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ECOLOGICAL CHARACTERIZATION AS A FOUNDATION FOR PREDICTION OF PLAINS VILLAGE TRADITION SITE LOCATIONS IN CENTRAL SOUTH DAKOTA

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ABSTRACT

Upland Plains Village archaeological sites in Central South Dakota located by pedestrian survey were described in terms of physiography and vegetation. Randomly selected, non-archaeological sites were similarly described and served to define the universe of sites available for habitation along the east bank of the Missouri River/Lake Francis Case Reservoir. Physiographic differences between actual and "simulated" archaeological sites suggested that several factors were important in predicting the location of upland archaeological sites. These included location in *Agropyron smithii* dominated plant communities with less than 5° of slope, and southern exposure. The model accounts for nearly 70 per cent of all variability associated with location and distribution of archaeological sites.

INTRODUCTION

The early Plains Village tradition along the Middle Missouri River in South Dakota is represented by two complexes of horticultural village peoples. The earlier complex, the Initial Middle Missouri variant, spans approximately 200 years beginning in the 11th century. That complex was supplanted by the Initial Coalescent, a blending of the Initial Middle Missouri peoples with Central Plains tradition peoples from the South, the latter having fled drought conditions. Both Middle Missouri and Coalescent populations built villages with semisubterranean earth lodges surrounded by fortification ditches with palisades.

Although many of these villages were located and tested during various River Basin Survey projects during construction of the Missouri River mainstem reservoirs, complete inventories of sites along the reservoirs have only recently been done under Executive Order 11593. The project described in this paper results from the inventory done for the east bank of Lake Francis Case (Ft. Randall Reservoir) between Pickstown and Ft. Thompson, South Dakota, during the summer of 1978.

While villages of both complexes exist as single components, as often as not there also seems to be a pattern of reoccupation of existing sites. Many reoccupied sites also have Woodland components as well. The question of site reoccupation when site densities are low and the more general question of site selection provided the research focus for this inventory.

Efforts to develop a model to predict the location of archaeological sites have attempted to isolate key resources that act as settlement determinants (Zimmerman, 1977). This paper documents the use of simple ecological characterizations of site environs as a technique for building a predictive locational model.

Upland archaeological sites located by pedestrian survey were described in terms of physiography and vegetation. Randomly selected, nonarchaeological sites were similarly described and served to define the universe of sites available for habitation along the east bank of the Missouri River/Lake Francis Case Reservoir. Physiographic differences between actual and "simulated" archaeological sites suggested that several factors were important in predicting the location of upland archaeological sites along the east bank of Lake Francis Case.

Regression analysis was employed to select those physiographic variables best able to distinguish an archaeological from a nonarchaeological site. Variables incorporated into the final predictive model were capable of explaining nearly 70 per cent of the variability associated with the location and distribution of archaeological sites.

METHODS

Archaeological sites located along Lake Francis Case by pedestrian survey crews were diagrammatically mapped and described in terms of vegetation and topography. Vegetation/landform maps and horizon panoramas were constructed for each site and distances to various resource types were measured.

Vegetation/Landform Maps

Qualitative descriptions of vegetation and landform types associated with each site were accompanied by field sketches illustrating the spatial distribution of major plant associations and landform types. Field descriptions and sketches were then used to outline fifteen natural vegetation/landform units (Table 1) and nine agricultural or recreational units on black and white 1969 Agricultural Stabilization and Conservation Service aerial photographs (scale: 1″ = 660′). The extent of the area mapped was arbitrarily set at 2.25 acres. The 2.25 acre area surrounding the site was then divided into nine .25 acre grids in such a way that grid numbers one and three occupied the northwest and northeast portions of the archaeological site and grids seven and nine the southwest and southeast portions, respectively. The geographic center of the site was always centered in grid five (Figure 1). This grid system was used to partition vegetation/landform types surrounding a site and to develop a composite picture of what an average site might look like. Percentage cover of each vegetation/landform type was then estimated by projecting the aerial photo onto graph paper and counting the number of graph paper units encompassed. If a grid contained an agricultural or recreational unit, two maps were drawn. One map showed

Table 1. Key to Vegetation/Landform Units Delineated on Archaeological Map Grids

Map Unit Number	*Vegetation/Landform Type*
1	Reservoir
2	Wooded Drainage
3	Grassland Drainage
4	Northerly Facing Grassland (Shallow)
5	Northerly Facing Grassland (Steep)
6	Southerly Facing Grassland (Shallow)
7	Southerly Facing Grassland (Steep)
8	Upland Plain
9	Alluvial Lowland
10	Creek Bottom
11	Upland Juniper Forest
12	Upland Mixed Forest
13	Upland Deciduous Forest
14	Closed Canopy Juniper Forest
15	Pierre Shale
16	Corn Field
17	Plowed Field
18	Shelterbelt
19	Oat Field
20	Wheat Field
21	Recreation Area – Mowed
22	Agricultural Field – Uncertain Crop
23	Millet Field
24	Alfalfa Field

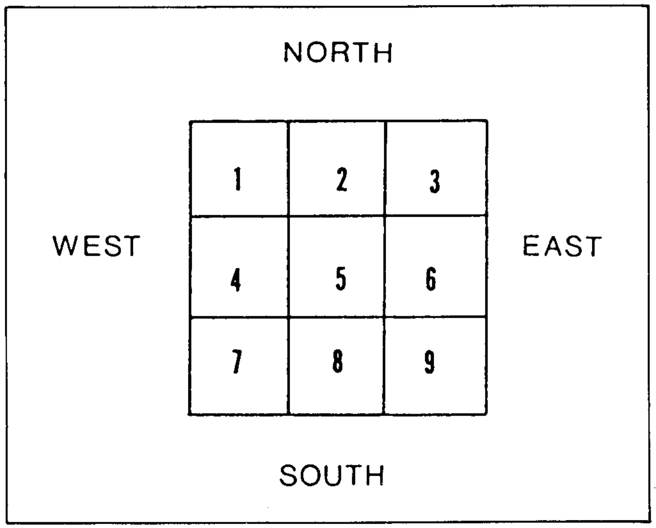

Figure 1. The 9.25 acre grid system used for mapping vegetation/landform units surrounding archaeological sites. Scale 1" = 660'. The geographic center of each site was always centered in grid 5.

the present vegetation/landform type (labeled "present") and one projected the native vegetation that would have been present had not the agricultural or recreational usage occurred (labeled "past"). Computations for sites falling on agricultural lands were based on these "past" vegetation/landform maps.

