ARCHAEOLOGICAL POLLEN STUDY OF TWO DUNE SITES IN NEW MEXICO

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Introduction

In their Research Design statement submitted to the Bureau of Land Management, archaeologists of the Museum of New Mexico identified two primary objectives in the scientific study of sites LA 11828 and 11904. On the one hand, they proposed to establish the culture historical positions of the sites and their relationship to the archaeological patterns of north-central and northwestern New Mexico which represent contemporary populations. On the other hand, they proposed to determine the principle cultural functions of the two sites. Among the hypotheses the excavation and study program was designed to test were two which may be tested by the methods of archaeological pollen analysis: First, that the occupations of the two sites occurred between 3000 and 500 B.C. Second, that each occupation at a site represented the same functional pattern; that is, whenever the site was occupied it was the locus of the same suite of cultural activities. The primary value of the palynological work is not that it allows testing of these hypotheses, for they are also testable through analyses of recovered artifacts. Rather, the pollen analysis provides an <u>independent</u> test of the hypotheses which is not only based upon a different sort of data but is responsive to wholly different theoretical and methodological parameters. If the two independent forms of analysis lead to the same conclusions, we have more confidence in the validity of the assumptions underlying the interpretations and also more confidence that the resultant interpretation represents "true" and factural information. If the two lead to different conclusions, the nature of the difference may be considered as a way of developing modifications of either or both procedures to make them ore congruent and more useful.

To test the first hypothesis palynologically, it was necessary to relate the pollen records derived from samples from the sites to pollen records recovered elsewhere of known antiquity. To test the second hypothesis, it was necessary to compare the samples representing one occupational horizon with another to determine the range of internal variability, and them to compare the samples representing potentially different horizons of occupations to identify any indication of distinctive cultural effects upon the pollen rain. Both tests require an adequate series of pollen counts. This was no minor matter in the present case because the sediments sampled for the pollen study were sand dune deposits. Such deposits contain little pollen per cubic volume, and are normally dismissed from considerations as a course of palynological data because of the probability that such records would be too equivocal for interpretation. It was necessary in this study to extract a sufficient amount of pollen for statistically valid analysis and also to attempt to control the work so that an assessment could be made of the credibility of the pollen records as a basis for interpretation.

The problem of stratigraphic control was also difficult to resolve in the present case. Site LA 11828 was a locale of deflated sand dunes. No natural strata were defined, and all of the pollen samples were recovered from the fills of two hearth features. LA 11904 was a sand dune locality where deposition and shifting of deposits was actively occurring. The dunes are composed of a number of strata which apparently represent distinctive aeolian and cultural events. The "levels" observed and described by the field archaeologists were recognized primarily in terms of color variations. Particle size analysis was not undertaken, but note was made of the relative coarseness or fineness of the deposits. The occurrence of cleavage planes and the relative friability of the sediments was also considered informally in the definition of levels. The lithological and sedimentological characterists of the depositions were never scientifically examined, however, and as of this writing their cultural character is not well understood.

The majority of pollen samples from LA 11904 derive from the sediments exposed by the long trench of Feature 2 and the "control" test of Feature 12. Since the samples were collected as a series of profiles, there is a body of internal data of relative stratigraphy which may be assessed. But natural strata were not recognized in the field, or during subsequent laboratory work, upon grounds that geologists would recognize as adequate for this purpose. The archaeologist's levels do not constitute natural strata since they are not supported by controlled lithostratigraphic, biostratigraphic or cultural stratigraphic evidence. They are, however, useful suggestions regarding the natural stratigraphy of the site area, and we have taken them as a working hypothesis.

Overall, the situation may be fairly characterized as one in which the research goals and objectives were well defined but there was a good deal of question regarding the capacity of the data to be applied effectively to those ends. First, there was a question as to whether any substantive pollen record could be obtained at all. Second, there was theoretical reason to question the credibility of any data that could be obtained. Third, resolution of the research goals requires stratigraphic control and the field observations are not necessarily adequate for this purpose. Finally, the number of samples collected was not particularly large (certainly not statistically adequate for the problems), and some of the samples were recognized as potentially contaminated. In a very real sense, the challenge of this research project was not that of fulfilling the research goals but that of determining how well methods of archaeological pollen analysis worked in overcoming theoretical and practical research difficulties.

Methods

The extraction procedure utilized to remove the pollen from the sediment samples and prepare it for viewing is based upon three assumptions: (1) the assumption that the sediments contain relatively little pollen; (2) the assumption that the specific gravity of the pollen grains in the samples was no greater than 2.0; and (3) the assumption that the pollen exines were not mineralized. The first of these is justified by the common experience of palynologists attempting to recover pollen from sandy deposits, and by the fact that since sand-size particles are large a given volume cannot contain as much pollen as the same volume of a sample dominated by silt- or clay-sized particles. The second assumption is based on the statement by Faegri and Iverson (1964:70) that pollen and other organic constituents of sediment samples have a specific gravity of 1.7, Juvigne (1975), however, reports that some pollen exines have a specific gravity of 2.25. The third assumption is based upon our understanding of the chemical nature of pollen exines.

The details of the extraction method need not be reported here. Generally, the samples were deflocculated in dilute HCl, then subjected to swirl flotation and screening for the removal of large and quite heavy particles. Following treatment with HCl and boiling HF, the residues underwent heavy liquid (stannous chloride) separation of the fraction with a specific gravity < 2.0. This fraction

Table I: Comparison of data before and after laboratory re-processing

Sample	Pinaceae	Juniperus	Quercus	Juglans	Chenopod.	Artemisia	Compos.	Gramin.	Ephedra	Others	Count No.
S5/21E	28.0	8.0	2.5	0.0	36.5	2.5	7.0	6.5	5.5	3.5	1
#1	32.0	8.5	0.5	0.5	38.0	5.5	5.5	2.5	5.5	1.5	2
S5/21E	25.0	8.5	1.5	0.0	32.0	2.0	8.0	6.5	11.5	3.0	1
#2	26.8	7.2	1.0	0.0	43.8	1.6	8.3	5.1	4.6	1.5	2
N30/E2	18.5	5.5	1.0	0.0	42.0	3.5	9.0	0.0	4.5	7.0	1
#3	29.5	5.5	2.5	2.0	38.0	1.0	6.0	4.0	10.0	1.5	2
N30/E2	26.5	3.5	2.5	0.0	36.5	3.0	7.0	11.5	6.0	2.5	1
#4	19.5	6.5	0.5	0.0	48.5	2.5	7.5	6.0	7.5	1.0	2

was then treated successively with a weak oxidant (20% HNO_3), bleached, and reduced with 10% lye to remove the bulk of organic materials. After microscopic examination of the resultant extract, about 2/3 of the samples were given an additional acetylation treatment to further eliminate organic detritus and make the pollen easier to observe.

