The Interpretation of Archaeological Spatial Patterning

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Chapter 5

Linking Ethnoarchaeological Interpretation and Archaeological Data

The Sensitivity of Spatial Analytical Methods to Postdepositional Disturbance

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1. INTRODUCTION

In this chapter we examine the extent to which archaeological techniques of spatial analysis produce satisfactory results when applied to an ethnographically recorded hunter–gatherer site, and we explore the degree to which useful results can be obtained after simulated disturbance of the site. We believe we have gained some insights into methods of spatial analysis and clarified our understanding of their strengths and limitations through this study. John Yellen's (1977) ethnoarchaeological study of !Kung sites in Botswana was selected to provide the basis

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for this investigation. Yellen's data were selected because we were curious to test the validity of our quantitative methods of spatial analysis with ethnoarchaeological data. His study provided a data set comparable to those from open-air sites of mobile hunter–gatherers on which such methods most commonly are applied archaeologically.

This chapter is a portion of a larger study in which we analyzed a series of Yellen's camps (see acknowledgments). Here we present a synopsis of three components of our inquiry using his Camp 14. First is a quantitative spatial analysis of the material distributions recorded for Camp 14. Second, we simulate the transformation of this ethnographic camp into three "archaeological sites." Third, we analyze each simulated archaeological site using the same techniques we had used for analyzing the undisturbed ethnographic data, and we compare the results with those of the original analysis.

2. ANALYSIS OF THE ETHNOGRAPHICALLY RECORDED CAMP

2.1. The Ethnographic Context

The data collected by Yellen provide a productive context in which to test the utility of quantitative methods of spatial analysis. His ethnographic observations of the camps include the number of inhabitants, the social relationships among the members of the different households, the length of occupation, and the locations and types of activities that took place. Because the camps were recorded only a short time after abandonment, Yellen's maps show the locations of the materials and features left by the inhabitants.

These maps clearly illustrate aspects of hunter–gatherer open-air sites that are easily overlooked by archaeologists. First, the distribution of remains over each of the camps is diffuse. Dense concentrations of cultural remains simply did not accumulate during the relatively brief period that each camp was occupied. Second, as Yellen points out, individuals cared for prized tools; they were rarely discarded (Yellen 1977:88). Material remains of the ethnographic occupation consisted, at the time of abandonment, of a scatter of organic materials as well as hearths, postholes, and expedient tools such as nut-cracking stones. Of course, under normal conditions, most of the floral debris would decompose quickly, so at best archaeologists would find features, postholes, charred floral remains, and faunal materials—but few formal tools. Sites with materials like these appear to comprise the bulk of open-air hunter–gatherer sites in prehistory. Thus Yellen's data provide a good opportunity to test the validity and robusticity of spatial analytical methods on the kind of hunter–gatherer sites we are most likely to encounter archaeologically.

Yellen developed an interpretive model in which he divided the ethnographic camps into a series of nested rings (Figure 1). The extreme extent of cultural remains at the camp defined the outer ring, the *absolute limit of scatter*. The inner ring, or *limit of nuclear area total*, was defined by what he called a "hut circle"—the hearths and their associated huts. Within this inner ring, the nuclear area

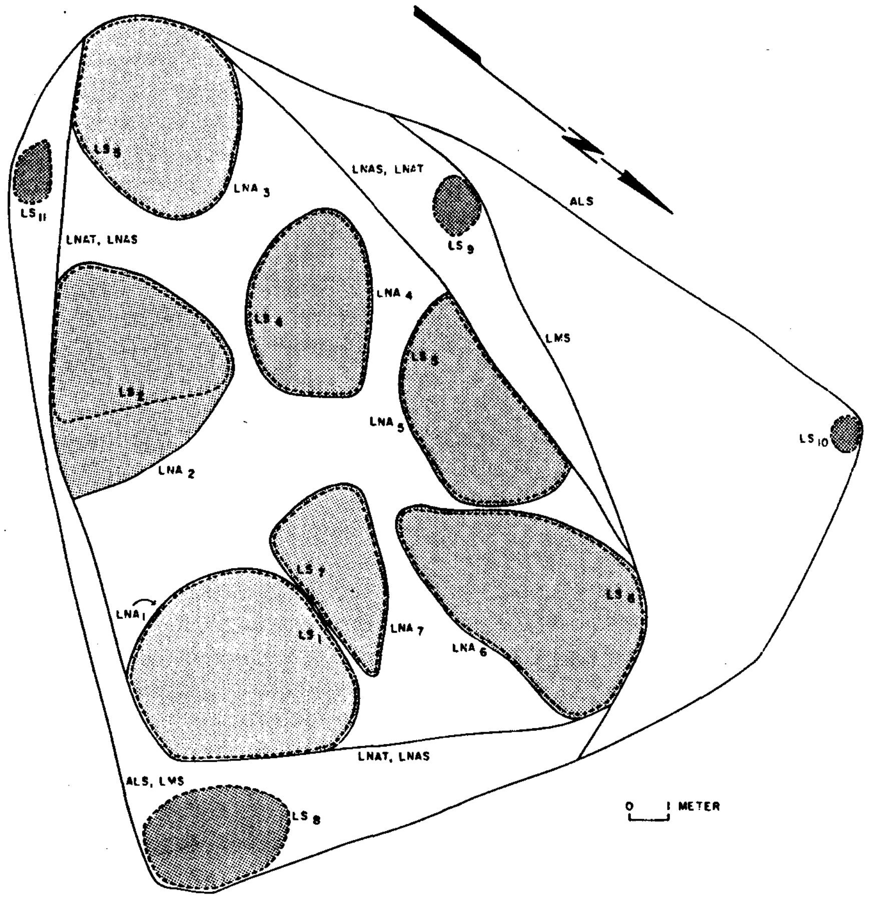

Figure 1. Yellen's model of !Kung camp organization applied to Camp 14 (redrawn from Yellen 1977).

used by a social unit, the *limit of scatter: nuclear area* was defined by the presence of a hearth and a scatter of debris. Yellen's model lends itself nicely to comparison with the results of a quantitative spatial analysis. If his model holds, our expectations are (1) nuclear areas should be identifiable by discrete clustering of materials, and (2) similar patterns of domestic activities should be identifiable within each nuclear area.

2.2. Alternative Approaches to Spatial Analysis

In conducting analyses of spatial distributions, archaeologists must consider two fundamental problems. First, the nature of the spatial structure at a site must be defined and described. Is material clustered throughout, or is it evenly distributed over the site—and what criteria have been used to identify the site structure? Second, the presence or absence of clustering must be interpreted. In particular, the degree to which clustering is due to natural agencies—including a host of taphonomic, chemical, biological, and physical factors—must be established, and the behavioral activities of the human inhabitants must be evaluated.

The problem of identifying spatial structure can be approached from two related perspectives, which we have called a pure locational approach and an assemblage composition approach. The pure locational approach first identifies the spatial structure at the site by evaluating the physical distribution of structures and material remains. Then, if clustering is present, discrete clusters are defined. Finally, the contents of each cluster are examined as a basis for interpreting the cluster's significance. The assemblage composition approach considers the problem from a slightly different perspective. This approach calls for determining whether clearly definable differences in assemblage composition exist. If so, sets of similar material remains are located and plotted. The composition and distribution of these assemblages provide the basis for the interpretation.

The two approaches are concerned with interrelated but different problems in defining and describing site structure. In essence, each approach analytically takes most into account what the other ignores. They therefore provide different, but complementary, results that mutually corroborate one another. The application of these approaches, however, does not provide an interpretation. This must be derived from multiple lines of evidence that, when they show concordance, give us confidence in our ideas.

The analyses presented here are aimed at determining whether Yellen's ring model—which he based on ethnographic observations as well as on his maps—can be replicated using objective, quantitative approaches. Yellen identified seven social groups at Camp 14, each with a hut and a hearth, as well as the anthropologist's campsite. In addition to these social units, an isolated hearth lies to the northwest of the huts, and activities took place in the shade of a tree to the northeast. Because the camp was mapped shortly after abandonment, it is assumed here that major postdepositional disturbances of the material remains did not occur. As discussed, if the ring model holds, the spatial analysis should reveal seven discrete clusterings indicating the social units, and each should have evidence of similar activity patterns.

2.3. Pure Locational Analysis

For the pure locational approach we used the method proposed by Kintigh and Ammerman (1982), which involves the use of k-means, nonhierarchical clustering. In contrast to some more common hierarchical clustering techniques, such as average linkage clustering, k-means analysis is driven by the global criterion of minimizing the within-cluster variation (which simultaneously maximizes the variation among clusters). The sum-squared-error (SSE) statistic is the measure of within-cluster variation that the analysis attempts to minimize, and this statistic is used in interpreting the k-means results. As the number of clusters increases, it is a mathematical necessity that within-cluster variation (SSE) decrease. As with any clustering routine, there is always a question of what defines a "significant" cluster that warrants further investigation. We used two methods for identifying the significant clustering levels, and both entailed using the SSE statistic. The easiest method is to plot the $\log_{10}$ %SSE against the clustering stage and to examine the resulting curve for negative inflection points. These points tend to indicate stages that produce more "economical" clustering, and these clusters should be further examined.

An independent method, which we also used, entails comparing the difference between the $\log_{10}$ %SSE statistic from the input data and the $\log_{10}$ %SSE statistics from the analysis of randomized versions of the input data. The plots of the $\log_{10}$ %SSE from both the normal run and the random runs are plotted against clustering stage. If the normal data plots within the range of the randomized data, then no significant clustering is indicated. Conversely, significant clustering is indicated where there is strong divergence between the real input and the random data. In conducting the k-means clustering, we specified that two random runs be completed. We then calculated the average $\log_{10}$ %SSE statistic for the two random runs and plotted the difference between this and the $\log_{10}$ %SSE statistic for the input data by clustering step. Peaks in the graph indicate clusters of the input data that diverge from the random data. The visual inspection of both the $\log_{10}$ %SSE plotted against clustering step and the difference between the average random clustering and the original data mutually reinforce one another.

To perform a pure locational analysis, the X and Y coordinates of all artifacts and features (excluding the separate scatter associated with Yellen's tent) were recorded from the map of the camp (Figure 2). (In terms of true compass orientation, these represent southwest–northeast [X] and southeast–northwest

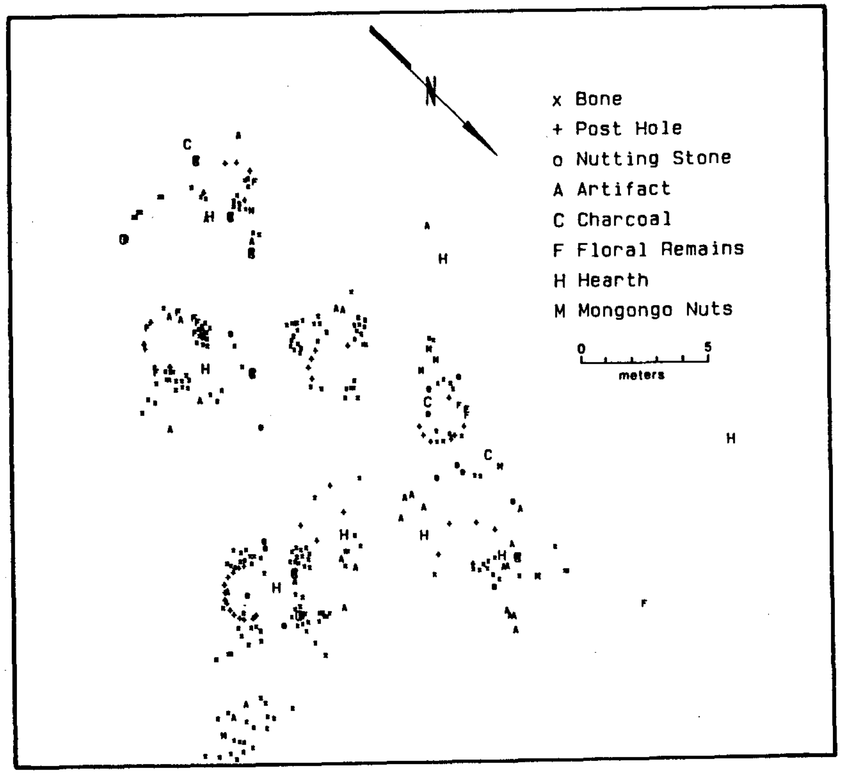

Figure 2. The distribution of materials recorded by Yellen at Camp 14.

[Y] directions.) The coordinates then were clustered using a k-means program written by Kintigh and Ammerman (1982). The plot of $\log_{10}$ %SSE against cluster step first shows a divergence from the random runs at Step 3, and thereafter the curve flows smoothly until Step 7, where it begins to flatten (Figure 3). A plot of the difference between the average random clustering and the original data (Figure 4) also shows that significant clustering occurs at Clusters 3 and 7. The assignment of each point in the three- and seven-cluster solutions is shown in Figures 5 and 6, respectively.

The three-cluster solution divides the site distinctly into Cluster 1 in the south, Cluster 3 to the west, and Cluster 2 to the north. Table 1 shows the material composition of each cluster. Faunal remains predominate in each cluster, followed by postholes. All other material classes are represented in relatively low proportions in Cluster 1, and similarly, all classes except floral debris occur in relatively low proportions in Cluster 2. Cluster 3 differs slightly in its relatively high percentage of nutting stones and logs. Virtually all artifact classes are present in every cluster, so at the grossest level, three basic living groups can be identified. How, then, does the seven-cluster solution differ from the three-cluster solution?

