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The Density-Dependent Method: Measuring the Archeological Record in the Northern Southwest

Cynthia Irwin-Williams, Christopher Pierce, Stephen R. Durand and Patricia Hicks

The density-dependent method consists of a coordinated group of techniques that are designed to measure large- and small-scale spatial variability contained in the archeological record. This is accomplished with a series of nested sampling schemes that focuses on the individual artifact or feature in its environmental context. The primary objective of this paper is to present the details of the density-dependent method as it was developed to deal with the Archaic hunter-gatherer record in the northern Southwest. It is recognized, however, that methods do not exist in a vacuum and in order to be useful must be related to a theoretical model and have real-world applications. Appropriate methods and techniques are determined by the interplay of theory and the empirical world under consideration. Therefore it is necessary to review briefly the conceptual structures and perceptions of the archeological record that conditioned the development of the methods and techniques described in this paper. In addition, a set of first-generation analyses are presented to demonstrate that these methods and techniques are applicable to the archeological record and provide a realistic translation of the facts or phenomena of that record to the data and information of archeological research.

The central objective in this endeavor, as in much hunter-gatherer archeological research, is to improve our understanding of prehistoric human behavior in relation to the resource environment. Reconstructions of Southwestern Archaic subsistence patterns have increased rapidly in recent years (e.g., Elyea and Hogan 1983; Reher and Witter 1977, Toll and Cully 1983; Vierra 1985; Vierra and Doleman 1984; Wait 1983). Therefore, a comment on the relation of the kinds of theoretical models employed in these reconstructions to the data base is appropriate. The view adopted here is that any model is unsatisfactory that *requires* unobtainable data to test its validity. Such a model cannot possibly produce an accurate interpretation or understanding of past behavior. This problem is particularly significant when attempting to adapt models originating in other fields to archeological data. The use of inappropriate models appears to be the cause of many difficulties experienced by the young and dynamic field of Southwestern hunter-gatherer research. Typical are the difficulties experienced by Vogler *et al.* (Vogler 1983) in their painstaking attempt to apply Jochim's (1976) optimal-foraging theory formulas to the Archaic of the Colorado Plateau. They found that information required on fat content and mobility was unobtainable and of questionable relevance, and that other crucial floral and faunal resources could only be estimated.

In common with the majority of Southwestern hunter-gatherer research (*e.g.* Baker and Sessions 1979; Baker and Winter 1981; Biella and Chapman 1979; Reher and Witter 1977; Vogler 1982, 1983), the theoretical perspective presented here is derived from basic ecologic theory relating to long-term human adaptation to regional environment (Goodman 1975; MacArthur and Pianka 1966; Margaleff 1969; Odum 1979; Wiens 1976; Yellen 1977b). From this conceptual base it is possible to propose that long-term, hunter-gatherer adaptation to an environment will involve (*a*) efficient economic-subsistence solutions, so as to insure, at minimum, population continuity and survival; and (*b*) stable economic-subsistence solutions, so as to afford sufficient flexibility to accommodate annual, short-term and long-term climatic change and subregional and regional resource variability.

These two general propositions and the specific hypotheses derived from them guided the present research in terms of identifying the requirements of the data base and of formulating methods for translating these data into a usable form. Each proposition is capable of generating a wide range of relevant hypotheses. Given our stated emphasis on the availability of relevant data from the archeological record, only four are addressed here. These hypotheses represent subsistence solutions that would result if the two propositions of efficiency and stability are primary factors in cultural adaptation. The relative significance of these four subsistence solutions in the actual, long-term adaptations of Archaic hunter-gatherers is not specified. This is an issue that will be addressed through analysis and interpretation.

Proposition 1 states that long-term successful adaptation involves relatively efficient economic-subsistence solutions. Spatial distance between locations of human behavior and exploited resources is one assessable measure of efficiency. Accordingly, it can be hypothesized that an efficient long-term adaptive strategy will (*a*) minimize the distance between human activities and the most critical limiting regional resources and (*b*) minimize the distance to the greatest abundance of locally or narrowly distributed resources.

Proposition 2 states that long-term, successful adaptations will involve relatively stable economic-subsistence solutions. Increasing niche width as a survival strategy, the significance of buffers, and the crucial significance of flexibility in the face of the environmental unpredictability characteristic of arid lands are all recognized as related ecologic concepts (Goodman 1975; Margaleff 1969; Odum 1979). These concepts underlie and are incorporated in the derivative hypotheses that a stable, long-term solution will distribute human activities so as to (*a*) minimize the distance to the greatest diversity of narrowly or locally distributed resources and (*b*) minimize the distance to the greatest number of broadly distributed resources or regional resource zones (patches).

Involved in each hypothesis is the assumption that the character of the archeological record itself will provide at least some indication of the specific large- and small-scale behavior involved in these solutions. The archeological record refers here to the distribution of cultural materials in space. Time is considered to be an inferred dimension of the record that is approached through a variety of exact and relative dating techniques. The spatial character of the archeological record is determined by cultural and natural processes. As discussed in more detail below, the nature of the Southwest Archaic record is such that the majority of the available evidence occurs on the surface, in situations where temporal control is minimal. The resulting problems associated with multicomponent occupation, geomorphic disturbance of archeological remains, etc., are becoming widely recognized (Beckett 1980; Irwin-Williams *et al.* 1981; Shelley and Nials 1983; Wandsnider, this volume). However, large-scale or regional regularities or patterns in the archeological record are thought to result primarily from repeated, patterned human behavior.

