THE LOS HORNOS POLLEN STUDY

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THE RESEARCH STRATEGY

Palynological research on sediment samples from Los Hornos was initiated in mid-October, 1979. Unlike traditional pollen studies, this effort was undertaken as one aspect of a program of research designed to mitigate adverse effect upon an archaeological context deemed eligible for nomination to the National Register of Historic Properties. United States Federal law and regulations demand that mitigation studies of the sort undertaken at Los Hornos recover information of importance in prehistory. To fulfill this obligation, one of the problems addressed by the research strategy of the pollen study was that of identifying information of this sort.

The structure of mitigation studies, unfortunately, happens to be innappropriate for the pursuit of archaeological pollen analysis. Mitigation studies normally are initially planned for the resolution of particular archaeological problems, but are also designed to identify and explore issues and questions important to prehistory which surface as excavation and subsequent analysis proceeds. The logistical structure of mitigation studies thus normally identifies at the outset major parameters of time, funding, research strategy and technology within which work will be constrained. Detailed logistical parameters are then set as seems most appropriate as the archeological work proceeds. Archaeological pollen analysis is defined (Schoenwetter 1970) as the application of the technique of pollen analysis to the resolution of archaeological problems. When archaeological pollen analysis is undertaken as an aspect of a mitigation program, it is not an independent research endeavor. Normally, it must be undertaken within constraints that have been imposed upon its capacity to function effectively by both broad and detailed logistical decisions already implemented during the course of archaeological field and laboratory operations.

There is no practical way to obviate this state of affairs, for the sediment samples to be examined cannot be obtained before excavation proceeds and major logistical constraints must be established before that. Similarly, detailed logistical decision-making must occur as excavation and laboratory studies proceed, and the pollen analyst cannot delay their implementation.

In the case of Los Hornos, logistical parameters set before the samples were collected which constrained the character of the pollen study were those of funding, extent and timing. A certain amount of money had been budgeted for pollen work, and more was not available. A schedule had been established which required the preliminary report of the results of the pollen study to be initiated .

before all of the potentially available sediment samples had been collected and before the results of laboratory studies of the archaeological materials associated with the sediment samples were even well underway.

Schedule and budget constraints dictated two detailed logistical parameters. Assuming that approximately 20 percent of the sediment samples would provide insufficient pollen for analysis--an assumption justified by the prior experience of Gish (1978a, 1979a), Smith (197[illegible]), Borher (1970, 1977) Schoenwetter and Batchelder (19[illegible]) and Schoenwetter (1977) at Hohokam locations--and assuming that patterns of palynological data would be adequately evidenced by simple univariate statistical tests or inspection, the research could involve analysis of no more than 100 samples. The realistic probability was that 60-80 samples would be actually analyzed and reported upon. Further, research design would be limited by the quality and character of the archaeological information available at the time the pollen study was initiated. Essentially, we could only recognize problems of importance in prehistory on the basis of patterns of archaeological evidence available at the time the decision was made on which sediment samples would be selected for analysis. Formal analysis of the spatial and stratigraphic relationships of archaeological features could not be accomplished before sample selection was scheduled. Other significant patterns (e.g. the ceramically evidenced chronological relationships of features and deposits, or the functional interpretations of features evidenced through assessment of associated artifact assembleges and morphology) had to be approximated from the evidence of field observations.

The research strategy adopted, then, had to be geared as much to the realities of what could be accomplished as it was geared to the nature of problems that might be addressed. It was necessary to establish a standardized field strategy likely to provide sediment samples for a variety of possible subsequent concerns before the stratigraphy, sedimentology or character and variety of cultural features encountered were known. It was necessary to make judgements of sample selection at a time that was not most appropriate for problem formulation. It was also necessary to choose between a research strategy which would maximize the number of samples to be investigated or one which would maximize the number of pollen observations made per productive sample. The former strategy would provide opportunity to investigate a wider variety of problems. The latter would provide a more credible basis for statistical analysis and would be required if multivariate statistical operations were necessary. In addition, it was necessary to choose amongst problems important to the prehistory of Hohokam culture as a general phenomenon of the Salt and Gila River Basins, problems important to the prehistory of Hohokam culture as expressed at the site of Los Hornos, and problems important to prehistory which dealt with the methodological significance of archaeological pollen analysis.

The research strategy adopted was constructed in a series of phases:

sample collection, sample selection, and analysis. The activities performed in each phase were designed to be related to the situation confronted, rather than to an abstract standard, to provide as much flexibility as possible within pre-established logistical constraints. In retrospect, the successes of the strategy devolve from its explicitness of objective and its flexibility. It's failures devolve from inaccurate assessments of the situation actually confronted.

The sample collection phase of the strategy recognized the value of recovering many more sediment samples as excavation proceeded than could possibly be analyzed in this project. Broadly speaking, prior study of Hohokam sites indicated that the excavators were likely to observe only three sedimentological units (calichified colluvium, undifferentiated colluvium and plow-disturbed colluvium), cultural features of relatively small size and a variety of functions (pits, graves, cremation, middens), sub-monumental constructions (barrow pits, hornos, trash mounds, houses) and, possibly, monumental constructions (pueblos, canals, platform mounds, ball courts). Sample collection would emphasize recovery of sediments of different proveniences that were likely to contain dissimilar pollen spectra as a function of temporal, cultural or spatial variance. The most intensively sampled deposits would be those for which the most elaborate and thorough field records would be available: the deposits of cultural features. A secondary emphasis was placed on sampling deposits from single proveniences that offered prospect of providing a controlled temporal sequence of pollen spectra variation. Traditionally, pollen profiles are collected from stratigraphic sections for this purpose. The field situation at Los Hornos exposed many such sections but offered few opportunities for collection of profiles in which the temporal order of the samples could be independently controlled. Samples collected from the stratigraphically superimposed units of trash-filled pits and hornos, which could be independently controlled by both superposition and associated temporally diagnostic ceramic types and styles, were therefore collected more frequently than profile sections. This phase of the research strategy was implemented by the principle investigator through instruction of the crew supervisors and excavators. Certainly, some sample collection opportunities , ignored and obviated by inexperience would not have occurred if an experienced palynologist had been continuously available during excavation. But samples were collected, in addition to the sediment samples that had been collected during earlier studies at Los Hornos (Francis and Coulam 1978, Large in prep.) To my knowledge, Los Hornos is the most intensively sampled Hohokam site ever excavated.

The second phase of the research strategy was initiated after the bulk of excavation had been completed. A listing of the samples then available was prepared, organized by the presumed cultural or sedimentological character of provenience (e.g. house floor deposits, trash-filled pit stratum, horno fill stratum). Review of the kinds of samples by myself and the principle investigator led to recognition of four potentially resolvable research problems they might address, and the priority each problem should be accorded in relation to its importance in prehistory.

Those samples that could be used to address the problem of temporally ordered climatic or ecological change were given highest research priority. Profile sample series that had been recovered from the natural infill of a large barrow pit and from the ball court were selected for this purpose.

Samples which could address the question of the relationship between palynological and macrofossil botanical evidence of plant resource utilization at Los Hornos were given second research priority. A group of pollen samples collected in direct association with flotation sam

a group of pollen samples directly associated with flotation samples of strata of trash-filled pits.

Samples that could provide information on the patterns of relationship between pollen record and features of distinctive function were given third priority. A group of samples from the floors of architectural features and the basal strata of trash filled pits were selected for comparison with the pollen records of the horno strata for this purpose.

An additional suite of samples of trash strata was selected to address the lowest priority concern: what, if any, cultural or biological inferences might be evidenced by patterns of palynological records occurring in the most abundant (and most thoroughly sampled) form of cultural deposit at Los Hornos.

