Overflow</td>
<td>32BO501</td>
<td>Thin Claypan</td>
</tr>
<tr>
<td>32GV401</td>
<td>Silty</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>32SL223</td>
<td>Sandy</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>32SL235</td>
<td>Shallow</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>32SL254</td>
<td>Sandy</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>32BO12</td>
<td>Thin Claypan</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>32BO247</td>
<td>Silty</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

The above information was correlated by tallying the number of McKean and Besant sites within the patch types which they occur. The resulting distribution patterns are presented in Tables 6 and 7. Patch types, their ranking (based on dry weight
Table 6. Distribution of McKean Archeological Sites by Patch Type.

<table>
<thead>
<tr>
<th>Patch Type</th>
<th>Rank</th>
<th>Archeological Sites (n/%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overflow</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.4%</td>
</tr>
<tr>
<td>Sandy</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21.6%</td>
</tr>
<tr>
<td>Silty</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>56.8%</td>
</tr>
<tr>
<td>Clayey</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.7%</td>
</tr>
<tr>
<td>Shallow</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.1%</td>
</tr>
<tr>
<td>Claypan</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.7%</td>
</tr>
<tr>
<td>Thin claypan</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.7%</td>
</tr>
</tbody>
</table>

Table 7. Distribution of Besant Archeological Sites by Patch Type.

<table>
<thead>
<tr>
<th>Patch Type</th>
<th>Rank</th>
<th>Archeological Site (n/%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overflow</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2%</td>
</tr>
<tr>
<td>Sandy</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32.3%</td>
</tr>
<tr>
<td>Silty</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32.3%</td>
</tr>
<tr>
<td>Clayey</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2%</td>
</tr>
<tr>
<td>Shallow</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25.8%</td>
</tr>
<tr>
<td>Thin Claypan</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2%</td>
</tr>
</tbody>
</table>

vegetation production), and the total number and percentage of archeological sites within each range site is given.

A chi-square analysis of site frequencies and patch types was conducted on the collected data. The critical value for an alpha of 0.05 with six degrees of freedom is 12.59. The observed value for the data is 7.28. This is not a significant chi-square and
random factors responsible for the observed distribution of sites cannot be rejected.
As stated in the previous chapter, chi-square analysis was conducted on the collected data. A significant chi-square value was not obtained for the study data. Random factors responsible for the observed distribution of sites cannot be discounted. Also, data distributions may be biased by site recording factors such as different survey types (linear versus block), survey locations within the badlands (upland versus lowland), and the limited number of excavated sites being examples.

The lack of datable sites is a problem when trying to discuss prehistoric variations in the Little Missouri Badlands archeological record. However, the present research is believed to have identified a trend in patch use between the McKean and Besant. Of course, the only way to know if this trend is valid is by including more sites in the sample until randomness can be rejected. Possibly this can be realized in the future of Little Missouri Badlands archeology.

Identified McKean archeological sites within the study area were present within seven patch types (range sites). These patch types were: Overflow, Sandy, Silty, Clayey, Shallow, Claypan, and Thin Claypan. Of the 37 total McKean sites, 56.8% (n=21) occur within the Silty patch. The Sandy patch was the second most intensively used patch with 21.6% (n=8) of the sites. The remaining patches show little use. The Shallow patch had three
sites, the Overflow patch had two, and the Clayey, Claypan, and Thin Claypan patches each had a single site.

The patterning of McKean sites by patch type indicates an intensive use of the Silty patch with the Sandy patch being utilized a distant second. These two patch types are near the middle of the patch rankings. However, the rankings are based on total production. As noted earlier patch rankings during the Sub-Boreal, when the McKean occupied the badlands, are believed to have shifted. Patches with abundant edible plant resources would now be ranked higher due to less access to high ranked big game animals.

Forage conditions for large game animals during the Sub-Boreal episode are not believed to have been as productive as during the succeeding Sub-Atlantic. Search, pursuit, and handling costs for big game would have been higher due to a reduction in their numbers, more mobility in search of food, and less time spent in large aggregations (bison). This resulted in lower net returns from large animal resources. This is not to imply that the McKean did not hunt large game animals. Large game would be hunted when encountered or during periods when game numbers increased.

Over the course of the Sub-Boreal lower ranked plant resources should be well represented in the McKean diet for economic reasons, as access to large game was not as high as during later climatic episodes. Patch use during the Sub-Boreal is expected to reflect more use of edible plant resources.