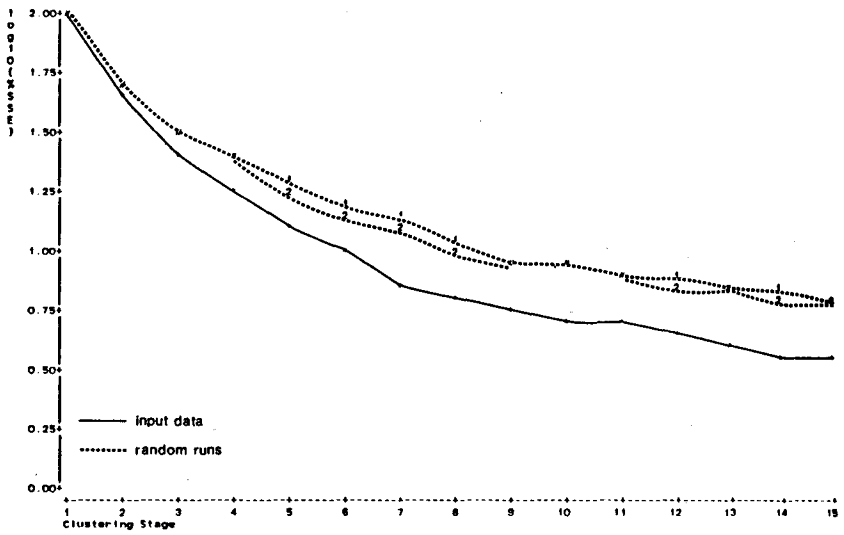

Figure 3. Plot of $\log_{10}$ %SSE for k-means clustering of Camp 14—Yellen's data; comparing runs of input and randomized data.

The frequencies of the various material classes represented in each cluster (Table 2) show that for Clusters 1–3, 5, and 7, faunal remains are the dominant material class, followed once again by postholes. As before, the remaining material classes occur in relatively small proportions, with the exception of mongongo nuts in Clusters 5 and 7, charcoal scatters in Cluster 5, and nutting stones and logs in Cluster 7. Either a hearth or a charcoal scatter (or both) are present in each of the aforementioned clusters. In conformity with Yellen's nuclear area construct, the content of the clusters suggests that similar activities occurred in every cluster. Cluster 6 stands out because faunal remains are overwhelmingly dominant in the assemblage, and neither charcoal scatters nor hearths are present. It would thus appear that a different range of activities occurred in Cluster 6. Because the cluster is located on the periphery of the site and is dominated by faunal remains, Cluster 6 seems to represent either a special activity area or a dump, whereas each of the remaining clusters represents the nucleus of a common suite of domestic activities.

Visually, the results of the seven-cluster solution (Figure 6) conform remarkably well with Yellen's behaviorally based interpretation; six of the clusters

Table 1. **Camp 14: Counts and Percentages of Material Classes for Three-Cluster K-Means Solution**

Cluster	1	2	3
N^a	136	117	72
Bones	91	81	27
%	66.9	69.2	37.5
Mongongo nuts	6	3	6
%	4.4	2.6	8.3
Nutting stones	3	4	8
%	2.2	3.4	11.1
Logs	7	4	11
%	5.1	3.4	15.3
Charcoal	6	2	3
%	4.4	1.7	4.2
Hearths	3	2	3
%	2.2	1.7	4.2
Postholes	14	18	12
%	10.3	15.4	16.7
Artifacts	3	3	1
%	2.2	2.6	1.4
Floral	3	0	1
%	2.2		1.4

[a] Number of items in cluster.

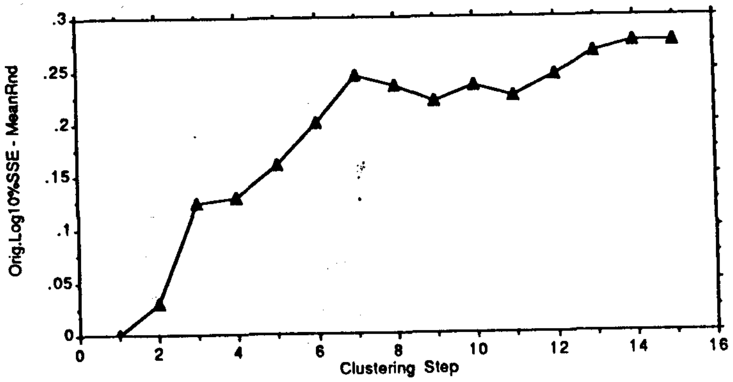

Figure 4. Plot of the difference between $\log_{10}$ %SSE and the mean $\log_{10}$ %SSE for random runs of Camp 14—Yellen's data.

Table 2. **Camp 14: Counts and Percentages of Material Classes for Seven-Cluster K-Means Solution**

Cluster	1	2	3	4	5	6	7
N^a	51	92	46	35	39	25	37
Bones	34	59	37	13	20	22	14
%	66.7	64.1	80.4	37.1	51.3	88.0	37.8
Mongongo nuts	1	2	0	2	5	1	4
%	2.0	2.2		5.7	12. 8	4.0	10.8
Nutting stones	3	4	0	2	0	0	6
%	5.9	4.3		5.7			16.2
Logs	2	4	3	7	2	0	4
%	3.9	4.3	6.5	20.0	5.1		10.8
Charcoal	1	2	0	1	5	0	2
%	2.0	2.2		2.9	12.8		5.4
Hearths	1	2	1	3	1	0	0
%	2.0	2.2	2.2	8.6	2.6		
Postholes	4	18	5	5	5	0	7
%	7.8	19.6	10.9	14.3	12.8		18.9
Artifacts	2	1	0	1	1	2	0
%	3.9	1.1		2.9	2.6	8.0	
Floral	3	0	0	1	0	0	0
%	5.9			2.9			

[a] Number of items in cluster.

correspond closely with household areas identified by Yellen (Figure 1). The only significant difference is that our Cluster 2 combines Yellen's Hut 1 and Hut 7, the households of two brothers, one of whom is not married. But as Yellen noted, the unmarried man spent so much of his time at his brother's hearth that he probably should not be considered to represent a separate social unit. Thus the locational analysis may actually mirror the reality of the situation. The locational analysis also identified, as a separate cluster, a concentration of material remains northeast of the hut area. The pure locational analysis at the seven-cluster solution confirms one level of Yellen's ring model, although, with the exception of the concentration of faunal debris, it does not highlight patterning of spatially distinct activities. This may be derived through an analysis emphasizing assemblage composition.

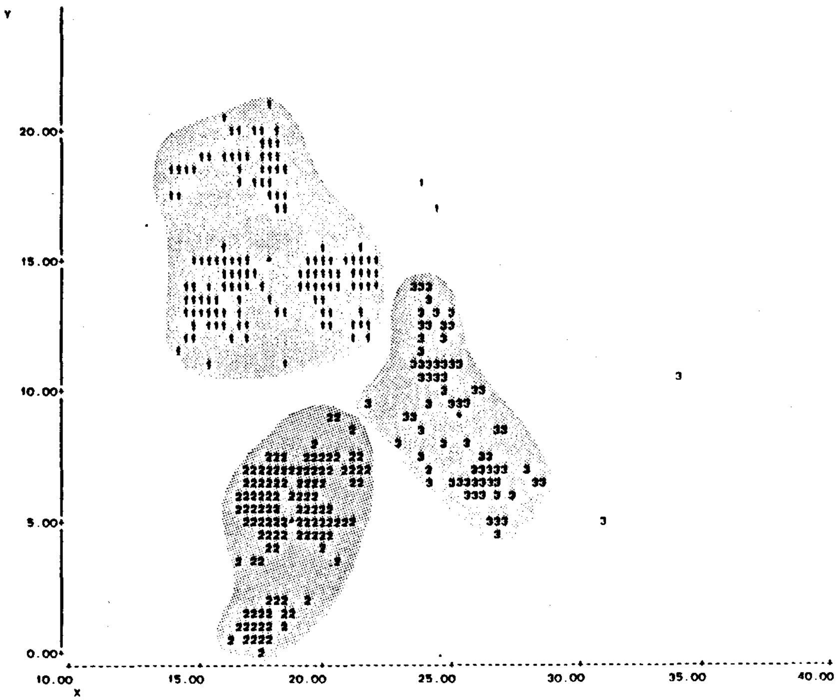

Figure 5. Distribution of three k-means clusters, Camp 14—Yellen's data.

2.4. Assemblage Composition Analysis of Camp 14

The same data from Yellen's Camp 14 were analyzed for significant spatial variation and patterning in assemblage composition using the "unconstrained clustering" approach proposed by Whallon (1984). This approach begins with the calculation of smoothed density contours for each artifact class over the area under analysis.

As pointed out in the original article on unconstrained clustering, the approach is quite sensitive to the spatial scale at which the smoothing and calculation of density contours is carried out, but the critical importance of smoothing was not made adequately clear in the original article. If spatial data are not smoothed, they tend to reflect, often rather strongly, small-scale irregularities that usually are introduced by the standard use of a grid or series of templates to define densities over the area under analysis. Smoothing, that is, using a *moving* template, eliminates the small-scale vagaries and provides a more general and interpretable picture of density variation over a site. However, caution is needed in selecting template size because a large-scale template may smooth the data excessively. This results in a picture of relatively bland uniformity of material distribution that obliterates the very patterns that might be attributable to the various formation processes—in particular, any cultural/behavioral formation processes—that created the site under investigation. As a general rule of thumb, it seems reasonable to smooth the data initially at a relatively small scale, not much more than is necessary to eliminate excessively frequent, sharp changes in density, which lead to a highly irregular or "choppy" picture of density distribution. Any final choice of the degree to which spatial data are smoothed for analysis will be based, of course, not only on the nature of the data itself but also very much on the questions and interpretive framework in the mind of the analyst.

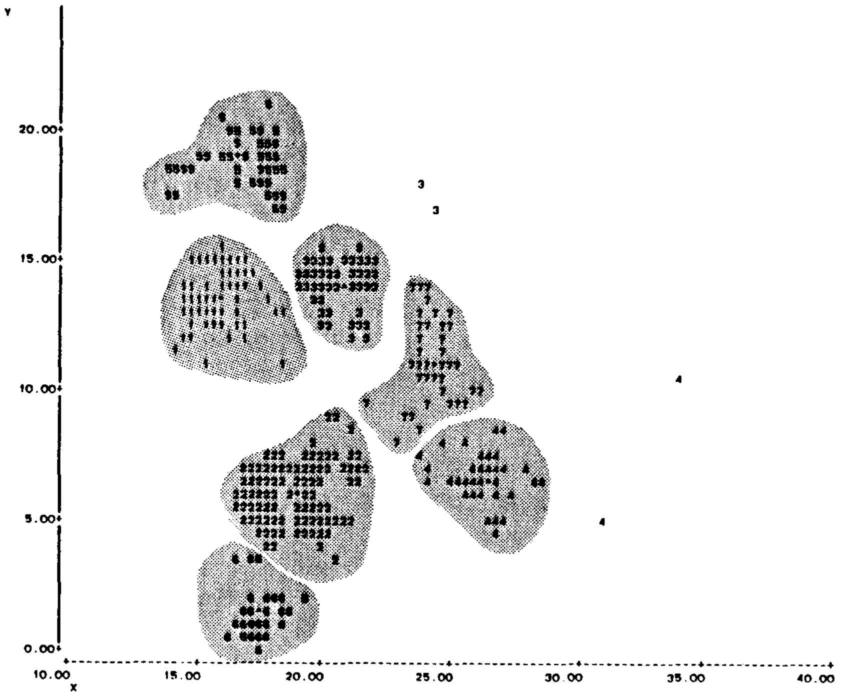

Figure 6. Distribution of seven k-means clusters, Camp 14—Yellen's data.

For Camp 14, after some experimentation, the spatial data were smoothed using a 1-m moving template (i.e., a circular template with a 1-m radius and displacement). At each move, densities for all classes of materials within the circle were determined and assigned to its center point. Smoothing thus occurs through the overlapping of templates in adjacent positions. Densities for all material classes then were calculated at each item location by interpolation from the smoothed densities.

Following the unconstrained clustering approach, the absolute densities of all material classes were summed at each point and then divided by this sum to create "relative" or proportional densities. These relative densities comprised the data for clustering the item points in terms of the similarities and differences in the density composition of the material assemblages in their near vicinities. Unconstrained clustering disregards completely the physical locations of the points at this step. Because the single material class of bones overwhelmingly outnumbered all others at the camp (comprising over 60% of all items), we decided to standardize the relative densities of each material class in order to weight them all equally in the cluster analysis and to prevent bone densities from dominating the results. Clustering was done using Ward's method (minimization of within-group variance).