The problem focus given the lowest priority was that which most strictly was significant to our comprehension of the prehistory of the Los Hornos site, while the successively higher priority problems were those successively more relevant to significant comprehension of the prehistory of the Hohokam and other ancient residents of the Sonoran Desert region. The highest priority research problem also attains significance because one of the more hotly debated questions of paleoclimatic study is the potential of site context pollen records to provide relative or absolute dates to associated artifactual assembleges. Smith (1979), Schoenwetter and Batchelder (1970) and Schoenwetter (1977, 1979a) have argued that pollen sequences can be established for Salt and Gila River Basin archaeological context deposits, and the resulting relative chronologies can provide absolute temporal control through correlation with the Colorado Plateau Pollen Chronology (Schoenwetter 1970). Berher (1970, 1977) and Gish (1979b) have argued just as forcefully that the apparent pollen sequences are not temporally, but behaviorally, controlled.

One effect of a selection of this broad a range of problems for investigation was that it offered potential to produce a data base applicable to the resolution of other research problems than had been originally defined. This struck us as consistent with the philosophy and purpose underlying mitigation studies. Even

Even if that potential turned out not to be realizable, the prospect that it might influenced our decision to risk dealing with several problems superficially rather than one problem in greater detail. It will also be noted that the research problems which deal with feature functions are approachable through other forms of study than pollen analysis. In those cases, pollen study would provide one of a number of independent bases for ultimate interpretation.

The analytic phase of the research strategy was staged to allow opportunity to assess the potential of the pollen record to address the problems within the constraints imposed, and also allow us to modify or re-evaluate the problems themselves if this seemed judicious. In the first stage of analysis, 20 of the 40 highest priority pollen extracts were given cursory microscopic examination to determine if an adequate number contained sufficient pollen for analysis. Since they did, the next step of work was the extraction of pollen from the group of 40 second priority samples.

The next work stage involved microscopic examination, with attendent identification and tabulation, of the pollen to be found on a 20% sample of the rows of the cover slip of a preparation of each of the 80 priority pollen extracts. The work effort expended on each sample was timed, and the results obtained from samples of similar and dissimilar spatial and stratigraphic positions were compared by simple statistical tests. This allowed us to establish projections of (a) the amount of time which would be required to complete the identification and tabulation procedure to any specificable standard for any given sample; (b) the probable range and variety of patterns of palynological information identifiable from simple inspection and statistical tests; and (c) the number of pollen records that could be generated within the time constraints set upon laboratory

These projections justified the acceptance of certain counting and identification standards on logistical grounds. They also justified continuing into a subsequent work stage in which fresh preparations of all samples evidencing a sufficient number of pollen grains were examined until a particular numerical standard was reached.

The pollen extraction procedure employed by this laboratory (Schoenwetter 1979b) is the same as that Gish has employed at other Hohokam sites (Gish 1978a, 1979a) and Rankin has employed at Sonoran Desert sites in northern Mexico (Rankin 1980). It is not distinct in any major way from the procedures employed successfully by Smith (1972), Da Costa (1976) or Borher (1970, 1977), as all are based upon the procedure established by Mehringer (1967). The identification - classification scheme utilized follows standards set in a variety of earlier works (Martin 1963, Hevly _et al_ 1965, Gish 1975, Schoenwetter and Doerschlag 1971, Schoenwetter 1977). The singular exception is adoption of the more botanically appropriate epithet "Chenopodinneae" for the pollen taxon which is more commonly called "Cheno-am", "Chenopodiaceae," or "chenopod". For logistical reasons, we adopted a system of observing either 100 or 200 pollen grains in order to establish a pollen sum for percentage and ratio calculations. The decision to observe 100 instead of 200 grains was made in cases where the latter demanded a significantly larger number of hours of microscopy than the projected mean time for the average sample. Our projections of the character of palynological data patterns suggested they would be better indicated by statistical tests performed independently on pollen frequencies and pollen ratios. We therefore followed the lead of certain workers (Schoenwetter and Batchelder 1970; Schoenwetter 1977, 1979a; Rankin 1977, 1980; Smith 1974), rather than others (Gish 1978a, 1978b, 1979a; Hill and Hevly 1968; Lytle-Webb
in establishing a pollen sum which excludes cultivar (_Zea_, _Cucurbita_) and insect pollinated taxa (_Sphaeralcea_, Nyctaginaceae, Cylindropuntia) occurring in abnormally high frequencies or in an abnormally high number of samples.

Tabulations of the actual number of each pollen type observed have been provided (Appendix I) to allow recalculation of pollen statistics according to other standards.

CONVENTIONS OF THE ANALYSIS

In this report certain conventions of traditional pollen analysis are retained, others are abjured, and some untraditional conventions are employed. The report retains the traditional usage of scientific names for pollen types, for example, despite recognition that common names are more familiar to most readers. On the other hand, the report displays the results of analysis in the form of tables rather than the traditional diagrams. Both of these conventions were adopted for the sake of precise reportage, with the intent of conveying the maximum amount of information possible to those who can use it in a professional manner. ~~The reader who is annoyed by the fact that he cannot translate the taxonomic category "Liguliflorae" into a common referent, or is distressed by the fact that data tables present a less immediately obvious display of pollen spectrum variability than diagrams might do, is in no position to make judgments about the relationships of these palynological data to the~~ [redacted] ~~this report~~. Appreciation of the botanical and ecological phenomena expressed by palynological data categories and data displays evolves through familiarization and expertise, not from general and common knowledge. If the conventions used here hinder naive judgment they will serve an intended function.

The principle data tables of the report present two kinds of non-taxonomic palynological information: pollen frequency values and pollen ratio values. To avoid misplaced concreteness, frequencies have been rounded to the nearest tenth of one percent, and the ratios rounded to the nearest hundredth. Both the frequency and the ratio values are calculated upon the pollen sum for that sample (N) rather than upon the sum of total pollen observed. Given a sum of 200 pollen grains, then, observation of two pollen grains of Zea would result in a ratio value of .01, but observation of a single Zea grain would result in the same tabular value. Alternatively, given a sum of 225 pollen grains, observation of one Zea grain would result in a tabular value of zero and observation of three such grains would result in a tabular value of .01. The data displays produced by the conventions adopted tend, on the whole, to de-emphasize the potential significance of rare observations. But this is only specifically true in those cases where N is greater than 222.

One of the traditional conventions used in the report is use of the binomial confidence interval to measure statistically significant similarities and differences. Faegri and Iverson (1975: 187-190) argue the effectiveness of this measure for univariate analyses, and it is generally a sound way to first address the sort of data base accumulated here. There is no doubt in my own mind that multivariate analyses of the Los Hornos pollen record would have proved more productive than any univariate procedure. There literally was no opportunity to implement it in the present situation, however.

THE TRASH DEPOSIT RECORD

Field diagnosis of a deposit as "trash" (a term often utilized interchangeably with the term "midden") is usually based on context, color, texture, artifact density and the modal size of the artifactual materials it contains. Trash is one of the normative categories archaeologists use in describing the types of artifactually rich deposits they encounter; others of this order are "fill", "roof fall" and "floor contact" deposits. At Hohokam sites such as Los Hornos, trash is normally recognized in one of three contexts: as infill deposits of aboriginal excavations, as mounded deposits established on an oboriginal surface, or as sheet deposits parallel to an apparent or presumed aboriginal surface. Deposits having the same character but observed in other contexts, such as the infill of architectural features, are usually provided with a modifier, e.g. "trash fill".

Trash is normally first recognized by its darker color - the result of a higher concentration of powdered or crushed charcoal and organic decomposition products. Many trash deposits have a decidedly different texture than surrounding deposits; trash is usually more friable, coarser or ashy. Diagnosis of a deposit as trash, however, normally rests most fully on its relatively high artifact content per unit volume and the tendency of the artifactual material encountered to involve a high proportion of small fragment remains, often burnt, showing indications of aboriginal breakage.