It is clear that the methods required to connect this conceptual framework to the archeological data base must be able to provide an adequate record of the nature and distribution of cultural materials in space. It also is necessary to provide relevant measures of the resource environment. The methods in use in the Southwest at the inception of this research in 1981 were incapable of doing so. The following discussion presents the new methodologic approaches developed to resolve this problem and an initial series of analyses oriented toward preliminary tests of the hypotheses outlined above.

Archeological Units and Human Activities in the Southwest Archaic

The nature of the Southwest Archaic record, which reflects more than 5,000 years of occupation by small mobile groups, provides a crucial conceptual and methodological dilemma for archeologists. At the heart of this dilemma is the relation between the kind of archeological record produced by mobile hunter-gatherers and the concept of the archeological site that is central to most archeological thinking. Broadly defined, the site may be any place where there are found traces of human activity or occupation. In practice, however, the site tends to be a specific geographic location with implied or identified boundaries, which contains unusually high concentrations of artifacts and/or features and is positioned in specific distance relations to other phenomena.

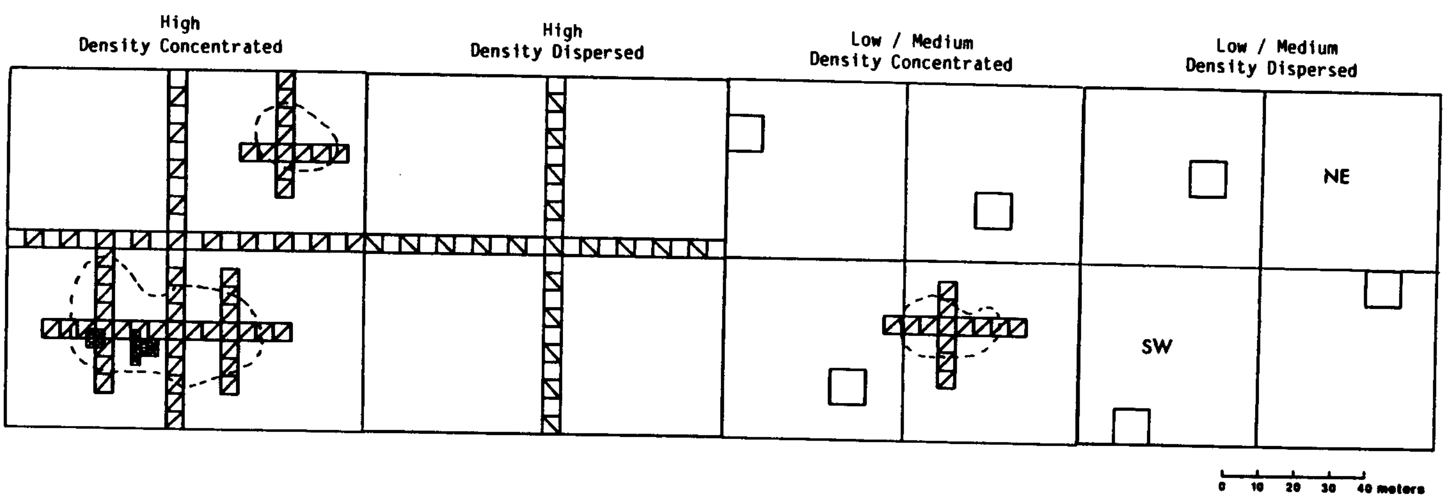
The problems associated with this usage of the site concept are two-fold—practical and conceptual. In practical terms, the site concept always proved troublesome in dealing with the Archaic, particularly in relation to site identification, multicomponent occupation, recognition of temporal affiliation, and assessment of integrity of apparent spatial-artifactual relations in the face of geomorphic process. As a result, the methods currently used to identify and record Archaic archeological "sites" are subjective and inconsistent. Conceptually, the site is an imprecisely defined archeological unit that is probably inappropriate to the Archaic. As noted by Yellen (1977a), the character of hunter-gatherer occupation does not lend itself to clear site definition, and universal site taxonomies can lead to interpretive distortion. In addition, many hunter-gatherer activities leave traces that are below the minimum definition of a "site," and are, therefore, recorded only in a cursory fashion or not at all.

Thomas and others (Dunnell and Dancey 1983; Foley 1978, 1981a, 1981b, 1981c; Thomas 1975) pioneered "nonsite" or "off-site" survey procedures where the archeological record is seen as spatially continuous and the basic units of observation are individual artifacts and features. By conceptualizing the archeological record in this fashion, it follows that it is necessary to sample the distribution of artifacts and features in space in order adequately to sample the archeological record (Dunnell and Dancey 1983). In a survey based on the simple assumption of spatial continuity and its corollaries, the basic sampling unit consists of quadrats or transects of fixed size. It is these sampling units that define assemblages for analysis. Analyses using data generated by nonsite surveys focus on the density and spatial dispersion of artifacts in relation to relevant aspects of the environments.

A clear advantage to sampling space in the nonsite approach as opposed to sampling "sites" is that environmental and cultural parameters can be compared logically. Both sets of data are drawn from the same sampling universe (space), thereby eliminating the validity problem often encountered in environmental assessments of the archeological record. Conversely, measuring the distribution of "sites" across environmental zones is not a reflection of human activity across environmental zones. It rather is a measure of the occurrence of archeological manifestations classed as "sites" across environmental zones. In order to relate aggregates of human activities (such as sites) to the environment, it is essential first to know the total range of relations between these activity aggregates and the environment.