The plot of the clustering criterion (sum of squared errors) as groups of item points are formed on the basis of the similarities in standardized relative densities show a single sharp and clear inflection at eight clusters (Figure 7), which is the solution examined here. The assemblage composition of each defined cluster is best expressed by the means and standard deviations of the relative densities of all material classes over the item points included in each cluster (Table 3). A material class was considered significant in the characterization of a cluster if its mean relative density was greater than its standard deviation. Within the group of significant material classes, particular attention was then paid to those whose mean relative densities were greater than 10%. Evaluated in this manner, the clusters defined by the analysis can be characterized as follows:

> *Cluster 1* is by far the largest, containing over two-thirds of all the data points in the analysis. In composition, it represents an assemblage made up largely of bones (an average of over 75% relative density), with only a small, insignificant smattering of other material classes. This corresponds well with the dominance of bones in the materials scattered over the camp, which manifests itself in this cluster in spite of the standardization of the variables in the cluster analysis to avoid an undue influence of the bones in defining assemblage composition clusters. Clearly, a bone-dominated assemblage is characteristic of much of the camp. It is worth noting that every other material class is represented to some extent in this cluster, although their means are invariably low and in every case the standard deviations are greater than the means, indicating extreme variability of occurrence.
>
> This is true also of *Cluster 3*. The major difference between Cluster 3 and Cluster 1 is that postholes are very common in Cluster 3, reaching their highest relative density (a mean of *ca.* 44%) in this cluster. Mean relative bone density is reduced accordingly, and most other material classes occur in trace frequencies only. However, nutting stones occur consistently, as

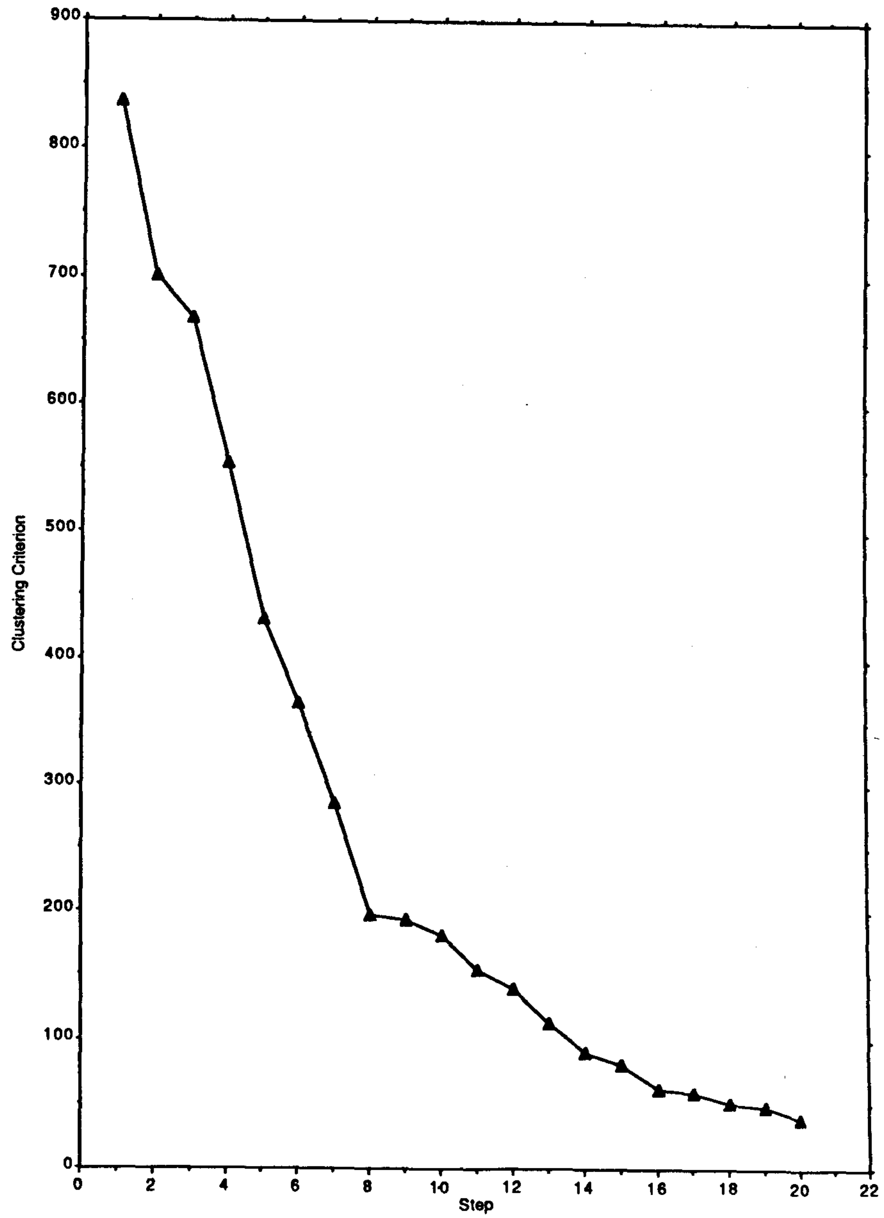

Figure 7. Plot of clustering criterion for unconstrained clustering of Camp 14.

Table 3. Camp 14: Means and Standard Deviations of Relative Densities by Unconstrained Cluster

Cluster	1	2	3	4	5	6	7	8
N[a]	219	1	48	15	6	25	9	2
Bones	76.5 ±14.3	0	46.9 ±11.2	42.4 ±13.6	23.1 ±15.7	35.8 ±12.4	2.0 ±5.6	0
Mongongo nuts	3.1 ±4.6	0	.3 ±1.1	7.5 ±7.1	1.9 ±2.5	28.3 ±12.4	.3 ±0.9	0
Nutting stones	2.0 ±3.5	0	4.5 ±4.1	26.3 ±20.9	11.1 ±15.7	2.7 ±5.0	4.8 ±4.3	0
Logs	4.6 ±6.9	0	.8 ±3.9	1.6 ±6.0	4.9 ±8.1	7.9 ±11.0	86.8 ±12.9	15.2 ±21.4
Charcoal	2.1 ±3.3	0	.5 ±1.1	6.6 ±3.7	.5 ±1.3	19.9 ±15.8	.2 ±0.5	0
Hearths	2.4 ±4.2	0	.5 ±0.9	0	.1 ±0.3	1.2 ±2.9	4.6 ±6.8	84.8 ±21.4
Postholes	6.7 ±8.0	0	44.2 ±7.7	15.6 ±7.8	23.0 ±9.0	4.0 ±9.9	1.4 ±3.0	0
Artifacts	1.4 ±4.0	0	1.9 ±2.4	0	33.2 ±10.8	.3 ±0.6	0	0
Floral	1.0 ±2.9	100	.3 ±1.6	0	2.1 ±2.6	0	0	0

[a] Number of items in cluster.

indicated by a standard deviation even lower than their low mean relative density.

Cluster 4 is similar in contents if not in precise proportions. It has high densities of bones, nutting stones, and postholes, in that order.

Cluster 5 also is characterized by relatively high densities of bones and postholes but adds a strong component of "artifacts" (tools).

Cluster 6 shows high relative densities of bones, mongongo nuts, and charcoal. Postholes are not represented in significant densities.

Cluster 2 represents a single, isolated fragment of floral debris (a water root in this case); *Cluster 8* consists only of two isolated hearths; and *Cluster 7* is made up of groups of logs, relatively separated from other material debris.

Inspection of the composition of these clusters along with their spatial distributions plotted over Camp 14 (Figure 8) suggests a relatively clear interpretation in standard archaeological and behavioral terms, which can be compared to ethnographic reality as recorded by Yellen. Thus one might identify Clusters 1, 3, 4, 5, and 6 as constellations of debris left from various "domestic" activities, deposited either *in situ* or as a result of sweeping, cleaning, and/or dumping. The differences among these clusters and their spatial distributions lead to a more detailed reconstruction. Cluster 1 could represent "core" domestic debris given its comparative frequency of occurrence, its wide and almost ubiquitous distribution over the site, and its composition. Proportionately, the largest component of this debris is bones, whose distribution thus constitutes the "core," but within and beside which examples of all other classes of material at this camp are found in comparatively small and highly variable numbers. Cluster 3 effectively represents the same thing, but in a position adjacent to structures, either as a result of activities in or beside them or by virtue of being swept up or dumped against their edges. Cluster 5 again consists of general debris, also in close association with structures, but with the added "specialization" of high densities of "tools" and nutting stones. It is worth noting that only these three clusters—1, 3, and 5—represent areas in which assemblage composition comprises all material classes recorded at the camp. Clusters 4 and 6 are somewhat more specialized, with 4 exhibiting high densities of nutting stones and propinquity to

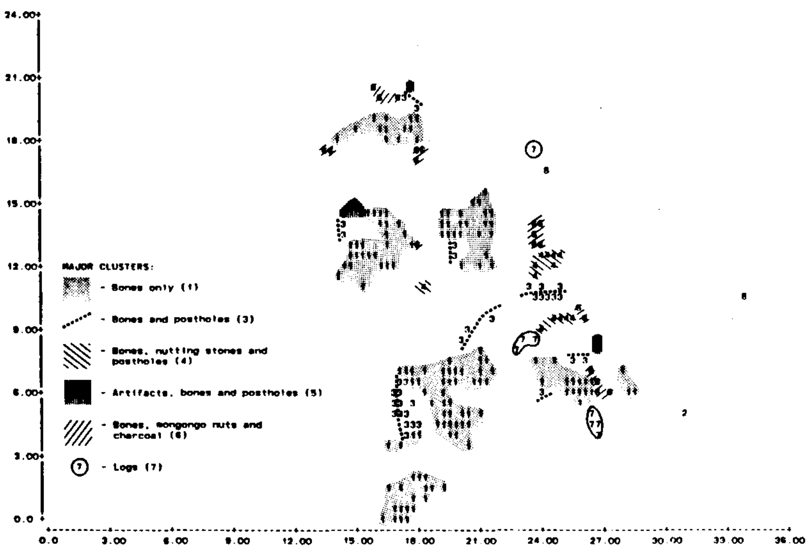

Figure 8. Distribution of eight unconstrained clusters, Camp 14—Yellen's data.

structures (with no associated "tools"), whereas 6 shows a concentration of mongongo nuts and charcoal. The remaining clusters must be interpreted as activity-specific or as isolated events.

These interpretations translate into a picture of camp organization that identifies seven structures (referring to the Y axis, one lies between 17 and 21 meters; three are between 10 and 15 meters, and three are between 3 and 9 meters) with associated materials, most of which are dominated by bones (Figure 8). Each separate indication of a structure generally seems to be linked to its own scatter of debris. These effectively are the "pure locational" clusters defined by the k-means analysis, which is why a direct comparison shows that the clusters defined by the one are subdivided extensively and spread right across the clusters defined by the other, and vice versa (Table 4). The one exception to this, noted before, is the dwelling of the one unmarried man in the group, who appears to share a central area of activities and deposition of debris with the adjacent dwelling of his married brother. An eighth, separate group of item locations, belonging only to Cluster 1, can be seen on the bottom of the map. Its position and composition would seem to argue that it represents simply a small bone dump here.

The more "specialized" clusters (Clusters 4, 6, and to some extent 5), however, are not ubiquitous, and are, in fact, noticeably differentially distributed among the "structural concentrations" seen on the map of the unconstrained clusters. In particular, the distribution of Clusters 4 and 6 and the contrasting distribution of Cluster 1 (and to a lesser extent Clusters 3 and 5) seem to indicate a general organization of the site into two general areas: (1) several "central" concentrations with little or no indication of important processing or consumption of mongongo nuts in comparison to the evidence for consumption of game and (2) an "arc," above and to the right of the "central" area, with evidence for greater use of nuts compared to game. The latter pattern reaches its strongest manifestation in one concentration on the middle right side of the camp that shows no Cluster 1 assemblage (dominated by bone) at all, consisting instead of Clusters 4 and 6 as well as 3. Cluster 4 is highly localized, virtually restricted to this particular concentration, and one normally would interpret its high proportion of nutting stones as indicative of mongongo nut processing, an apparently plausible interpretation, judging from ethnographic observations.

Interestingly, at Camp 14, nutting stones (which, in the context of a Bushman camp, typically are thought of as functionally linked directly to the cracking of mongongo nuts) are consistently and strongly disassociated from mongongo nuts remains themselves. This can be seen in a comparison of the content of Clusters 4 (to a lesser extent 5 as well) and 6 in this analysis, and it holds true at other spatial scales and in the k-means analysis as well. A plausible interpretation eludes us for the spatial segregation of the probable processing equipment and the mongongo nut shell debris supposedly resulting from such processing at this camp.

Table 4. Comparison of K-Means and Unconstrained Clustering of Camp 14

		K-means clusters						
Unconstrained		(1)	(2)	(3)	(4)	(5)	(6)	(7)
clusters, N = 325		51	92	46	35	39	25	37
Row%		15.7	28.3	14.2	10.8	12.0	7.7	11.4
Column%								
(1)	219	43	66	41	19	25	25	0
Row%		19.6	30.1	18.7	8.7	11.4	11.4	
Column%		67.4	84.3	71.7	89.1	54.3	64.1	100.0
(2)	1	0	0	0	1	0	0	0
Row%					100.0			
Column%	3				2.9			
(3)	48	2	26	3	3	2	0	12
Row%		4.2	54.2	6.3	6.3	4.2		25.0
Column%	14.8	3.9	28.3	6.5	8.6	5.1		32.4
(4)	15	1	0	0	0	0	0	14
Row%		6.7						93.3
Column%	4.6	2.0						37.8
(5)	6	3	0	0	2	1	0	0
Row%		50.0			33.3	16.7		
Column%	1.8	5.9			5.7	2.6		
(6)	25	2	0	0	5	11	0	7
Row%		8.0			20.0	44.0		28.0
Column%	7.7	3.9			14.3	28.2		18.9
(7)	9	0	0	1	4	0	0	4
Row%				11.1	44.4			44.4
Column%	2.8			2.2	11.4			10.8
(8)	2	0	0	1	1	0	0	0
Row%				50.0	50.0			
Column%	.6			2.2	2.9			

Nonetheless, in broad strokes, we reach the same conclusions, interpretations, and reconstruction of the ethnographic camp, treated as if it were an archaeological site, from both a pure locational (k-means) and an assemblage composition (unconstrained clustering) approach. The results from the two techniques mutually reinforce and corroborate each other. This not only gives us increased confidence in both methods and in their results but suggests strongly to us that they are not competing or alternative approaches but rather are best seen and used together as complementary methods for spatial analysis.

3. ANALYSIS OF THE "ARCHAEOLOGICAL SITES"

3.1. Simulation of Archaeological Site Formation

We have shown that quantitative methods of spatial analysis can be used productively on the comparatively low density distributions recorded ethnographically. But to what degree could these results have been obtained from archaeological data? To explore this question, we simulated the process of archaeological site formation for the Camp 14 distributions three separate times, varying the degrees of disturbance each time. Each simulation involved "destroying" a substantial fraction of the floral and faunal remains and randomly moving the remaining artifacts. The first simulated site has a low degree of random artifact movement; in the second, artifacts were moved to a moderate degree; movement in the third was relatively extreme.