As its name implies, this form of deposit is considered to represent materials discarded in prehistoric times in fashions analogous to the disposal practices of ethnographic cultures. Presumably, trash-filled pits represent the disposal of waste materials resulting from a potentially wide variety of domestic, manufacturing and other behavioral patterns. The stratigraphy of trash filled pits at Los Hornos is in many cases physically variable, and thus divisible through field observation into successive "natural" strata. Abbot and Lindauer (this volume) argue the credibility of analytic mechanisms for determining stratigraphically superimposed behavioral units in trash-filled pit deposits, as well. These may or may not be congruent with ostensible natural strata of deposition.

Given this situation, one anticipates that sediment samples of trash-filled pits should represent a variety of spatially and behaviorally disjunct depositional episodes ranging over a series of temporal intervals. The pollen records such samples contain could expectably vary as a reflection of the variety of cultural activities responsible for the oeneration of disposed wastes; the varying locations in which such activities were undertaken (presuming disposal was more often localized than dispersed); variation through time in both the character of cultural activities and waste disposal patterns; variation in space and time of the numbers and distributions of plants contributing pollen to the record in ways not directly influenced by behavioral patterns; and the potential of different pollen types to be differentially preserved under varying geochemical and geophysical conditions.

The pollen samples from trash-filled pit features 218, 430A, 485, 75 and 99 (levels 12-14) were collected from segregate depositional episode units. In four of the five pits these were the three lowermost sampled depositional strata. In the case of Feature 75 the two lowermost strata are involved. The decision to constrain sample selection to lowermost strata was made in an attempt to provide maximal comparability in the analysis. To control for variability in the pollen record that might result from spatial factors affecting vegetation, three of the pit features were selected from the northern portion of the area of Los Hornos excavated in 1979 and two were selected from the southern area.

Three trash deposit samples from Feature 16 were also studied, but they have not been taken into consideration in this report since assessment of field records subsequent to the pollen study indicates that they probably derive from mixed depositional episodes. Other trash deposit samples which provided data are labelled Feature 99 level 7SE and level 7SW in Appendix I. When these samples were selected for analysis it was thought they were replicate samples of a younger depositional episode in Feature 99. Later evaluation indicates 7SE is more likely to be a sheet trash deposit superimposed on Feature 99 and 7SW a trash deposit overlying a horno feature.

Intra-pit Variability

Considering the potential for variability in intra-pit pollen records induced by distinctive behaviors responsible for the production and disposal of trash, the data of Table I is surprisingly uniform. In any given pit, the pollen

	Depositional Level	Pinus	Juniperus	Quercus	cf. Agave	Sarcobatus	cf. Yucca	Ephedra-m	Cercidium	Papilionoide	Olneya	Prosopis	Larrea	Chenopodineae	Artemisia	Liguliflorae	Ambrosieae	Tubuliflorae	Gramineae
F.218 Sacaton	17		1.0							1.0				50.9			6.9	10.8	17.6
	18	0.5					1.0							58.0			9.0	15.5	13.0
	19													59.4			5.0	14.3	16.8
F.485 Sacaton	21	0.5							0.5					50.7			15.8	14.3	12.8
	22	2.9					2.9							48.1			14.4	13.5	12.5
	23	1.0					1.0			0.5				60.5			5.9	7.8	18.5
F.430A Early Sacaton	13	2.4					0.5			1.4				65.9			12.8	4.3	9.0
	14	1.0					0.5			1.9				60.7			14.1	5.8	14.6
	15	0.5					0.5			0.5		1.0		58.1			9.1	9.1	19.2
F.99 Colonial	12	0.5		1.0						1.0				50.7			11.4	19.4	13.9
	13	0.5		.5						0.5				58.2			16.4	9.4	10.9
	14	1.8												62.8			5.3	15.2	10.6
F.75 Colonial	22			4.5						1.0		0.5		45.3			10.4	27.4	14.4
	23													49.0			10.3	22.1	16.2

	Depositional Level	cf. Tidestromia	Onagraceae	cf. Kallstroemia	Plantago	cf. Cactaceae	Platyopuntia	Polygonum	Salix	Cyperaceae	Unknowns	N	Zea	Cylindropuntia	Nyctaginaceae	Sphaeralcea	Cucurbita
F.218 Sacaton	17							1.0			4.9	102	.02	.01	.02	.08	.01
	18										3.0	200	.01	.02	.08	.06	.01
	19			1.0							3.0	101		.01	.06	.15	
F.485 Sacaton	21				0.5						4.9	203	.02	.04	.03	.12	
	22		1.0						1.0		2.9	104	.01	.01	.01		
	23										4.9	205	.01	.01	.02	.12	.01
F.430A Early Sacaton	13		0.5								3.3	211					
	14										1.5	206	.01				
	15										2.0	198	.02	.02	.02	.04	
F.99 Colonial	12	0.5		0.5							1.0	201	.03	.16	.02	.02	
	13		0.5	0.5							2.5	201	.02	.08	.08	.02	
	14		1.8								3.5	113	.04	.04	.04	.01	
F.75 Colonial	22	0.5	1.0								0.5	201	.01	.01	.05	.01	
	23										1.0	204	.02	.05	.07	.02	.01

Table I. Trash-filled pit pollen records. Pollen frequency values (left) and ratios to the pollen sum (right).

frequency values are dominated--and to some degree mathematically constrained--by high values for Chenopodinneae pollen. In none of the five pits, however, do significant differences from the mean [illegible] The other three prominent taxa in the pollen frequency record--Ambrosieae, Tubuliflorae and Gramineae--are nearly as non-variant. There is no case in which values for either Tubuliflorae or Gramineae pollen depart significantly from the mean value for the pit as a whole. In one case Abrosieae values vary significantly from the mean in one of the three samples. Given the overall record, however, there seems little reason to suspect this is a result of the effect of patterned human behavior rather than chance.

Five pollen taxa (Zea, Cucurbita, Cylindropuntia, Nyctaginaceae and Sphaeralcea) were excluded from the pollen sum for one of more of three reasons. Two (Zea and Cucurbita) are probable cultigens in this context. One (Cylindropuntia) is a significant ethnographic food resource of the area which is processed for human consumption in a fashion (Greenhouse 1979) likely to result in the dispersal of quantities of its pollen in kitchen and latrine waste. Four (Cylindropuntia, Cucurbita, Nyctaginaceae, Sphaeralcea) are produced by zoophilous (generally insect-pollinated) plants. Since zoophilous pollen is not well adapted to wind transport, these pollen types would be expected to be rare or sporadic in sediment samples under conditions unaffected by human behavior or extraordinary ecological relationships. A pattern of consistant occurrence of these pollen types in archaeological deposits in the Sonoran Desert region, however, occurs in marked contrast to a pattern of their inconsistent occurrence in surface sediment samples. This is traditionally interpreted (viz. Lytle 1971, Gish 1978a) as an effect of patterned human behavior on the pollen record of archaeological context samples, reflecting one or more forms of human activity or cultural ecological relationships. If patterned human behavior is represented palynologically in these pollen counts, it is most expectably represented by variations in the ratio values of these taxa. At very least, one would anticipate that variability in pollen ratios would occur within all pits as a result of distinctions in the wastes disposed of in different periods.

It is therefore intriguing to report that this expectation is not fulfilled by the record. There is no case of a pit in which any set of values for these taxa varies significantly from the mean values for the pit in any patterned fashion. There are two cases (F.430A and F.99) in which one taxon (Sphaeralcea and Cylindropuntia, respectively) yields a value significantly different from the mean values for the pit in one sample. It is difficult to interpret these results as other than the effect of chance when the overall record is considered, however, since the expectation is that variance in human activity referent to any of these taxa would result in much more variability than is expressed.