Horizon Panoramas

From the geographic center of an archaeological site the direction of and distances to topographic barriers that defined the horizon around the site were noted at 10° intervals (Figure 2). These measurements served as an indication of the openness of a site. Vegetation, such as isolated stands of trees, was not considered a barrier that defined the functional horizon surrounding a site. Topographic structures constituting the horizon (ridge, hill, bend in river) were noted and their distances from the geographic center of the site measured on topographic maps to the nearest 0.1 km. In cases where there were no topographic obstructions for several kilometers, one of two things was done. If the direction extended over what is presently reservoir, the distance to the near edge of the original channel was measured—the reasoning being that the once extensive floodplain forest would have been a major visual barrier. If the direction was over land, the distance to the 1800 ft contour was measured. This contour generally defined the rim of the upland plain; inhabitants of a

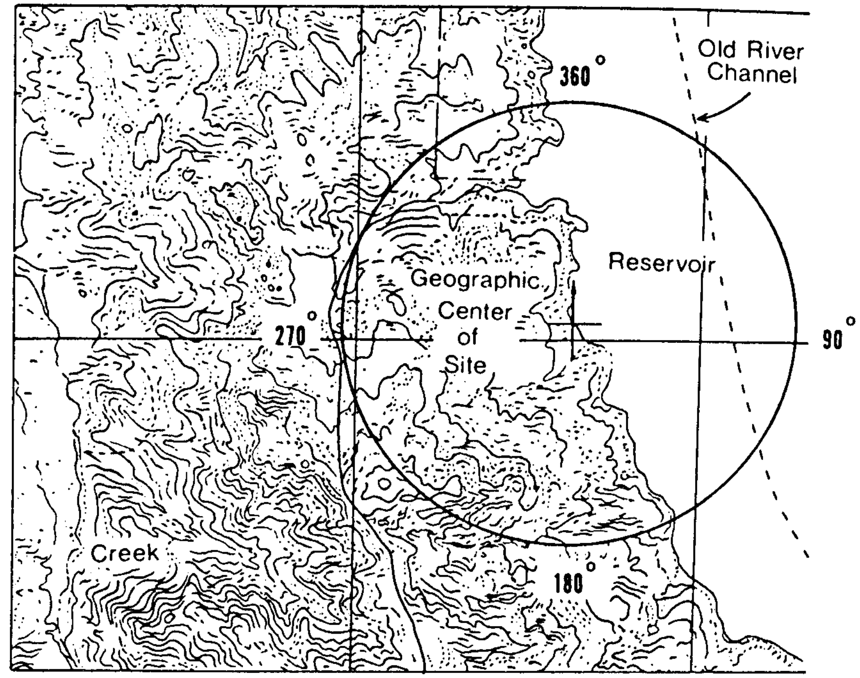

Figure 2. Portion of a 7.5' topographic map illustrating the setting of a hypothetical archaeological site. Distances to various resource types and topographic obstructions were used to describe site locations and construct horizon panoramas.

site could not see over the rim from their location in the breaks below. Distances were recorded up to 4.5 km. Anything further than 4.5 km was recorded as 4.5 km.

Distances to Resource Types

Four broad categories of resource types were recognized: upland plains (above the 1800 ft contour), wooded drainages, creeks or tributaries of the Missouri River, and floodplain forest. Although the floodplain forest has been inundated with the creation of Lake Francis Case, the general extent of its boundaries were extrapolated from the Lake Francis Case Boating and Recreation Map (U.S. Army Corps of Engineers, 1975). These four categories represent gross habitat associations of major floral and faunal resources that were of use to occupants of archaeological sites. The distance from the geographic center of a site to each of these resource types was computed on topographic maps and verified with field observations. In addition, the distance from the geographic center of the site to the 1400, 1500 and upland plain (approximately 1800 ft) contours were also noted in order to better define the topographic setting of the site. The greater the distance between these contours, the more gentle the topography. Mean slope aspect and inclination were also noted for each site.

Regression Analysis

Ward's multiple linear regression technique (Ward, 1962; Kerlinger and Pedhazur, 1973) was used to determine the unique contribution of proper sets of descriptive variables (Table 2) useful in defining the physiognomy of archaeological sites along Lake Francis Case. Basically, the regression model compared the values of the descriptive variables obtained for actual sites to values for those same descriptive variables obtained from 20 "simulated" sites. Simulated sites were arbitrarily located at five mile intervals along the east bank of Lake Francis Case between the Fort Randall and Big Bend Dams. The geographic center of each simulated site was 50 m inland from the edge of the reservoir, the estimated mean distance inland of archaeological sites located in the area. From this geographic center, vegetation/landform grids and horizon panoramas were constructed and distances to resource types were computed for each simulated site. These simulated sites, located randomly throughout the predefined study area (the east bank of Lake Francis Case) served to define the physiognomic universe available for prehistoric inhabitation. Significant differences in the values obtained for descriptive variables on composite actual and simulated archaeological sites would indicate which criteria might have been most important in determining what particular type of site a prehistoric group of people might have selected to occupy or use. Because of the large numbers of variables used in the analysis, a systematic approach was used to reduce the number of variables to approximately a five-to-one subject-to-variable ratio for each regression run. Significant predictors for each of the several, different runs were then pooled for the final run.

Table 2. Environmental Variables Considered in Regression Analysis of Factors Influencing the Location and Distribution of Archaeological Sites Along the East Bank of Lake Francis Case

Distance Measurements
to horizon at 90°, 180°, 270°, and 360°
to 1400′, 1500′, and upland plain (1800′) contours
to nearest intermittent drainage
to nearest creek
to floodplain forest
of channel width
Topographical Measurements
slope aspect (northerly, easterly, southerly, or westerly)
slope inclination (no incline; 1-5°; 6-10°; 11-15°; greater than 16°)
Vegetation/Landform Units
considered individually on each .25 acre grid one through nine.
considered as a composite for entire 2.25 acres.

RESULTS AND DISCUSSION

Vegetation/Landform Maps

Vegetation/landform maps illustrating the spatial distribution of major plant and landform associations were compiled for 41 archaeological sites and 20 "simulated" sites. Map units were recognized on a large scale and on the basis of dominant floristic associations. Because variations in plant expression occurred within topographic units due to microrelief and associated microclimatic differences, several plant communities recognizable in the field were grouped into larger associations, in proportion to the degree to which they were distinguishable on black and white aerial photographs (scale: 1″ = 660′). Also, seral communities occupying relatively small areas were integrated into larger macrocommunities judged to be characteristic of the topographic site. This was done to standardize the various stages of perturbation and succession encountered between sites. Fifteen native vegetation/landform units and nine agricultural or recreational units were recognized (Table 2). Only the native vegetation/landform units will be discussed here. Maps of the present and extrapolated past vegetation/landform units surrounding each archaeological site, descriptions of each unit based on dominant floristic associations, and vegetation composition and mean percentage cover of each species for each landform unit were summarized by Zimmerman and Emerson (1979). Archer and Tieszen (1979) described in detail the methodology used in selecting and describing stands and vegetation/landform maps of "simulated" sites.