Item destruction was governed by a number of factors (Table 5). Each class of materials was assigned an overall probability of surviving in the archaeological record. The probability of a bone's survival was further affected by factors relating to the species, the anatomical part, and the condition of the bone. For example, let us look at the probability of survival of an unbroken gemsbok femur. As a class, bones were accorded a probability of survival of 0.6. The gemsbok (this is a relatively large animal) has a species factor of 0.8 (as compared to a guinea fowl with a species factor of 0.2). A femur has a part factor of 0.8, and because the bone is whole it has a condition factor of 1.0. The simulated probability of survival of that bone is 0.6 × 0.8 × 0.8 × 1.0 = 0.38.

The original site has 325 artifacts and features, and each was subjected to the item destruction every time the simulation was run. A total of 84 items survived the first run, 94 survived the second run, and 75 survived the third. The artifact and feature compositions for the original and the three "decomposed" camps are given in Table 6. Bones and postholes comprise the two largest material classes in the original data; all other materials are present in relatively low frequencies. The simulated decomposition changes the relationship between material classes. The proportion of bones in the simulated camps drops to roughly 30% and that of postholes falls to between 7% and 10%. Conversely, the proportions of nutting stones, charcoal scatters, and hearths show increases because of the loss of organic materials and the obliteration of features. Furthermore, because some of the botanical materials might have been charred, the proportion of botanical remains also increases in assemblages of the decomposed camps. The loss of organic materials and the obliteration of features has resulted in all three cases in an assemblage composition that is quite dissimilar from the original data.

Table 5. Abbreviated List of Decomposition Simulation Survival Probabilities, Survival Factors, and Random Walk Factors

Material	Survival probability	Walk factor	Element survival factors	
Bone	0.60	1.00	Cl: Clavicle	0.50
Mongongo nuts	0.80	1.00	Ca: Carapace	1.00
Hammer stone	1.00	0.80	Cr: Cranium	0.90
Water root	0.10	1.00	F: Femur	0.80
Monkey orange	0.10	1.00	Fi: Fibula	0.60
Spiny melon	0.10	1.00	H: Humerus	0.80
Log	0.10	1.00	Ho: Horn	0.50
Tin can	0.50	1.00	Ri: Rib	0.50
Hut post mold	0.20	0.00	St: Sternum	0.20
Charcoal	0.80	1.00	Te: Tooth	1.00
Raised hearth	0.80	0.00	Ti: Tibia	0.90
Depressed hearth	0.90	0.00	V: Vertebra	0.50
Digging stick	0.10	1.00		
Artifact	0.50	1.00		

Species survival factors		Condition survival factors	
Aw: Aardwolf	0.50	C: Complete	1.00
Dk: Duiker	0.50	Fr: Fragmentary	0.50
Gb: Gemsbok	0.80		
Gf: Guinea fowl	0.20		
Gi: Giraffe	1.00		
Li: Lizard	0.10		
Pc: Porcupine	0.50		
Sp: Springhare	0.50		
To: Tortoise	0.60		

Table 6. Camp 14—Global Counts and Percentages of Material Classes in the Original Data and for All Degrees of Simulated Decomposition

Artifact class	Original data	Degree of disturbance Minimum	Moderate	Maximum
Bones	199 61.2%	27 32.1%	36 38.3%	21 28.0%
Mongongo nuts	15 4.6%	7 8.3%	13 13.8%	10 13.3%
Nutting stones	5 4.6%	15 17.9%	15 16.0%	15 20.0%
Logs	22 6.8%	6 7.1%	1 1.1%	3 4.0%
Charcoal scatters	11 3.4%	11 13.1%	11 1.7%	8 10.7%
Hearths	8 2.5%	7 8.3%	7 7.4%	7 9.3%
Postholes	44 13.5%	7 8.3%	7 7.4%	8 10.7%
Artifacts	7 2.2%	2 2.4%	3 3.2%	2 2.7%
Miscellaneous floral	4 1.2%	2 2.4%	1 1.1%	1 1.3%
Total	325	84	94	75

The loss of major portions of analytical classes presents a significant obstacle for archaeologists to surmount in their interpretations; however, it is compounded by the postdepositional disturbance of materials at the site. To simulate this disturbance, each surviving item was individually subjected to physical disturbance, which was simulated by a "random walk." The movement of an artifact was determined by the maximum length of a walk step, the number of steps, a material-dependent walk factor, and by the slope. The walk factor was a measure of the degree to which a specific material might move. It ranges from 0 (no movement—for postholes) to 1 (for most organic remains). The direction of the walk step is chosen at random. The distance of a given walk step is the product of a randomly generated number from 0 to 1, the maximum step length, and the item's material walk factor. In addition, a simulated slope has the effect of lengthening movement if the direction is downslope and shortening movement if the direction is upslope. The effect of extreme disturbance on one class of artifacts, nut-cracking stones, which have a walk factor of 0.8, is shown in Figure 9. Materials with a higher walk factor move further than the nutting stones, whereas those with a lower walk factor move a correspondingly shorter distance.

The parameters controlling step length and number of steps were varied for each run (Table 7). As Figures 10a–d show, the spatial patterning of the original

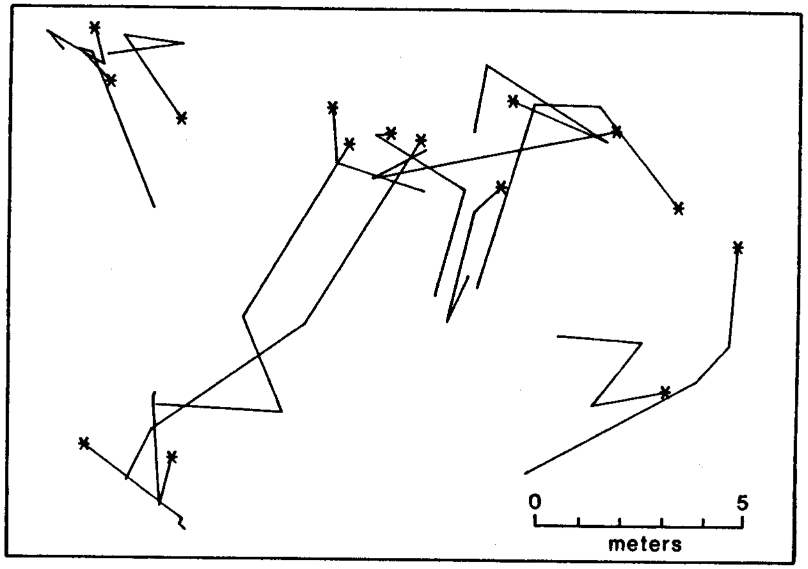

Figure 9. Displacement of nutting stones by random walk at the level of maximum disturbance.

Table 7. Parameters Characterizing Simulated Decompositions of Camp 14

Camp decomposition	Program parameters Slope (%)	Random walks	Maximum step length (cm)	Program results Average move (cm)	Number of objects
14a Minimum	5	3	50	35	84
14b Moderate	20	3	100	71	94
14c Extreme	50	3	400	282	75

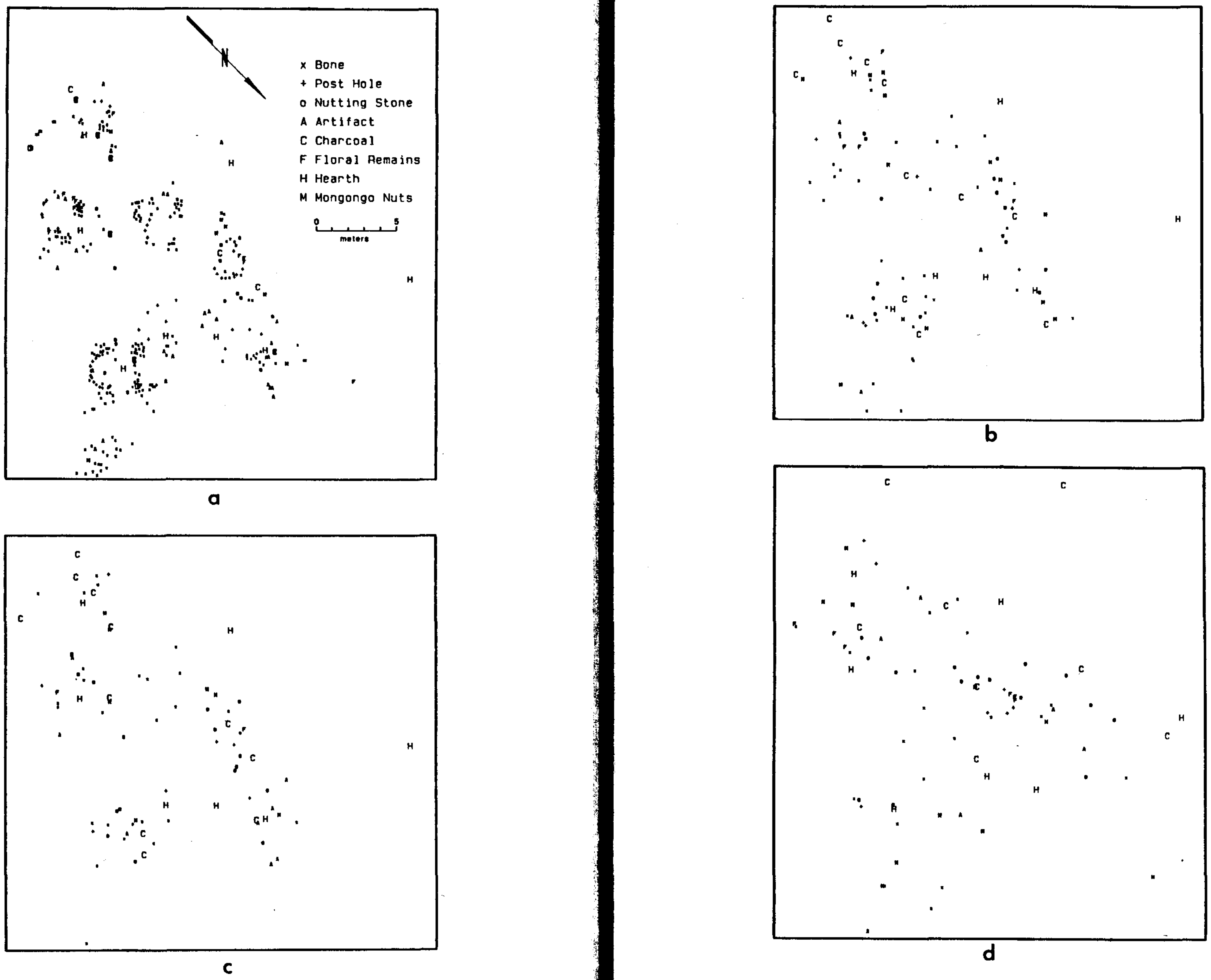

Figure 10. The distributions of original and "decomposed" data for Camp 14: a—original distribution; b—minimum decomposition; c—moderate decomposition; d—maximum decomposition.

data (Figure 10a) becomes blurred as the degree of disturbance increases (Figures 10b–d). Some of the original patterning is visible in the minimum and moderate levels of disturbance, but virtually all patterning is lost to the eye at the extreme level. To what degree would the results of locational and compositional analyses of the disturbed data (particularly the maximum level) conform to the results obtained with the original data?

3.2. Pure Locational Analysis of the Simulated Sites

K-means clustering of the artifact and feature coordinates was performed for each simulated camp just as it had been for the original camp. The plots of the $\log_{10}$ %SSE and the differences between the input data and the average of randomized data clustering were also plotted. The three simulated camps are discussed in turn.

3.2.1. Minimum Disturbance (Figure 10b)

The plot of the $\log_{10}$ %SSE (Figure 11) shows a rather steep drop from the two- to the three-cluster solutions, but the four- and five-cluster levels differ little from the randomized data. The drop from the fifth to the sixth step is fairly steep. The curve flattens at the seventh step and makes another relatively steep drop to the eighth step. Thereafter the plot is a straight line. The $\log_{10}$ %SSE graph suggests that Clusters 3 and 6, 7, or 8 are potentially interesting. A plot of the difference between the average $\log_{10}$ %SSE of the random runs and the input data against clustering step (Figure 12) confirms that Cluster 3 warrants further inspection, and it vividly shows that Cluster 8 is of interest. A plot of the cluster assignments for the three-cluster solution (Figure 13) shows the same three clusters that were obtained with the original Camp 14 data. The composition of each cluster (Table 8) is dominated by bones. Nutting stones and mongongo nuts are the other primary components of each cluster, and both hearths and charcoal scatters are present in each. The three clusters appear to reflect a similar set of processes and/or activities, which would probably be interpreted as representing three basic residential areas containing multiple family units.

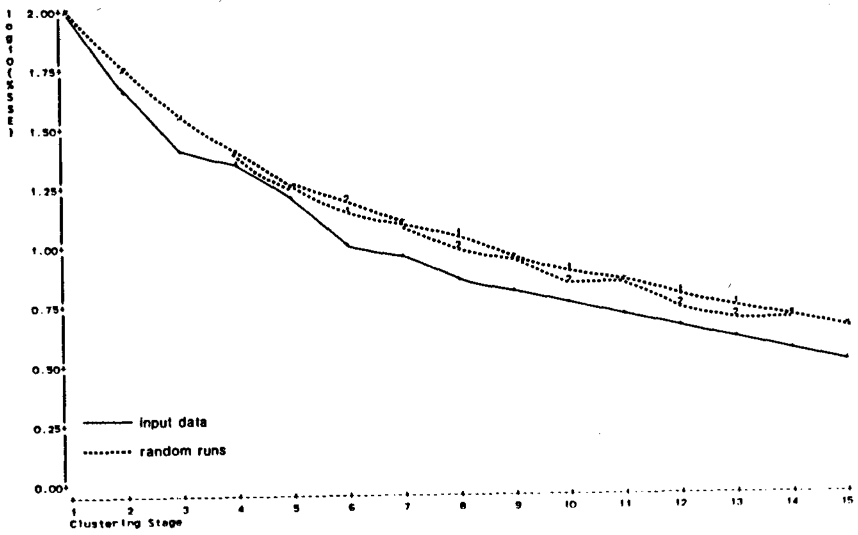

Figure 11. Plot of $\log_{10}$ %SSE for k-means clustering of Camp 14—minimum "decomposition," comparing runs of input and randomized data.