One explanation for the lack of expected results lies in the character of the test employed to identify statistically significant variability in the data. The confidence interval test is recognized as highly appropriate for pollen frequency and pollen ratio evaluation by both pollen analysts (Faegri and Iverson 1975) and statisticians (Mosimann 1965). But this is in part due to the fact that the test requires no assumptions regarding characteristic patterns of pollen dispersal, production or preservation. It is thus a conservative test, capable of documenting the occurrence of variation only in situations where arguments concerning the relevance of the biology of pollination and the geophysics of pollen preservation are dismissed *a priori*. Pollen analysts normally prefer this conservative test because empirical evidence pertinent to the biological and geophysical issues is limited and subject to varying interpretation. Thus where the confidence interval test documents variance in the record which is unlikely to be an effect of chance, interpretation of the variability is thought to be on firm ground. Here, however,

Feature	Level	Chenopod-ineae	Ambros-ieae	Tubuli-florae	Zea	Nyctag.	N
218	17	4			1		115
	18	3	1				223
	19						123
485	21	1					225
	22						107
	23	1					215
430A	13						211
	14	3					207
	15	4	1				225
99							
	12	6	1	1		3	255
	13	11	2			3	236
	14	5	1			2	126
75	22	7		1			216
	23	5	1			2	236

Table II. Observed pollen aggregates of trash-filled pit samples.

	Chenopodinneae	Ambrosieae	Tubuliflorae	Gramineae	Unknowns	N	Zea	Cylindropuntia	Nyctaginaceae	Sphaeralcea	Cucurbita	
Population Mean	56.2	10.5	13.5	14.3	2.8	2,450	.02	.03	.03	.03	.00	
F.218	58.8	6.9	13.7	15.9	3.6	403	.01	.01	.03	.10	.01	
F.485	53.1	12.0	11.9	14.5	4.2	512	.01	.01	.02	.01	.00	
F.430A	61.5	12.0	6.4	14.3	2.3	615	.04	.01	.00	.01	.00	IIIA
F.99	57.2	11.0	14.3	11.8	2.3	515	.03	.09	.06	.02	.00	
F.75	47.1	10.4	24.8	15.3	1.8	405	.02	.03	.07	.02	.01	
Northern Features	57.4	9.4	17.6	14.3	2.6	1,323	.02	.04	.05	.05	.01	IIIB
Southern Features	57.4	12.0	9.2	14.5	3.3	1,127	.03	.01	.01	.01	.00	
Sedentary Features	56.0	9.5	12.8	15.3	3.9	915	.01	.01	.02	.05	.00	
Early Sedentary Feature	61.6	12.0	6.4	14.3	2.3	615	.04	.01	.00	.01	.00	IIIC
Colonial Features	52.1	10.7	19.6	13.6	2.1	920	.02	.06	.06	.02	.00	

the conservative character of the test may be misapplied, since there is every reason to suspect that ratios for these taxa may be particularly influenced by human activities affecting pollen dispersal and preservation.

Gish (1979a) has argued that, in samples of archaeological context, data exists which specifically addresses the question of human influences on pollen dispersal. Anemophilous (wind-pollinated) taxa are adapted to maximize the chances of cross-pollination by dispersal of individual pollen grains. Gish argues that the occurrence of aggregates of pollen grains of such taxa in an archaeological sample should be recognized as the result of one of two responses by plants to the occupation of the area by human beings. On the one hand, the occurrence of pollen aggregates may reflect the artificial establishment of a habitat to which such taxa are so well adapted that extraordinary quantities of their pollen is locally produced. On the other hand, it may reflect human behaviors (e.g. seed collection or processing) which would affect the dispersal of such pollen. Both phenomena, of course, could act interactively to effect such a result at any given time. Pollen aggregates (defined in this study as clumps of 4 or more grains of the same taxon) observed during the course of the pollen counts were recorded and are tabulated on Table II. Since these data apparently directly address the issue of the influence of human behavior, use of the confidence interval test to assess variation from the mean frequency value of a taxon seems appropriate and its conservative character seems useful. When the test is applied, however, intra-pit variability is not evidenced.

Overall, three potential palynological indices of intra-pit variability induced by human behavior were assessed: pollen frequencies, pollen ratios and number of pollen aggregates. Though we began with the expectation that such variability would be the rule, and significant variability was identified in both pollen frequency and pollen ratio values, the data do not provide clear support for the hypothesis that human behavior significantly affected the pollen records of trash-filled pit deposits at Los Hornos. All the variability observed could be an effect of chance upon a normally distributed population of pollen grains. Part of the problem of lack of correspondence between expected and achieved results could be a function of the small numbers of samples per pit and the small numbers of cases which could be studied. This can only be resolved by further research, but a statistically conclusive study would require a large number of samples from each pit and would not rule out the effects of chance unless a statistically large number of such pits were examined. The opportunities for pollen sampling provided by the field situation at Los Hornos would not allow such an investigation to be made. In any case, it would seem more cost-effective to address the issue through multivariate analysis of the existing data, supplemented by 3-5 sample records from another 10-20 such pits. Multivariate analyses of variance are more likely to prove productive in confirming or disconfirming the hypothsis in question because they would limit the mathematical constraint imposed by the preponderence of Chenopodinneae pollen in the record. This constraint could also be limited through larger pollen counts per sample (on the order of 10000 observed grains), but it seems a more expensive an inefficient procedure.

Inter-Pit Variability

The simplest way inter-pit variability can be assessed through the statistical test employed here is by comparison of the mean pollen record values of any given pit against the mean values for the population of pits. Since the test is conservative, statistically identifiable variability is likely to be meaningful. Because the number of pollen observations from any one of the pits is large (N 400), the statistical adequacy of the camparisons is not an issue. However, the number of pits analyzed is small; at best, the data of one pit can only be compared against the data of four others. If the population of five pits is divided into sub-populations, comparisons may be made between the grouped data of two pits against the grouped data of only one, two or three others. There is, therefore, a statistically real prospect that the comparison made does not in fact characterize the situation for the true populations compared.

For example, three of the sampled trash-filled pits were from the northern part of the site and two were from the southern. The northern pits yielded 1,323 pollen observations and the soulthern yielded 1,127 pollen observations. Given data bases of this size, statistically significant contrasts in the frequency values for a given pollen taxon are not likely to be an effect of chance. Whether or not the two samples available for the northern population adequately characterize that population, however, is not known. They might do so, but it would be far preferable to have thirty or more such samples to engender confidence that the total range of variability in the population of pollen frequency values from the northerly pits is expressed in the data base. Thus the inferences regarding patterns of inter-pit variability in pollen record that can be presently drawn must be recognized as inconclusive. They must be based upon the assumption that the number of samples available to represent a population adequately characterizes the population from which they are drawn.

This assumption is not statistically justified, but a statistically adequate number of pollen samples of any particular population is rarely available. In a lacustrine pollen profile, for example, the number of samples representing a given pollen zone will usually be small, and such zones are often identified on the basis of two or three samples. The operant assumption is that the number of observations is sufficiently large that the statistical error imposed by small sample numbers does not affect the establishment of inferences. The theory of pollen analysis accommodates this assumption, since it is based on the proposition that the pollen of any given sample is likely to be a random selection of pollen grains drawn from a massive population of pollen rain.

The mean pollen frequency values and mean pollen ratio values for the population of trash filled pit samples and for individual pits are presented in Table IIIA. Mean values which are not significantly greater than 0.0 percent have been excluded.

