

**Rockshelters, Rockart and Grinding Activity:  
A Preliminary Assessment of Relationships in Picket Wire  
Canyonlands, Comanche National Grasslands**

Ralph J. Hartley  
Anne M. Wolley Vawser

Midwest Archeological Center  
National Park Service  
February, 2003



## Table of Contents

|                            |    |
|----------------------------|----|
| Introduction.....          | 1  |
| The Approach .....         | 4  |
| Background and Method..... | 4  |
| Results .....              | 6  |
| Discussion.....            | 13 |
| End Notes.....             | 16 |
| References Cited.....      | 17 |

## List of Figures

|  |    |
|--|----|
| Figure 1. Archeological Sites locations in the Picket Wire Canyonlands, Comanche National Grasslands.....                                | 2  |
| Figure 2. Example of one of the many rockshelters found at the sites along the river (Site 5LA5841).....                                 | 3  |
| Figure 3. A view of the Purgatoire River valley from a rockshelter at Site 5LA5841 .....   | 3  |
| Figure 4. Example of the many bedrock grinding surfaces documented (Site 5LA5844).....   | 5  |
| Figure 5. Rock art in this example is in a small sheltered area with a nearby grinding surface (lower left of photo) (Site 5LA5841)..... | 5  |
| Figure 6. View of a circular stone ‘structure’ at site 5LA5838. ....   | 7  |
| Figure 7. Thiessen polygons for rockshelters and the locations of associated features at site 5LA1023. ....                              | 9  |
| Figure 8. Thiessen polygons for rockshelters and the location of associated features at site 5LA5838. ....                               | 10 |
| Figure 9. Thiessen polygons for rockshelters and the location of associated features at site 5LA5841. ....                               | 11 |
| Figure 10. Thiessen polygons for rockshelters and the location of associated features at site 5LA5844. ....                              | 12 |

## List of Tables

|   |    |
|---|----|
| Table 1. Associations with unmodified and modified rockshelters.....          | 7  |
| Table 2. Logit analysis of rock art and groundstone at PCMS rockshelters..... | 8  |
| Table 3. Content of spatial units (polygons).....                             | 8  |
| Table 4. Co-occurrence of variables in spatial units (polygons). ....         | 14 |
| Table 5. Distance (meters) from rockshelters.....                             | 14 |

## Introduction

Rockshelters and caves used by prehistoric people have fascinated archeologists and the general public for many years. Such sheltered locations often contain a wide range of perishable material remains and as well as intact geological and cultural deposits that make them particularly significant loci for archeological investigation. Frequently rockshelters, caves, and alcoves served as important locations within past land-use systems. It is the topographic situation, distribution, and domestic activity in proximity to rockshelters along the Purgatoire River in southeast Colorado that is the focus of this paper.

The Purgatoire River flows northeast to the Arkansas River through an area known as the Picket Wire Canyonlands. This component of Comanche National Grasslands is bounded on the northwest by the U.S. Army's Pinon Canyon Maneuver Site (PCMS), an area of approximately 104,000 ka. The landscape is characterized by a semi-arid environment of tablelands, mesas and several canyon systems that drain southeast to the Purgatoire River (Figure 1). A systematic inventory of cultural resources in 7,150 acres of Picket Wire Canyonlands was undertaken in 1993 and 1994 (Reed and Horn 1995). Four of the 263 Native American cultural resource locations documented during that inventory are examined in this study (5LA1023, 5838, 5841, and 5844).<sup>1</sup>

Rockshelters and "alcoves" are often differentiated from "caves" in archeological literature but less so in ethnographic and ethnohistoric accounts. Characteristics of a "rockshelter" as defined for central Texas by Collins (1991:158) are appropriate for southeastern Colorado where bedrock overhangs and the area beneath is "within reach of daylight and ambient temperature and moisture" (Figure 2). In the study area examined here shelters formed by large boulders have the potential to offer similar characteristics (Loendorf 1989; Loendorf and Kuehn 1991; Reed and Horn 1995).

Ethnographically documented use of rockshelters and archeological investigations of prehistoric rockshelter sites often reveal that a number of human activities took place outside the sheltered or roofed floor area on nearby talus slopes or terraces. Ethnographic and ethnohistoric accounts suggest that the occupants of these places who used the shelter for more than one night were usually, but not always, kin-based groups (i.e. either nuclear or extended families). For example, mobile kin-based groups inhabiting a wide range of environments (central Desert of Australia, tropical environments of Malaysia and Sri Lanka, and so forth) are known to have carried out a number of different domestic activities within caves, overhangs, and alcoves. The duration of occupation, from a few nights to several months, is conditioned by variable subsistence needs and opportunities. The duration of such stays is generally reflected by the degree to which sheltered spaces were enhanced or modified with material such as brush or portable rock (Seligmann and Seligmann 1911; Evans 1937; Gardner 1972; Veth 1993; cf. Reed and Horn 1995:111).

The four "site" localities examined here are assumed to have been a magnet for a number of activities by kin-based groups due to their proximity to the Purgatoire River (Figure 3). This contextual setting, based for the most part on ground surface observations, constitutes relevant data for this study. Exploratory analyses are pursued in one dimension since the data are available in presence/absence format only. The direct behavioral context and/or simultaneous use of features or artifacts cannot be assessed reliably at this time. We must also remember that the