The Density-Dependent Method

The density-dependent method is a nonsite survey approach that was developed and tested in 1981 (Irwin-Williams *et al.* 1981) and implemented on a large scale in the Arroyo Cuervo region of northwestern New Mexico from 1982-85. The density-dependent method is characterized in general by the following elements: (*a*) its objective is to document large- and small-scale variation in the distributions of artifacts and features in space by using a series of nested sampling schemes within 100-m² quadrats that are aligned in regional



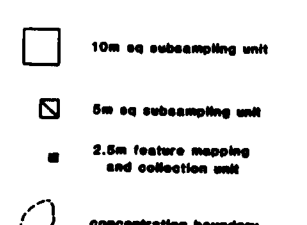


Figure 1.
Diagram of nested sampling procedures of the density-dependent method for 100-m² quadrats with different artifact densities and dispersions.

transects (Figure 1), and (*b*) the information on cultural materials is accompanied by environmental information, which is used as an indicator of both potential resource distributions and alteration by natural processes.

Like other nonsite approaches, the density-dependent method focuses on the individual artifact and feature in its environmental context as the basic unit of observation. The archeological record is viewed as overlapping accumulations of discarded artifacts and abandoned features. These accumulations have been modified partially by postdepositional, primarily geologic, processes. By focusing on large- and small-scale distributions together with geologic process, the density-dependent method allows a more accurate assessment of prehistoric land use than do approaches that are tied to *a priori* site taxonomies and the problems of "site" identification. In addition, the method provides a consistent data base and framework for comparability between investigators, which currently is virtually nonexistent. The method is compatible with the site-based approach. If subsequently it is desirable to define a series of archeological units as "sites," these definitions will be based on the recognition of polythetic sets, directly reflecting artifact density and concentration-size modality, analytic artifact class and associated environmental setting. In this way, the range of defined site "types" will comprise the most accurate representation of prehistoric land use.

Application of the density-dependent method in the field begins with laying out the boundaries of the quadrat or primary sampling unit. The size of this quadrat and of subsequent subsampling units is determined through consideration of the archeological and environmental characteristics of the region and through field logistics. In a region where environmental diversity is low and cultural materials are sparse, a large sampling quadrat may be used, such as the 500-m^2 quadrats employed by Thomas (1975:65). Since environmental diversity and artifact density within much of the Arroyo Cuervo project area is relatively high, 100-m^2 quadrats were selected. Similarly, other subsample-unit sizes and specific values employed in the example were determined on the basis of existing regional resource information and may be modified for use elsewhere.

Once the boundaries are established, the entire area contained within the quadrat is then swept at intervals no greater than 10 m. All individual artifacts and features exposed on the surface are marked with pin flags. At the time that the quadrat is surveyed, a map of the landform, drainage, and vegetation patterns within the quadrat is made. The specific sampling scheme to be used within the 100-m^2 quadrat is then determined on the basis of the density and dispersion of artifacts and features located during the sweep. The density-dispersion continuum is broken down into six categories by combining three density classes (low, medium, and high) with two dispersion classes (dispersed and concentrated). In the Arroyo Cuervo example, low-density quadrats contain 100 artifacts or less, medium-density quadrats contain 101 to 500 artifacts, and high-density quadrats have more than 500 artifacts on the surface. Quadrats placed in the concentrated class contain localized areas where the artifact density exceeds the overall quadrat density by a factor of 10. Quadrats that contain no such concentrations are assigned to the dispersed class. As noted, the exact values that determine the density and dispersion classes are flexible and may be adapted to fit other archeological situations.

Each of the six density-dispersion categories are sampled differently with the goal of maximizing data collection while minimizing recording time. Collection units are located by using a tape and compass to "pull" from a well-controlled point within the quadrat. All artifacts found in low-density, dispersed quadrats are collected or recorded with provenience at the level of 10-m^2 units. Collection decisions may also vary depending on the goals of the particular project. In this case, fire-altered rocks and historical-period materials are the only artifacts not collected systematically, but they are recorded in the field. Sampling of medium-density, dispersed quadrats begins with collection or recording of all artifacts in the northeast and southwest quadrants by 10-m^2 (Figure 1). If 100 artifacts are not collected during this procedure, the other two 50-m^2 quadrants are sampled similar to the previous two. High-density, dispersed quadrats are sampled with alternating 5-m^2 units aligned in centrally located cross transects (Figure 1). If 100 artifacts are not collected in the cross-transect units, the northeast and southwest quadrants then are collected. If one or more concentrations are located within a low-, medium-, or high-density quadrat, they are sampled with at least one north-south and one east-west transect composed of contiguous 5-m^2 units. Features located in any of the six density-dispersion categories are mapped and collected within a grid of one or more 2.5-m^2 units, and appropriate samples are collected. Finally, temporally diagnostic artifacts not collected by the sampling procedures are collected and provenienced to units 10-m^2.

Collected artifacts are divided into very general classes (e.g., chipped-stone tools, debitage, cores, groundstone, ceramics, etc.) in the field, and the counts for each class are recorded on the field forms. These artifacts then are analyzed in the laboratory in much greater detail, and artifact-density figures are calculated using the laboratory data. These data then are combined with the field counts of fire-altered rocks to compute the final density figures. Since concentrations are sampled disproportionately to nonconcentrations, weighted densities must be calculated to avoid over-representation of the concentration density in the overall 100-m^2 quadrat density. This weighted density for quadrats containing concentrations is calculated using the following formula:

$$\text{Weighted Density} = (CA \times CD) + (NCA \times NCD)$$

where: CA = the proportion (expressed as a fraction) of the 100-m^2 quadrat area covered by the concentration(s),

CD = the concentration density (artifacts/m^2),

NCA = the proportion (expressed as a fraction) of the 100-m^2 quadrat outside of the concentration(s), and

NCD = the density of artifacts (artifacts/m^2) in the area of the 100-m^2 quadrat outside the concentration(s).