Significant variance from the population mean is evident for the Chenopodinneae frequency value in Feature 75, and the Tubuliflorae value in Features 430A and 75. The variance in Tubuliflorae value in Feature 75, however, is probably a function of reduced constraint consequent upon the lower Chenopodiineae value and thus irrelevant to interpretation. Though the variations observed are statistically real, they could be a result of chance. Significant variation from the mean population pollen ratio values is evident for Sphaeralcea in Feature 218, Cylindropuntia in Feature 99 and for Nyctaginaceae in Features 99 and 75. Though the first two could be an effect of chance, the third is less likely to be since the variance is not only replicated but in the same (positive) direction.

When the mean values of the northerly features (218, 99 and 75) are contrasted against those of the southerly features (430A and 485) a slightly different picture emerges (Table IIIB). The significant differences in Tubuliflorae frequency, and in Cylndropuntia, Nyctaginaceae and Sphaeralcea ratios are uniformly higher in the northerly features. The increased Tubuliflorae frequency value, however, seems likely to be a function of the release of constraint in the samples of feature 75 occasioned by a reduced Chenopodinneae frequency value.

When the mean values for different time horizons are contrasted (Table IIIC), the only significant variance in frequency values which is observed (low mean Tubuliflorae value for early Sedentary) may be an effect of chance. Two of the three significant differences which occur in the ratio values (Cylindropuntia and

Nyctaginaceae) are referent the Colonial Period; the third (*Sphaeralcea*) is referent to the Sedentary period.

Pollen aggregate numbers for Chenopodinneae and Nyctaginaceae are significantly greater than the population means (4.2 and 0.7., respectively) in features 99 and 75 (Table II). Since both of these features come from the same area and the same time period, significantly positive Chenopodinneae and Nyctaginaceae aggregate values are thus evidenced for the northerly and the Colonial Period features.

A different index of inter-pit variation, which also can be controlled spatially and temporally, is the constancy of occurrence (ubiquity) of pollen types which are found in frequencies or ratios not significantly larger than 0.0. An example in this data set (Table I) is the ubiquity of *Yucca* pollen, which is observed in 50% of the Sedentary Period samples, 100% of the early Sedentary Period samples and none of the Colonial Period samples. Significant variability in ubiquity values can be recognized for *Quercus*, *Yucca*, Onagraceae and *Cucurbita* pollen. The ubiquity value for *Cucurbita* pollen is patterned spatially with positive values in the northern district. Significantly positive ubiquity values for the other pollen types are patterned temporally. *Quercus* and Onagraceae pollen are both more ubiquitous in Colonial Period trash and *Yucca* pollen is more ubiquitous in Sedentary Period trash.

Statistically significant inter-pit variation from the population mean which is not likely to be an effect of chance is thus observed in the Nyctaginaceae ratio, the number of Nyctaginaceae aggregates and the number of Chenopodinneae aggregates. This form of inter-pit variability is the type which is most likely to reflect meaningful relationships, so it is of some moment that neither pollen aggregates nor large numbers of zoophilous pollen types can be easily explained as natural consequences of known processes of pollen production, pollen dispersal or pollen preservation. The inference drawn is that the variations observed are consequences of the effect of behavioral practices upon the pollen rain of the Los Hornos site.

Statistically significant inter-pit variation which is not likely to be an effect of chance and is spatially ordered must be considered in light of similar variations which may be temporally ordered, since both the natural and the behavioral conditions which might account for such variability occur in time as well as space. Also, simultaneous consideration of the available evidence in spatial and temporal terms partly compensates for the small numbers of samples in any given temporal or spatial category.

The only significant variability in inter-pit pollen records which seems uniquely spatially ordered is that observed in the ubiquity value for Cucurbita pollen. For this data set, it seems that regular disposal of pollen of this genus was limited to the northern portion of the site. Of equal interest, perhaps, is that there is no uniquely spatially ordered significant variation in the records of pollen types which might indicate habitat disturbance or the more proximate occurrence of larger quantities of certain plant taxa. The inference to be drawn from such negative evidence is that tne trash-filled pits sampled were not located relatively nearer or farther from particular kinds of habitats and ecological niches. Decisions about what kinds of trash should be disposed of in particular districts of the site, at least, seem to have been little influenced by the natural environment characteristics of those locations.

Significant variation unlikely to be due to chance which is uniquely patterned temporally is evidenced in the ubiquity values for Yucca, Quercus and Onagraceae pollen. Both Yucca and Quercus pollen records at the site are likely to represent long distance transport, but the former derives from zoophilous and the latter from anaemophilous pollen producers. Plants which yield pollen referable to Yucca include Dasylirion and Nolina as well as Yucca. All are ethnographically utilized as fiber resources, or for raw materials for basketry, and some species of Yucca yield edible fruit. It seems not unlikely that the ubiquity of Yucca pollen in Sedentary Period records documents some processes of resource extraction that occurred more consistantly at that time.

The curious thing about the probable long distance transport of Quercus pollen is not that it seems to have occurred during the Colonial Period, but that it is not evidenced to have occurred at all during the Sedentary Period. Surface sample pollen records from Sonoran Desert Scrub locations almost invariably contain Quercus pollen, which indicates that natural processes of pollen dispersal and preservation are not likely to account for its lack in these fossil records. The lack of Quercus pollen in Sedentary Period records seems to me most likely a function of the over-representation of one or more other pollen types, with consequent constraint. Given the context of deposition, it seems probable that the over-representation involved is behaviorally induced. The obvious candidate for the over-representated taxon is Chenopodineae pollen, since it dominates the pollen record of the Sedentary Period samples to a somewhat greater degree than those of the Colonial Period. The pollen aggregates data, (which is theoretically the best index of local over-representation available), however, indicates that Chenopodinneae pollen is more likely to be over-represented in the Colonial Period record. Thus the obvious candidate is not necessarily the best one, and it seems likely that a multivariate analysis of a larger number of samples of each temporal period will be required to identify the Sedentary Period pollen taxa which are over-represented.

The ubiquity value for Onagraceae pollen in the Colonial Period records is significantly higher than the Sedentary Period records (3/5 vs. 2/9), but may not be meaningful. Gish (1978a: 164) discusses the possibility that

Onagraceae pollen aggregates in trash filled pit deposits may reflect use of the roots of certain species for food. The variation observed seems more likely to be behaviorally than naturally induced, since Onagraceae pollen producers are zoophilous. The issue here is whether the behavior involved is or is not as temporally patterned as this data set indicates.

Significant inter-pit variation which may be spatially patterned, temporally patterned or both spatially and temporally patterned is evidenced in the ratio values for Sphaeralcea, Cylindropuntia and Nyctaginaceae, and also in the pollen aggregate numbers of Chenopodinneae and Nyctaginaceae. All of these taxa are potential food resource taxa, though the case for Nyctaginceae is admittedly weak since it is not supported by regional ethnographic analogs (see Borher 1977:27). It seems unlikely that there would be segregate explanations for the variation which occurs in these taxa, or that their variation would be differentially patterned in regard to both time and space. They seem to be likely to reflect a single complex pattern of subsistance-related behaviors oriented towards the utilization of wild food resources. Since the pollen aggregates variability seems to relate to the Colonial Period record, my feeling is that there is somewhat more reason to infer that if such a complex behavior pattern existed at all, it was more prevalent during the Colonial than the Sedentary occupations.

Summary

Both intra- and inter-pit variability in the pollen records of trash-filled pit deposits was expected as a result of variation in the human activities which could affect the production and disposal of such sediments. From an archaeological perspective, it would not have been surprising if each sample or each pit produced a wholly distinctive pollen record. Nor would it have been surprising if each sample or each pit had produced pollen records which were strongly patterned in respect to spatial or temporal variables. These expectations are not supported by the data. Three independent measures of intra-pit variability and four independent measures of inter-pit variability document the general conclusion that the pollen records of trash deposits at Los Hornos are far more homogeneous than they are variable.