In order to maintain control of data quality and insure profitable use of laboratory time, an analytic procedure was implemented which is not usually considered necessary. After the initial laboratory processing of the samples a microslide preparation was made of the extract and the amount and types of pollen observable on ten percent of the slide was tabulated. This allowed a sufficient body of observations to determine a number of things: (a) to allow recognition that a normal range of pollen types occured, indicating that differential preservation of pollen taxa was not obviously biasing the data; (b) to allow recognition that samples from all strata would provide adequate numbers of pollen grains for analysis; and (c) to allow assessment of which samples should be returned to the laboratory for additional processing to make observation easier and more consistant from sample to sample.

In order to document that the initial pollen observations in fact provide a sound basis for evaluation, a comparison was made of the results of 200-grain pollen counts made prior to and subsequent to laboratory reprocessing. The four surface samples were used for this test, since they contained the pollen most likely to be adversely affected by the laboratory procedure. Table I illustrates the results of the two analyses in percentage terms. Clearly, the reprocessing laboratory procedure has had no influence on the pollen record.

Pollen of 50 samples was extracted and observed. The goal of 200-grain counts was obtained within an arbitary observation limit of 44 mm^2 surface of viewing area in the case of 30 of the samples, and another 11 samples yielded 100- or 50-grain counts. Of the 9 samples which produced insufficient pollen for study, 5 were considered potentially contaminated by handling procedures before being sent to the Palynology Laboratory. Thus 93% of the contextually intact samples collected from LA 11904, and 85% of the samples collected from LA 11828, provided data for the pollen analysis. Considering the normal claim that sandy and aeolian deposits cannot provide data for palynological study, these figures are impressive.

Two formats of analysis have been applied to the data obtained. One form uses a total pollen sum in order to establish biostratigrphic units. The other form utilizes the adjusted pollen sum (Schoenwetter 1970) to investigate the problem of cultural functions of the sites. Two formats are used in this study because each has unique properties which made it more appropriate to the issues at hand. The total pollen sum format expresses all available paleofloristic data. This is more appropriate for the identification of stratigraphic horizons because biostratigraphic units are defined in terms of paleofloristic variations. The adjusted pollen sum format is designed to isolate locally over-represented pollen types such as occur in the record as the result of cultural activity. The total pollen sum analysis could be used to the same ends, but the adjusted sum format makes the relationship between evidence and conclusions more obvious and hence is more useful for these specialized purposes.

Tests of the Credibility of the Data

How does one recognize "good", i.e. credible, palynological data? The problem arises because all pollen is not produced, dispersed or preserved equally.

Obviously, the pollen analyst has little means of controlling data which is biased by natural processes of differential production of pollen by plants. If a pine tree happens to produce more pollen than a 4 o'oclock plant, the best that can be done is to determine the mathematical relationships of such differential productivity and attempt to apply them to the analysis of the pollen record where this is meaningfully relevent to the problem under investigation (see Faegri and Iverson 1975:154-56). The matter of differential dispersal
concern in the pollen analysis of terrestrial (specifically, non-lactustrine) sediments, because pollen-dispersing plants may once have lived and died directly at the point of sampling. One may anticipate a degree of effect upon the pollen record because of this or any other factor that could cause an extraordinary amount of one kind of pollen to become concentrated at the sampling locus. In palynological jargon, such an effect is called "local over-representation."

The most crucial problems, however, are those created by the inherent likelihood of differential preservation of pollen in terrestrial deposits. Pollen grains may be destroyed by the mechanical abrasion of mineral particles, by the chemical effects of oxidation, and by the feeding activities of herbivores and saprophytes. In the lacustrine and peat deposits more routinely utilized by pollen analysts, the affects of these destructive agents are much reduced. In terrestrial deposits all of them are aggravated. Further, each distinctive depositional event offers a different physical and/or chemical environment so the destructive effects may be felt distinctively on the pollen record of different samples. In the present case, the abrasive character of the quartz crystals of the deposits; the large number of air spaces in the aeolian deposits which provide an oxygen-rich environment conducive to the support of organisms which may feed on pollen; the alternate wetting and drying and heating and cooling of the deposits in response to weather conditions; and the disturbance of the deposits resulting from the use of the locale by prehistoric man all combine to establish a sampling location rife with prospect that differential preservation of pollen will affect the pollen record.

When one compares pollen extracted from terrestrial and lacustrine deposits, it is very obvious that a good deal of destruction of pollen occurs in the former situation. A far larger proportion of the pollen is corroded, broken and deformed. Some pollen grains in a sample are very well preserved, others of the same taxa are poorly preserved. Far fewer pollen grains occur per unit volume of deposit, and a substantially smaller number of pollen taxa are represented in statistically adequate proportions. Generally, it is clear that the destruction of pollen relates to the passage of time and the potential of the depositional environment to reduce the adverse conditions noted above. Surficial terrestrial deposits, for example, contain more pollen and more types of pollen than deposits having an antiquity of 400 years or more. Alluvial deposits tend to contain more pollen than colluvial or aeolian deposits; fluviatile deposits tend to contain more pollen than non-fluviatile deposits; and sediments which evidence slow deposition tend to contain more pollen than those which evidence rapid deposition.