The map of the eight-cluster solution (Figure 14) is not simply a subdivision of the clusters defined at the third level. Instead, it represents a division of some clusters and the recombination of others. First, an isolated feature to the west of the site was split off to form its own cluster (Cluster 4). Second, portions of Clusters 1 and 3 were combined to form Cluster 8. Finally, parts of Clusters 3 and 2 were split off to form new clusters. The table of cluster compositions (Table 9) shows that bones dominate Clusters 1, 2, 6, 7, and 8, and either hearths or charcoal scatters are found in all but Cluster 6. Mongongo nuts occur in Clusters 1–3, 5, 7, and 8. Nutting stones occurs in Clusters 1, 2, and 5. Clusters 1–3, 5, 7, and 8 appear to represent a wide range of activities that archaeologists normally would interpret at representing individual living areas. Clusters 4 and 6, however, have strikingly different artifact assemblages. Cluster 6 consists exclusively of

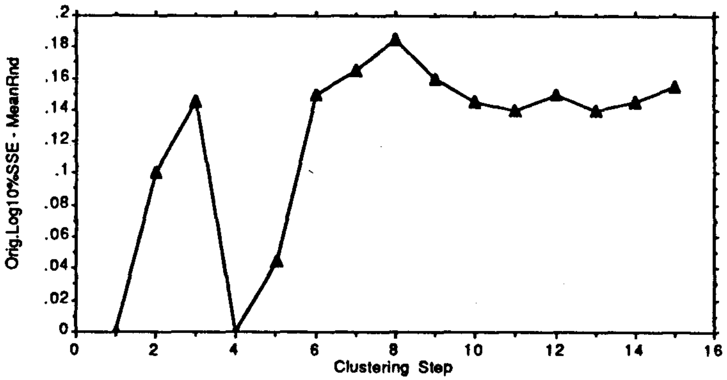

Figure 12. Plot of the difference between $\log_{10}$ %SSE and the mean $\log_{10}$ %SSE for random runs, Camp 14—minimum "decomposition."

Table 8. Camp 14—Minimum "Decomposition": Counts and Percentages of Material Classes for Three-Cluster K-Means Solution

Cluster	1	2	3
N^a	36	20	28
Bones	14	9	4
%	38.9	45.0	14.3
Mongongo nuts	3	1	3
%	8.3	5.0	10.7
Nutting stones	4	5	6
%	11.1	25.0	21.4
Logs	2	1	3
%	5.6	5.0	10.7
Charcoal	7	2	2
%	19.4	10.0	7.1
Hearths	1	1	5
%	2.8	5.0	17.9
Postholes	3	1	3
%	8.3	5.0	10.7
Artifacts	1	0	1
%	2.8		3.6
Floral	1	0	1
%	2.8		3.6

[a] Number of items in cluster.

bone, which suggests that it represents either a special activity area, such as a butchering area, or a garbage dump. Cluster 4 is an isolated hearth.

The eight-cluster solution provides a more refined picture of the spatial structuring at the site than was obtained by the three-cluster solution. Clearly, the site is comprised of three fundamental units that can be subdivided and recombined into what might be interpreted as six household groups and two special activity areas. The results obtained from the k-means analysis of the minimally disturbed camp conform surprisingly well with the original data.

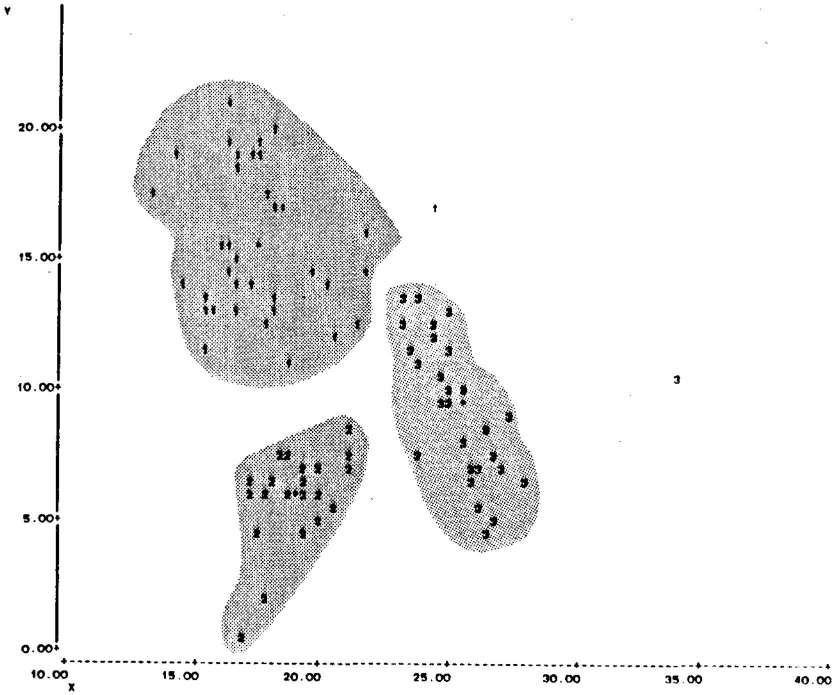

Figure 13. Distribution of three k-means clusters, Camp 14—minimum "decomposition."

3.2.2. Moderate Disturbance (Figure 10c)

The $\log_{10}$ %SSE plot (Figure 15) shows that at the one- and two-cluster levels, there is virtually no difference between the input and the randomized data. Differences, however, do exist from the three-cluster solution onwards. Once again, there is a rather steep drop from the six-to the seven-cluster solution; the curve flattens slightly at the eight-cluster solution and drops relatively steeply to the nine-cluster level. Thereafter the plot forms a straight line until an inflection occurs at the 14-cluster solution. The site has 94 artifacts and features, so each of the clusters in this solution could be expected to contain only six or seven items. Even though the negative inflection at that level on the $\log_{10}$ %SSE plot indicates significant improvement in clustering, common sense eliminates the 14-cluster solution from further consideration. The plot of the difference between average random clustering and the input date (Figure 16) shows a plateau at the 3- and 4-cluster levels and peaks at the 8- and 10-cluster levels. Once again the 3- and 8-cluster solutions appear to warrant further examination.

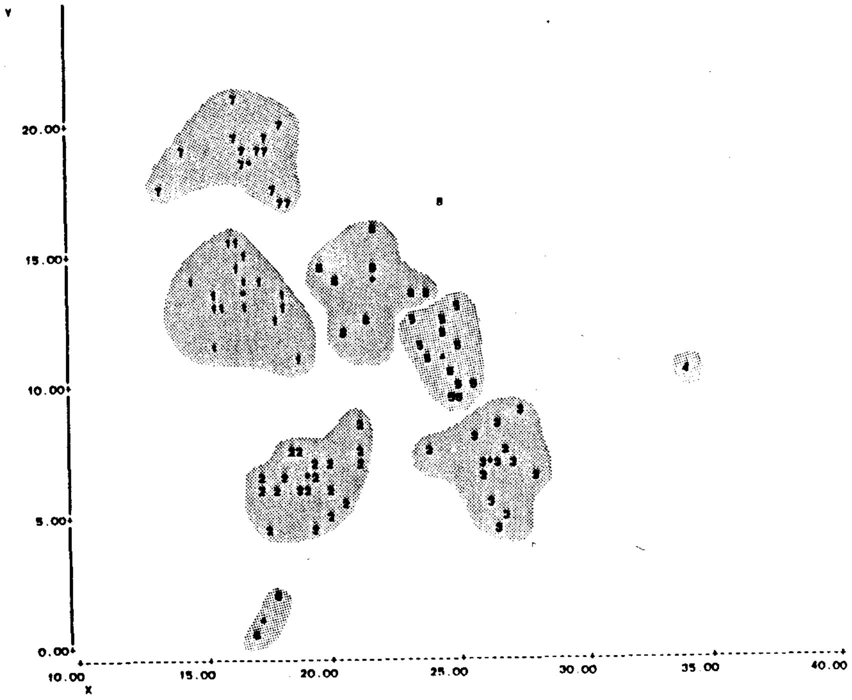

Figure 14. Distribution of eight k-means clusters, Camp 14—minimum "decomposition."

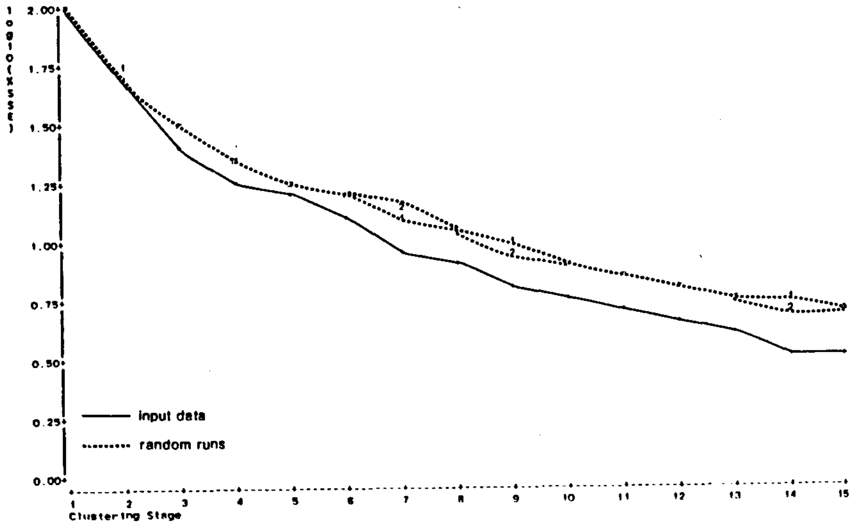

Figure 15. Plot of $\log_{10}$ %SSE for k-means clustering of Camp 14—moderate "decomposition."

Table 9. Camp 14—Minimum "Decomposition": Counts and Percentages of Material Classes for Eight-Cluster K-Means Solution

Cluster	1	2	3	4	5	6	7	8
N^a	16	18	13	1	12	2	13	9
Bones	5	7	2	0	2	2	3	6
%	31.3	38.9	15.4		16.7	100.0	23.1	66.7
Mongongo nuts	1	1	1	0	1	0	2	1
%	6.3	5.6	7.7		8.3		15.4	11.1
Nutting stones	4	5	0	0	6	0	0	0
%	25.0	27.8			50.0			
Logs	2	1	3	0	0	0	0	0
%	12.5	5.6	23.1					
Charcoal	2	2	2	0	0	0	5	0
%	12.5	11.1	15.4				38.5	
Hearths	0	1	2	1	1	0	0	2
%		5.6	15.4	100.0	8.3			22.2
Postholes	1	1	1	0	2	0	2	0
%	6.3	5.6	7.7		16.7		15.4	
Artifacts	0	0	1	0	0	0	1	0
%	0			7.7			7.7	
Floral	1	0	1	0	0	0	0	0
%	6.3		7.7					

[a]Number of items in cluster.

The map of the cluster assignments for the three-cluster level (Figure 17) agrees with the three-cluster solutions obtained for the original camp and for the minimally disturbed camp. Bones dominate the composition of Clusters 1 and 3 (Table 10), but nutting stones are the most frequent type of material in Cluster 2. Logs occur only in Cluster 2; miscellaneous floral remains appear only in Cluster 3, and artifacts are found in both Clusters 1 and 3. The mapped cluster assignments for the eight-cluster solution (Figure 18) shows basically the same results as obtained earlier. The cluster compositions (Table 11) again show that bones, mongongo nuts, nutting stones, and hearths or charcoal scatters occur in the majority of clusters.

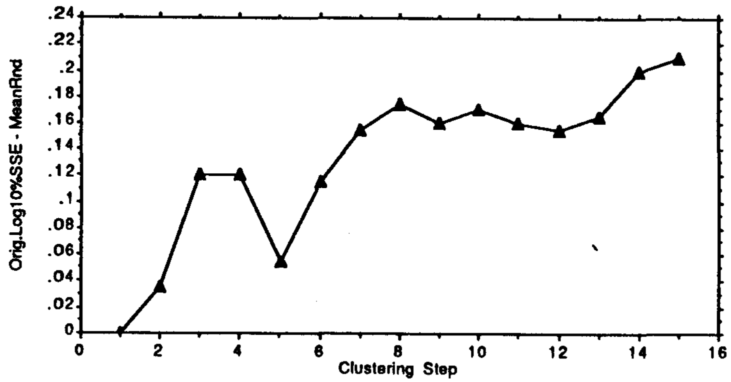

Figure 16. Plot of the difference between $\log_{10}$ %SSE and the mean $\log_{10}$ %SSE for random runs, Camp 14—moderate "decomposition."