When one examines Table 3 it is apparent that the Silty patch, among patches with McKean sites, has many edible plant
resources, including highly ranked root and berry species. It is 
the only represented patch with two root species, Scurfpea and 
Biscuitroot. Among plant resources roots are ranked very high, if 
not the highest. The importance of Scurfpea (tipsin, breadroot, 
etc.) is well documented among cultures on the Northwestern Plains 
(Gilmore 1977; Kaye and Moodie 1978). It is also one of the 
patches with the potential for a wide diversity of berry species. 
In addition, although grass seeds are among the lowest ranked 
plant resource (Table 4), the Silty patch contains Bluegrass, 
whose seeds are a potential food item.

The second most frequently used patch in the McKean data, the 
Sandy patch, also contains high ranked edible plant foods. These 
include Scurfpea, Western Snowberry, and lower ranked Indian 
Ricegrass, and Bluegrass.

However, why would the other patches that also contain edible 
plants be used far less frequently, according to the available 
data? For instance, potential highly ranked edible plant 
resources in the Shallow patch include Scurfpea, Western 
Snowberry, and many other berry species may occur in this patch. 
The Clayey patch may contain Biscuitroot, onion, and Nuttall 
Saltbush (seeds). Nuttall Saltbush seeds are very high ranked, 
just below roots in mean return rates (Table 4). Nuttall Saltbush 
also occurs in the Claypan patch.

I think we must remember that the McKean practiced a broad 
spectrum foraging strategy. Although large game were not as 
accessible as during the later Sub-Atlantic episode they were 
still included in the diet when they could be successfully hunted. 
Table 2 indicates the Silty and Sandy patch types are the two most
diverse with respect to animal species, both high and low ranked, which use them for forage and cover. Characteristic fauna for both patches include bison (suitability of range site for domestic livestock used as correlate), white-tailed and mule deer, antelope, jackrabbit, and sharp-tailed grouse (USDA, SCS 1998a, 1998b). It is probable that big game species (elk and bighorn sheep) eliminated from the region by European settlement would have utilized these patches.

The data indicate that the McKean concentrated their foraging efforts within a single patch type, using a second patch far less often. The Silty patch was by far the most intensively used (56.8%), followed by the Sandy patch (21.6%). The Silty patch contained a diversity of edible plant species, highly ranked according to mean return rates for plant resources. The Silty patch ranks very high if considering access to edible plant resources. In addition, along with the Sandy patch, it also contains the widest diversity of animal species among all the patch types containing McKean sites.

Archeological evidence from McKean sites throughout the Northwestern Plains indicates a broad spectrum foraging subsistence strategy with the utilization of many different floral and faunal resources. The resource characteristics of patches within the Little Missouri Badlands during the Middle Archaic is believed to have been comparable to the present due to the climatic conditions of the Sub-Boreal episode. A subsistence strategy utilizing a broad array of resources would key in on patches with high ranking plant food species. If these patches also contained game animals which could be hunted when the
opportunity presented itself, all the better. These patches would provide access to a diversity of plant and animal resources and should, because of cost/benefit considerations, be ranked higher in relation to other patches. The archeological record should reflect this with sites concentrating in these patches. The intensive use of the Silty patch and to a lesser degree the Sandy patch, over all other patches types, by the McKean appears to support this.

Besant archeological sites located in the study area were present within six different patch types. These patches were: Overflow, Sandy, Silty, Clayey, Shallow, and Thin Claypan. They are very similar to the patches utilized by the McKean. The only exception is the absence of the Claypan patch from the Besant data (a single McKean site was present in this range site).

The Besant data varies from the McKean regarding site distribution within patches. Unlike the McKean, Besant sites are evenly distributed within the Silty and Sandy patches. Both Silty and Sandy patches had 32.3% (n=10) of the 31 total Besant sites. Also, eight Besant sites (25.8%) were located within the Shallow patch, in comparison to only three McKean sites recorded for this patch type. The remaining patches show little use, with the overflow, Clayey, and Thin Claypan patches having a single site each.

Forage productivity within badlands patches would have been high due to the improved conditions of the Sub-Atlantic episode. As forage improved, access to big game species within patches probably increased, with bison congregating into large herds (badlands bison herd sizes were most likely smaller than would
have been in the surrounding upland plains). The archeological record for the Besant across the Northwestern Plains testifies to their adeptness at upland big game hunting, especially bison. There is no archeological evidence within the Little Missouri Badlands for Besant large communal hunts using traps. Either different hunt types were practiced with fewer individuals being taken than would a large communal kill or natural erosional processes have destroyed evidence of Besant communal kills (Kuehn 1997).