The issue, however, is not whether or not differential preservation and local over-representation occur. The issue is whether or not their occurrence affects the pollen record to such a degree that the pollen data recovered from terrestrial deposits is inadequate for the resolution of problems and questions we have regarding the past. Obviously, the pollen record of terrestrial deposits is not exactly comperable to that of lacustrine or peat deposits and it cannot be treated as if it were. Certain objectives, clearly, are not appropriately pursued through investigation of terrestrial pollen records. For example, if one wished to identify the variety of floral types which existed at a given time in the past

		Abies	Picea	P. ponderosa-type	P. edulis-type	Pinus 1/3	Juniperus	Quercus	Juglans	Ulmus	Artemesia	Ephedra N	Ephedra T	Cactaceae	Chenopodiineae	Ambrosieae	Tubuliflorae	Gramineae	Leguminosae-type	Onagraceae	Polygonum	Cleome	Unknowns	Total
S5/E21	Surface	1		8	55		17	1	1		11	7	4		76	10	11	5					3	210
S5/E21	Surface		1		48	9	14	2			3	8	1		85	8	16	10					3	202
N30/E2	Surface			5	54		11	5	4		2	19	1		76	7	12	8	2				1	207
N30/E2	Surface			1	38		13	1			5	14	1		97	9	15	12	1				2	209
Feature 2																								
S5/E5	Level 1				57		10				13	77	2		24	16	15	1					1	216
S5/E5	Level 2				14		11		1		9	28	4		60	6	37	14					3	207
S4/E5	Level 2				21		18		1		8	29	9		78	7	23	8	1				5	207
S3/E5	Level 2				18		12				10	18	5		93		27	10	2	1			6	200
S6/E5	Level 3				16		19				17	25			60	5	55	5	1				2	205
S5/E5	Level 3				15		21		1		19	21	7		68	16	33	11				5	5	221
S4/E5	Level 3				38		10	2			10	22	21		71	5	21	1	1				3	205
S3/E5	Level 3				13		20				7	19			74	4	50	11	1			7	5	204
S6/E5	Level 4				8		13				11	4			34	5	19	8					3	105
S5/E5	Level 4				18		21				21	13	3		57	8	39	18	3				7	208
S4/E5	Level 4				5		20				10	13	1		105	4	34	9					3	204
S3/E5	Level 4				16		12			1	26	12	2		84	2	34	9				2	4	204
S6/E5	Level 5				3		1				8				20	6	14	3					1	56
S5/E5	Level 5				6		5				15	2	3		44	7	16	7					2	107
S4/E5	Level 5				58		6				7	24	2		91	3	11	1						203
S3/E5	Level 5				10		16				19	16	7		50	5	65	11			1		5	205
S7/E5	Level 6				46				9		11	68	2		53	5	4	2						214
Feature 12																								
N28/E1	Level 2				22		19	1			13	46	6		42		35	11				6	5	206
N28/E1	Level 3				16		15	1			18	55	4		43		30	13	1				4	200
N28/E1	Level 5				3		3				10				22		8	3					1	50
Feature 3																								
S1/E27	Level 1				50		21	3			5	68	5		31	4	12	3			1	4	1	208
S1/E23	Level 2				7		6	1			6	10			151		16	2					1	200
S1/E19	Level 3				23		12	1			14	4	4		109	9	24	9				16		225
N1/E22 ash deposit below charcoal					7		2				10				12		14	3					2	50
Feature 4																								
S21/E6	Level 2				64		27				7	37	10	1	28	11	20	3					3	211
S21/E6	Level 3				70		22				7	18	39	2	34	11	3	4		1				211

TABLE II Pollen observed a LA 11904

the pollen analysis of terrestrial sediments would not provide adequate direct evidence. But this does not mean that such pollen records are necessarily inadequate for all purposes.

In the present case, the primary issue is the credibility of the pollen record as a tool of biostratigraphic analysis. This may be examined in two ways. First, we are assured that pollen recovered from surficial layers constitutes the biological expression of modern, existing conditions of ecology and biogeography. The surface deposits are presently being formed by the active shifting and redeposition of sands in the dune field. Any pollen they contain must be modern pollen which is derived from the modern flora. If the fossil pollen record conforms to this modern pollen record as regards the nature of its principle components, it would appear that there has been no substantial qualitative effect of differential destruction on the fossil pollen record. At least, no kinds of pollen presently preserved in quantity in these deposits have not been preserved there as a record of prior ecological and biogeographic patterns. Second, we may compare the palynological records of different samples collected horizontally at the site from a given lithostratigraphic unit. If differential preservation or differential distribution of pollen would affect those data, it is likely that significant quantitative differences would be detected among the various samples known to represent a specific horizon. But if differential preservation or distribution of pollen did not in fact affect the record, then the quantitative values of pollen in the different samples would be statistically conformable.

The area of LA 11904 is today characterized as one of active aeolian deposition. From the descriptions of vegetation at and near the site which have been provided (Whiteaker, Snow, pers. comm.), it is clear that the ecological pattern of the site and its environs is of the sort classed as Desert Grassland (Brown and Lowe 1974; Little 1950:7) Grasses are the dominant, if sparse, plants found on the dunes themselves. A few junipers and some riparian flora also occur on the site. Close by, mormon tea, cacti, snakeweed, rabbit brush, salt bush, wolfberry and tumbleweed are found prominantly in the grassland--probably upon a more stable (if overgrazed) substrate.

The pollen record recovered from each of the four surficial sediment samples collected at LA 11904 is quite uniform from the qualitative perspective (see Table II). Fifteen taxa are represented among the samples, with no specimen providing less than 12 or more than 14 taxa. Only two taxa are represented by single occurrences among the four samples, and only two others occur only twice. According to the tables provided by Snedecor (1956:4) for binomially distributed data see Mosimann (1965) for support of the assumption that "fixed N" pollen counts have this distribution), a number of the taxa do not provide sufficiently large numbers of grains to be assessed as significant at the 95% level of confidence. Most of these taxa (Abies, Picea, Pinus ponderosa-type, Quercus) represent plant populations not present at or near the site. Others (Juglans, Leguminosae) appear to represent plant forms having specialized requirements which are not representative of the Desert Grassland ecological pattern. The taxa which occur consistantly in the pollen spectra, and occur in large enough frequency to be evaluable as data, are those which are produced by the plant forms typical of the Desert Grassland. These are Pinus edulis-type, Juniperus and Quercus pollen, among the arboreal types, Artemisia, Tubuliflorae and Ephedra pollen, among the shrub pollen types, and Gramineae, Ambrosieae and Chenopodiineae pollen, among the herbaceous types.