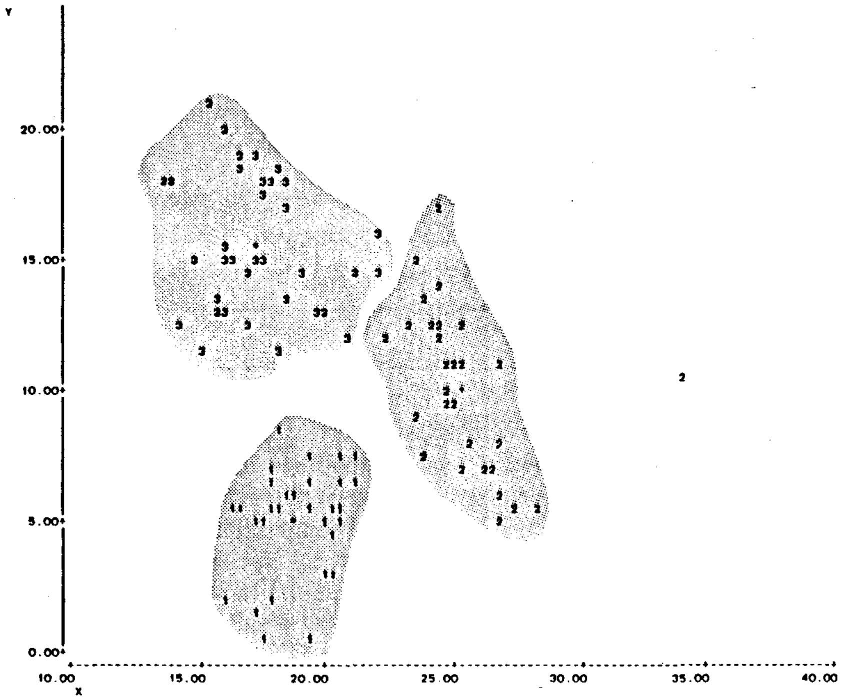

Figure 17. Distribution of three k-means clusters, Camp 14—moderate "decomposition."

Table 10. Camp 14—Moderate "Decomposition": Counts and Percentages of Material Classes for Three-Cluster K-Means Solution

Cluster	1	2	3
N[a]	30	29	35
Bones	15	6	15
%	50.0	20.7	42.9
Mongongo nuts	3	5	5
%	10.0	17.2	14.3
Nutting stones	4	8	3
%	13.3	27.6	8.6
Logs	0	1	0
%		3.4	
Charcoal	2	3	6
%	6.7	10.3	17.1
Hearths	2	4	1
%	6.7	13.8	2.9
Postholes	2	2	3
%	6.7	6.9	8.6
Artifacts	2	0	1
%	6.7		2.9
Floral	0	0	1
%			2.9

[a] Number of items in cluster.

Once again the clusters would be interpreted as representing the same polythetic set of processes, most likely those referable to the activities of individual family units. Interpretive problems could arise from the similarities of the compositions of Clusters 3 and 7. Bones dominate both assemblages, neither has a hearth, and Cluster 3 has nutting stones, whereas Cluster 7 has one of the three artifacts. It would appear that both clusters were formed by different processes than those affecting the other clusters. The locational analysis cannot clarify the range of activities that did occur at either of these clusters, nor can it illuminate the degree to which Clusters 3 and 7 are similar to one another. The assemblage composition analysis is very much needed to complement the locational analysis.

Table 11. **Camp 14—Moderate "Decomposition": Counts and Percentages of Material Classes for Eight-Cluster K-Means Solution**

Cluster	1	2	3	4	5	6	7	8
N^a	23	16	15	10	1	13	7	9
Bones	0	3	8	2	0	2	5	6
%	43.5	18.8	53.3	20.0		15.4	71.4	66.7
Mongongo nuts	2	3	1	2	0	4	1	0
%	8.7	18.8	6.7	20.0		30.8	14.3	
Nutting stones	4	6	3	2	0	0	0	0
%	17.4	37.5	20.0	20.0				
Logs	0	1	0	0	0	0	0	0
%		6.3						
Charcoal	2	2	0	1	0	5	0	1
%	8.7	12.5		10.0		38.5		11.1
Hearths	2	0	0	2	1	1	0	1
%	8.7			20.0	100.0	7.7		11.1
Postholes	2	1	1	1	0	1	0	1
%	8.7	6.3	6.7	10.0		7.7		11.1
Artifacts	1	0	1	0	0	0	1	0
%	4.3		6.7				14.3	
Floral	0	0	1	0	0	0	0	0
%			6.7					

[a] Number of items in cluster.

3.2.3. Maximum Decomposition (Figure 10d)

The plot of the $\log_{10}$ %SSE of the input data does not vary to a large extent from the plots of the random runs (Figure 19). Only at the 4-cluster level does there appear to be a significant divergence between the input and the randomized data. The plot of the difference between the average random clustering and the original input data (Figure 20) confirms that significant patterning is obtained with the 4-cluster solution; furthermore it shows a peak at the 11-cluster solution.

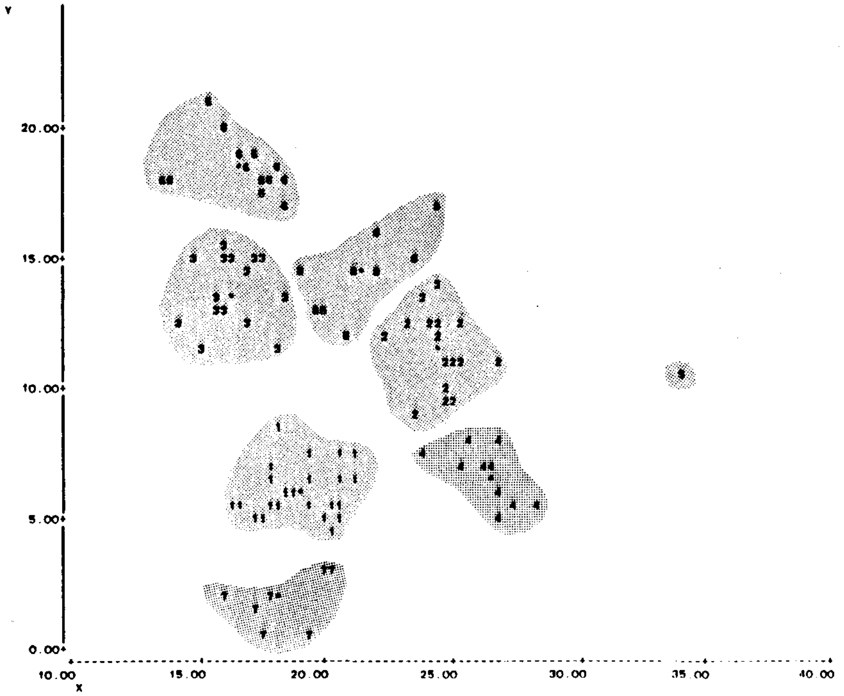

Figure 18. Distribution of eight k-means clusters, Camp 14—moderate "decomposition."

The mapped cluster assignments for the 4-cluster solution (Figure 21) differ from the results obtained for the previous analyses. The displacement of the materials along the northwestern side of the site is responsible for the differences. The composition of the clusters (Table 12) shows that bones dominate Clusters 1–3. Hearths, nutting stones, mongongo nuts, and postholes are also found in these clusters. Clearly, the same set of processes formed Clusters 1 to 3. Cluster 4 differs to some degree from the other three because it does not contain postholes, and it has relatively few bones. Thus, at least three, and possibly four household groups could be identified with the maximally decomposed data. The degree of movement, however, has obliterated the spatial integrity of what might have been identified as individual family units.

Pure locational analysis has proved effective in identifying both the underlying spatial structure of the site as well as the more refined structuring of what we know ethnographically to have been the individual households. At the maximum level of disturbance, even though virtually all of the spatial structuring of

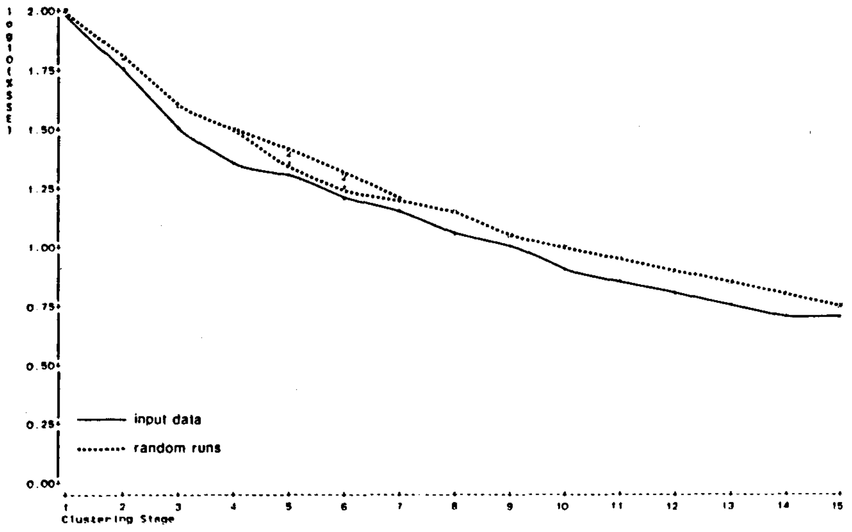

Figure 19. Plot of $\log_{10}$ %SSE for k-means clustering of Camp 14—maximum "decomposition," comparing runs of input and randomized data.

the original site had been obscured to the eye, the locational analysis was still able to identify the underlying structure of three units. In all instances, however, a pure locational analysis was not able to identify co-occurring sets of artifacts and features that might illuminate processes that occurred at the site. The compositional analysis was directed at determining whether spatial differences within the artifact assemblage could be identified.

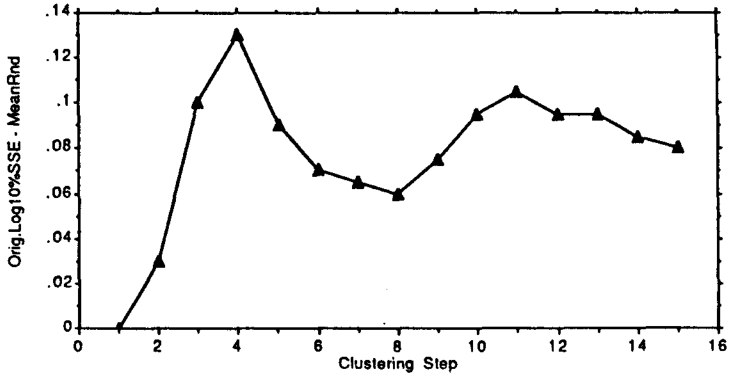

Figure 20. Plot of the difference between $\log_{10}$ %SSE and the mean $\log_{10}$ %SSE for random runs, Camp 14—maximum "decomposition."

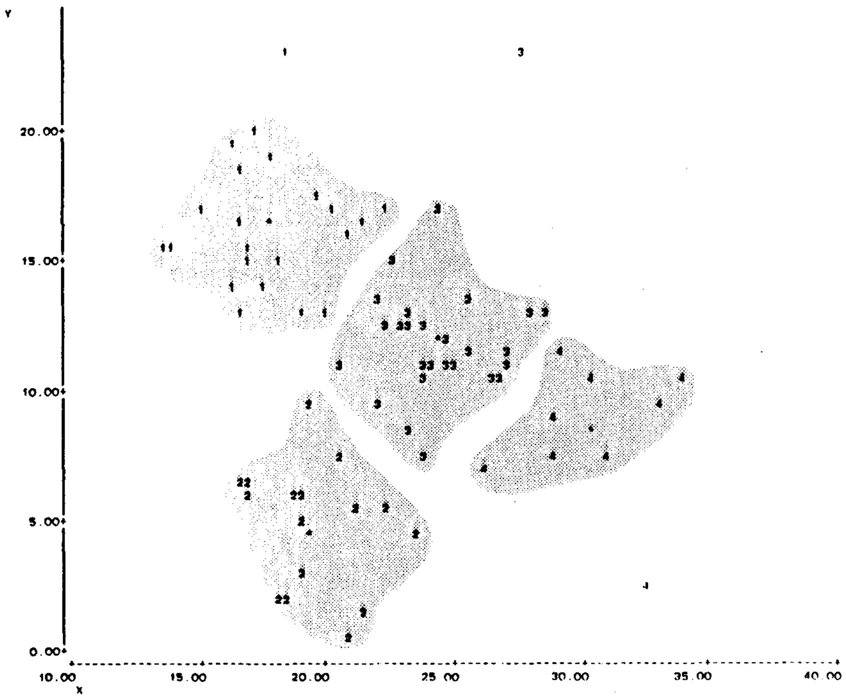

Figure 21. Distribution of four k-means clusters, Camp 14—maximum "decomposition."

3.3. Assemblage Composition Analysis of "Decomposed" Camp 14

The artifact distributions for the minimum, moderate, and maximum simulated "decompositions" of Camp 14 were analyzed using an unconstrained clustering approach in the same way as the original data. The only modification in an otherwise identical procedure was to use a 1.5-m moving template to generate the smoothed density contours for the maximally decomposed data, rather than a 1-m template as was used for the original camp and the other, less extensively decomposed sets of data. This was necessary in order to smooth adequately the small-scale, local variations in the comparatively low-density scatter of material resulting from the maximal decomposition of the camp, following the general rule of thumb discussed briefly above.

The clustering of item points based on standardized relative densities in the minimally decomposed data showed a rather clear break at seven clusters (Figure 22). Clustering of points for the moderate and the maximum decompositions of Camp 14 both revealed marked and unmistakable breaks at a nine-cluster solution (Figures 23–24).

Table 12. Camp 14—Maximum "Decomposition": Counts and Percentages of Material Classes for Four-Cluster K-Means Solution

Cluster	1	2	3	4
N[a]	22	17	27	9
Bones	6	8	6	1
%	27.3	47.1	22.2	11.1
Mongongo nuts	3	4	2	1
%	13.6	23.5	7.4	11.1
Nutting stones	3	2	7	3
%	13.6	11.8	25.9	33.3
Logs	1	1	1	0
%	4.5	5.9	3.7	
Charcoal	3	0	4	1
%	13.6		14.8	11.1
Hearths	2	1	2	2
%	9.1	5.9	7.4	22.2
Postholes	2	1	5	0
%	9.1	5.9	18.5	
Artifacts	1	0	0	1
%	4.5			11.1
Floral	1	0	0	0
%	1.3			4.5

[a] Number of items in cluster.

The compositions of the clusters so defined are presented in Tables 13 to 15, and they can be compared directly with Table 3, which has the results for the original, undecomposed data from the camp. A number of similarities strike one on the first inspection of theses tables, but their evaluation is much easier when the material classes significantly represented and characteristic of each cluster are listed in a comparative table, where the clusters that appear to be most alike among the four different analyses are aligned as well as possible, and distinctively different clusters are separated and allowed to stand apart.