Big game species that would have been present in the badlands and potentially targeted for Besant hunting include bison, white-tailed and mule deer, antelope, elk and bighorn sheep. As stated above, the improved forage base resulting from Sub-Atlantic climatic conditions would have led to elevated numbers of these species. This is not to suggest that the use of plant resources and smaller game was abandoned but that less time was allocated to these pursuits due to the increased access to highly ranked large game animals. It is probable that as high ranked animals began entering the diet on regular basis because of the changing environmental conditions of the Sub-Atlantic the lowest ranked resources (lower ranked plant resources) in the diet were dropped.

Besant subsistence practices primarily focused on high ranked big game resources. This should be evident in their use of badlands patches. During the Sub-Atlantic patch ranking would be linked to diversity and numbers of highly ranked big game within certain patches. Table 2 indicates that the Silty and Sandy patch types are the two most diverse with respect to different animal species which occupy them for food and shelter. Animals which use
both patches include bison (suitability of range site for domestic livestock used as correlate), white-tailed and mule deer, antelope, jackrabbit, and sharp-tailed grouse (USDA, SCS 1998a, 1998b). As noted above, it is likely that big game species such as elk and bighorn sheep, eliminated from the region by European settlement, would have utilized these patches also.

The distribution of Besant sites indicates that they focused much of the subsistence effort within the Silty and Sandy patches. These two patches would have been very highly ranked with regards to diversity of highly ranked animal species during the improved conditions of the Sub-Atlantic.

It is unknown why the Shallow patch received so much attention, eight sites (25.8%), from the Besant. Although high ranking bison and deer are listed in Table 2 as potentially occurring in the patch the somewhat low forage productivity value indicates that these animals probably spent less time in this patch compared to higher ranked patches. The Shallow patch is one of three patches represented in the data that potentially can contain a variety of berry producing shrubs (Table 3). Perhaps berries were an important resource for the Besant (manufacture of pemmican, drying, etc.). However, this is speculation and the data at hand do not provide a clear reason for the heavy use of this patch by the Besant.

When considering effects of preservation and erosion the sites in the study were very similar with respect to distribution across landforms as described by Kuehn (1993). The majority of McKean sites were in the uplands with few being present in lowland
settings. Besant sites, although predominantly on upland landforms, have more sites occurring in the lowlands. Erosional factors can’t be ignored when considering patch use. Data are lacking for the lowlands. However, it is felt that the patch use model will indicate general differences in subsistence behavior because the patch types represented in the study occur throughout the badlands environment and are not segregated by elevation.

The patterns evident in the data for McKean and Besant sites with respect to patches utilized indicates a difference in the way the two used the badlands landscape, a difference believed to directly relate to changes in foraging strategies. Environmental factors played a significant role in the noted differences. Variations in patch productivity values between the Sub-Boreal and Sub-Atlantic climatic episodes are felt to be a critical factor responsible for the patterns noted in site distribution between the McKean and Besant.

The under-representation of the Overflow patch in the data for the McKean and Besant is another question. Judging from Tables 2 and 3 this patch, whether considered for plant or animal resources, should rank high among available patches. Two reasons are believed to be responsible for this apparent lack of use. They are linked to geomorphological characteristics of the Little Missouri Badlands and to the small number of sites in the sample.

### Table 8. Distribution of Sites by Landforms.

<table>
<thead>
<tr>
<th>Site Affiliation</th>
<th>Uplands</th>
<th>Foothills</th>
<th>Lowlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>McKean</td>
<td>27</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Besant</td>
<td>20</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>
The Overflow range site is present in swales, depressions, and on footslopes in the uplands and on low terraces and floodplains adjacent to streams. This range site is regularly flooded by run-off from higher land surfaces in the uplands and overflow by streams on the low terraces (USDA, SCS 1998a, 1998b).

In upland settings this range site is generally small in area and probably did not receive as much attention as did larger patches by prehistoric groups. On terraces, archeological materials are apt to be deeply buried below sediments and not visible on the surface. Archeological sites are discovered by survey only when there has been some form of disturbance to the terrace, including natural erosional processes and/or recent human activities. Also, and probably most important, many lower terraces in the badlands are of relatively recent age and may have not been present for use by the study populations, more so for the McKean than the Besant.