Among the 26 fossil pollen spectra, 17 taxa are represented. Three are represented by a single occurrence and two are represented by two occurrences, however,

	Pedulis-type	Juniperus	Chenopod.	Artemisia	Tubuli. & Ambrosieae	Gramineae	Ephedra	Others
Fea 12, sample 5	22	19	42	13	35	11	52	12
Fea 2, S5/E5-15	14	11	60	9	63	14	32	4
Fea 2, S4/E5-1	21	18	78	8	30	8	38	7
Fea 2, S3/E5-10	16	12	93	10	27	10	23	9

Degrees of freedom = 21

Chi square = 2.151

Table III: Data for the test for homogeneity of samples from one level and three of the taxa which occur in the modern record are not found in the fossil record. Again, there are nine taxa which occur consistantly and in sufficient frequency to qualify as statistically evaluable data. These are the same taxa as the ones so recognized in the pollen record of the surficial deposits.

Because the surficial deposits sampled for pollen are of recent origin, there is every reason to believe that the pollen they contain constitutes the palynological expression of the modern pattern of ecology in the site area. This conclusion is reinforced by the fact that those pollen taxa which occur irregularly or in insufficient quantity for evaluation are all produced by plant forms which are today located at a considerable distance from the site or produced by plant forms not typical of the ecological pattern which occurs today. The fossil pollen records of the site locality have the same essential palynological characteristics as those of the surficial deposits. It would thus appear very improbable that differential destruction of pollen has affected the character of the fossil pollen record specifically. While such destruction probably does occur, it does not seem to occur uniquely to fossil pollen records at LA 11904 but to both modern and fossil pollen rains equally.

To test for horizontal consistancy as a means of assessing credibility, we have chosen to consider the pollen records assigned to "level" 2. This choice was influenced by two factors: (1) Level 2 was sampled in two trenches dug at the site, not only in one, so a broader horizontal range can be studied. One of the loci of sampling was the Feature 12 test area, where cultural intrusions do not occur. (2) The color and sedimentological distinctions between the uppermost (level 1) deposit and the level 2 deposition are sharply drawn and obvious in the field. The samples assigned to level 2 are thus most likely to be properly assigned on the basis of the limited field information used to determine the stratigraphic positions of the samples. Three specimens labelled as derived from level 2 have, however, been exempted from the text because they were assessed as contaminated prior to submission for pollen analysis.

A multinomial homogeneity test (Table III) has been applied to the four pollen records from stratum 2 to determine their similarity. The test requires some lumping of data into categories, but asks whether the true proportions of all taxa are the same for all samples; i.e. if the pinyon pine value is statistically the same and the *Juniperus* value is statistically the same and the Chenopodiineae value and the *Artemisia* value, etc. in the group of samples (Mosimann 1965:646-49). The resultant chi square value of 2.151 is not significant at the .005 level (Snedecor, 1956:29). The hypothesis that the samples derive from a homogeneous population is therefore not rejected and it would appear that contemporary fossil pollen records do form a cohesive group. Differential preservation of pollen does not appear to affect the data in any significant quantitiative fashion any more than it seems to affect it in qualitative fashion. There is thus reason to support the position that the data are credible and may be taken at face value.

Results and Discussion: Total Pollen Sum Analysis

The sediment samples collected at LA 11904 were recovered as stratified suites from a number of different sections in different features. In feature 2, four sections were sampled at approximately one meter horizontal intervals along the profile exposed at grid location E5. One sample was collected from each "level" exposed in each section. At feature 12, another stratified series of samples was collected. The "levels" were identified similarly in both features. Levels 1