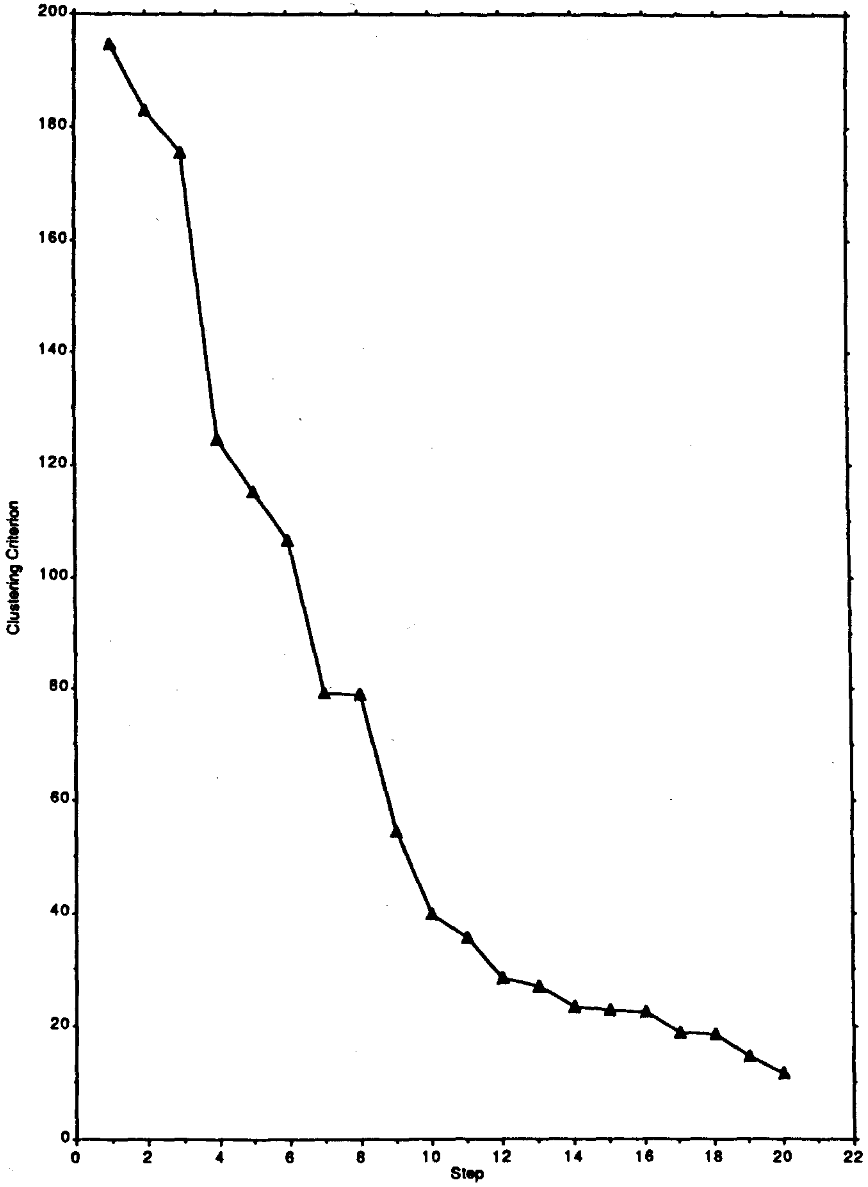

Figure 22. Plot of clustering criterion for unconstrained clustering of Camp 14—minimum "decomposition."

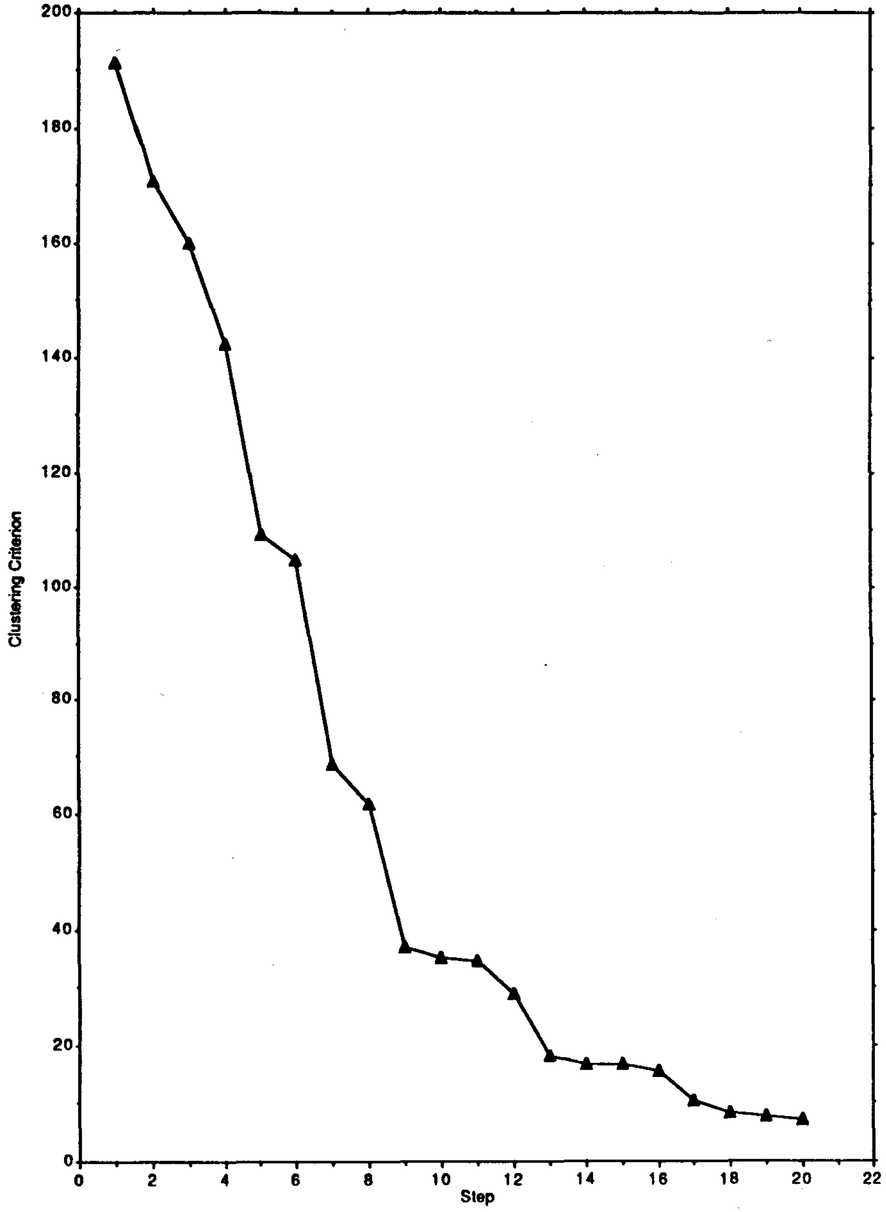

Figure 23. Plot of clustering criterion for unconstrained clustering of Camp 14—moderate "decomposition."

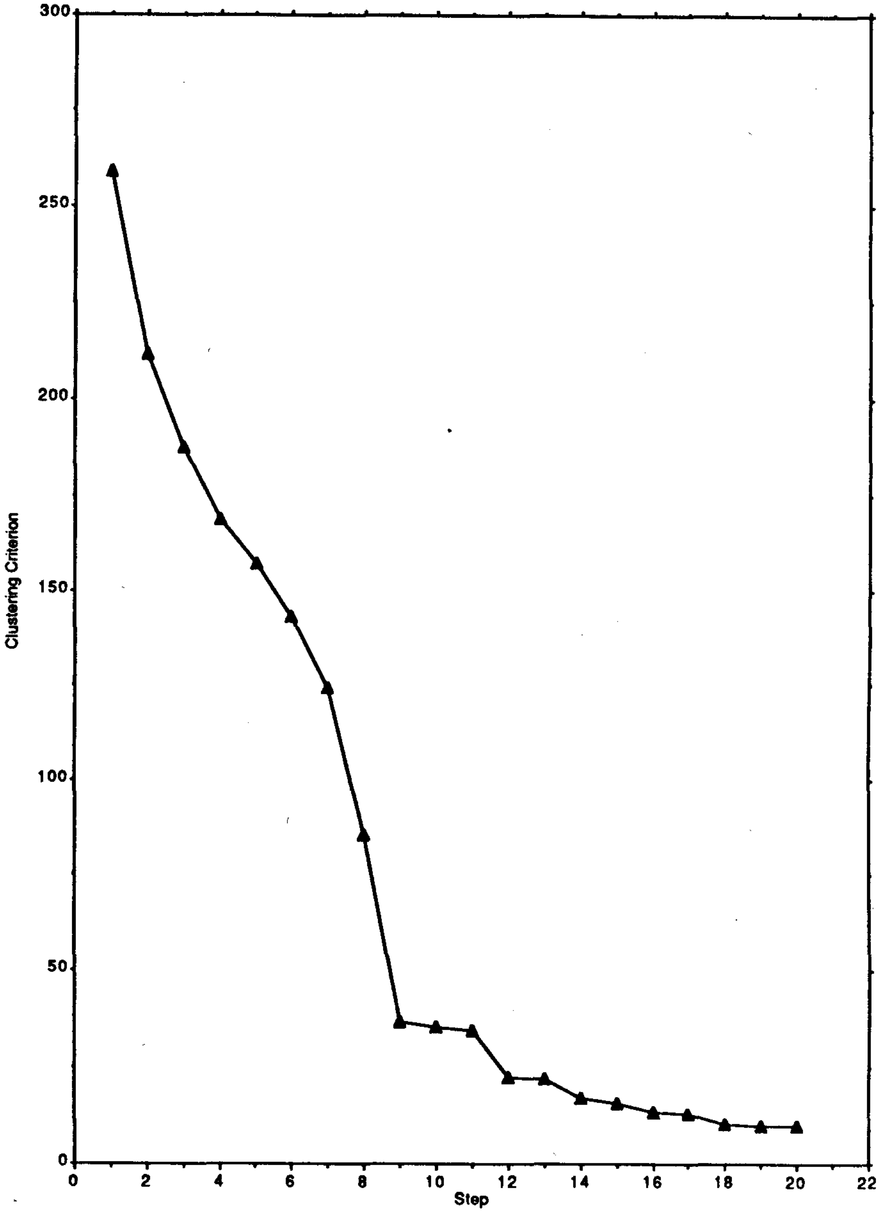

Figure 24. Plot of clustering criterion for unconstrained clustering of Camp 14—maximum "decomposition."

Table 13. Camp 14—Minimum "Decomposition": Means and Standard Deviations of Relative Densities by Unconstrained Cluster

Cluster	1	2	3	4	5	6	7
N[a]	32	6	27	9	3	4	3
Bones	57.8 ±28.3	5.2 ±5.6	23.0 ±18.8	1.6 ±4.9	0	42.4 ±22.8	14.3 ±12.6
Mongongo nuts	7.5 ±12.0	58.4 ±15.8	1.4 ±3.1	6.5 ±12.3	0	0	2.0 ±3.5
Nutting stones	4.4 ±9.2	16.8 ±21.5	38.8 ±22.1	7.2 ±8.9	0	1.4 ±2.7	26.7 ±9.4
Logs	2.3 ±5.5	0	3.8 ±8.3	57.6 ±25.7	0	3.1 ±3.9	2.0 ±3.5
Charcoal	19.4 ±23.2	18.9 ±19.7	9.5 ±12.2	10.8 ±11.8	0	0	0
Hearths	5.9 ±10.5	.7 ±1.8	4.8 ±12.7	15.8 ±12.6	100 ±0	5.4 ±4.3	0
Postholes	.7 ±2.5	0	18.0 ±16.9	.5 ±1.5	0	18.2 ±28.5	0
Artifacts	.9 ±3.5	0	.4 ±1.4	0	0	0	36.8 ±12.1
Floral	1.1 ±3.7	0	.2 ±1.0	0	0	29.6 ±3.2	18.0 ±15.8

[a] Number of items in cluster.

Table 14. Camp 14—Moderate "Decomposition": Means and Standard Deviations of Relative Densities by Unconstrained Cluster

Cluster	1	2	3	4	5	6	7	8	9
N[a]	24	8	11	18	23	3	3	3	1
Bones	84.8 ±15.4	48.9 ±13.7	23.8 ±23.6	15.6 ±11.8	25.7 ±15.8	6.3 ±11.0	0	8.1 ±7.3	4.5 ±0
Mongongo nuts	3.8 ±9.2	0	7.4 ±11.5	16.9 ±18.6	40.5 ±22.2	0	0	.8 ±1.4	0
Nutting stones	4.2 ±8.6	5.1 ±5.9	13.1 ±14.3	53.4 ±22.8	5.9 ±7.8	0	0	58.9 ±11.7	45.3 ±0
Logs	0	0	0	.5 ±1.5	0	0	0	0	50.2 ±0
Charcoal	2.1 ±5.0	0	19.6 ±16.9	4.3 ±7.1	22.9 ±7.1	91.5 ±12.9	0 ±9.7	0	0
Hearths	3.5 ±9	.2 ±0.4	4.9 ±9.3	6.0 ±9.6	4.3 ±7.9	1.1 ±1.9	100 ±0	0	0
Postholes	.3 ±1.2	15.2 ±16.5	30.8 ±12.9	2.8 ±4.7	.7 ±1.8	1.1 ±1.9	0	0	0
Artifacts	1.2 ±4.1	30.7 ±10.3	.3 ±0.9	.5 ±1.4	0	0	0	1.0 ±1.7	0
Floral	0	0	0	0	0	0	0	31.3 ±3.5	0

[a] Number of items in cluster.