In constructing the vegetation/landform maps, emphasis was placed primarily upon topographic features and secondarily on gross vegetation patterns for several reasons. First, the vegetation associations and community structure had not been defined at the time of construction of the maps. Secondly, the maps were constructed with the primary goal of functioning as a tool for the ecological classification of archaeological sites. While a field archaeologist or surveyor may not be able to classify a site with respect to a distinct vegetation community, he can classify it topographically and from there utilize the community topographic descriptions (Zimmerman and Emerson, 1979) to more fully interpret vegetation patterns associated with a site. A broader classification into formal vegetation noda as defined by Archer and Tieszen (1979) may then follow. Thirdly, plant communities similar in structure may occur in topographically dissimilar locations. For example, the vegetal composition of upland plain, grassy drainage, and alluvial lowland sites in the northern half of the reservoir are comparable. Thus, by presenting merely plant community descriptions, the unique contributions of each of these topographic units, representing different resource or habitat types, would be lost. A diagrammatic illustration of recognized topographic units is given in Figure 3.

The .25 acre area surrounding the geographic center of archaeological sites was dominated by grassland vegetation in nearly every instance. *Agropyron* dominated south facing slopes of less than 15° inclination and alluvial lowlands occurred in grid five with the greatest relative frequencies (Figure 4). These vegetation landform units were followed by upland plains and steeper south facing grasslands. Communities found on north facing slopes had the lowest frequency of occurrence. In fact, no sites occurred on northly slopes. Nearly 90 per cent of the sites were on slopes with either no aspect (no inclination) or southerly exposure (Figure 5). Nearly 85 per cent of the sites surveyed were on slopes with an inclination of less than 5° (Figure 6). No sites were encountered on inclinations greater than 16°.

Based upon percentage cover, vegetation/landform units six through ten were the dominant features of the 2.25 acres surrounding archaeological sites (Figure 7). This corresponds well with frequency estimates. All of these units, with the exception of the creek bottoms, were grassland associations. Upland plain and alluvial lowland types had the greatest mean cover. In terms of overall community diversity, archaeological sites were comparable to randomly located, simulated sites (Figure 8). However, simulated sites averaged 4.7 vegetation/landform types per 2.25 acre grid, while archaeological sits averaged 3.9. Given the mosaic pattern of community distribution along the east bank of Lake Francis Case, it appears that archaeological sites were not systematically located in either more or less diverse areas than were available.

Distance to Resource Types

Distance from the geographic center of archaeological sites to various upland resource units were computed and compared to simulated sites. Creeks and drainages were considered to be sources of wood for lumber and fuel, sources of potable water, and as habitat for deer, elk, small game, and various edible, medicinal and ceremonial plants. Upland plain areas were considered the primary habitat of antelope, bison and various utilitarian prairie plants. Due to its gentle topography, the upland plain would be a good place for travel while also affording an excellent vantage point of both the plains and river bottom. Distance between major contour lines served to indicate the openness or accessibility of a site to the upland plain habitat.

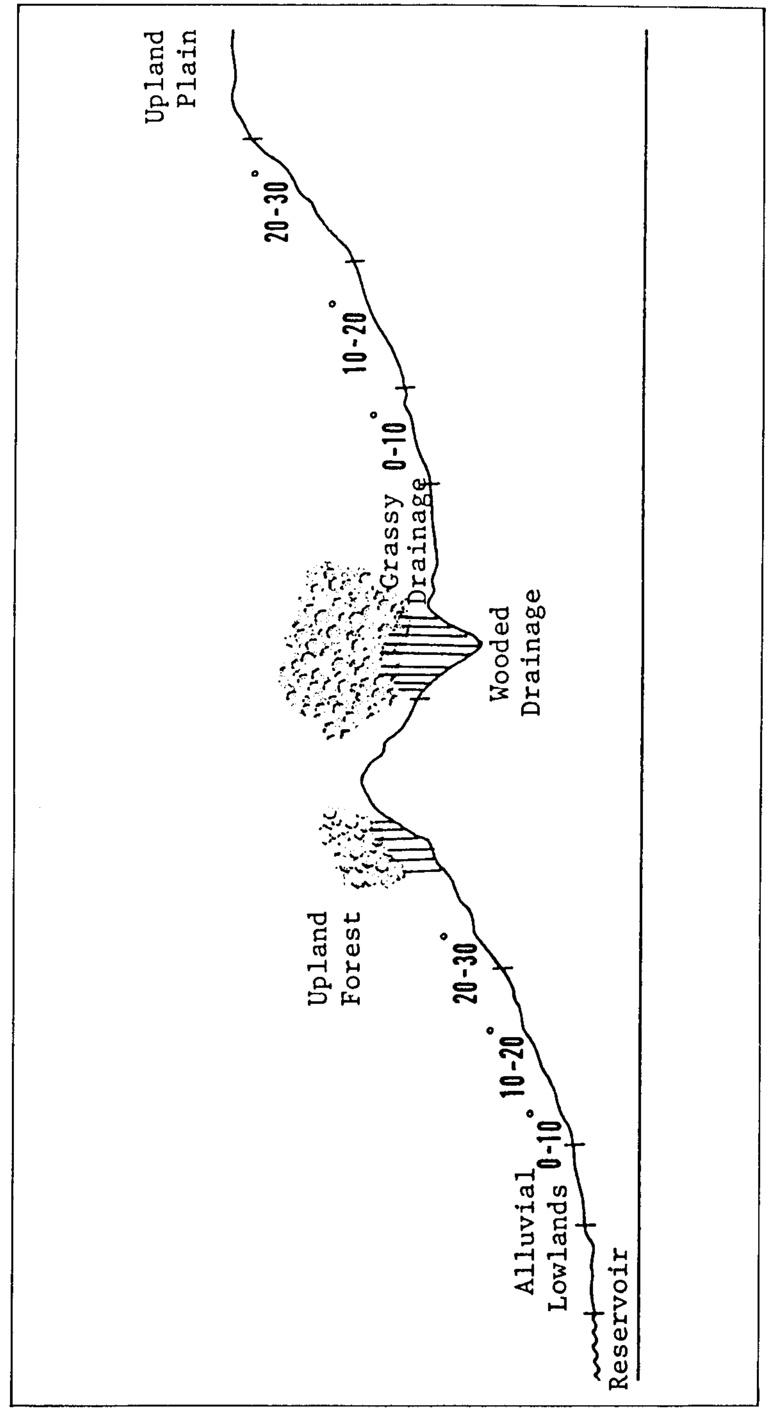

Figure 3. Diagrammatic cross-section of topographic units recognized along the east bank of Lake Francis Case. The designations of 0-10°, 10-20° and 20 to 30° refer to slope inclinations.