Figure 1. Pollen spectra from Features 2 and 12, LA 11904

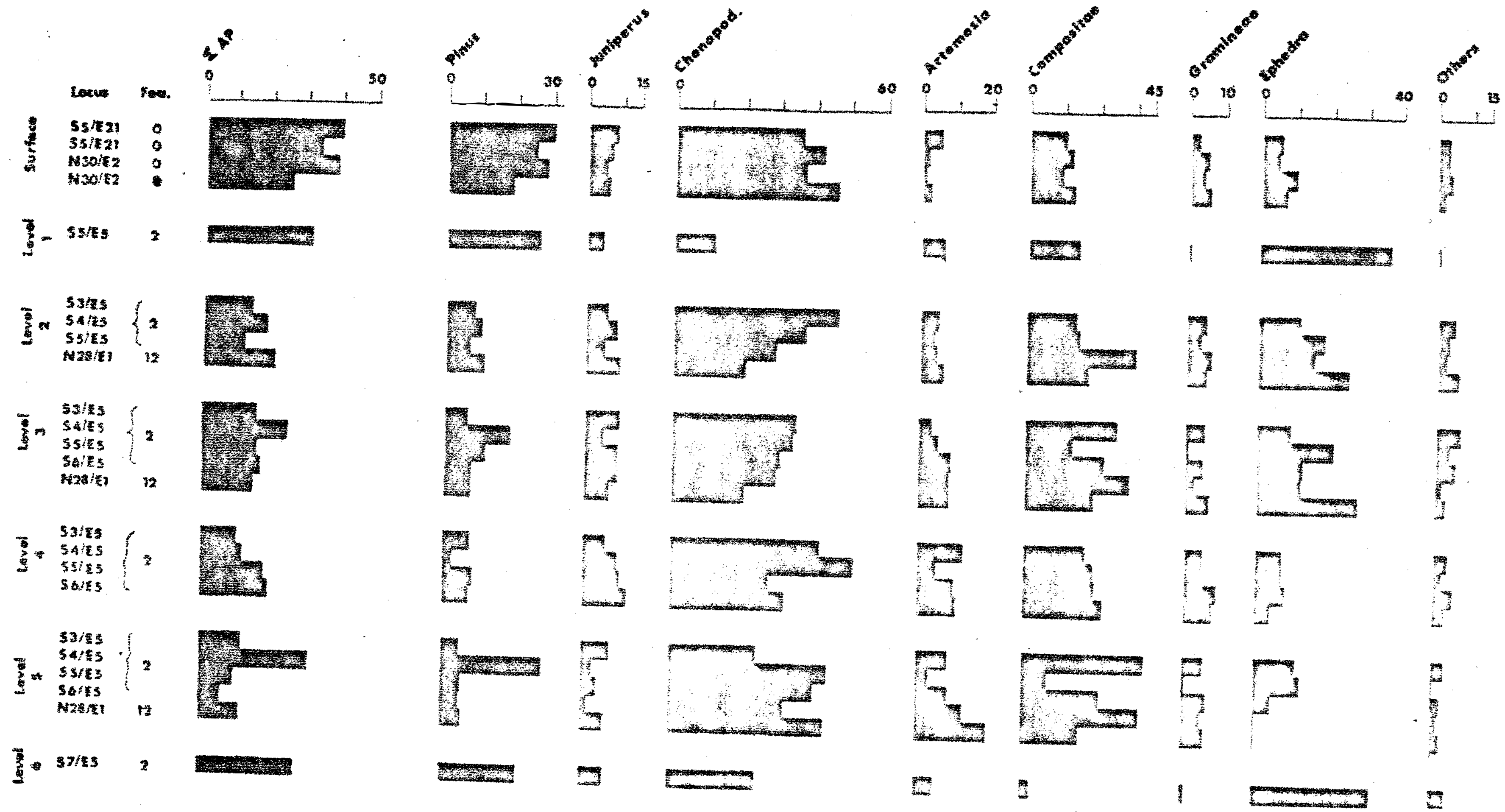
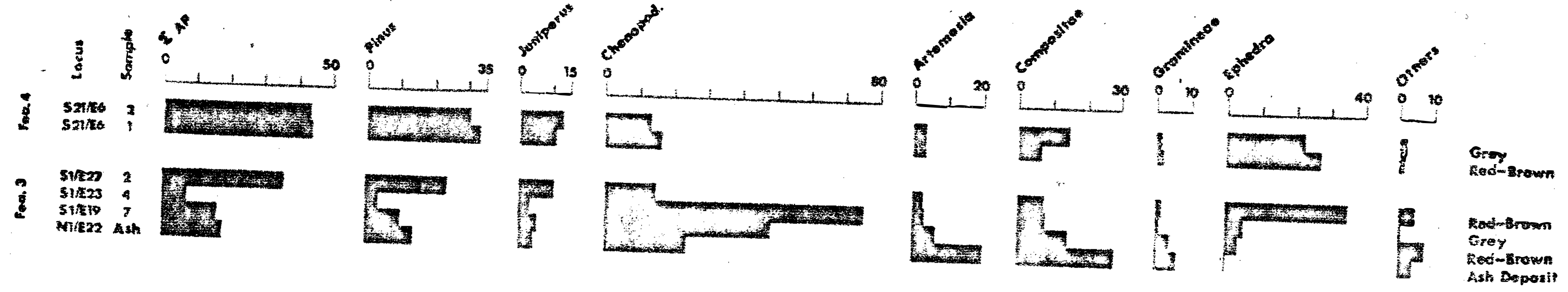


Figure 2. Pollen spectra from Features 3 and 4, LA 11904



and 6 were sampled only once. Figure 1 illustrates the pollen spectra of the samples collected from each level, with the samples from the surficial sediments included for comparison. The diagram specifically allows us to evaluate the similarity among samples which presumably represent the same stratigraphic horizon, and allows comparison of the different horizons.

The comparability of data from samples attributed to the same stratigraphic horizon is striking, particularly in light
were defined. The most apparent variability is observed in the samples from level 2, but we are assurred by the test for homogeneity that this is not statistically real. The sample from level 5 collected at section S4 is aberrant, as the AP and Pinus values are significantly larger than the others of this level. Otherwise, the palynolgocal record tends to confirm the field diagnoses of the levels and, particularly, to provide support for the correlation of levels between Feature 2 and Feature 12.

It is particularly unfortunate that only one sample was collected from level 1 and from level 6, since those two samples are very distinctive palynologically. Aside from the pollen records of the surficial deposit, those two samples provide the primary basis for biostratigraphic separation of the site
stratigraphic units. These samples yield significantly higher pollen values for both arboreal pollen and Ephedra pollen than any of the other stratified samples from the site. Taken at face value, they indicate that a substantial time interval separates the period of deposition of the sample from level 6 and those from levels 5 through 2, and that another time interval separates the deposition of levels 5 through 2 from the period of deposition of the sample from level 1. Yet another time interval presumably separates the deposition of the sample of level 1 from the surfical deposition occurring today.

This interpretation is severely threatened by the fact that half of the biostratigraphically significant data from Feature 2 derives from unique samples. Pollen analysis establishes the credibility of palynological data as a basis for interpretive conclusions through use of statistical procedures. The interpretation presented cannot be examined statistically because no opportunity exists to determine whether or not the samples from levels 1 and 6 are representative of the deposits from which they derive. Thus the pollen analysis cannot be considered to have demonstrated that the interpretation is valid. At best, the pollen study has suggested this interpretation as an hypothesis for consideration.

There were two other features at LA 11904 from which sediment samples were collected for
4, however, and all but one recovered from Feature 3, had been removed from the containers used in the field and had been transferred to other containers under non-sterile conditions. They were submitted to this laboratory marked as contaminated samples. However, we were requested to prepare them for analysis as a normal series for comparison with the samples from Features 2 and 12. The most striking difference between these sets of samples is the fact that pollen was far less frequent in those from Features 3 and 4. 45.5% of the samples submitted from those features did not yield sufficient pollen for analysis, while 7.0% of the samples from Features 2 and 12 were not polliniferous. However, the samples from Features 3 and 4 that contain pollen yield spectra which are conformable to the expectations generated by study of the pollen records of Features 2 and 12.