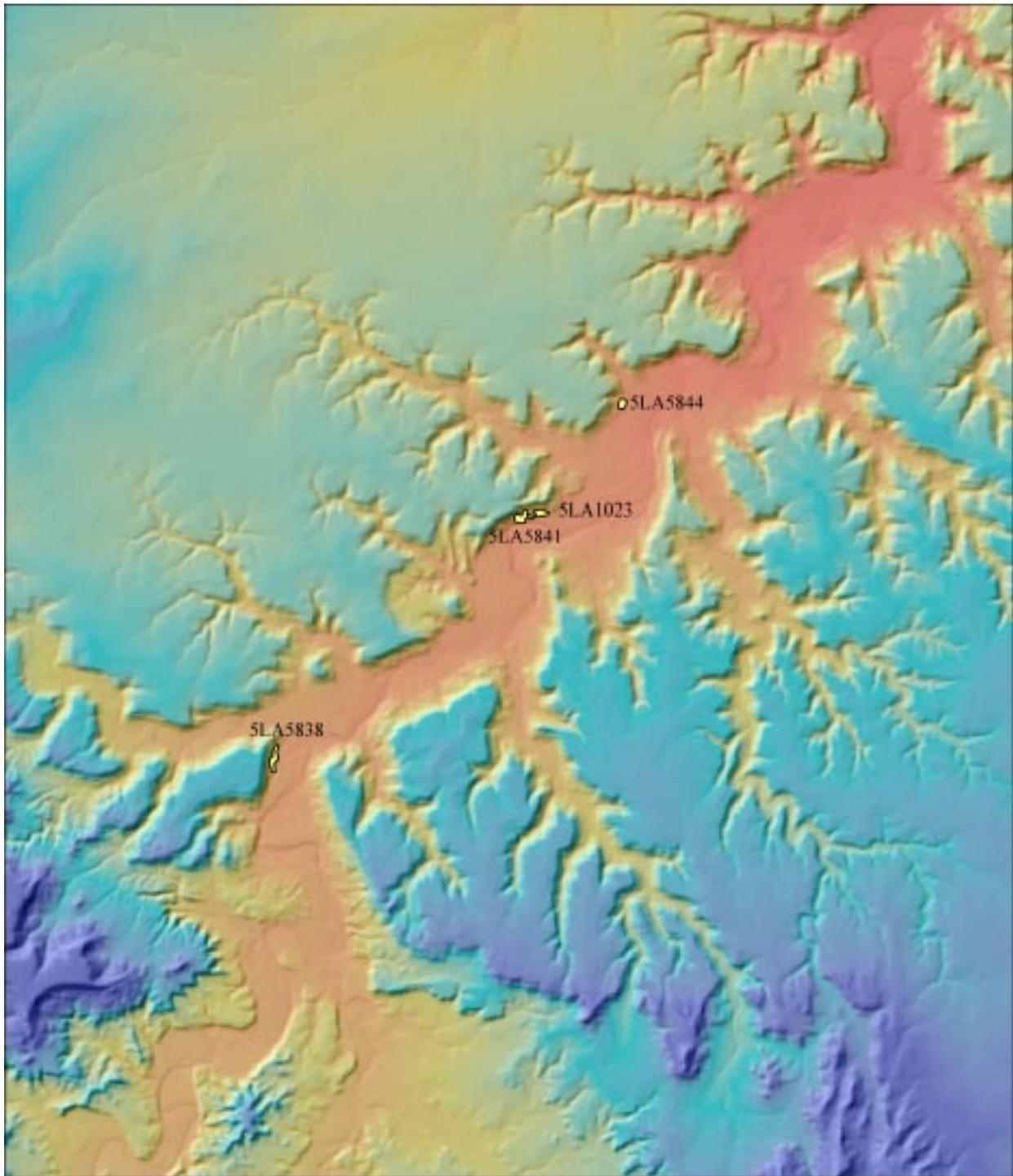


Figure 1. Archeological Site locations in the Picket Wire Canyonlands, Comanche National Grasslands



Figure 2. Example of one of the many rockshelters found at sites along the river (Site 5LA5841).



Figure 3. A view of the Purgatoire River valley from a rockshelter at Site 5LA5841.

“presence” or the “absence” of a surface observation can also be the result of depositional and erosion activity. Failure to observe surface remains like portable groundstone does not necessarily indicate that food processing did not occur at the site (e.g. Veth 1993:78). Simply stated, in the present study we do not know the formational history of the cultural remains on this landscape. We also acknowledge that the development of methods to determine high temporal resolution for these observations may be highly unlikely (Wandsnider 1996:322).

## **The Approach**

In some cases we can address the ambiguity in surface observations by constructing variables that are the result of minimizing assumptions about the correct identity of the observations. Generating well-structured hypotheses for the derivation of models can be one goal of exploratory data analysis (Carr 1991). With data from sites on the Pinon Canyon Maneuver Site (PCMS) as referential background, we examine archeological surface observations in Picket Wire Canyonlands to identify spatial relationships between rock-art “panels”, plant-grinding activities, and nearby rockshelters. The presence of grinding or milling activities is assumed here to be a rough index of the domestic investment in the site. These exploratory analyses pursue a recognition of spatial patterns from which variation in cultural remains stemming from the use-history of a place can influence inference, derived for the most part, inductively (cf. Binford 1987:465-466). Rather than formulating an interpretation of occupation and use, however, the goal of this paper is to present questions regarding prehistoric use of space in this landscape that have the potential to be investigated empirically.

## **Background and Method**

The Pinon Canyon Maneuver Site (PCMS) has undergone extensive inventory over the last two decades. Although several thousand Native American sites have been recorded within the PCMS boundaries there are 662 that can be used for this analysis. In these cases, the observations were recorded in a consistent fashion. This limited database contains both nominal and categorical variables or fields. Within this data set there are 171 sites that possess observations with at least one of the following variables:

**ROCKSHEL** – rockshelters that show evidence of prehistoric occupation or use that have not been modified with architecture, such as stacked rock.

**ROCKWARC** – rockshelters that show evidence of prehistoric occupation or use and exhibit the remains of architectural modification.

**GROUNDSTONE** – Artifactual remains that show evidence of grinding or milling activity, such as metates, manos, bedrock metates or other grinding surfaces (Figure 4).