Selected environmental data from each of the smaller subsampling units and for the quadrat as a whole are recorded systematically. These data include the nature of landform classes and large scale topographic relief; sediment texture and color; the presence and nature of paleosols; proximity and type of potable water sources; proximity and type of lithic raw-material sources; and evidence of potential disturbance processes active within the unit. The environmental observations of greatest significance to the analyses presented in this paper relate to the landform classification. The underlying concepts and applications of this classification are presented in the following section. The landform classes are ranked in two ways. First, they are ranked according to the area they cover within the quadrat. Second, they are ranked according to their association with different densities of cultural materials. Field determinations of sediment texture are made according to the method described by Foss *et al.* (1975:801), and color is determined by using the Munsell soil-color charts. Four types of paleosols occur within the Arroyo Cuervo region: late Holocene, mid-Holocene, Pleistocene, and composite soils (Fred Nials, personal communication). Associations between artifacts and paleosols are recorded where possible. Potable surface water occurs as seep springs of highly variable discharge. Recent lowering of ground-water levels has severely affected spring discharge in the region, making identification of all but the most permanent springs difficult. Potential ephemeral water sources such as *tinajas* and sandy wash bottoms also are recorded. Useful lithic raw materials are found in Pleistocene gravel deposits and in certain bedrock outcrops in the Arroyo Cuervo region. Potential disturbance processes are recorded in terms of the type of process and presence of small-scale topographic features. Vegetation is mapped and noted within the subsample units.

Classifying Environmental Resource Parameters

Studies of changing prehistoric adaptation and land-use patterns require the development of models of plant- and animal-resource distribution. The only reasonably constant characteristics of regional flora and fauna are the habitat requirements (autecology) of the component species. These habitat requirements belong to two distinct classes: (*a*) relatively invariant conditions, primarily geologic, relating to soil characteristics, slope, elevation, geologic substrate, drainage relations, and geomorphologic origin, and (*b*) highly variable conditions, primarily climatic, relating to precipitation, temperature, and seasonality. The present focus in this analysis of Archaic forager adaptation is on the relatively less variable geologic factors that provide the long-term resource structure for the region. Since the same autecologic limitations operate at any time, the basic relations between primary soil-landform contexts should hold relatively constant. Accordingly, in spite of altered species proportionality, it should be possible to order these geologic contexts in terms of the potential total range of diversity-productivity. In addition, the existence of readily identifiable resource zones provides an easily accessible source of information on regional environmental variation.

To implement these concepts, geologist Fred Nials identified a range of Southwest topographic landform configurations that are combined with characteristics of soil and substrate conditions. These configurations are termed landform environment classes (LECs) and comprise the relatively invariant structure underlying regional resource distribution. The classification is a hierarchical taxonomic scheme where large-scale landform features are divided into smaller and smaller units by specifying conditions of slope, substrate, surficial deposits, surface water, and geomorphic origin. Each level of the hierarchy is given a letter or number code so that specific LECs can be keyed out and labeled. Figure 2 presents a graphic representation of the relations

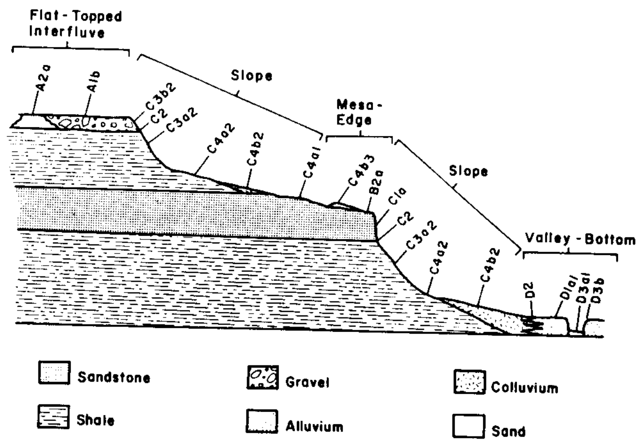


Figure 2.
Idealized model of the landform environment classification.

between different LECs. For example, it is possible to contrast shallow colluvial slopes underlain by shale bedrock (C4a2) with those underlain by colluvium (C4b2) or with aeolian deposits (C4b3). In the procedure developed, archeological and geological field identifications are combined with photogeologic mapping from 1:12,000 scale, stereo, color, and false-color infrared aerial sets and 1:24,000 topographic maps. Efforts are presently underway to test the ability of Landsat imagery to record these data. When information on resource-affecting variables (e.g., climatic change) ultimately is added, it becomes possible to deal with the effects of environmental change on resource distribution and abundance. The landform environment classification is easily comprehended and may act as a first approximation of regional-resource structure.

Implementation of the Density-Dependent Method in the Arroyo Cuervo Region

The Arroyo Cuervo region of northwestern New Mexico (Figure 3) was the principal area originally

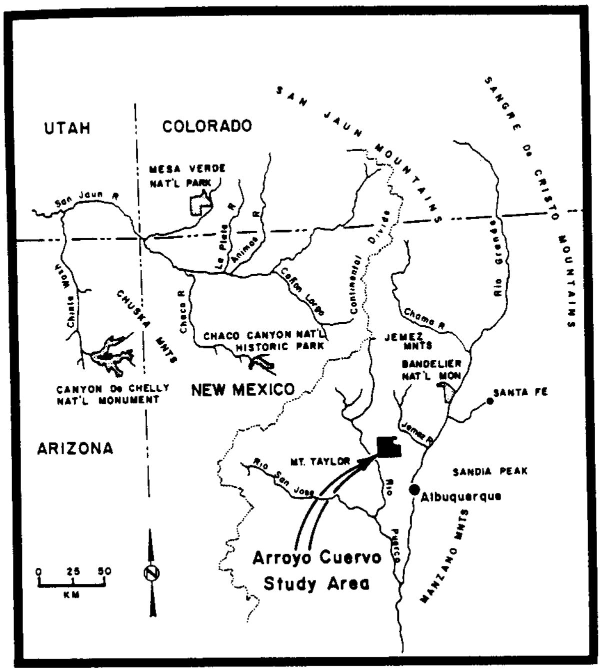


Figure 3.
Location of the Arroyo Cuervo project area in the northern Southwest.