Statistically significant intra-pit variation does exist in the pollen record, but that observed can be accounted for as effects of chance. Statistically significant variations occur more frequently when the pollen records of different pits are compared, and most inter-pit variability cannot be easily accounted for as effects of chance. In those cases, however, none is easily explained as a function of natural processes of pollen production and dispersal, either. The best explanation of the observed variations is that they have been effected by human behavior patterns oriented towards the utilization and disposal of cultivated and wild plant resources.

The statistically significant variations evidenced in the inter-pit comparisons occurs in pollen ratios, numbers of pollen aggregates and pollen ubiquity values. Most of the variation centers on five pollen taxa: Chenopodinneae, Nyctaginaceae, Cylindropuntia, _Sphaeralcea_ and _Yucca_. All are apparent food resource taxa. The character and distribution of the variations observed for these taxa may be explained as the result of more systematic disposal of food waste products of Chenopodinneae, Nyctaginceae and Cylindropuntia pollen producers during the Colonial Period, and more systematic disposal of food waste products of _Sphaeralcea_ and _Yucca_ pollen producers during the suceeding Sedentary Period.

Statistically significant variations in the ubiquity values for _Cucurbita_, Onagraceae and _Quercus_ pollen also occur. The disposal of _Cucurbita_ pollen in the trash of trash filled pits seems to have been spatially controlled, and limited to the northern portion of the studied districts of Los Hornos. Disposal of Onagraceae pollen is more consistantly a feature of Colonial Period records than of Sedentary Period records. The observed variability in the ubiquity of Quercus pollen in trash deposits indicates that over-representation of pollen of local plants is greater during the Sedentary than the Colonial Period. The apparent reduction in systematic disposal of food wastes of Chenopodinneae, Nytaginaceae, Cylindropuntia, Sphaeralcea and Yucca in Sedentary contexts may similarly be an effect of local pollen over-representation at that time. However, the most accurate available monitor of local over-representation (pollen aggregate numbers) indicates that the pollen taxon which dominates the Sedentary Period record (Chenopodinneae) is not solely responsible for this effect.

Pollen studies of trash deposits at other Hohokam sites have produced results similar to those from Los Hornos. They have tended to reveal little palynological variability and they have been dominated by high frequency values for Chenopodinneae pollen. One of the explanations which has been offered (Lytle 1970) is that trash provides a substrate for plant growth and reproduction (and therefore pollination) to which Chenopodinneae pollen producers are particulary well adapted. Another explanation (Bohrer 1970) has been that these characteristics of trash deposit records are case examples of a general pattern of uniformity in pollen records found in Hohokam context sediment samples. In light of the Los Hornos data, both explanations seem facile. Given an adequate data base, statistically significant variability in the pollen records of trash can be identified which is not likely to be an effect of chance. Variability is not common, but it exists and it seems to be patterned. Further, while it is true that the pollen record of such deposits is heavily influenced by Chenopodinneae pollen, the evidence from Los Hornos is not consistant with the inference that this occurs because Chenopodinneae pollen producers are better adapted to the specialized habitats of trash substrates or archaeological sites. If this were the case Chenopodinneae aggregate numbers should be of the same orders of magnitude in all such samples or should be recovered in numbers proportional to the Chenopodinneae frequency values of individual samples or populations of samples. That is not the situation observed.

MICROFOSSIL - MACROFOSSIL RELATIONSHIPS

The hornos for which the site is named yield quantities of charred vegetal remains indicative of a variety of behavioral patterns (Le Pere, this volume). The pollen of such contexts could have been incorporated by either natural or behavioral mechanisms, but if patterned relationships exist between the two data sets it seems likely such patterns are effects of behavioral, not natural, processes. To explore the matter, twenty pollen samples were selected from depositional units which had already yielded macrofossil plant remains data. In addition, a few of the trash pit samples and two samples collected from the hearth fill of a pithouse feature were selected because they were directly associated with flotation samples undergoing concurrent investigation.

This research design came unravelled at its seams when none of the 20 horno sediment samples yielded sufficient pollen for analysis. To compound this difficulty, both of the hearth fill flotation samples and some of the trash deposit flotation samples failed to yield adequate macrofossil data.

There is more at issue here, unfortunately, than a good plan gone wrong. It is evident that the failure of the horno deposit samples to yield an adequate pollen record is not an effect of chance. Further, Gish (1978a) was able to recover adequate pollen for analysis from horno deposits at another portion of the same site utilizing the same extraction and counting procedures. One explanation may lie in the fact the horno deposits selected for this study were primarily composed of charred vegetal matter while those selected for Gish's research were "an ashy-gray color, with apparently silt to coarse sand and gravel composition" (Gish 1978a:2). Pollen grains oxidize relatively easily, so the pollen of our samples may simply have been destroyed by the very burning process which created an abundance of charred vegetal material. But this explanation may be facile. Pollen grains are resistant to heat in a non-oxidizing atmosphere, and our knowledge of the prehistoric use of hornos is not adequate to assess whether the charred material sampled resulted from an open or a smothered burning process. Also, burning may have less to do with the character of the results than other aspects of the depositional context. The sediments analyzed by Gish may represent longer time intervals, and thus have provided more opportunity for inclusion of pollen per unit volume, than those analyzed in this study.

My point is that though it is not difficult to present an explanation which will account for the relative lack of pollen in any given sample or set of samples, we have only minimal comprehension of the processes of pollen distribution and preservation based on experimentally controlled evidence. Thus, a suite of alternative explanations is usually possible and the probability of one is not necessarily greater than the others. We are not now prepared to say with any confidence what samples of archeological context in any given site are or are not likely to yield pollen data. Nor can we predict that innovations in procedures of extracting pollen from sediments will not allow effective analysis of sediment samples previously assessed as inadequate (witness Woosley 1976). At this juncture it remains injudicious for the archaeologist to abjure sampling any particular type of deposit that offers potential (however apparently small) for resolving identified problems of interest on the grounds that such samples are not likely to yield pollen data.

RELATIONSHIPS OF POLLEN RECORDS AND FEATURE FUNCTIONS

In the original research design our concern was comparison of pollen records from trash, horno and floor contexts. This plan was frustrated by the lack of data from horno deposits, but can be compensated to some degree by the availability of floor context samples representing features of two distinctive functions and by the availability of pollen data from canal-fill contexts from the portion of the Los Hornos site investigated by Large (Gish 1978a).

The floor context samples selected for analysis were obtained from pithouses (which are here presumed to have had domiciliary functions), and from the ball court feature. The function--or use, if we adopt Linton's (1936:404) more precise terminology--of Hohokam ball courts is unclear. On the basis of morphological similarity to Mesoamerican ball courts, students have argued that they were used as playing fields, and this interpretation has been buttressed by the recovery of crude hard rubber balls in the Hohokam region. They have also been interpreted as dance plazas or, more generally, as locations used for public displays or ceremonials of unspecified nature.

Canal-fill deposits are of a variety of types. Those of interest to this study are sediments deposited during the period of canal use, in contrast to those which may have in-filled the canal subsequent to use or which are directly associated with artifacts embedded in canal deposits (e.g. metates, vessels) that probably had specific functions.

In a strict sense, the deposits of trash-filled pits may be considered irrelevant to the problem at hand. Presumably, the morphology and typology of any given pit feature reflects its original function; the trash in-filling the pit merely reflects a convenient re-utilization for waste disposal. The documentable homogeneity of pollen records from such trash deposits, however, indicates that as far as their pollen content is concerned the re-utilization of pit features is strongly and uniformly patterned. For purposes of this study, such uniformity is considered relevant and significant to a comparative analysis.