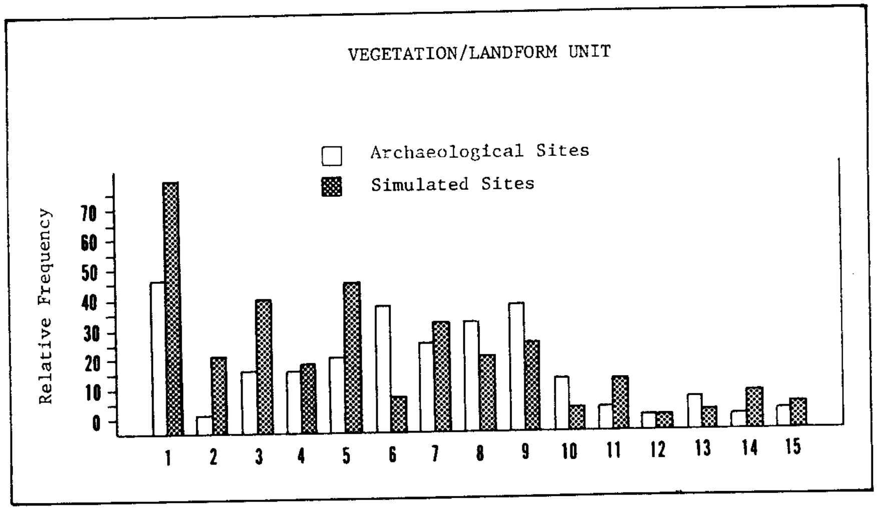

Figure 4. Relative frequency of occurrence of various vegetation/landform types on archaeological and randomly located non-archaeological sites. See Table 1 for numerical key.

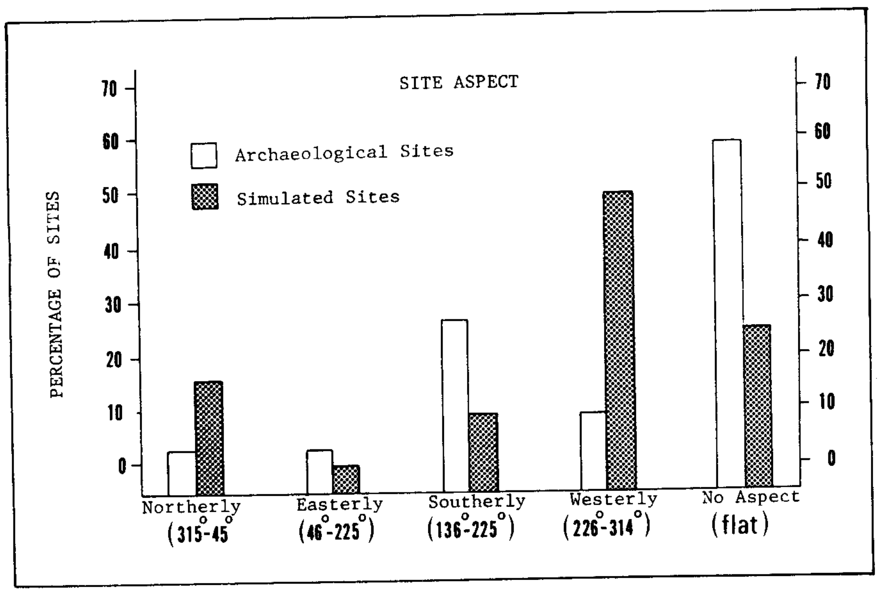

Figure 5. Mean slope aspect for simulated and real sites.

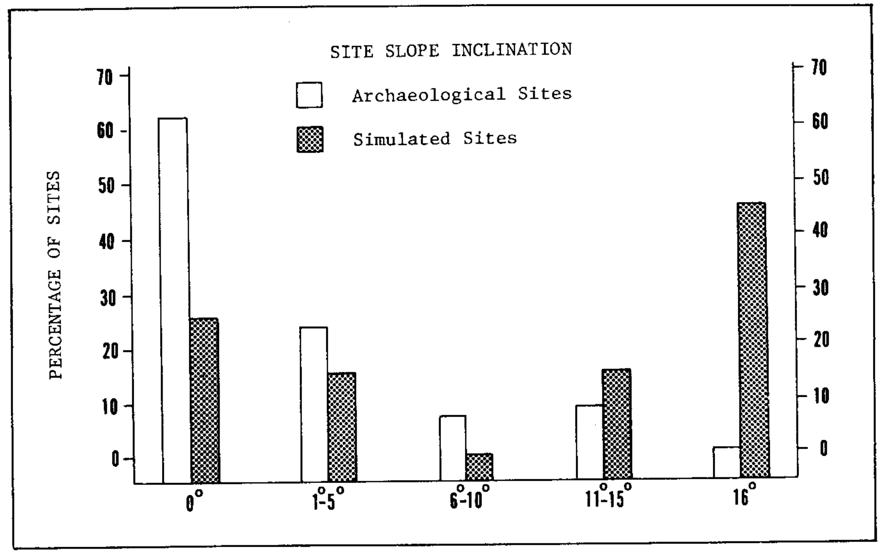

Figure 6. Observed mean slope inclinations on real and simulated sites.

No significant differences were noted in the distances to creeks and wooded drainages for actual or simulated sites, indicating that these resources were either not specifically sought or that they occurred with sufficient regularity so as not to be difficult to encounter near a site (Figure 9). Intermittent drainages were significantly closer to site centers than flowing streams, suggesting that they may have been considered a more important or widely used resource than flowing stream habitats, especially for upland sites further removed from the wood and water of the river bottom.

Distances from the geographic center of archaeological sites to the 1500 ft and upland plain contours were greater than those distances measured for simulated sites (Figure 9). This suggests that archaeological sites were purposely situated on topographically gentle, open areas which provided easy access to the upland plain habitat type.

Horizon Panoramas

The composite horizon panorama obtained for actual and simulated archaeological sites indicates that openness was a likely criterion used in selection of a habitation site (Figure 10). The area within the topographic barriers defining the horizon around an archaeological site averaged 16.0 km^2—more than three times the 5.1 km^2 encompassed by nonarchaeological sites. Distances to topographic barriers defining the horizon were greatest from the northwest to the

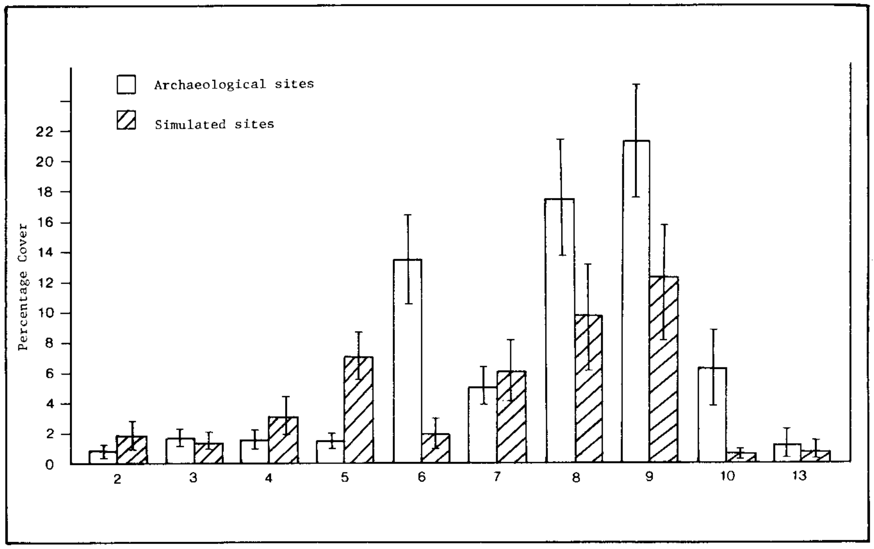

Figure 7. Mean percentage cover (± 1 standard error) of various vegetation landform units occurring on archaeological and non-archaeological sites. See Table 1 for identification of vegetation/landform codes. Units 11, 12, 14 and 15 were not significantly represented on any sites and are not shown.