investigated in the 1960s for defining the Archaic Oshara Tradition (Irwin-Williams 1973). The region lies between the drainage of the Rio Puerco (of the east) and the Rio Grande. The region encompasses an area of about 200 mi^2 of Mesozoic and Cenozoic marine and terrestrial sedimentary beds eroded into mesas, canyons, and pediments with occasional Pleistocene gravel terraces. Altitude ranges from 5000-7000 feet, and rainfall at present averages about 10 in annually, strongly concentrated in the summer months. The present geomorphic landscape reflects the very rapid erosion-dissection of the area, which has occurred largely since the middle nineteenth century. The semi-arid floral pattern, though considerably disturbed by overgrazing, includes a large number of floral communities varying with topography, pedology, and absolute altitude. Principal drainages are oriented north-south, and maximum environmental variability occurs from east to west. An essential element of the regional-resource structure is provided by the limited number of permanent and semipermanent water sources, principally seep springs located at the heads of the deeply cut sandstone canyons. Seasonally available water could also be obtained during the summer rainy season in "dugout wells" in arroyo bottoms and in bedrock pools or *tinajas*.

During 1982-85 the Arroyo Cuervo region was sampled by the use of systematic transects. The transects are 100 m wide, aligned on an east-west axis. They also are designed to pass through or "anchor" to a known permanent or significant seasonal water source that is considered to be the most critical limiting resource in the region. Transect orientation and placement was designed to reflect the primary east-west variability characteristic of the region and to investigate the significance of major water resources in the overall subsistence pattern. Seven anchored survey transects have been completed to date (Figure 4) and have resulted in collection and recording of 440 100-m^2 quadrats covering 143 linear kilometers.

A series of analyses was undertaken to assess the relations between the distribution of artifacts and features and the distribution of environmental parameters. Given the nature of the archeological record and conceptual structure discussed above, certain predictions can be made concerning the character of these relations. In general, the locations whose resource associations best fulfill the spatial constraint of efficiency and stability would have been selected more regularly for use. These locations will reflect increased activity through greater densities and diversities of archeological remains in relation to less suitable locations. From the basic assumptions about the relation of the archeological record to human behavior outlined above, it can be inferred that the artifact density and diversity of a particular location reflect respectively the intensity (quantity-duration-redundancy) and range of the activities conducted there. In addition, the distribution of cultural materials in relation to the resource environment provides a source of information on the long-term priorities or significance of the various constraints (stated in the hypotheses at the beginning of the paper) within the overall adaptive strategy. To test these predictions or expectations, the resource data available are manipulated so that they represent, as closely as possible, the four identified factors thought to control the locations of various activities. These parameters are then compared directly to the density and diversity of cultural materials.

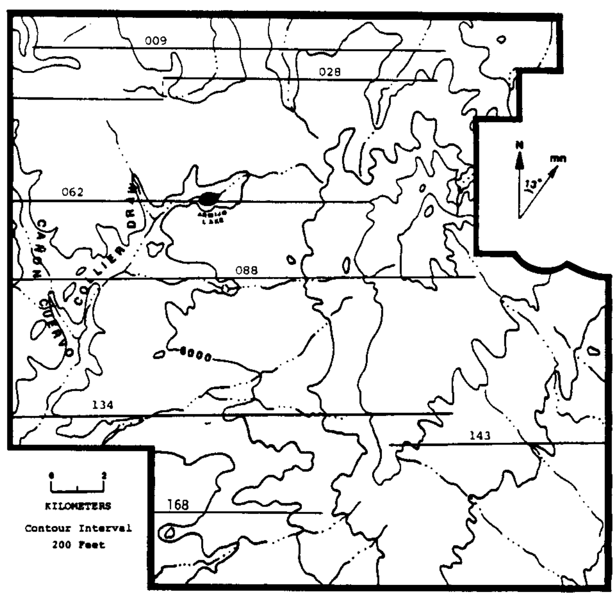


Figure 4.
Locations of regional-survey transects.