At Feature 4 a red brown sandy deposit is observed overlain by a gray sandy deposit and at Feature 3 the reverse is true. In Feature 2, levels 1 and 3 are characterized by the occurrence of red brown sands. At Feature 2, both levels 1 and 3 are superimposed upon gray deposits; level 3 is also overlain by gray deposits but level 1 is highest in the stratigraphic column so is not superimposed at all at Feature 2.

The red brown deposits at both Feature 3 and Feature 4 could correlate with the red brown deposits of level 1 at Feature 2. Since level 1 is palynologically distinctive, we would expect that if this were true pollen samples 2 and 1 from Feature 4 and pollen sample 2 from Feature 3 would contain high values for Arboreal Pollen, Pinus and Ephedra pollen. We would further expect that the pollen samples which were collected from the deposits under the red brown sands at Feature 3, would contain pollen spectra equivalent to those of level 2 at Features 12 and 2. These expectations are exactly borne out by the pollen spectra of these features (Figure 2). The implication of these results is two-fold: (a) it would appear that the pollen records from Features 3 and 4 may be correlated with those of the upper levels at Features 2 and 12, and (b) it would appear that the three additional pollen spectra containing high AP, Pinus and Ephedra pollen values act to support the interpretation that level 1 represents a distinct natural stratum.

Again, however, it must be recognized that these interpretations of the record cannot be considered wholly demonstrated by the evidence available. Analysis of stratigraphic units, and correlation of natural strata, is a scientific procedure in geology which is accomplished in very well defined and strictly established fashions (American Commission on Stratigraphic Nomenclature 1961). The interpretations offered above depend upon the presumption that there is a lithostratigraphic relationship between the red brown sandy deposits of level 1 at Feature 2 and the deposits of the same color at Features 3 and 4. Further, they depend on the presumption that there is no such relationship with the red brown deposits of level 3. The sedimentological data available is inadequate to allow evaluation of those presumptions; they may be correct or incorrect. But lithostratigraphic relationships of deposits constitute a form of evidence which must be given priority over biostratigraphic relationships when defining natural strata. The palynological similarity therefore cannot be taken to demonstrate the relationship between the sampled deposits at Features 3 and 4 and Feature 2. The pollen data can only suggest a relationship, unless supported by lithostratigraphic evidence.

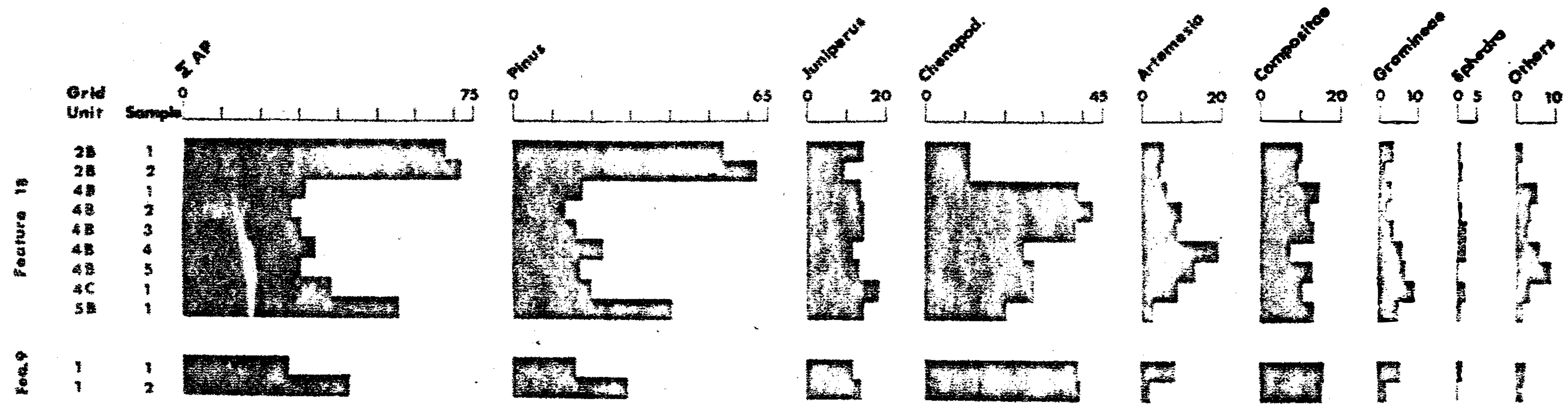
Our tendency is to accept the palynological relationship as supportive evidence for the working hypothesis that the red brown deposit at Features 3 and 4 is correlative with the level 1 deposition at Feature 2. But this is only advanced as our opinion. We note that acceptance of this notion requires that one grant that the pollen samples from Features 2 and 3 were never contaminated beyond the point of usefulness.

The samples submitted from LA 11828 (Figure 3 and Table IV) derive from two features. Feature 18 has been identified as an early historic period hearth structure. A number of pollen records are available from some of the grid units by which the feature was excavated. The two samples from grid unit 2B are similar to each other but distinct from those of the other grid units by virtue of higer AP and Pinus values. The suite of samples from grid units 4B and 4C constitutes a second group; the single sample from grid unit 5C yields a pollen record which relates it closely to the samples from grid unit 2B. The samples submitted from Feature 9 presumably relate to a prehistoric horizon of occupancy at the site. Palynologically, however, these samples produce
the samples from grid units 4B and 4C at Feature 18. The Feature 9 pollen records are not like those which derive from the prehistoric horizon at LA 11904, as they