This systematic comparison (Table 16) seems to us to show a substantial degree of overall similarity in the assemblage composition of the clusters defined for the original and all degrees of "decomposed" data. One cluster that consistently appears in every analysis is composed only of a high proportion of bones. This is also the numerically dominant cluster for all but the maximum degree of decomposition, where it is displaced by two clusters characterized by postholes, nutting stones, and bones, and by nutting stones and bones, respectively (compare Table 15 to Tables 3, 13, and 14). These latter two clusters also find one or two counterparts in all other analyses, indicating that some combination or combinations of proportions of nutting stones and bones, in association with structural remains (postholes) or not, is typical of the spatial organization of the debris scattered over Camp 14 and of the simulated "decompositions" of this camp.

Another common pattern of assemblage composition in all of the analyses comprises clusters with important proportions of mongongo nuts, either alone or in association with significant amounts of bones and charcoal or logs. A cluster characterized by bones and "artifacts" (tools) is found in three out of four analyses, as is a cluster dominated by logs, but with variable secondary contents.

Table 15. Camp 14—Maximum "Decomposition": Means and Standard Deviations of Relative Densities by Unconstrained Cluster

Cluster	1	2	3	4	5	6	7	8	9
N[a]	10	6	2	7	6	16	20	6	2
Bones	83.1 ±18.8	39.4 ±29.8	49.7 ±5.6	25 ±23.9	33.1 ±16.9	20.8 ±13.3	12.6 ±10.7	9.6 ±16.1	0
Mongongo nuts	1.0 ±2.1	0	1.4 ±1.9	66.3 ±18.5	28.2 ±20.6	2.9 ±5.6	10.2 ±11.5	0	0
Nutting stones	6.0 ±10.2	19.5 ±30.9	0	0	9.2 ±11.2	46.9 ±15.4	26.4 ±16.2	0	0
Logs	.5 ±1.6	.5 ±0.8	0	2.6 ±6.8	26.1 ±6.9	7.9 ±9.3	0 ±0.1	0	0
Charcoal	5.0 ±10.7	10.2 ±9.3	0	4.9 ±12.2	.7 ±1.0	11.0 ±13.5	3.9 ±5.0	34.3 ±28.2	100 ±0
Hearths	2.2 ±5.2	0	0	1.0 ±2.0	0	7.5 ±10.7	5.8 ±10.5	56.1 ±23.8	0
Postholes	1.6 ±5.1	0	0	.2 ±0.4	2.0 ±4.3	1.7 ±3.5	41.2 ±14	0	0
Artifacts	.6 ±1.9	30.4 ±11.9	0	0	.7 ±1.1	1.3 ±3.5	0	0	0
Floral	0	0	48.9 ±7.5	0	0	0	0	0	0

[a]Number of items in cluster.

Finally, hearths along define a cluster of three of the analyses and combine with a secondary component of charcoal in the fourth. These broad similarities among all the analyses account for virtually all of the clusters defined, leaving less than a half-dozen clusters that do not recur in at least three of four cases, and no cluster that does not have a possible counterpart identifiable in another analysis.

In spite of the apparently substantial uniformity in results with both the undecomposed and decomposed data, there are some noticeable differences that demonstrate a gradual degradation in the resolution of the reconstructed picture of the spatial organization of the camp as the original data are subjected to increasing degrees of disturbance and attrition. One can see this degradation

Table 16. Comparison of Cluster Compositions for Unconstrained Clustering Analysis of Camp 14, Original and "Decomposed" Data[a]

	Decomposed		
Undecomposed	Minimum	Moderate	Maximum
1. Bones	**1.** Bones	**1.** Bones	**1.** Bones
3. Bones Postholes (Nutting stones)		**3.** Postholes Bones Charcoal	**7.** Postholes Nutting stones
4. Bones Nutting stones Postholes (Mongongo nuts) (Charcoal)	**3.** Nutting stones Bones Postholes	**4.** Nutting stones Bones	**6.** Nutting stones Bones
2. Floral[b]	7. Artifacts Nutting stones Floral Bones	8. Nutting stones Floral Bones	
	6. Bones Floral (Hearth)		3. Bones Floral
5. Artifacts Bones Postholes		**2.** Bones Artifacts	**2.** Bones Artifacts Charcoal
	2. Mongongo nuts		**4.** Mongongo nuts
6. Bones Mongongo nuts Charcoal		**5.** Mongongo nuts Bones Charcoal	**5.** Bones Mongongo nuts Logs
7. Logs (Nutting stones)	**4.** Logs Hearths	9. Logs Nutting stones (Bones)	
8. Hearth[b]	5. Hearth[b]	7. Hearth[b]	**8.** Hearths Charcoal
		6. Charcoal	9. Charcoal

[a]Bold numbers = clusters with more than five members; nonbold numbers = clusters with five or fewer members; parentheses = item classes with mean relative densities below 10%, although this value is greater than its standard deviation.
[b]Isolated.

when the assemblages defined by unconstrained clustering are characterized by their content and seen in their distribution over the site area, plotted to produce a picture of the spatial organization of the "decomposed" camps that can be compared to that obtained from the original data. This picture of overall spatial organization normally would represent, in this approach, the final analytical results that would constitute the basis on which interpretations—archaeological, geological, and the like—might be made.

Because there is a good deal of similarity in the clustering results across all four analyses, we generally can characterize the different scatters of material assemblages commonly, in terms of five main assemblage types, plus a few minor clusters, as follows: (1) an assemblage dominated only by bones, (2) bones and postholes, separately or in various combinations with (3) nutting stones and bones, (4) bones and "artifacts" (tools), and (5) mongongo nuts, either alone or with bones and charcoal or logs, followed by (a) concentrations of logs, (b) isolated hearths, (c) isolated patches of charcoal, and (d) mixed assemblages with significant proportions of floral remains as secondary components. When these assemblages are plotted over the camp area, a picture of spatial organization very similar to that in the original data, but in one respect increasingly less detailed, is evident in all the decomposed camps.

At every level of decomposition, we easily can see that the various defined assemblages (clusters) are organized in spatial groups, each of which exhibits evidence for structural remains in the form of an important component of postholes in one or more clusters, plus patches of most of the other clusters defined in the analysis (Figures 25–27). These are the sorts of spatial groups that an archaeologist very likely would tend to identify as "domestic" or "residential" locations, and which, in the undisturbed, original data, replicated the ethnographically observed seven dwellings with their associated debris at this site. They are also the spatial groupings that tend to be identified by a pure locational (k-means) approach to spatial analysis, leading to a close complementarity between these two analytical approaches.

However, as simulated "decomposition" increasingly disturbs the original data, both through a high level of attribution and through physical movement, the number of these spatial groupings gradually declines, and the distinction of a core area with little evidence for processing of mongongo nuts, as against a periphery in which such evidence is relatively abundant, disappears. In the original camp, seven such spatial groups were identified (Figure 8). The number declines to five for minimal decomposition (Figure 25) or six for moderate decomposition (Figure 26) and drops sharply to three for the maximum level of simulated disturbance (Figure 27). The general restriction of significant evidence for mongongo nut processing to the peripheries of the site disappears in all the decomposed camps. Evidence for the small dumping area on the southern edge

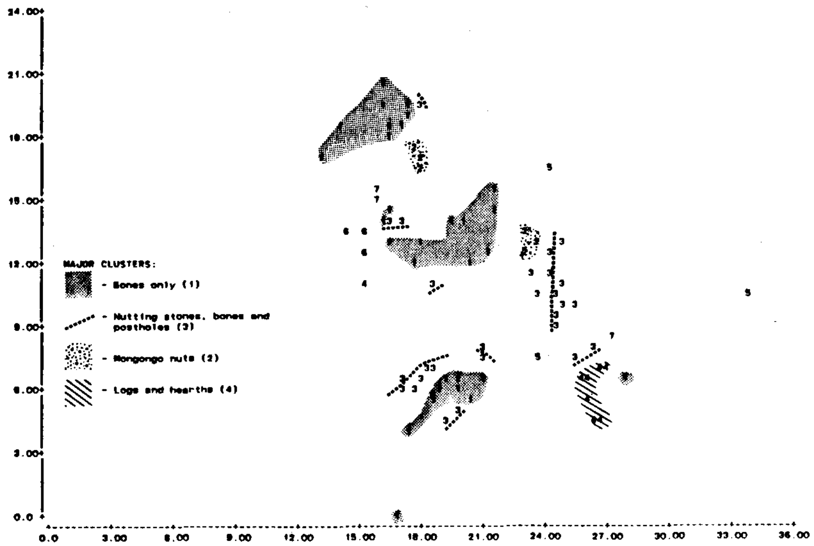

Figure 25. Distribution of seven unconstrained clusters, Camp 14—minimum "decomposition."

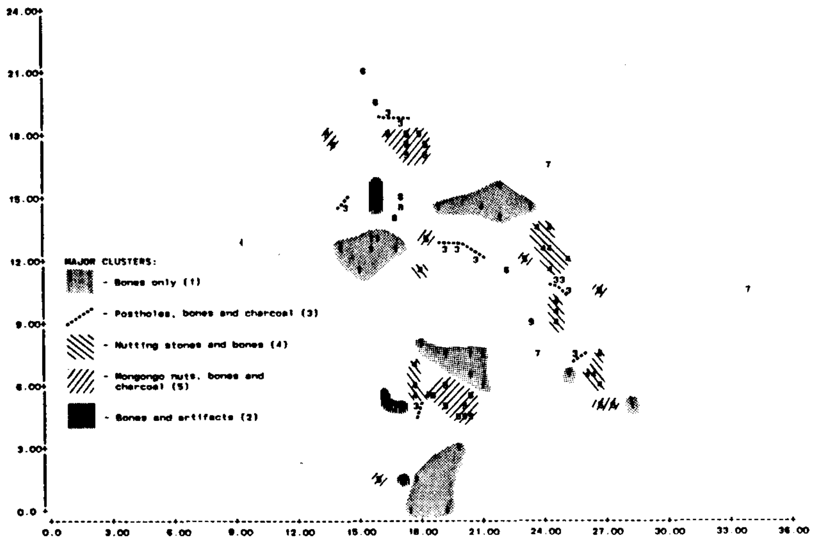

Figure 26. Distribution of nine unconstrained clusters, Camp 14—moderate "decomposition."

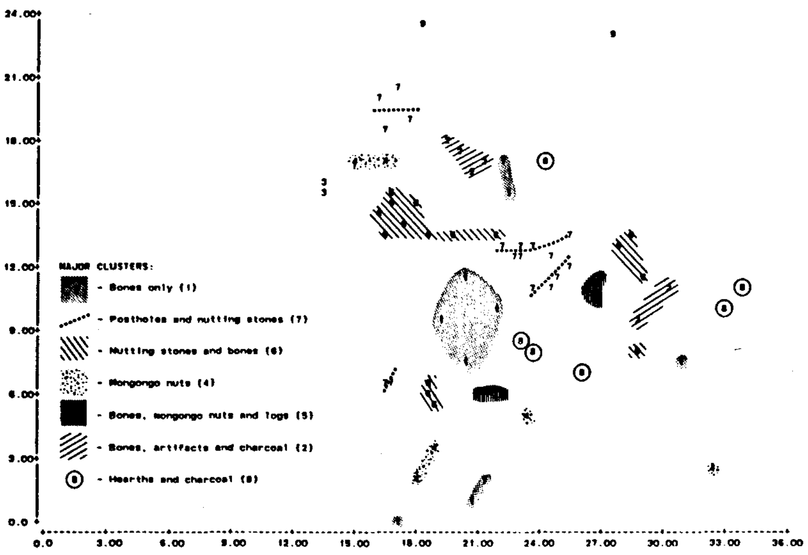

Figure 27. Distribution of nine unconstrained clusters, Camp 14—maximum "decomposition."

of the site is present only in the moderately disturbed data, and equivocally even there.

However, the clear spatial segregation of mongongo nut remains themselves and the nutting stones presumably used in their processing is maintained consistently and clearly at all scales and in all analyses. This is rather striking and suggests strongly that this pattern is very real at this camp.

4. CONCLUSIONS

What then can we conclude from this project? Yellen based his ring model on the repeated observation that the San conceptually divide themselves into identical units (Yellen 1977:131). The pure locational analysis confirmed that the spatial distributions of materials and features accurately reflect Yellen's observation that six or seven social units were present at the site. The assemblage composition analysis showed that a consistent pattern of activities occurred throughout the site and that hearths were the focus of specific activities. The combination of the pure locational and the activity-based methods produced objective results that correspond well with the results of Yellen's subjective analysis. In at least this instance, these methods have provided an objective means for identifying the structure and patterns of variability inherent in the ethnographic record.

All of the patterns revealed in the data by our analyses, including of course all the specifics of assemblage composition and spatial organization, are simply demonstrated, not explained. Although in any practical application, the steps of description and interpretation of analytical results typically are closely linked, frequently blending right into each other, they are in fact logically quite independent. Quantitative spatial analysis provides a rigorous description of data structure on a site; it is up to the archaeologist to interpret this description using whatever analogies, interpretive principles, additional data, and the like that he or she sees fit in any particular case.

However, we have seen two things in the comparison of the assemblage composition spatial analyses of original and "decomposed" data from Yellen's Camp 14: (1) a great robustness of both site structure and the analytical approach employed to define and describe it, and (2) a gradual loss of resolution of absolute spatial location while maintaining general integrity of the assemblage composition and pattern of distribution over the site.

The conclusions we can draw from these results seem to us generally positive. The original spatial organization of a human site may be maintained in large part, though probably with some generalization or loss of resolution, through the relatively extensive attrition and physical disturbance that may occur during the process of its transformation into an archaeological location. Relatively simple approaches and methods of quantitative spatial analysis now available to us can, particularly when used together in a complementary fashion, adequately reveal this organiztion and make it available for archaeological consideration and interpretation.

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