**ROCKART** – Petroglyphs and/or pictographs (Figure 5).



Figure 4. Example of the many bedrock grinding surfaces documented (Site 5LA5844).



Figure 5. Rock art in this example is in a small sheltered area with a nearby grinding surface (lower left of photo) (Site 5LA5841).

ARCHITECTURE – Rock aligned or stacked so as to be or contribute to a structural form (Figure 6).

We asked one fundamental question of the PCMS data set: To what extent is the presence of prehistoric grinding or milling activity, rock-art, and architectural remains spatially associated with the human use of a rockshelter? Analysis suggests that rockshelters, both modified and unmodified, show a weak association with evidence of grinding activities (Table 1). The presence of rock art is much less associated with modified rockshelters and devoid of any demonstrable association with unmodified rockshelters. Log-linear analysis (binary logit SYSTAT v.10.2) indicates however that the presence of grinding activities is the best predictor of rockshelter occupation (Table 2). That is, controlling for rock art, the probability of groundstone being present at an unmodified rockshelter is 16.5 times greater than evidence of these remains being absent. Similarly, at modified rockshelters, the probability of groundstone being present at the site is 5.75 times greater than its presence not being observed.

With some measure of associations established for the presence of remains at rockshelter sites in the PCMS we examined the content of the four “site” localities along the Purgatoire River. Three fundamental questions were asked of observations made at these places:

- I. To what extent are rock art, grinding and milling materials, and structural features spatially associated with rockshelters?
- II. To what extent do these remains co-occur in proximity to rockshelters?
- III. How are these observed remains positioned relative to rockshelters?

The spatial extent of these “site” localities, as determined by initial documentation of the cultural features and remains, was apportioned into spaces, such that each rockshelter functioned as the nuclei by which tessellation procedures forming polygons were constructed to establish a “proximal solution” to the “sites”.<sup>3</sup> With this procedure every location of rock art, grinding and milling material, and architectural or structural feature is designated as nearer to a given rockshelter than any other rockshelter. Each polygon, as a unit of analysis, is then conceptualized as a space “oriented” to a particular rockshelter. For the purpose of these analyses we consider these spatial units to be similar in utility to the spatial units (“primitive structural elements”) conceptualized by Wandsnider (1996). Differences include, however, that they are not uniformly distributed in space and that the fundamental assumption being explored here is that the spatial unit is defined by domestic activities associated with use of the rockshelters.<sup>4</sup>

## Results

A total of 47 spatial units (polygons) stemming from rockshelter locations was derived from the four “site” localities examined (Figures 7 through 10). Of these, approximately half contain evidence of grinding or milling activity or rock art (Table 3).<sup>5</sup> Reed and Horn (1995:111,141) noted a roughly similar occurrence of grinding activity at “modified rockshelters” among all sites recorded in Picket Wire Canyonlands, but far less than the nearly



Figure 6. View of a circular stone ‘structure’ at site 5LA5838.

Table 1. Associations with unmodified and modified rockshelters.

|              | n (%)     | $\chi^2$ | Cramer’s V | Russel/Rao <sup>2</sup> |
|--------------|-----------|----------|------------|-------------------------|
| ROCKSHEL     |           |          |            |                         |
| GROUNDSTONE  | 11 (78.6) | 2.62     | .124       | .064                    |
| ROCKART      | 1 (7.1)   | .108     | .025       | .006                    |
| ARCHITECTURE | -         | -        | -          | -                       |
| ROCKWARC     |           |          |            |                         |
| GROUNDSTONE  | 17 (73.9) | 8.77     | .226       | .099                    |
| ROCKART      | 5 (21.7)  | 14.47    | .291       | .029                    |
| ARCHITECTURE | 4 (17.4)  | .248     | .038       | .023                    |

Table 2. Logit analysis of rock art and groundstone at PCMS rockshelters.

|                                 | Coefficient | T-ratio | p     | Odds Ratio |
|---------------------------------|-------------|---------|-------|------------|
| ROCKSHEL                        |             |         |       |            |
| GROUNDSTONE                     | 2.80        | 5.44    | 0     | 16.5       |
| ROCKART                         | 25.78       | .022    | .987  | -          |
| GROUNDSTONE<br>AND ARCHITECTURE | 12.819      | .015    | .988  | -          |
| ROCKWARC                        |             |         |       |            |
| GROUNDSTONE                     | 1.749       | 5.322   | 0     | 5.75       |
| ROCKART                         | -0.784      | -0.499  | 0.618 | .457       |
| GROUNDSTONE<br>AND ARCHITECTURE | -1.499      | -1.36   | 0.174 | .223       |

Table 3. Content of spatial units (polygons).

| Site    | Polygons | Rock Art | Grinding/Milling | Architecture |
|---------|----------|----------|------------------|--------------|
| 5LA1023 | 14       | 6 (43%)  | 2 (14%)          | 6 (43%)      |
| 5LA5838 | 4        | 1 (25%)  | 4 (100%)         | 3 (75%)      |
| 5LA5841 | 21       | 10 (48%) | 9 (43%)          | 11 (52%)     |
| 5LA5844 | 8        | 7 (88%)  | 6 (75%)          | 0            |
| Total   | 47       | 24 (51%) | 21 (45%)         | 20 (43%)     |