southeast portions of the diagrammatic panorama, and least toward the south and west. The short distance to the southern and western portions of the panorama were due to the fact that the most sites, both simulated and actual, were relatively close to the reservoir and the old river channel which generally formed the southwest border of the panorama. This openness, which appears to be characteristic of most of the upland archaeological sites along the east bank of Lake Francis Case, is largely due to the gentle topographic situation of such sites and supports Lehmer's (1970) speculation that upland sites, while removed from the wood, water, and garden lands of the river bottoms, afforded a wide view of the lower river valley and of upland sites frequented by bison.

Regression Analysis

The ultimate selection of a site for habitation was likely the result of a complex interaction of many considerations, several of which may not be measurable: religious convictions, or cultural, physical, or social circumstances present at the time of site selection. However, of the many physical parameters that are tangible and measurable, it is important to know which of those are most consistent in distinguishing a potential archaeological site from other sites available for habitation. The multiple regression analysis employed here analyzed

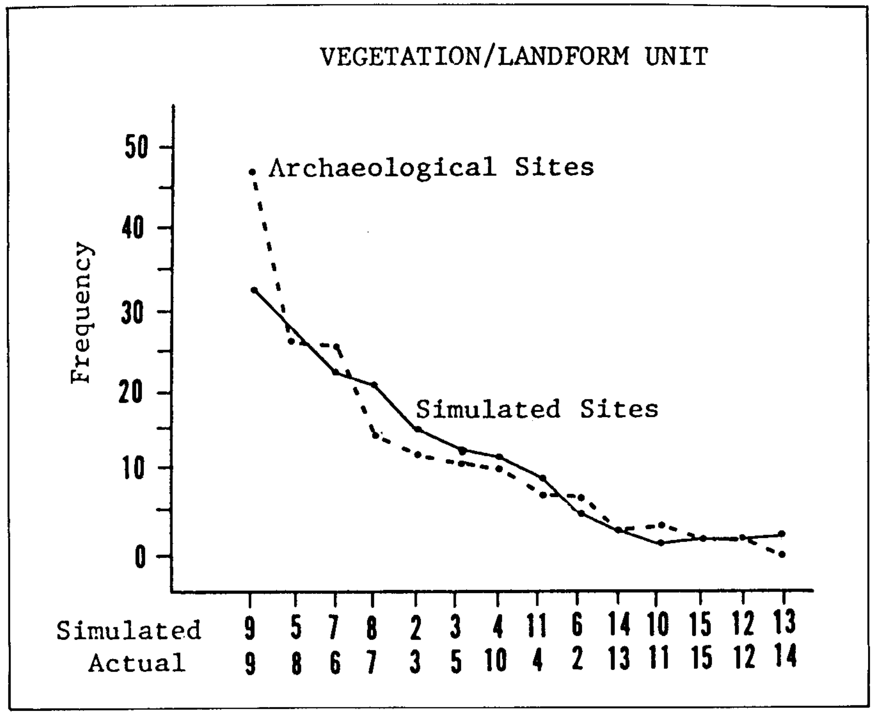

Figure 8. Dominance-diversity curves of vegetation/landform units associated with archaeological and non-archaeological sites. See Odum (1971) for discussion of dominance-diversity curves. See Table 1 for vegetation/landform codes.

the collective contribution of several variables toward explaining the variability associated with the location and distribution of archaeological sites. Variables that accounted for a significant proportion of the variance were retained in the model; those that did not account for a significant proportion were discarded in a stepwise fashion. The primary objective was to reduce the initial set of variables to a smaller subset that contained pertinent information. Also, from a practical point of view, it was feasible to select those variables that were the least expensive and the most quickly and efficiently estimated in the field. In addition, it should be pointed out that only those variables which were important as a group were retained in the model. Due to interaction of, and intercorrelations between variables, a given variable, considered alone, might be important in distinguishing an archaeological site from the universe of sites available for habitation. But, when considered simultaneously with other variables, it did not necessarily contribute toward reducing variability and hence was not retained in the model.

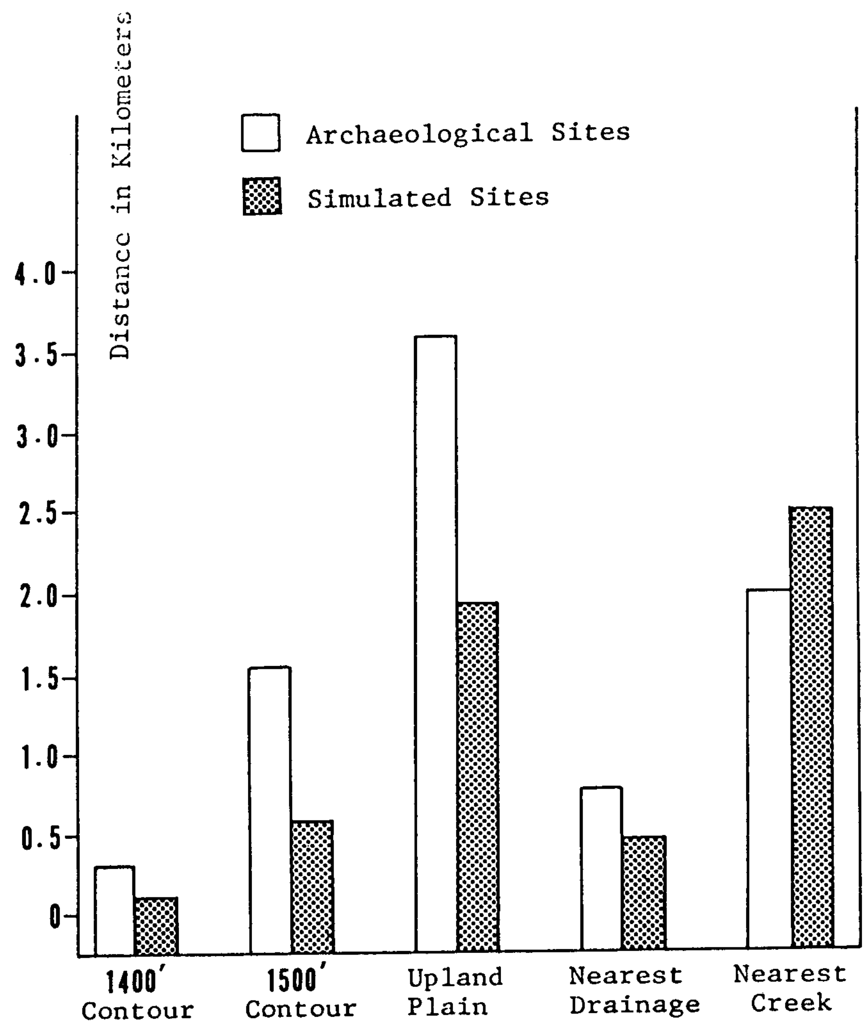

Figure 9. Mean distances to various topographic features and resource types measured from geographic centers of archaeological and non-archaeological sites.