The small number of total sites in the sample data for the McKean (n=37) and the Besant (n=31) most likely contributed to the lack of information concerning the use of certain patches. Numerous archeological sites have been recorded within patch types considered in the current study and it is probable that a number of these sites are related to McKean and Besant use. However, the absence of diagnostic artifacts attributable to either the McKean or the Besant prevented these sites from being included in the study.

The number of archeological sites is believed to be adequate for getting a sense of how the badlands landscape was utilized by the McKean and Besant during the periods of their respective
occupations. In the future as more McKean and Besant sites are discovered and linked to specific patch types a better understanding of their occupational histories within the Little Missouri Badlands will emerge.

In reviewing the above data two questions arise. First, were potential resources within patches a significant factor influencing site location? Yes. Of the many reasons considered for the location of activities by mobile hunter-gatherers access to food is often a primary concern (Schiffer 1975; Smith 1991). The location of sites within areas of dependable food resources is a common feature of hunter-gatherer settlement (Greiser 1985:8; Deaver and Deaver 1988a:5; Smith 1991:254).

Second, would the presence of humans within selected patches affect the success of resource harvests? With regards to floral resources no, as they are immobile. A human presence would have an effect on game behavior. Large game species (and small game too) all have behaviors geared towards avoiding predators which feed on them (Jarman 1974:235; Schaeffer 1978; Geist 1981:167-174). An effect of hunting pressure by predators, including humans, is game wariness and increased mobility (Moen 1973:236; Bamforth 1987:5). In certain cases, frequently related to extreme weather conditions, actively hunting predators do not seem to hinder the presence of prey animals at, or travel to, locations which offer food, water, and/or shelter (Bowers 1960:60-61; Arthur 1975; Reed 1981:534; Verbicky-Todd 1984).

Regardless, prey animals frequent areas where their needs for food, water, and shelter are met, making them somewhat predictable. Predators, humans included, are aware of prey
behavior, including wariness and eluding tactics, and the areas they are likely to be in. With this in mind hunters focus their hunting activities in areas which give them the best chance to be successful (Bamforth 1987:2).
The hypothesis tested for this study was based on the Marginal Value Theorem, a patch use model drawn from foraging theory. It was predicted that during the Sub-Boreal climatic episode, when conditions were similar to the present, the McKean, being broad spectrum foragers, would allocate more foraging effort in patches characterized by diverse, abundant high ranked plant resources. Conversely, during the improved conditions of the subsequent Sub-Atlantic episode, resulting in better forage conditions for large herbivores, more Besant foraging time would be spent in patch types that contained an abundance of high ranked animal resources.

The hypothesis was tested using archeological data from the study area within the Little Missouri Badlands in southwestern North Dakota. The data concerning archeological site distribution and patch type provides tentative support for the model. However, the results must be viewed with caution as the data were not adequate for a true quantitative test of the MVT. A chi-square test of the data failed to reject the possibility of random factors being responsible for the observed distribution. However, it is felt that the data were sufficient to gain a preliminary understanding of McKean and Besant patch use in the badlands.

Within the data for the McKean a site distribution pattern emerges of the concentrated use of a single patch type, Silty (n=21), over all others. A second patch type, Sandy (n=8), is
used to a much lesser degree. The Silty patch contains varied highly ranked plant resources. The Sandy patch also contains highly ranked edible plants, but not to the extent the Silty patch does. Both patches would be ranked at or near the top of all badlands patches when considering access to edible plant items that have high return rates.

In comparison, the site distribution pattern by patch type for the Besant is much different. Instead of intensively using a single patch they spread their use more evenly over three patches, Silty (n=10), Sandy (n=10), and Shallow (n=8). The Silty and Sandy patches of all badlands patch types support the widest variety of highly ranked big game resources. For foragers whose subsistence strategy is geared towards big game hunting these two patches would rank high. The Shallow patch type, according to Table 2, is only suitable for one large game animal, bison. Why this patch was used so much by the Besant is unclear. Other patch types with far fewer Besant sites show more animal diversity. Possibly the presence of several different berry producing shrubs is a factor. Or more likely, too few Besant sites in the sample.

These results correspond with implications raised by the MVT (Smith 1991:253-255). Patch use data for the McKean and Besant suggests that their choice and use of specific patches was associated with the resource characteristics of other patches. Patch selection and time allocation decisions were made by considering the quality of all available patches.

The badlands environment during the Sub-Boreal climatic episode was such that populations associated with the McKean complex considered access to floral resources in making patch use
decisions. The character of chosen patches would have provided an abundance of diverse floral resources. Animal resources were also considered, but were not a primary focus owing to high search and pursuit costs and, thus, lower return rates when compared to the Sub-Atlantic episode.