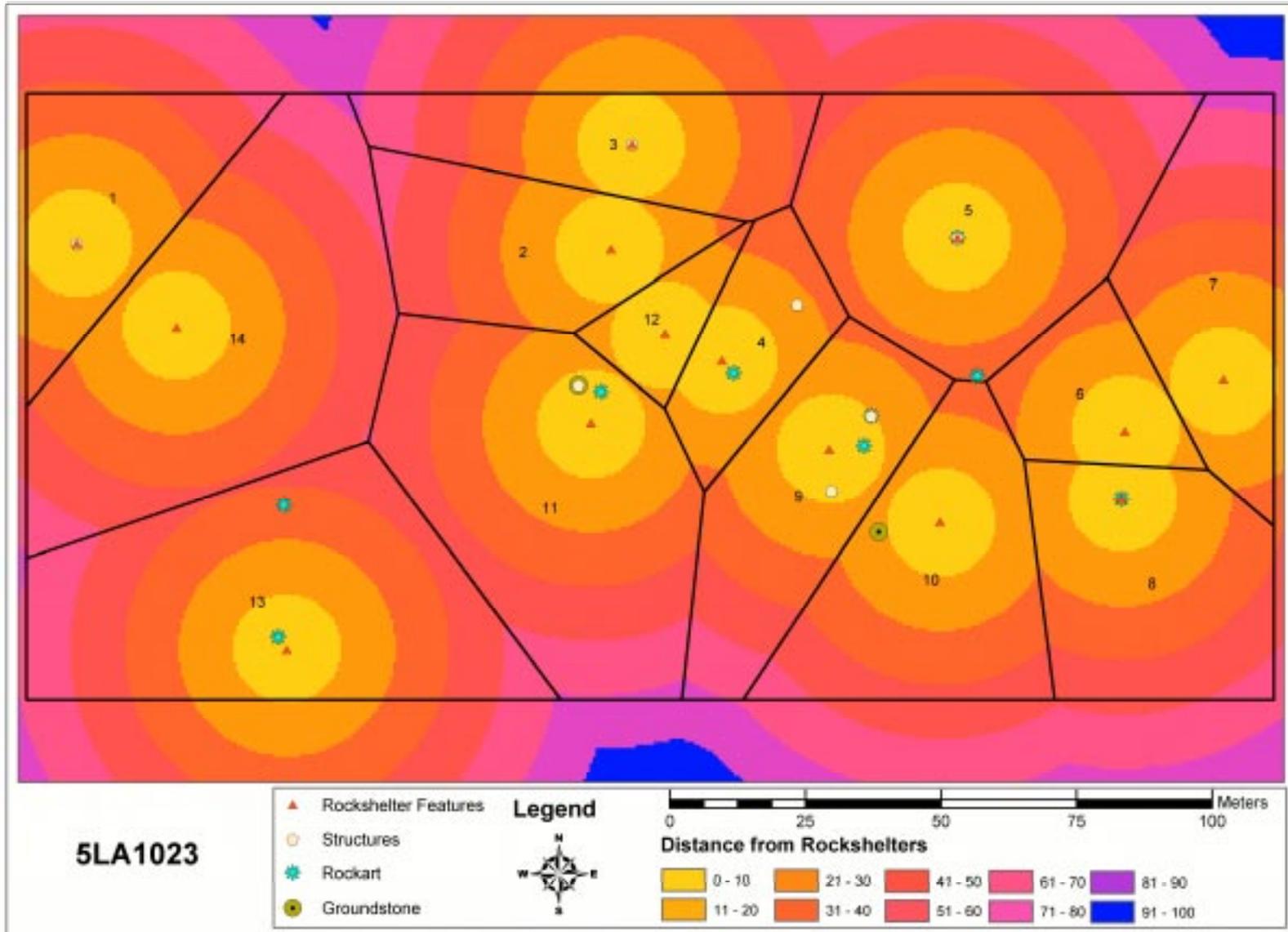


Figure 7. Thiessen polygons for rockshelters and the locations of associated features at site 5LA1023.