The regression procedure used here first analyzed all variables to determine their unique contribution toward distinguishing between actual and simulated archaeological sites. Those variables which, when dropped from the full model, did not cause a significant ($P < 0.5$) drop in the F statistic were discarded. Subsets of variables were then dropped or retained until a minimum number

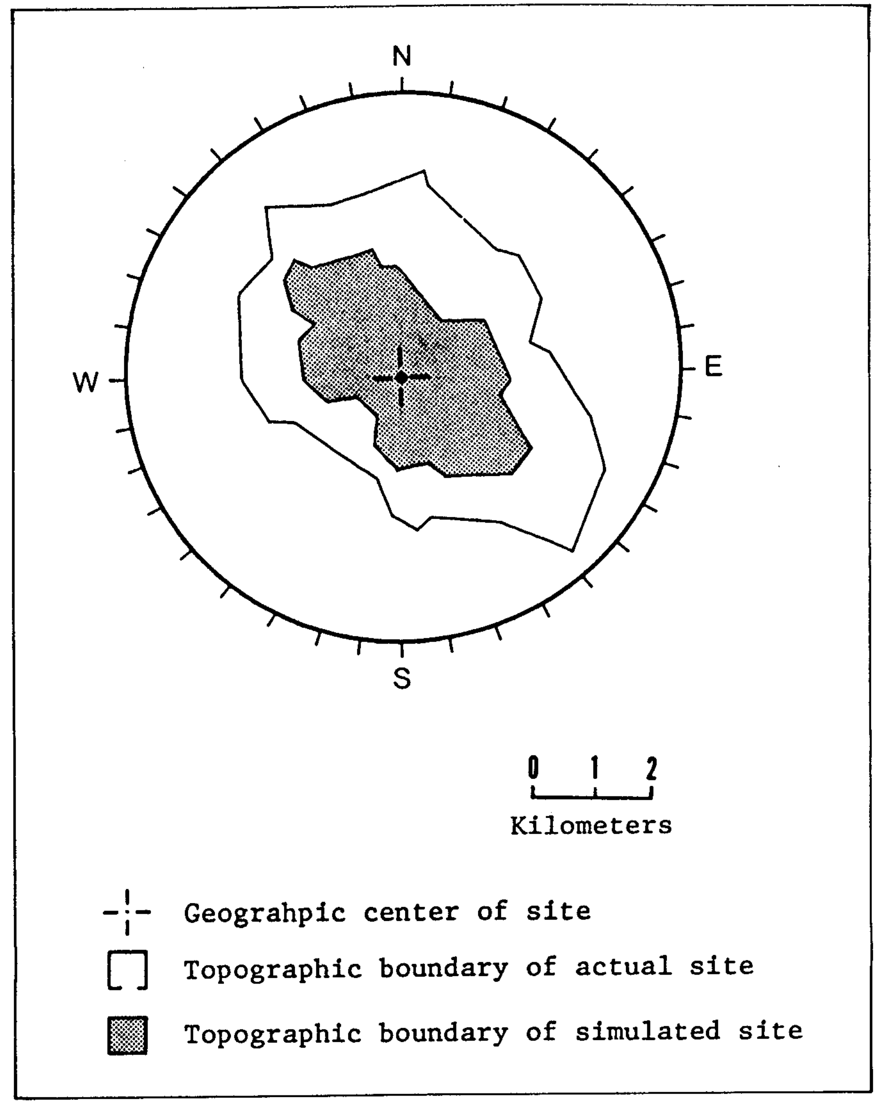

Figure 10. Horizon panorama depicting mean distances to topographic obstructions defining the horizon of acutal and simulated archaeological sites.

of variables explaining a maximum amount of variance resulted. The emphasis of the analysis was to analyze sets of predictor variables in terms of their contributions toward distinguishing archaeological sites from nonarchaeological sites. Consequently, we were more interested in these contributions than in the actual regression equation.

Of the variables examined (Table 2), thirteen were selected that best enabled a distinction to be made between archaeological and nonarchaeological sites along the east bank of Lake Francis Case. Of these thirteen significant predictors, eleven were related to vegetation/landform units. The remaining two were slope aspect and slope inclination. While none of these variables had a very high correlation with the dependent variable (Table 3), they did account for an overall multiple R^2 of 0.68. In other words, considered singly, none of the variables was very important in distinguishing a potential archaeological site from the array of sites available for habitation. However, considered as a group, these variables accounted for nearly 70 per cent of the variability associated with the location of archaeological sites. The *F*-value obtained from the regression model, 7.7, was significant at the .01 level of probability.

Based upon standardized regression coefficients, the presence of alluvial lowlands or an upland plain vegetation/landform type in the 2.25 acre area surrounding the geographic center of a grid was the most important feature in distinguishing between an archaeological and nonarcheaological site (Table 4). This was followed by slope aspect and inclination. The least important variables in making this distinction were the presence of steep, south facing grasslands in the composite 2.25 acre grid and the presence of shallow, south facing grasslands in grid nine.

Because of the high degree of variability associated with estimates of areal extent of vegetation/landform types, it was not realistic to place quantitative limits or minimum values on these variables in conjunction with their occurrence on archaeological sites. At best, one can say that the .25 acre surrounding the geographic center of an archeological site was characterized by a south facing *Agropyron* dominated grassland slope with generally less than 5° of inclination (but ranging up to 15°) and no north facing slope. The presence of shallow, south facing *Agropyron* slopes in grid nine and the lack of wooded drainages in grid three were also characteristics of archaeological sites. However, the latter may have been a statistical artifact while the former is highly correlated with variable 9 (Table 3). The 2.25 acres surrounding the geographic center of an archaeological site were characterized by the presence of upland plain or alluvial lowland grasslands that graded into south facing *Agropyron* slopes. Such grassland communities were often in close proximity to creek bottom or upland forest vegetation types.

A simpler, four-variable submodel was also developed which accounted for 60.5 per cent of the variation associated with distinguishing archaeological from nonarchaeological sites. The overall *F*-value of this model, 21.4, was significant at $P < .01$. Each predictor was significant at $P < .005$ (Table 5). In this simplified model, the single most important feature in distinguishing among sites was slope inclination, followed by the predominance of south-facing slopes of slight or no inclination dominated by western wheatgrass (*Agropyron smithii*), and distance to the 1500 ft topographic contour. The final variable in this simplified model was related to the presence of an upland plain vegetation/landform type.