	P. ponderosa-type	*P. edulis*-type	*Juniperus*	*Artemesia*	*Ephedra* N	*Ephedra* T	Chenopodiineae	Ambrosieae	Tubuliflorae	Gramineae	Leguminosae-type	Unknowns	Total
Hearth 9													
9-1 (1)		33	24	18	2		80	6	27	11		5	206
9-1 (2)		15	7	1			18	1	7	1		1	51
Hearth 18													
18-2B (1)	1	107	28	11	1		23	2	19	7		3	202
18-2B (2)	1	126	19	10		2	23	4	15	3		1	204
18-4B (1)		39	30	14			85	18	14	7	4	7	218
18-4B (2)		15	16	11		1	47	10	4	2		4	110
18-4B (3)		18	16	10	1	1	42	10	5	4		3	110
18-4B (4)		12	6	10		1	13	2	2	3	1	2	52
18-4B (5)		18	14	14			29	5	9	7	4	5	105
18-4C (1)		11	10	5	1		15	5	1	5		2	55
18-5B	2	81	30	6	1	1	42	4	24	10		3	204

TABLE IV: Pollen observed at LA 11828

Figure 3. Pollen spectra from LA 11828



yield significantly more Juniperus and less Ephedra pollen. Biostratigraphic evidence, then, does not link the prehistoric occupations at 11904 and 11828 to the same horizon. It suggests, however, that the fill of Feature 9 may not be older than some of the fill sampled at Feature 18.

The objective of the total pollen sum format of analysis was the identification of biostratigraphic units which could be used to date the prehistoric occupations at LA 11828 and LA 11904. This is accomplished through comparisons with the pollen records of other sites. Particularly, comparisons with pollen sequences established for sites dating 500-3000 B.C. are appropriate.

Two pollen sequences are known which represent this time horizon in New Mexico. The San Jon I sequence from the San Jon Site on the Llano Estacado has been analyzed by Oldfield (1975:129), who concurs with Judson (1953) that the latest samples derive from sediments of the post-Altithermal period. The pollen spectra of these samples are referred to Post Tahoka phase H by Oldfield and Schoenwetter (1975:157) which is characterized by high values of non arboreal pollen "bracketing a minor pine peak [zone]." In the Arroyo Cuervo Region of New Mexico, Schoenwetter (n.d.) has identified a sequence of palynologically variable horizons associated with archaeological materials of the Oshara Tradition (Irwin-Williams 1973). At the sites of Colliers Dunes, Moquino Dunes, Ojito Dunes and Dunas Altas, pollen sequences have been recovered which are dated to the 1800-3000 B.C. horizon by virtue of associated artifacts and C-14. At each location, a younger depositional unit which yields high values for Arboreal Pollen is observed stratigraphically superimposed upon an erosion surface. This surface, in all cases, forms the top of a depositional layer which yields pollen spectra containing much less AP and dominated by the occurrence of Chenopodiineae pollen.

Our knowledge of the depositional history at LA 11904 is limited. We suspect, however, that the red brown deposits of level 1 at Feature 2, and the red brown deposits observed at Features 3 and 4, may be separated from the deposits they overly by an erosion contact. If this is true, a lithostratigraphic correlation as well as a biostratigraphic correlation with the dune geology of the Arroyo Cuervo Region would provide grounds for dating the prehistoric occupation at LA 11904 to the 1800-3000 B.C. period. The agreement with the palynological sequence at the San Jon site also indicates an antiquity not greater than 3000 B.C.

Results and Discussion: The Adjusted Pollen Sum Analysis

The adjusted pollen sum format of analysis was established to allow palynological interpretation of effective moisture level at archaeological locations on the Colorado Plateau (Schoenwetter 1970:41-42). The format of analysis proceeds by recalculating the pollen values of taxa in a spectrum after removing the influence of those pollen types indicative of localized vegetation or the behavioral patterns of human beings. For example, if the palynologist had observed 120 pollen grains of Pinus, 18 of Juniperus, 5 of Juglans, 30 of Gramineae, 25 of Tubuliflorae, 6 of Ambrosieae, 7 of Chenopodiineae of 15 of Zea the total pollen sum would equal 226. Juglans, however, is a plant having specialized water requirements which can only be accomodated in particular local topographic-geographic contexts. Ambrosieae pollen is produced by plants adapted to disturbed soils (Schoenwetter and Eddy 1964:70-71). Maize pollen is invariably introduced to the record of archaeological contexts as a function of human behavior. These pollen types are therefore excluded from consideration in calculating the adjusted pollen sum.

Level	Provenience	Adj. Pollen Sum	% Opuntia	% Cleome	% Juglans	% Legum.	% Ephedra
Surf.	S5/E21	180			0.6		10.2
	S5/E1	185					4.9
	N30/E2	176			2.3	1.1	11.4
	N30/E2	185				0.5	8.1
1	F.2:S5/E5	121					65.3
1?	:S21/E6	153	0.7				30.7
	:S21/E6	143	1.4				39.9
	F.3:S1/E27	127		3.1			57.5
2	F.2:S3/E5	177				1.1	13.0
	:S4/E5	162		0.6		0.6	23.5
	:S5/E5	168		0.6			19.0
	F.12:N28/E1	148		4.1			35.1
3	F.2:S3/E5	181		3.9		0.6	10.5
	:S4/E5	157				0.6	27.4
	:S5/E5	172		2.9	0.6		16.3
	:S6/E5	175				0.6	14.3
	F.12:N28/E1	141				0.7	41.8
4	F.2:S3/E5	186		1.1			7.5
	:S4/E5	186					7.5
	:S5/E5	184				1.6	8.7
	:S6/E5	96					4.2
4?	F.3:S1/E23	190					5.3
	:S1/E19	192		8.3			4.2
	:N1/E22	50					
5	F.2:S3/E5	193					3.6
	:S4/E5	174					14.9
	:S5/E5	95					5.3
	:S6/E5	50					
	F.12:N28/E1	50					
6	F.2:S7/E5	130			6.9		53.8

TABLE V: Adjusted Pollen Values

The adjusted pollen sum in this case would equal 200, and the adjusted AP frequency--which may be used as an index of effective moisture represented in this sample--would equal the frequency of Pinus and Juniperus (120 + 18 ÷ 200 X 100 = 69.0%). The pollen value for Juglans, Zea or any other taxon excluded from the sum is expressed as a frequency value proportional to the adjusted pollen sum. In this case the value for Juglans is 2.5% (5 ÷ 200 X 100 = 2.5%). Since the frequency of Juglans in the total pollen sum (5 ÷ 218 X 100 = 2.3%) is less, there are two effects of use of this format of analysis. On the other hand it isolates and amplifies the AP value which has been determined to be a palynological index of effective moisture. On the other hand, it isolates and emphasises the values of pollen types which reflect local and behavioral conditions.