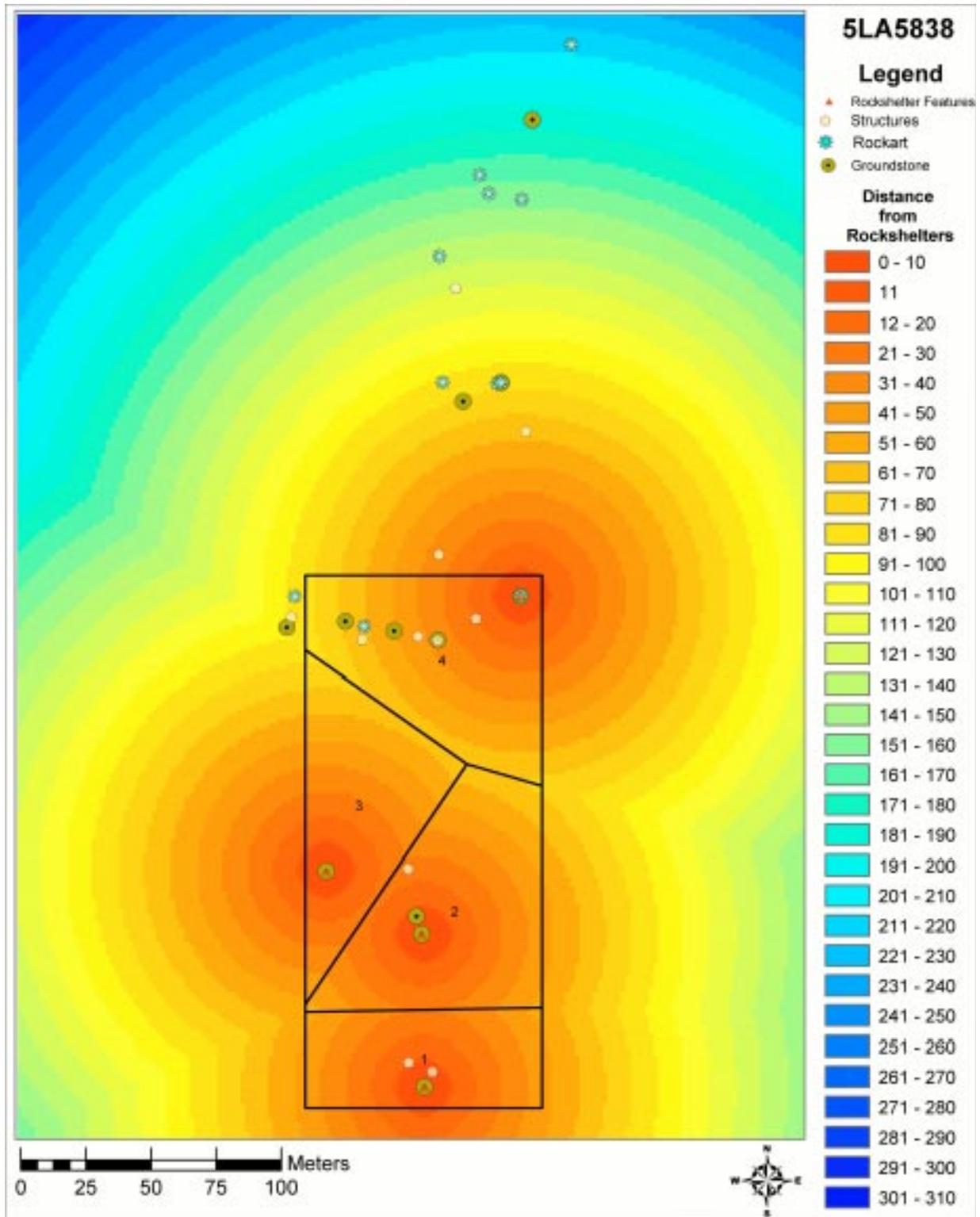


Figure 8. Thiessen polygons for rockshelters and the location of associated features at site 5LA5838.

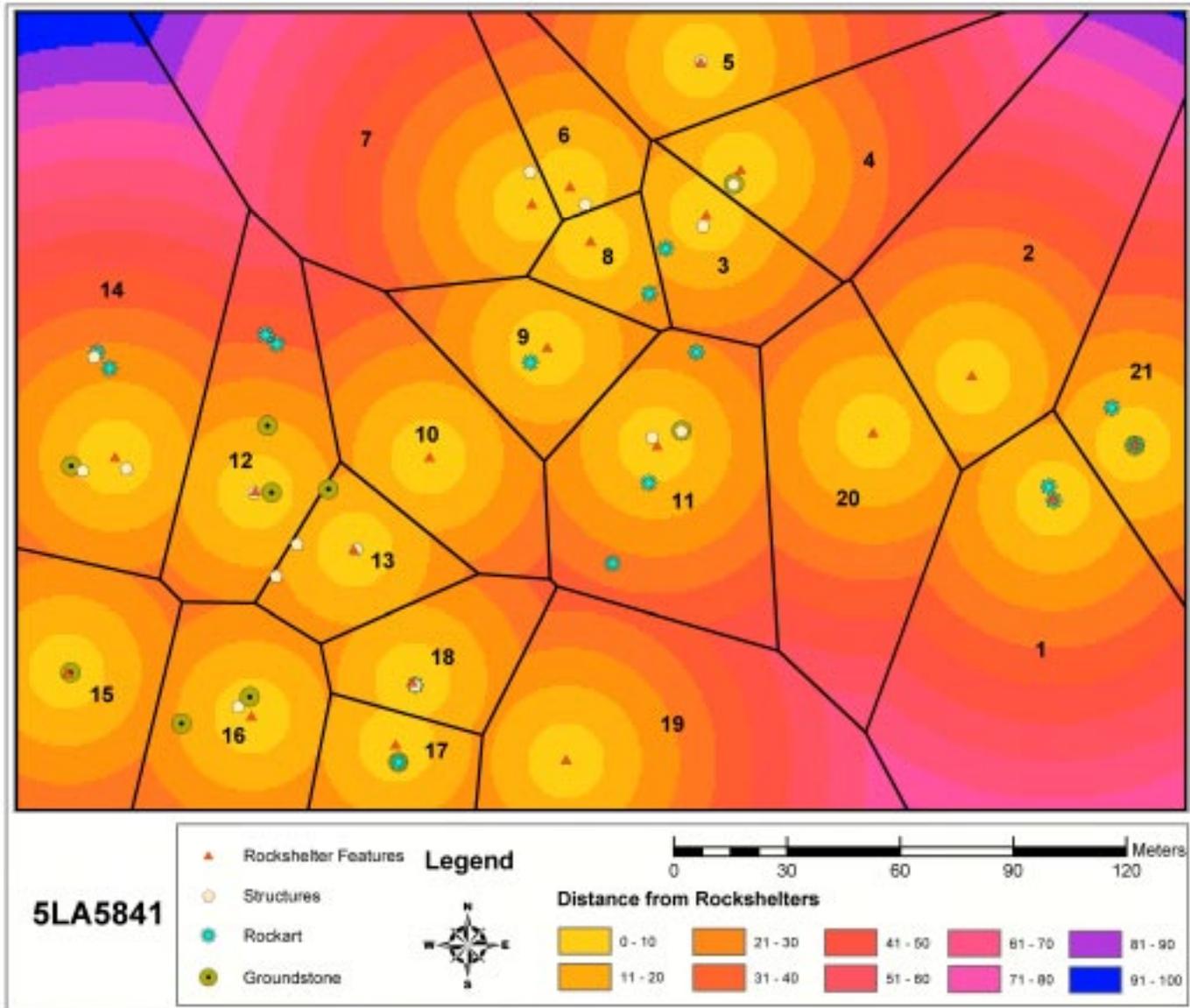


Figure 9. Thiessen polygons for rockshelters and the location of associated features at site 5LA5841.