Table 3. Correlation Matrix of Variables Significant in Describing Differences between Archaeological and Non-archaeological Sites Along the East Bank of Lake Francis Case. Variable 1 is the dependent variable (actual or simulated site). Variables 2 and 3 are slope aspect and inclination, respectively. Variables 4-14 are associated with vegetation/landform units. (See Table 4 for identification)

Correlation Matrix

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1	1.00	0.20	-0.57	-0.32	-0.09	0.29	-0.17	0.27	0.33	-0.06	0.17	0.14	0.19	0.01
2	0.20	1.00	-0.60	-0.32	-0.54	-0.33	-0.11	-0.12	-0.26	-0.13	0.37	0.35	0.24	0.04
3	-0.57	-0.60	1.00	0.34	0.16	0.07	0.48	-0.01	0.03	0.29	-0.29	-0.37	-0.23	0.11
4	-0.32	-0.32	0.34	1.00	0.55	-0.10	0.11	-0.09	-0.06	0.02	-0.07	-0.14	-0.06	0.04
5	-0.09	-0.54	0.16	0.55	1.00	-0.11	-0.13	-0.12	-0.04	-0.10	-0.14	-0.16	-0.06	0.05
6	0.29	-0.33	0.07	-0.10	-0.11	1.00	-0.02	0.53	0.79	0.16	-0.22	-0.30	-0.13	0.09
7	-0.17	-0.11	0.48	0.11	-0.13	-0.02	1.00	-0.10	-0.02	0.65	0.03	-0.36	-0.06	0.02
8	0.27	-0.12	-0.01	-0.09	-0.12	0.53	-0.10	1.00	0.70	0.13	-0.20	-0.18	0.09	0.05
9	0.33	-0.26	0.03	-0.06	-0.04	0.79	-0.02	0.70	1.00	0.11	-0.16	-0.34	-0.08	0.04
10	-0.06	-0.13	0.29	0.02	-0.10	0.16	0.65	0.13	0.11	1.00	-0.00	-0.37	-0.07	-0.01
11	0.17	0.37	-0.29	-0.07	-0.14	-0.22	0.03	-0.20	-0.16	-0.00	1.00	-0.39	-0.04	-0.04
12	0.14	0.35	-0.37	-0.14	-0.16	-0.30	-0.36	-0.18	-0.34	-0.37	-0.39	1.00	0.03	-0.17
13	0.19	0.24	-0.23	-0.06	-0.06	-0.13	-0.06	0.09	-0.08	-0.07	-0.04	0.03	1.00	-0.08
14	0.01	0.04	0.11	0.04	0.05	0.09	0.02	0.05	0.04	-0.01	-0.04	-0.17	-0.08	1.00

Table 4. Standardized Regression Coefficients of Variables Significant in Distinguishing Archaeological Sites from Nonarchaeological Sites. (Composite refers to the sum for all grids [1-9] totaling 2.25 acres around a site.)

Vegetation/Land from Unit	Grid	Variable Number	Regression Coefficient
Alluvial Lowland	Composite	12	0.7506
Upland Plain	Composite	11	0.6438
Slope Inclination	5	3	-0.4572
Slope Aspect	5	2	-0.3712
S-facing Grasslands (< 15°)	Composite	9	0.3394
S-facing Grasslands (> 15°)	5	7	0.3223
S-facing Grasslands (< 15°)	5	6	0.2767
Creek Bottom	Composite	13	0.2728
N-facing Grasslands (< 15°)	5	5	0.2329
Wooded Drainage	3	4	-0.2276
Upland Forest	Composite	14	0.2065
S-facing Grasslands (< 15°)	9	8	0.1001
S-facing Grasslands (> 15°)	Composite	10	0.0482

Table 5. Summary of Variables Selected as Being Significant Predictors in Distinguishing Archaeological from Non-archaeological Sites in a Simplified Four-Variable Model. These four predictors, listed below, accounted for 60.5 per cent of the variation associated with distinguishing between archaeological and non-archaeological sites.

Variable	*Standardized Regression Coefficient*	*F* *
Slope inclination	-0.447	17.9
Per cent of area on gentle south-facing slope (grid 5)	0.374	18.7
Distance to 1500′ contour	0.369	12.1
Per cent of area on upland plain site (grid 4)	-0.262	9.12
Constant	0.663	

*Significant in all cases at $P < .005$.

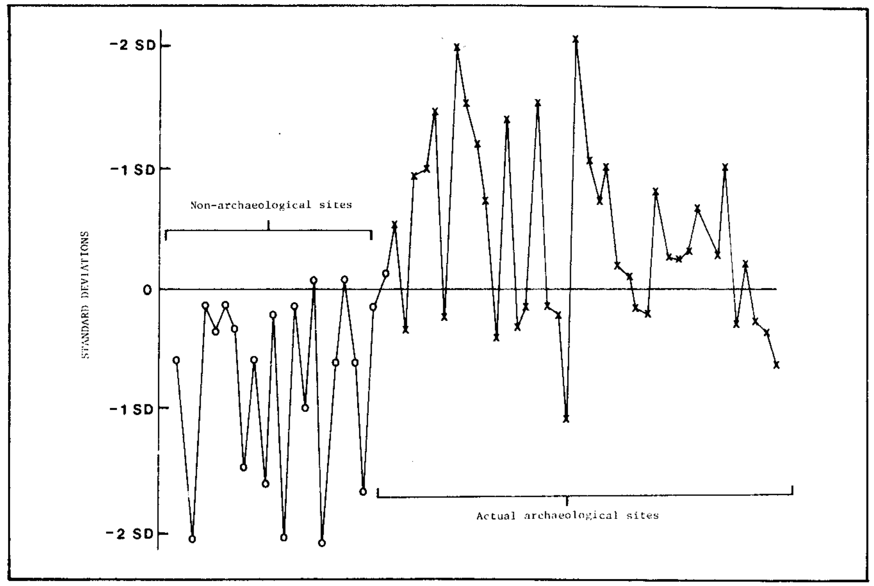

Figure 11. Sequence-ordered residual plot on the four-variable regression model using coefficients in Table 6. The plot shows that non-archaeological sites (-0-0-) typically yielded substantially negative standardized residuals while actual archaeological sites (-x-x-) typically yielded highly positive standardized residuals.

An analysis of the residual plot generated from this four-variable submodel serves to illustrate the utility of such a model in locating archaeological sites in the field (Fig. 11). Sites generating residuals close to zero would fall nearest the predicted regression line and would be acturately classified. If the residual values generated by variables in the proposed models were highly positive, then the site in question has a relatively high likelihood of being an archaeological one. If the residual values were low (very negative), the site was likely not suitable for prehistoric habitation. Thus, it appears that even when the model errs in classifying a site (e.g., standardized residuals > ± 1 standard deviation) it errs in a consistent fashion which yields valuable information on site classification.