During the Sub-Atlantic episode forage conditions improved with a corresponding increase in large game numbers. This increase provided the Besant, noted for their big game hunting prowess, easier access to highly ranked animal resources. As a result they allocated more time to patches with a diversity of high ranked large animal resources.

The results of this study, within the badlands of North Dakota, suggest that alterations in patch characteristics and productivity in response to climatic changes led to an adaptive shift in foraging strategies between the McKean and the Besant. This is evident in their use of the badlands landscape, specifically in patterns of patch use.

These results lend support to the usefulness of foraging theory, a branch of evolutionary ecology, in the study of hunter-gatherer subsistence behavior. The models used in the theory (e.g. the Marginal Value Theorem) provide a general approach, without sacrificing a significant degree of realism, to understanding the differences evident in human foraging behavior (Winterhalder 1981:13). These differences are considered as being the result of evolutionary design (Smith 1991:41). Foraging strategies that maximize net rate of energy capture are the economic result of natural selection (Winterhalder 1981a:15;

In addition, foraging theory focuses attention on the environment (Winterhalder and Smith 1992:9). The argument is that the environment plays a major role in influencing behavioral adaptation. Environmental research over long time spans is essential in understanding the effect ecological factors have on foraging adaptations (Winterhalder 1980).

The above characteristics make foraging theory a productive means of investigating the variety evident in hunter-gatherer foraging behavior through time. The generality feature of the approach, predictions based on a narrow range of parameters (Winterhalder 1981:13) was important in this research of McKean and Besant foraging behavior.

Examining prehistoric use of the Little Missouri Badlands has proven difficult due to the dynamic nature of the badlands and, related to this, the incomplete archeological record. The model used in this analysis from foraging theory, the Marginal Value Theorem, offered a means to test for differential patch use between the McKean and Besant. The results provide a preliminary explanation for the differences noted in the use of the badlands by the McKean and Besant. While both participated in the same cultural system, hunting and gathering, a change in the badlands environment over time resulted in different patterns of resource patch use.

This is of considerable importance for Little Missouri Badlands archeology, as well as for prehistoric research conducted in other badlands areas. Significant portions of the
archaeological record have been impacted by the erosional nature of the badlands environment. However, within the remnants of the archaeological record, patterns remain which are indicative of distinct adaptations (Broughton and Grayson 1993:333) to the changing nature of the badlands environment. Models from foraging theory can aid in identifying and interpreting these patterns.

Seasonal use of patch types was not approached in this study due to the relatively small number of sites in the sample and the broad time frame considered. However, seasonal patch utilization would be important to furthering information concerning McKean and Besant use of the Little Missouri Badlands. This could be accomplished by noting seasonal game movements and the times when plant resources became available for human consumption. By comparing the distribution of archaeological sites within patch types with the above data it might be possible to infer the time(s) of year selected patch types were used. Of course the presence of floral and faunal remains at archaeological sites would aid greatly in any such research.

Patch use studies should help inform on plant foraging. Perhaps by investigating patch use during dry climatic episodes (e.g. Scandic episode) in the badlands we could determine if changes in resource use occurred, and if so, to what extent. Were high ranking plant resources, such as tubers and berries, depleted by dry conditions to the point that patches with weed and grass seed plant resources intensively used? Edible plants were definitely utilized by prehistoric groups, but more needs to be understood about which resources were sought after and used under different environmental conditions. Much is currently known
regarding how individual plant species and plant communities react to variations in climate but more research needs to be conducted concerning how humans in the past responded to variations in plant communities. This is important because prehistoric peoples were intricately linked to the plants that surrounded them.

It would also be of value to the understanding of badlands prehistory to test for optimal patch use in the badlands as whole, including data from Montana and Wyoming. The introduction of additional archeological sites into the data base could enhance the validity of the results of the present study by rejecting randomness, or possibly indicate different patch use patterns for the McKean and Besant. Regardless, the information generated by a larger data base would provide increased knowledge concerning the use of the badlands by the Middle Archaic McKean and the Late Archaic/Woodland Besant.

In addition, other groups within the Middle Archaic and Late Archaic/Woodland, and from the Late Prehistoric, should be included in the patch use data base. This would further our understanding of prehistoric patch use and environmental variability within the badlands region through time. Also, the above future research suggestions would further test the reliability of the MVT in predicting prehistoric foraging behavior.
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