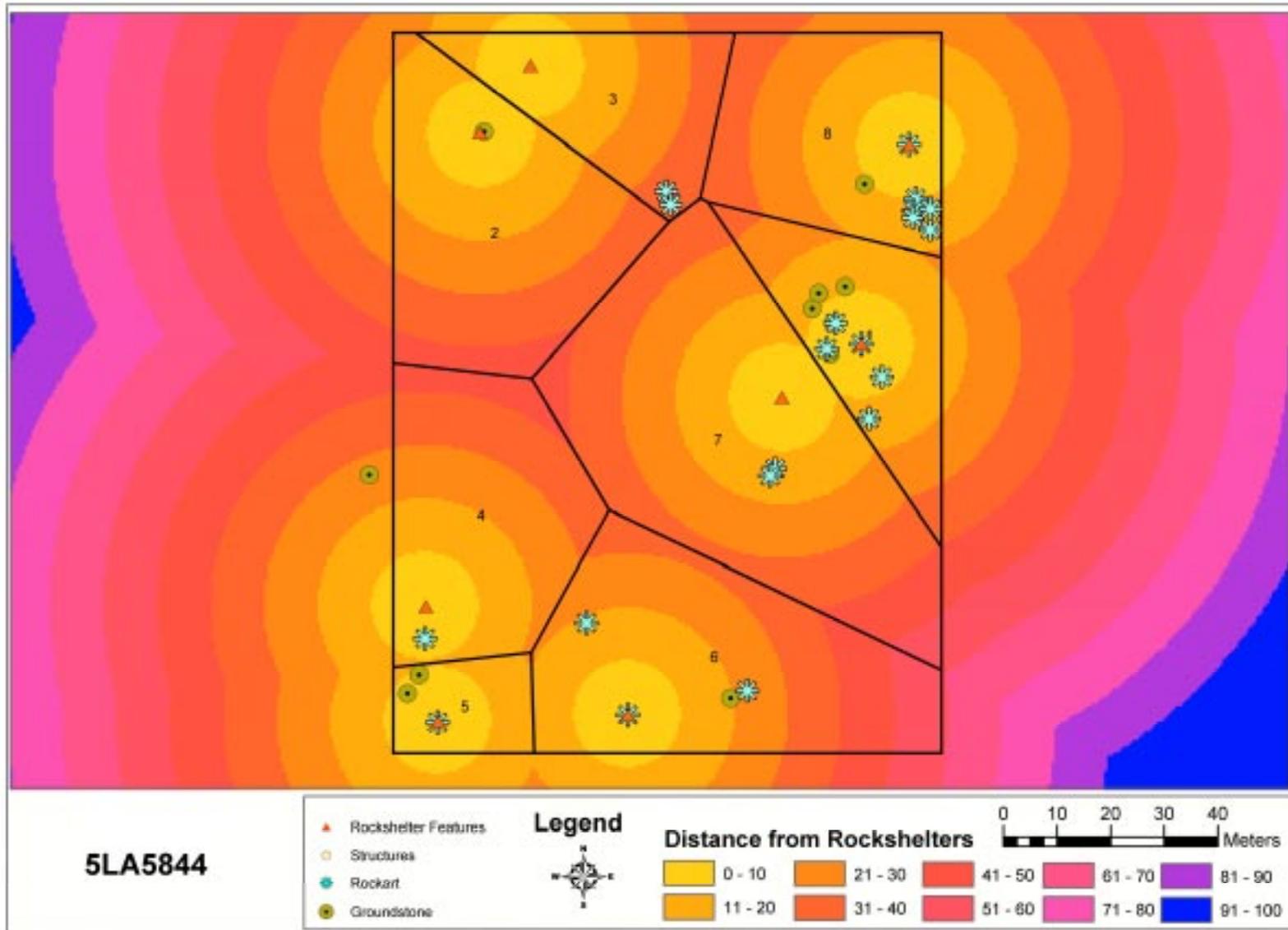


Figure 10. Thiessen polygons for rockshelters and the location of associated features at site 5LA5844.

75% of rockshelter sites in the PCMS sample. The presence of rock art, however, is much greater in the spatial units partitioned here than that of sites defined in the extensive inventory (about 27%) of Picket Wire Canyonlands. Notable is the comparable infrequent rock art recorded at rockshelter sites in the PCMS sample.

Our interest in exploring associations between rockshelters, grinding or milling evidence, and the presence of rock art required assessing the co-occurrence of rock art and grinding evidence in each spatial unit. Nearly 75% of all spatial units at these four “site” localities do not reveal the presence of rock art and surface indication of grinding or milling activity together (Table 4). However, the co-occurrence of these remains in Picket Wire Canyonlands is far greater than that indicated by the PCMS sample, where at more than 97% of the rockshelter sites evidence of grinding or milling and rock art are not found together.

The positioning of rock art, grinding or milling activities, and structural features relative to rockshelters indicates a somewhat consistent mean maximum distance for all but site 5LA5838 (Table 5). Polygon #4 of that site skews the mean range of distance of features from rockshelters. For all sites defined during the inventory of Picket Wire Canyonlands rock art extended up to 130 m from “habitation areas” prompting Reed and Horn (1995:168) to suggest that “little patterning” was observed in the placement of rock art panels.

## Discussion

The search for patterns in the human use of space can be fraught with problems, both conceptual and real. And, of course, the high potential for an accumulation of material remains and artifactual features in a landscape over time embodies a fundamental challenge to anthropological archaeology. But even without the confounding effect of historical phenomena, constructing conclusive inductive inferences about any process from spatial patterning generated by empirical observations (even where time is controlled) should be considered conjectural (Taylor 1977:149). For, as Binford (1987:450) emphasized, an archaeological record is the result of an accumulation of episodes of activity and the translation of information into data rarely informs us about factors that conditioned behavior that resulted in those activities. An argument could be made that questions that address how, let alone why, humans used the Purgatoire valley in prehistory should not be the burden of the analyses of archeological observations alone. So then how do analyses of static point locations contribute to the pursuit of understanding the processes that generated these locations? Relations among individuals or social groups or between them and the physical non-human environment are often reflected in observations that can be defined spatially. The characteristics in any patterning in one plane can, quite simply, help frame questions that are oriented toward investigating the behavior underlying observations. We should not, however, expect the archeological record to be the sole source of information for answering questions about relationships reflected in the physical distances between points in space.