SUMMARY

While most, if not all, archaeological sites located along the Missouri River floodplain and the first terrace above the floodplain have been inundated, a substantial number of upland archaeological sites remain. By systematically and quantitatively describing the physiographic setting of upland archaeological sites along the east bank of the Missouri River/Lake Francis Case Reservoir and comparing these sites to the universe of sites available for habitation, several significant differences were observed. These differences suggest that several factors are important in distinguishing archaeological sites from nonarchaeological sites.

The geographic centers of upland archaeological sites along the east bank of Lake Francis Case were systematically located in *Agropyron smithii* dominated grasslands of upland plain or alluvial lowlands sites. The 2.25 acres surrounding the geographic center of the typical site was characterized by upland plain or alluvial lowland grasslands that graded into south facing *Agropyron* dominated slopes of less than 15° inclination. Such sites were often in close proximity to creek bottom or upland forest vegetation types. No sites occurred on north facing slopes. Nearly 90 per cent of the sites were on slopes with either no inclination or southern exposure. Nearly 85 per cent were on slopes with inclinations of less than 5°, and no sites were encountered on inclinations greater than 16°. Most sites had easy access to upland plain bison habitat overlooking the breaks that form the border of the Missouri River trench. Sites were generally situated in open areas that afforded a good, topographically unobstructed view of the plains. Regression analysis indicated that several of these characteristics, considered as a group, could account for nearly 70 per cent of the variability associated with the location of archaeological sites.

Given this generalized physiographic description of the "typical" archaeological site, upland areas of likely prehistoric settlement along unsurveyed portions of the Missouri River can be delineated on aerial photographs or topographic maps and ranked in a hierarchical fashion. Those areas meeting the greatest number of criteria have the highest probability of containing an archaeological site and should be surveyed first. Sites meeting fewer criteria could be catalogued and surveyed later as time and money permit. Also, field personnel of governmental agencies (Corps of Engineers, Soil Conservation Service, Fish and Wildlife Service, and other groups) could be familiarized with these characteristics so that they might recognize a potential habitation site and be alert for telltale depressions and artifacts.

Several refinements and extensions of these results should be made. First, it would be interesting to stratify an expanded sample by archaeological site type, age, and cultural affiliation and determine, for example, whether or not permanent, long-term villages were located on physiographic sites significantly different from short-term, temporary village sites, or whether or not older sites were located differently from more recently inhabited sites. Discriminant analysis (Fryer, 1966) might be employed to define physiographic differences among various kinds of archaeological sites. Secondly, this model should be tested on and adapted to other reservoirs along the Missouri River trench on the west bank as well as the east. Thirdly, the model should be expanded or revised to include the undammed, semi-natural portion of the river between Pickstown and Yankton, South Dakota. Finally, similar models should be developed for other ecologically distinct portions of the state or region thought or known to contain significant archaeological sites. Two such areas in South Dakota would be the Tall Grass Prairie lake counties in the northeast and the Black Hills and Cave Hills in the west and northwest.

Now that a rather complete inventory of existing vegetation has been completed (Archer and Tieszen, 1979) and the resource units which were potentially available to prehistoric settlers have been preliminarily described and related to the location and distribution of archaeological sites, there is a need for a clarification of paleoenvironmental dynamics. Ahler et al. (1974) have begun this clarification process and a continuation of their work should enable the development of models of past plant and animal communities from which the spatial and seasonal concentrations of prime resources can be identified and quantified (e.g., Zawacki and Hausfater, 1969; Wood, McMillan and King, 1976).

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BIBLIOGRAPHY

AHLER, STANLEY A., D. K. DAVIES, CARL R. FALK, and DAVID B. MADSEN
1974 Holocene Stratigraphy and Archeology in the Middle Missouri Trench, South Dakota, *Science, 184,* pp. 905-908.

ARCHER, STEVE and LARRY TIESZEN
1979 A Classification and Gradient Analysis of Upland Plant Communities, *A Cultural Resources Reconnaissance of the Federal Lands on the East Bank of Lake Francis Case, South Dakota,* Larry J. Zimmerman and Gary Olson (eds.). U.S. Army Corps of Engineers, Omaha.

FRYER, H. C.
1966 *Concepts and Methods of Experimental Statistics.* Allyn and Bacon, Inc., Boston.

KERLINGER, FRED N. and E. J. PEDHAZUR
1973 *Multiple Regression in Behavioral Research.* Holt, Rinehart and Winston, New York.

LEHMER, DONALD J.
1970 Climate and Culture History in the Middle Missouri Valley, *Pleistocene and Recent Environments of the Central Great Plains,* W. Dort, Jr. and J. K. Jones, Jr. (eds.). University of Kansas Press, Lawrence.
ODUM, E. P.
1971 *Fundamentals of Ecology.* W. P. Saunders Co., Philadelphia.
U.S. ARMY CORPS OF ENGINEERS
1975 Lake Francis Case Boating and Recreation Map, Town Manager's Office, Pickstown, South Dakota (Second printing, revised March 1975).
WARD, J. H., JR.
1962 Multiple Linear Regression Models, *Computer Applications in the Behavioral Sciences,* H. Borko (ed.). Prentice-Hall, Englewood Cliffs.
WOOD, W. RAYMOND, R. BRUCE McMILLAN, and JAMES E. KING
1976 Models in Western Missouri Paleoecology and Prehistory: The Future, *Prehistoric Man and His Environemnts: A Case Study in the Ozark Highland,* W. Raymond Wood and R. Bruce McMillan (eds.). Academic Press, New York.
ZAWACKI, APRIL A. and GLENN HAUSFATER
1969 Early Vegetation of the Lower Illinois Valley: A Study of the Distribution of Floral Resources with Reference to Prehistoric Cultural-ecological Adaptations, *Report of Investigations, 17,* Illinois State Museum, Springfield.
ZIMMERMAN, LARRY J.
1977 *Prehistoric Locational Behavior: A Computer Simulation. Report 10,* The State Archaeologist of Iowa, Iowa City.
ZIMMERMAN, LARRY J. and THOMAS EMERSON
1979 An Archeological Reconnaissance and Evaluation of the East Bank of Lake Francis Case, *A Cultural Resource Reconnaissance of the Federal Lands on the East Bank of Lake Francis Case, South Dakota,* Larry J. Zimmerman and Gary Olson (eds.). U.S. Army Corps of Engineers, Omaha.

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A SIMULATION APPROACH TO
OF CHANGE IN CERAMIC FREQ

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ABSTR

This paper examines the problems enco
seriation in distinguishing chronological
ground stochastic "noise" inherent in
manufacture, breakage and discard be
the creation of "noise" in the archaeol
(POTS), which simulates both chronolo
in the ceramic assemblages of hypothe
effects of sample size on the chronologic
It is concluded that in order to maximi
a chronological ordering device, users sh
adequacy of their sherd samples and that
with artificial data sets generated under e

INTRODU

In spite of the dating revolution brou
ceramic frequency seriation as a chronol
important role in contemporary archaeol
in the discipline has been reviewed by a
Johnson, 1972; Michels, 1973), and it
creation, growth in popularity, and parti
the hallmark of the seriation method itself