On anthropological grounds, one would anticipate that the functional diversity represented by pits, canals, domiciliary structures and public structures would influence associated pollen records in fairly clear and unambiguous ways. This derives from recognition that distinctive patterns of man-plant interaction are likely to occur in such different social environments, resulting in the differential distribution and/or preservation of pollen types. Both the theory of pollen analysis and the results of pollen studies undertaken at Hohokam locations, however, suggest that such an expectation may be unrealistic.

Palynological theory is structured upon the recognition that spermatophytes produce quantities of pollen of different orders of magnitude depending upon whether the pollination mechanism is anemophilous or zoophilous. This factor is the primary controlling variable on pollen dispersal and pollen preservation. While man-plant interactions are not unlikely to affect dispersal and preservation of pollen in significant ways, the reflection of such affects in a pollen record may be drowned by, or inseparable from, reflections of variations in pollen production controlled by ecological or climatic factors affecting the adaptive relationships of the entire local or regional population of spermatophyte plants.

The essence of difference between the positions of anthropology and palynology is that the anthropologist views pollen rain as a potential dependent variable varying in response to the independent variable of human behavior. The palynologist views pollen rain as a dependent variable varying in response to the totality of adaptive relationships among the organisms producing the pollen and the environment in which they survive. Human behavior patterns may or may not be a significant factor of that environment. In many cases it is apparent that human behavior is a significant ecological parameter affecting the pollen producers. However, there is no theoretical basis upon which to suggest any <u>specific</u> form of adaptive response will be reflected in the preserved pollen record. The response may exist in a form inseperable from those indicating other adaptive interactions, it may exist in a form which requires a particular analytic procedure to separate it from other response functions, or it may not be preserved at all because of the depauperate character of the fossil record.

Because the totality of adaptive relationsnips existing among tne members of a plant population and between that population and its environment is so large (and so poorly comprehended in the vast majority of cases), pollen analysts rarely attempt to explain variation in pollen records unless the variations are very strongly patterned. Further, they consider most variations likely to be explained as responses of the plant population to factors (e.g. climatic conditions) which affect its overall vitality and reproductive potential. Some fossil pollen records seem clearly to document the powerful influence of human technology upon the vitality and reproductive potential of plant populations, normally as a consequence of land clearance (Iverson 1949, McAndrews 1966). But man-plant interactions of this order of magnitude are not those of archaeological concern when the problem at issue is the relationship of pollen records and feature functions. From the perspective of palynological theory, there is little prospect of resolution of matters of such minor ecosytemic moment.

The empirical results obtained from analysis of pollen records of Hohokam contexts also discourage the expectations archaeologists may generate on anthropological grounds. Published studies began a decade ago (Bohrer 1970), and unpublished studies as well (e.g. Schoenwetter and Batchelder 1980), have consistently reported the occurrence of an essentially non-variant pollen record from Hohokam sites irrespective of the feature contexts sampled. The results of the trash-filled pit deposit samples illustrated on Table I are wholly typical. Further, a normal characteristic of such results is that the patterns of palynological variation existing in the record are as easily explained as an effect of chance as any alternative, including plausible cultural ecological reconstructions.

It should also be recognized that the fossil record does not provide internal evidence which can detail the geographical extent of the plant population represented. Modern surface sediment pollen records (which may or may not be adequate homolouges of those obtained from archaeological contexts), may be interpreted distinctively on this issue. All investigators (Hevly, *et al* 1968, Schoenwetter and Dorshlag 1971, Gish 1975, 1978b, Cross 1978) agree that there is no evident correspondence between the character of the plant community existing at the sampling locus and the character of the pollen rain in the Sonoran Desert. But they do not agree on what controlling parameters effect observed statistically significant variations. Schoenwetter and Dorshlag (1971) suggest that very local, habitat-specific, effective moisture values control some particulars of the variation observed. Gish (1978b) disagrees, and argues that the controlling variable is more likely to be pollen production responses of the anemogamous flora of a territory extending well beyond the confines of the sampled locus. Cross (1978) disagrees further, arguing that the depositional context of the sample strongly affects the preservation potential of different pollen taxa and introduces variability. In his view, geographically delimited plant populations may not be represented in the pollen rains of Sonoran Desert sediment samples at all.

Given a lack of consensus or clear evidence regarding the meaning of statistically significant variability in Sonoran Desert pollen records, and faced with a situation in which the variability observed in the fossil record may be explained as a result of chance, most investigators have interpreted the fossil records of Hohokam contexts in conservative terms. They have tended to seek explanations only for the more strongly patterned aspects of the record, and related them to factors likely to significantly affect pollen production by local plant populations. In her more recent work, Gish (e.g. 1979a) has diverged from this tendency in her willingness to argue cultural ecological significance of the occurrence of pollen aggregates of cultivated and zoophilous taxa. Here too, however, the argument is based upon the general patterns of biological adaptation of the taxa involved, rather than assessment of the pollen record as a dependent variable fluctuating in response to human behavior. From the perspective of spermatophyte reproduction biology, dispersal of a pollen aggregate into the atmosphere is an inefficient, energy wasteful, event; in a word, maladaptive. When it occurs as a regular condition of the fossil record, an explanation based upon other criteria than factors responsible for the reproductive success of the pollen producer seems called for.

Intra-feature Variability

Bohrer (1966, 1968), Hill and Hevly (1968) and Lytle (1971) have assessed intra-feature variability in archaeological context pollen records as a response to human activities. In those cases, however, replicate samples of the same provenience have either failed to yield sufficient pollen for analysis or have been unavailable. Rankin (1980, n.d.) has analyzed pollen from different sectors of the same house floor in two different parts of the Southwest. When not directly associated with architectural features (e.g. pits, hearths) or function-specific artifacts (metates, manos) she has observed homogeneity in non-ethnobotanic pollen taxa but occasional significant variability in ethnobotanic taxa. The latter are the sort which are displayed as ratios in this study. Rankin's results are not supported by the more intensive research effort undertaken by Lytle-Webb (1978:23), who compared replicate floor deposit pollen records from nine houses at Ushkalish Ruin. Through use of a Chi Square statistic, Lytle-Webb tested the hypothesis that the pollen records of two or more samples from a given house floor were members of the same population. Four of the house floors failed the test. In those cases, however, it was non-ethnobotanic taxa which introduced variance into the record, not ethnobotanic taxa.

There were three cases in which replicate samples of the same pithouse floor were selected at Los Hornos. (Features 1, 140 and 191), but only one sample from Features 140 and 191 yielded sufficient pollen for analysis. In the case of the ball court (Fea. 340) two of the three samples selected were clearly from the same floor context. Field records are ambiguous concerning the third sample because the field situation was not as clear.

The pollen frequency records of the four floor context samples from Feature 1 (Table IV A) are quite non-variable. There is also no significant intra-feature

Feature	Spec.	Chenopodinneae	Tubuliflorae	Zea	N
140	1159				106
1	319	3			204
	320				202
	401	2			205
	318				100
170	2025	1			201
191		6	1	2	213
340		1			102
		1			101
		1			200
Canal 3					190
Canal Trench	4				160
	3				187
	1				180

Table V. Observed pollen aggregates of the feature samples variability in ethnobotanic pollen ratios and no significant variation occurs in the numbers of pollen grain aggregates (Table V). This result is exactly paralleled in the two floor context samples from the ball court which were clearly from the same context. (Table IVB) The other sample has a significantly increased Chenopodinneae frequency value and a significantly decreased frequency value for Ambrosieae pollen. I believe these aberations are functions of misidentification of sample context. That is, the third ball court floor sample is not from the same floor as the others.