The presence of numerous and highly variable rock art panels along this portion of the Purgatoire River is acknowledged. The variance in morphology of the rock art is attributed to different groups and time periods (Loendorf 1989; Loendorf and Kuehn 1991; Reed and Horn 1995; Zier and Kalasz 1999). One might assume, based on PCMS site density information, that the Purgatoire River valley landscape varies from the adjacent tablelands, not only topographically, but also in “place-use” and “place-occupation” history (Wandsnider 1998).

Table 4. Co-occurrence of variables in spatial units (polygons).

| Site    | Rock Art and Groundstone | Rock Art and Architecture | Groundstone and Architecture |
|---------|--------------------------|---------------------------|------------------------------|
| 5LA1023 | 1 (7%)                   | 4 (29%)                   | 1 (7%)                       |
| 5LA5838 | 1 (25%)                  | 1 (25%)                   | 1 (25%)                      |
| 5LA5841 | 5 (24%)                  | 5 (24%)                   | 6 (29%)                      |
| 5LA5844 | 5 (63%)                  | 0                         | 0                            |
| Total   | 12 (26%)                 | 10 (21%)                  | 8 (17%)                      |

Table 5. Distance (meters) from rockshelters.

| Site      |            | Rock Art       | Grinding/milling | Architecture   |
|-----------|------------|----------------|------------------|----------------|
| 5LA1023   | mean<br>sd | 11.67<br>11.50 | 10.0<br>2.83     | 5.50<br>6.90   |
| 5LA5838 * | mean<br>sd | 62<br>-        | 19.0<br>32.90    | 33.67<br>28.30 |
| 5LA5841   | mean<br>sd | 16.50<br>13.34 | 9.33<br>7.59     | 7.55<br>8.86   |
| 5LA5844   | mean<br>sd | 15.86<br>11.91 | 13.33<br>8.90    | 0              |

\* Measures include maximum distance within the geometric boundaries of polygon number 4.

Does the extent or duration of occupation of this area account for the higher density of rock art relative to the tablelands to the north? What accounts for the greater frequency of rock art and grinding or milling remains in proximity to rockshelters in Picket Wire relative to rockshelter sites on the PCMS?

In the twelve polygons where rock art and evidence of grinding or milling are observed to co-exist visual assessment suggests that rock art is often positioned somewhere near the boundaries of the spatial unit, irrespective of other rock art locations within the space. Where these spatial units are examined as a whole and including the most extreme distribution in polygon #4 at 5LA5838, rock art lies at a median maximum distance from rockshelters (15m) that is greater than that of grinding or milling evidence (11.50m). Does an extended stay and investment in a place foster proprietary behavior manifested in rock art symbols and their location? Does the distribution of rock art panels in the vicinity of a rockshelter vary with respect to the remains of activities in this space? Do the content of rock art panels vary relative to their positioning in this space?

Hispanic ranching and settlement in the Purgatoire valley during the 19<sup>th</sup> century may contribute to any “noise” in presumed patterning of activities by Native Americans (Reed and Horn 1995:122-139; Church 2002). Cultural remains at site 5LA5844 are especially vulnerable to being a locale where features such as rockshelters, bedrock metates, groundstone, and rock art were used or altered. Does an intensity of use of this portion of the riverway over time account for an accumulation of remains of activity that make spurious any static associations?

Procedures by which to minimize the “noise” that is inherent to the archeological record at these localities is, we believe, to be found in investigations of spatial variation at scales that are smaller than what is often deemed an archeological “site”. Patterning or the absence of spatial association at various scales may solicit new questions about the dynamics that produced the observations, but that it itself is of value (Binford 1992:51-52). Visualization of multivariate spatial data, while fostering assumptions and interpretations, requires quantitative methods by which to reliably assess relationships (Fotheringham 1997; 1999). Analysis of the Purgatoire valley localities, at more than one spatial scale, using the procedures and structural descriptors proposed by Wandsnider (1996) may, for example, offer an objective means of insight into the intensity of occupation or use of these places.

## End Notes

<sup>1</sup> Four sites in the study area were chosen by US Forest Service personnel for site condition assessments. The identification of current impacts or threats to the integrity of the cultural remains along with the potential treatment of these impacts constituted the focus of field documentation in September of 2001.

<sup>2</sup> This similarity measure as a coefficient of resemblance indicates the properties of sites exhibiting this characteristic at modified and unmodified rockshelters. Similarity scores offer some indication of association, whereas Cramer's V offers a measure (0-1) of the proportion of maximum variation due to interaction between the variables. This level of analysis minimizes assumptions inherent in the data (see Sneath and Sokal 1973:129-137; Spaulding 1982; Liebetrau 1983).

<sup>3</sup> This method forms a mosaic of tiles commonly called Dirichlet tiles, Thiessen or Voronoi polygons (see Upton and Fingleton 1985: 96-104; Haining 1990: 20, 101-110).

<sup>4</sup> We acknowledge that the geometric nature of these spatial units, in all likelihood, is not reflective of the "real" use of space. Also, we are aware that clusters of small rockshelters may have been used contemporaneously by non-kin related families forming "camps" (e.g. Gregg 1980:130; cf. Binford 1991; Gould and Yellen 1991). Aggregation of families relying on the protection offered by rockshelters may be reflected in the spatial structure of remains at a scale differing from that explored here. The purpose of the methodology used in this paper is one of assessing spatial efficiency, all other variables held constant.