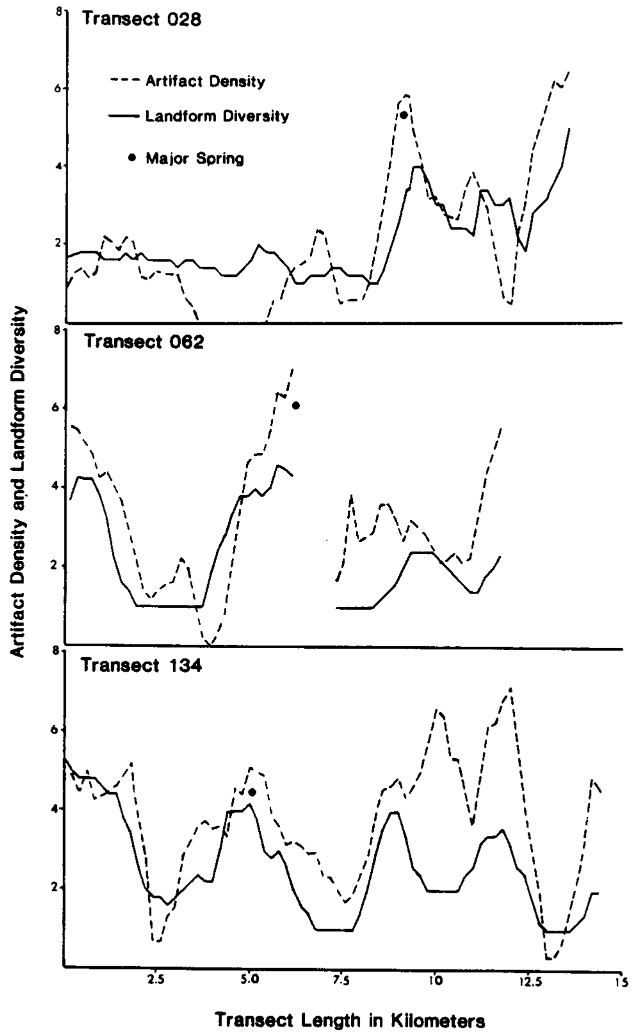


Figure 5.
Moving averages of artifact density and landform diversity for three of the regional-survey transects.

In the first analysis, the intensity of prehistoric activity as reflected by the density of artifacts in the 100-m^2 quadrats recorded along each transect is compared to the diversity of LECs (number of different LECs recorded in each quadrat). To filter out the effects of incomplete sampling and high-frequency variance, moving averages of artifact density and the number of LECs were calculated at one kilometer intervals along the transects. As seen in Figure 5, the trends in landform environmental diversity and in artifact density (activity intensity) closely parallel each other. This graphical relation supports the hypothesis that the location of hunter-gatherer activities presents a spatial solution that maximizes accessibility to the greatest diversity of broadly distributed economic-resource zones (patches).

A second factor reflected by these cross-regional transect graphs is the specific significance of the most crucial localized economic resource, here permanent springs, in determining the location of the most concentrated human activity (Figure 5). This tends to confirm, at least in first approximation, the hypothesis that hunger-gatherer activities will occur in close proximity to the most critical localized subsistence resource.

A second regional-level analysis was aimed at determining whether artifact concentrations as defined above, reflecting focuses of sustained or repeated human activity, occur with significantly greater frequency on specific high-diversity landforms, while nonconcentration, low-density quadrats occur more frequently on lower-diversity landforms. Landform environment classes (LECs) were grouped in terms of surface deposits and geologic substrata and were given preliminary ranking in terms of contemporary, total, plant diversity (based on preliminary regional botanical surveys) rather than proportional diversity indices. The highest-diversity class comprised aeolian sand deposits; the lowest, shallow colluvial slopes underlain by shale. Other landforms fell between those extremes.

A contingency-table, Chi-square test was applied to the regional sample. It is clear from Figure 6 that (*a*) aeolian environments are indeed strongly selected for as the locations of concentrated or repeated artifact-producing human activities and (*b*) shale environments are rarely selected. The shale quadrats do, however, routinely contain low levels of dispersed artifacts, which might not be entered at all in a "site-based" record. Initial tests, discussed below, suggest that these low-level, dispersed assemblages are not random but occur in specific patterns. The aeolian-concentration and shale-slope-nonconcentration pattern parallels that recorded by Reher and Witter (1977) elsewhere in northern New Mexico. As might be expected, artifact occurrence on other landforms fell between these extremes. Taken together, these data tend to support

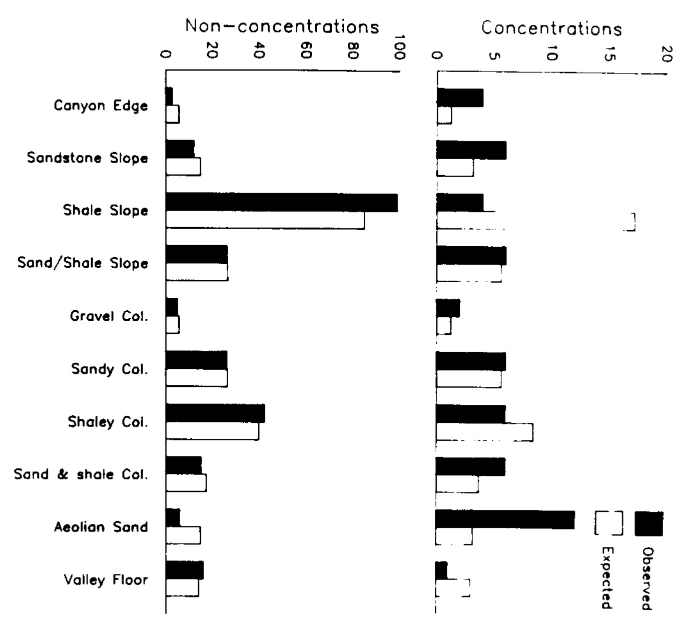


Figure 6.
Histogram of observed and expected frequencies of concentrations and nonconcentrations in relation to landform groups.

Table 1.
Analysis of Variance in Artifact Density
by Landform Diversity and Landform Type

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Main effects	.088	14	.006	2.096	.022
LEC division	.019	6	.003	1.048	.402
LEC Type	.054	8	.007	2.245	.034
Two-way interactions					
LEC Div. & LEC Type	.266	13	.020	6.843	.001
Explained	.354	27	.013	4.382	.001
Residual	.209	70	.003		
Total	.563	97	.006		

the hypothesis that an efficient foraging strategy concentrates activity so as to minimize distance to the most abundant and diverse localized resources.

The information presented above indicates that both regional environmental diversity (LEC diversity) and differential diversity-productivity of individual areas (LEC classes) influence the location of hunter-gatherer subsistence activities. An analysis of variance was employed to establish their relative significance. From Table 1 it is clear that local productivity (i.e., LEC type in Table 1) explains more of the variance and therefore may have been more central to the overall adaptation than regional-scale diversity or patchiness (i.e., LEC diversity). Together, these two locational factors explain 63% of all variability in artifact density.