To date, the adjusted pollen sum format has only been applied to pollen records of the last two thousand years, and it has only been used to determine adjusted AP values as a means of addressing paleoecological and chronological problems of archaeological character. Here, we wish to apply it in another way: to determine the pollen values of plants reflecting local and behavioral patterns so we may compare their influence on the pollen record during different horizons of occupation. If differential use of the site occurred on the different horizons that would affect the pollen record, we would anticipate it might be indicated in one or both of two ways. First, a change might be observed in the distribution or frequency of pollen of plants that have an economic function. Second, a change might be observed in the distribution or frequency of plants indicative of local conditions; such a change would demonstrate that the potential of the resource base of the site area was different at different times.

Almost all of the pollen types observed derive from plants which have some economic potential among aboriginal Southwestern populations (see Whiting 1939; Robbins et al. 1961). Clearly, however, the occurrence of most of these pollen types in the fossil records cannot have been behaviorally controlled because the taxa also occur in the modern pollen rain, which we know is not influenced by human occupation of the site area. The only pollen types which occur in the fossil records that do not also occur in the surface pollen records are Cleome, Onagraceae, Polygonum and Opuntia (Cylindropuntia-type). Onagraceae and Polygonum only occur in one sample each, so provide no basis for interpretation. Opuntia pollen only occurs in the two samples from Feature 4 that have been tentatively assigned to the level 1 horizon of site occupancy. Cleome pollen, on the other hand, occurs frequently in samples referent to the earlier period of site occupancy, associated with samples of the level 2, 3 and 4 depositions at Feature 2 (see Table V).

These data provide evidence for the conclusion that somewhat different patterns of behavior referent to the local plant resource base were occurring at different times at the site. Opuntia and Cleome are both zoogamous plants which pollinate by insect vectors. One would not anticipate these pollen types to be recovered regularly unless the plant had been manipulated by humans during the flowering period so its pollen would be dislodged to the ground surface. But Opuntia flowers early in the growing season and Cleome flowers in mid to late summer. It would appear that the site was being visited, and its flora exploited, during the spring at the time of occupation of level 1 but during the summer at the time of occupations of levels 2, 3 and 4. The pollen record thus provides evidence which supports an interpretation of differential functions for the site during different horizons of occupancy.

There are three pollen taxa which refer to local floristic conditions: Juglans, Ephedra and Leguminosae-type. Juglans (walnut) pollen occurs sporadically in the pollen records older than level 1. Its low and inconstant frequency in the fossil pollen spectra is similar to its representation in the modern pollen spectra.

No substantive differences from today's situation are evident. Pollen values of Ephedra (mormon tea) are significantly higher in the records of levels 1, 2 and 3 than in the records attributable to the modern surface deposits or levels 4 and 5. At least one of the species of this genus which is adapted to sandy substrates (E. Cutleri Peebles) is recognized as a valuable soil binder (Kearny and Peebles 1951:60). We think it likely that the low Ephedra values of the surface samples are edaphically controlled by the present situation of dune movement, and that the low values in levels 4 and 5 reflect similar conditions of dune activity while the high Ephedra values of the other levels reflect periods of dune stability.

Leguminosae-type pollen is produced by a number of genera and species of plants in the bean family; most are low forbes such as lupine or loco weed. In the fossil record, almost all pollen of this sort was recovered from levels 2 and 3. Though the frequency of the pollen is not statistically significant, its occurrence is significantly consistant in those levels. We suspect that this is also a pollen indicator of relative stability of the dune field, but that it is responding to somewhat different edaphic variables than the Ephedra pollen.

Summary

The two objectives of this palynological research were to identify the period of occupation of sites LA 11904 and LA 11828 and to determine whether or not functional differences in site occupation were evidenced at different horizons of occupation. Despite the uncertainties generated by limited controlled information on the sedimentology and cultural stratigraphy of the sites, and those generated by the sandy character of the deposits, both objectives were fulfilled.

The data provided regarding the provenience of the samples from LA 11828 indicate that all of the pollen records from Feature 18 are referable to the historic horizon. There are at least two different types of pollen spectra represented, however, and one of them is exactly equivalent to the record recovered from Feature 9, a prehistoric hearth. Whether or not this means that Feature 9 is not prehistoric is a question that can only be resolved by more specific study of the associations of the pollen records. In any case, there is no palynological evidence of any temporal relationship between the prehistoric materials from sites LA 11828 and LA 11904.

The pollen record of LA 11904 suggest the occurrence of three biostratigraphically definable natural strata related to the prehistoric period. The youngest of these appears correlative with the sediment recognized in Feature 2 as "level 1" which is characterized by red brown sands; next oldest is that group of deposits recognized as levels 2, 3, 4 and 5 at Features 2 and 12; and the oldest is associated with level 6 deposits. Pollen correlations with San Jon on the Llano Estacado and with dune sites in the Arroyo Cuervo Region indicate that the occupational levels at LA 11904 are post Altithermal in age, and date 1800-3000 B.C.

Application of a second format of analysis indicates that there is some likelihood that three occupations of the site were functionally distinct. Occupations of levels 5 and 4 may well have taken place during a period when the dune field was actively migrating, which would have provided a situation of distinctive resource potential relative to other periods of occupation. Occupation of levels 3 and 2 is evidenced as a probable summer occupation, while that of level 1 is evidenced as a possible spring occupation. These seasonality distinctions indicate different exploitation strategies were developed for the same site locus as environmental conditions changed over the course of the prehistoric record.

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