<sup>5</sup> The presence of structural features and architecture are included in these analyses, however, the variability of morphology included in this category in both original site documentation and our field assessments exceeds any attempt here to define meaningful associations (cf. Zier and Kalasz 1999). The presence of these features may be considered indicative of the degree to which occupants were willing to invest in a given space.

## References Cited

Binford, Lewis R.

- 1987 Researching Ambiguity: Frames of Reference and Site Structure. In *Method and Theory for Activity Area Research: An Ethnoarchaeological Approach*. Ed. Susan Kent, pp. 449-511. Columbia University Press, New York.
- 1991 Is Australian Site Structure Explained by the Absence of Predators? *Journal of Anthropological Archaeology*. 10:255-282.
- 1992 Seeing the Present and Interpreting the Past – and Keeping Things Straight. In *Space, Time, and Archeological Landscapes*. Ed. Jacqueline Rossignol and LuAnn Wandsnider, pp.43-59. Plenum Press, New York.

Carr, Christopher

- 1991 Left in the Dust: Contextual Information in Model-Focused Archaeology. In *The Interpretation of Archaeological Spatial Patterning*. Ed. Ellen M. Kroll and T. Douglas Price, pp. 221-256. Plenum Press, New York.

Church, Minette C.

- 2002 The Grant and the Grid: Homestead Landscapes in the Late Nineteenth-Century Borderlands of Southern Colorado. *Journal of Social Archaeology*. 2:220-244.

Collins, Michael B.

- 1991 Rockshelters and the Early Archaeological Record in the Americas. In *The First Americans: Search and Research*. Ed. Tom D. Dillehay and David J. Meltzer, pp. 157-182. CRC Press, Boca Raton, FL.

Evans, Ivor H.N.

- 1937 *The Negritos of Malaya*. Cambridge University Press, Cambridge.

Fotheringham, A. Stewart

- 1997 Trends in quantitative methods I: stressing the local. *Progress in Human Geography* 21:88-96.
- 1999 Trends in quantitative methods III: stressing the visual. *Progress in Human Geography* 23:597-606.

Gardner, Peter M.

- 1972 The Paliyans. In *Hunters and Gatherers Today*. Ed. M.G. Bicchieri, pp. 404-447. Holt, Rhinehart and Winston, Inc., New York.

- Gould, Richard and John E. Yellen  
 1991 Misreading the Past: A Reply to Binford Concerning Hunter-Gatherer Site Structure. *Journal of Anthropological Archaeology*. 10:283-298.
- Gregg, Susan A.  
 1980 A Material Perspective of Tropical Rainforest Hunter-Gatherers: The Semang of Malaysia. In *The Archaeological Correlates of Hunter-Gatherer Societies: Studies from the Ethnographic Record*. Ed. F.E. Smiley, pp. 117-135. Michigan Studies in Anthropology, Vol. 5, Nos. 1 & 2., Ann Arbor.
- Haining, Robert  
 1990 *Spatial Data Analysis in the Social and Environmental Sciences*. Cambridge University Press, Cambridge.
- Liebetrau, Albert M.  
 1983 *Measures of Association*. Sage Publications, Beverly Hills, CA.
- Loendorf, Lawrence L.  
 1988 *Nine Rock Art Sites in the Pinon Canyon Maneuver Site, Southeastern Colorado*. Department of Anthropology Contribution No. 248, University of North Dakota.
- Loendorf, Lawrence L. and David K. Kuehn  
 1991 *1989 Rock Art Research Pinon Canyon Maneuver Site, Southeastern Colorado*. Department of Anthropology Contribution No. 258, University of North Dakota.
- Reed, Alan D. and Jonathan C. Horn  
 1995 *Cultural Resource Inventory of a Portion of the Picket Wire Canyonlands, Comanche National Grassland, Las Animas and Otero Counties, Colorado*. Manuscript on file, Midwest Archeological Center, National Park Service, Lincoln, NE.
- Seligmann, C.G. and Brenda Z. Seligmann  
 1911 *The Veddas*. Cambridge University Press, Cambridge.
- Spaulding, Albert C.  
 1981 Structure in Archaeological Data: Nominal Variables. In *Essays on Archaeological Typology*. Ed. Robert Whallon and James A. Brown, pp. 1-20. Center for American Archaeology, Evanston, IL.
- Sneath, Peter H. and Robert R. Sokal  
 1973 *Numerical Taxonomy*. W.H. Freeman and Co., San Francisco.
- Taylor, Peter J.  
 1977 *Quantitative Methods in Geography: An Introduction to Spatial Analysis*. Houghton Mifflin Co., Boston.

Upton, Graham J.G. and Bernard Fingleton

1985 *Spatial Data Analysis by Example. Vol 1. Point Pattern and Quantitative Data.* John Wiley and Sons, Chichester.

Veth, Peter M.

1992 *Islands in the Interior: The Dynamics of Prehistoric Adaptations within the Arid Zone of Australia.* International Monographs in Prehistory, Ann Arbor, MI.

Wandsnider, LuAnn

1996 Describing and Comparing Archaeological Spatial Structures. *Journal of Archaeological Method and Theory* 3:319-384.

1998 Landscape Element Configuration, Lifespace, and Occupation History: Ethnoarchaeological Observations and Archaeological Applications. In *Surface Archaeology*. Ed. Alan P. Sullivan III, pp. 21-38. University of New Mexico Press, New York.

Zier, Christian J. and Stephen M. Kalasz

1999 *Colorado Prehistory: A Context for the Arkansas River Basin.* Colorado Council of Professional Archaeologists, Denver.