The fourth analysis represents an initial attempt to understand the nature of assemblage variability and its relation to the regional-resource framework as defined by the landform environmental classification. The analysis was carried out to assess the relation between artifact density and aitifact diversity. There is a growing awareness among archeologists that the degree of assemblage diversity is strongly correlated with sample size (Grayson 1978, 1981; Kintigh 1984; Leonard *et al.*, 1984; Thomas 1983). As the number of artifacts increases, there tends to be a corresponding increase in the number of different classes of artifacts. Any meaningful consideration of assemblage diversity must therefore control for sample size. Otherwise, all large multicomponent surface sites may automatically become "base camps," all small single component sites, "limited activity loci."

In the present analysis, artifact diversity is measured in terms of number of different classes of artifacts per 100-m^2 quadrat. Linear regression was used to determine the relation between artifact diversity and artifact density (Figure 7). In the initial sample (representing 20% of the total transect sample), there was, as predicted, a strong positive correlation between the natural log of artifact density (sample size) and artifact diversity. Of the 95 100-m^2 quadrats represented, only four fell *well* outside the diversity range predicted from sample size at the 95% confidence interval. Two are large, quite dense, highly diverse assemblages, located on or close to highly productive and diverse landforms, permanent water sources, and gravels containing useful lithic raw material. It is possible that these do indeed represent semipermanent or seasonal residential camps. The significant difference of this distinction from the traditional definition of "base camps" lies in the fact that they can be quantitatively distinguished from the very numerous other localities, whose apparent diversity of activity reflects only sample size and probably redundance of occupation. At the opposite end of the spectrum, two quadrats with significantly lower diversity than predicted were located on gravel-rich outcrops and yielded assemblages composed primarily of early-stage lithic-reduction debris. In brief, these initial analyses indicate that in addition to sample size, presence/absence of specific resources or resource clusters may be used to predict elements of assemblage content, here artifact-class diversity.

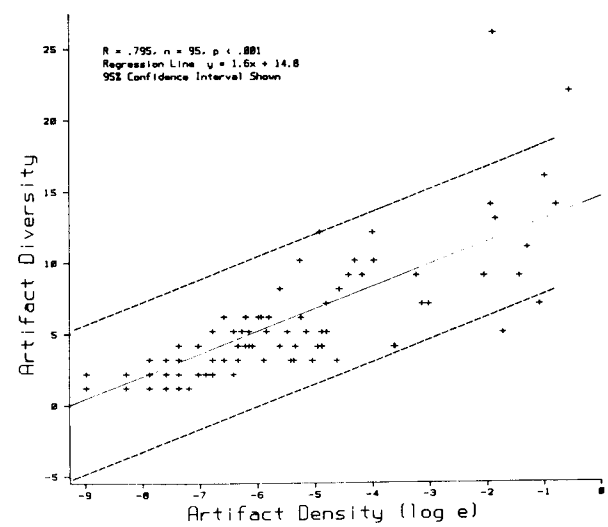


Figure 7.
Two-dimensional plot of artifact density against artifact diversity.

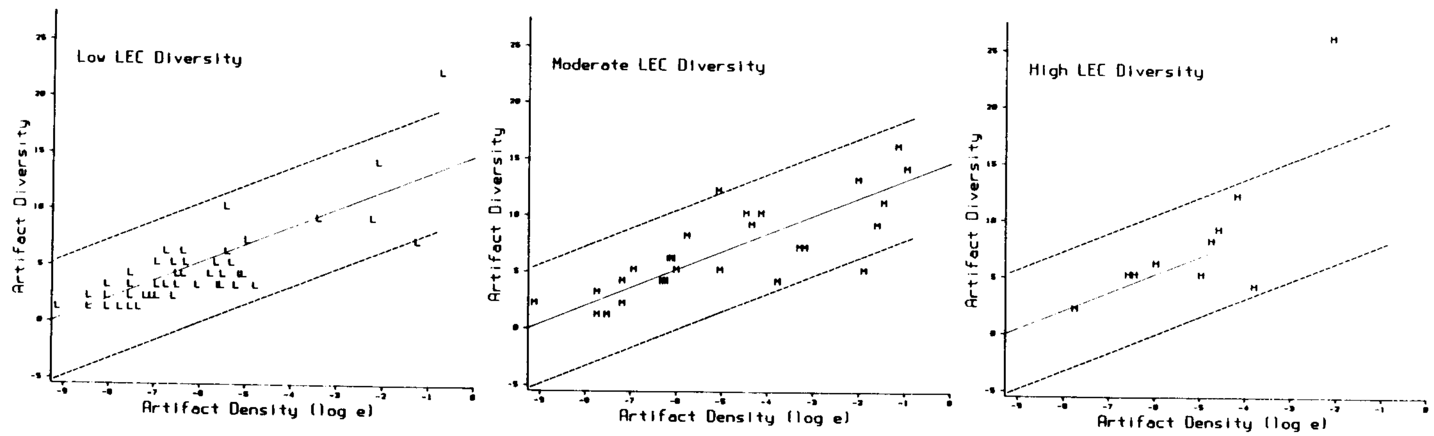


Figure 8. Two-dimensional plots of artifact density and artifact diversity by landform diversity.

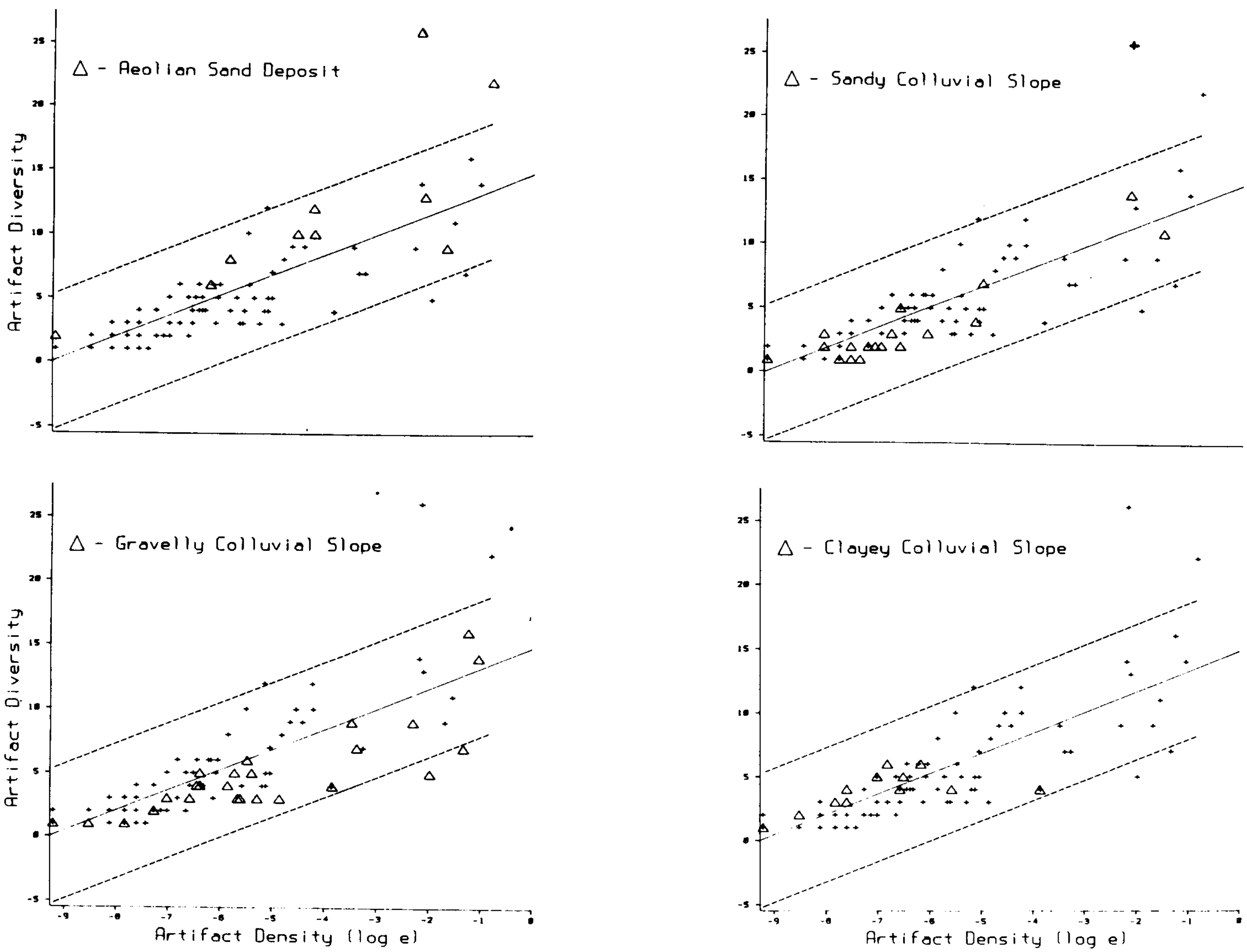


Figure 9. Two-dimensional plots of artifact density against artifact diversity, with associated LECs indicated.

To explore further the relation between assemblage content and landform class, two additional exploratory analyses were undertaken. In the first, data points on the density-diversity plots are shown with their associated LEC diversity class (Figure 8). However, this analysis showed no apparent patterning of artifact diversity that was independent of artifact density.

In the second analysis, density-diversity plots are shown with associated LEC classes. This approach demonstrates several interesting trends. Quadrats located in aeolian sands have relatively higher artifact diversities, while those located on gravels have lower diversities (Figure 9). While this might seem in part intuitively obvious (e.g., relating gravels to quarrying raw materials), this method permits the relation to be expressed graphically. Less obvious is the difference between the low-density assemblages from shaley colluvium (relatively higher diversity), versus sandy colluvium (lower diversity) (Figure 9). This suggests the possibility that functionally distinct low-visibility activities may have been occurring in these two environments. In the site-based approach, neither of these classes of assemblage might have been recorded.

In brief, the series of analyses carried out in 1984, employing data collected during 1982-84, produced highly satisfactory results. Analyses were focused on testing initial hypotheses concerning Archaic adaptive strategy in relation to (*a*) critical (limiting) local resources, (*b*) abundance and diversity of localized resources, and (*c*) broadly distributed resources or resource zones. We were able to characterize the relation of cultural materials to all three environmental parameters. Further analyses were undertaken to assess quantitatively the nature of assemblage variability in relation to the regional-resource framework, as defined by the landform environment classification. Both directions produced useful results. This kind of information is basic to understanding patterns of resource exploitation and demonstrates the utility of conceptualizing the archaeological record as the distribution of artifacts and features in space.

In this paper we have presented a series of methods and techniques for dealing with the hunter-gatherer record in the northern Southwest. These methods and techniques, termed collectively the density-dependent method, form a nonsite approach. This method of data collection presents a clear advantage over the traditional, site-based approach, because both environmental and cultural parameters can be compared logically in the same spatial framework. Data generated by the density-dependent method was used successfully in a set of first-generation analyses oriented toward testing basic propositions and hypotheses concerning the hunter-gatherer record. The applicability of the method is demonstrated in this example of ongoing research on the Archaic of the northern Southwest.

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