Significant intra-feature variability is expressed in the pollen ratios data of the canal in-fill deposits (Table IVC) but existing stratigraphic information indicates this may be a temporal distinction. These canal fill samples were selected as controls for comparison with pollen data recovered from sediments directly associated with the surfaces of metates embedded in the canal deposits (Gish 1978a). Canal Trench samples 1 and 3 were collected at the same depth as the metates (77 cm below surface), while sample 4 was collected 10 cm above the other two. The pollen ratio values for Nyctaginaceae and Sphaeralcea pollen in samples 1 and 3 are significantly different from the values for those taxa in sample 4, but not significantly different from each other.

At Los Hornos, intra-feature variability in pollen records seems no better evidenced for floor context or canal in-fill data than for trash-filled pit context data. If anything, there is somewhat less evidence for the sort of intra-feature variations others have reported and interpreted as responsed to human behavior.

Inter-feature Variability

Cross-feature comparison of the Los Hornos pollen records allows assessment of the results obtained from different house features (Table IVA) and also those obtained from different kinds of features (Table VI). Both comparisons document

	Pinus	Juniperus	Quercus	cf. Agave	Celtis	cf. Yucca	Ephedra-N	Cercidium	Papillionoid	Olneya	Prosopis	Larrea	Chenopodinne	Artemisia	Liguliflorae	Ambroseae	Tubuliflorae	Gramineae	cf. Tidestromia	Onagraceae	cf. Kallestroemia	Plantago	Labitae	Platyopuntia	Polygonum	Salix
F.140													58.0			9.4	14.2	15.1								
F.1	0.5						0.5	0.5	1.5				52.5			10.3	14.7	15.7	0.5		0.5					
			0.5			1.0						0.5	57.4			4.5	15.8	15.3	1.0							
	1.0						0.5	0.5	0.5				54.6			4.9	10.6	17.1	2.0							
							0.5						49.0			11.0	16.0	17.1								
F.170			0.5								0.5		53.0			5.5	17.5	17.5	2.0	0.5				0.5		
F.191	0.5		0.5			0.5	1.0						52.6			5.6	13.6	19.7	1.4	0.5		1.4				
F.14-L	0.6							0.6					78.6			7.1	8.4						0.6			
												IV A	Pithouse Floor Records													
F.340													48.0			9.8	18.6	19.6								
							1.0						54.5			11.9	12.9	16.8								
									1.0				64.5			6.0	9.0	15.0	1.0		1.0					
												IV B	Ballcourt Floor Records													
Canal 3					0.5								88.4			7.9	1.6	0.5								
Canal Trench #4	0.6										0.6	1.9	80.0		0.	10.6	4.4									
#3												0.5	83.9			9.1	3.7	0.5								
#1	0.6									0.6		0.6	71.7			17.8	6.7									
												IV C	Canal Fill Records													

Table IV Pollen records of features.

Pollen Taxa	Trash-filled pit deposits	House floor deposits	Ball court floor deposits	Canal infill deposits
Pinus	0.8	0.3		0.3
Quercus	0.5	0.2		
Yucca	0.5	0.2		
Ephedra-N		0.3	0.5	
Cercidium	0.1	0.2		
Papillionoideae	0.6	0.3		
Chenopodinneae	56.2	57.0	51.3	81.0
Ambrosieae	10.5	7.3	10.9	11.4
Tubuliflorae	13.5	18.4	15.8	4.1
Gramineae	14.3	14.7	18.2	0.3
Tidestroemia	0.1	0.9		
Onagraceae	0.3	0.1		
Kallestroemia	0.2			
Plantago		0.1		
Unknowns	2.8	3.5	3.5	1.7
N	2,450	1,385	203	717
Zea	.02	.03		
Cylindropuntia	.03	.04		.01
Nyctaginaceae	.03	.05	.03	.08
Sphaeralcea	.03	.02	.01	.05
Cucurbita				

Table VI. Population mean values for spectra of different features the occurrence of statistically significant variation in pollen frequencies, pollen ratios, and pollen aggregate values.

Significant variations in the frequency values for Chenopodinneae and Gramineae pollen occur in house 14-L and also evidence significant variation in Tubuliflorae frequency values. All the records with variant pollen frequency values come from a different part of the site and were observed by a different investigator (Gish 1978). They also may represent a different temporal horizon. Given this situation, it is difficult to argue that the variability evidenced has anything to do with feature function - pollen relationships.

Significant variation which is unlikely to be an effect of chance occurs in a number of comparisons of pollen ratios. Positive departures from mean population values for <u>Zea</u> and Cylindropuntia pollen occur in house feature 191, and for Nyctaginaceae pollen in house feature 14-L. The canal in-fill deposits contain significantly larger amounts of <u>Sphaeralcea</u> pollen than other kinds of samples, and significantly more Nyctaginaceae pollen than occurs in trash pit or ball court samples. The canal in-fill and ball court floor samples contain significantly less <u>Zea</u> and Cylindropuntia pollen than house floor and trash pit samples. Trash-filled pit deposits contain significantly greater quantities of Chenopodinneae and Nyctaginaceae aggregates than the samples from other kinds of features.

Ratio value comparisons indicate that the most aberrant pollen records come from ball court floors. This seems not so much a result of the specialized function of this type of feature, however, as it is a result of the indications that food resource utilization behavior was oriented fairly consistantly towards all the other feature types. A close relationship between the food resource utilization behavior occurring on house floors and that evidenced for trash pits might be expected, since the trash could represent floor sweepings and waste products disposal from the houses. But a similarity between the food utilization activities of houses and canals is not expected.

Gish (1978a) has argued that this expectation may be biased by lack of recognition that canals provide benefits beyond domestic and agricultural water. Borher (1970) pointed out that canals constitued extensions of the riparian habitat Desert Scrub ecological niche. Gish notes:

> Canal embankments provide beneficial habitats for many plant species, including numbers of the Chenopodiaceae, Amaranthaceae, Malvaceae, Onagraceae, Nyctaginaceae, Cruciferae and Compositae. Prehistorically, many of these plant species were most likely exploited directly along canal situations (Gish 1978a:15)

Gish's reasoning serves well to explain the higher ratio values of Nyctaginaceae and Sphaeraleca pollen in the canal deposits and also the basic similarity between canal, floor and trash deposits as regards the pollen ratios of food resource plants. A behavioral interpretation of the distribution of these values is that canal deposits reflect the location where the plants were processed for use, the house floors reflect the locations where the resource product was used, and the trash deposits reflect the locations where waste materials resulting from use were discarded.

Significantly higher pollen ratio values for Zea and Cylindropuntia pollen occur in domiciliary contexts than the other contexts, and the ubiquity value for Cucurbita pollen is significantly greater for trash contexts than any of the others. Cylindropuntia and Cucurbita are zoophilous taxa. Zea is anemophilous, but surface sediment pollen records collected from maize fields (Berlin et al 1977, Fish 1971) and the foliage of maize plants (Bohrer 1972) demonstrate that Zea pollen is not widely dispersed from the parent producer. Zea, then, is an anemophilous taxon which has evolved a pollination mechanism acting to the same effect as that employed by zoophilous taxa.

If Zea, Cucurbita and Cylindrouuntia are considered as zoophilous taxa, the variant distributions of their pollen in these records may be explained as functions of human activity patterns differentiated by distinctive activity loci. All three are recognized as food resources which may be stored for subsequent consumption. But, judging by ethnographic analogs, those portions of the plants which are stored have different probabilities of resulting in the distribution of unusually high pollen values in sediment samples. Ethnographically, Cylindropuntia is stored in the form of roasted flower buds. _Zea_ is stripped of its husk, and sometimes shelled, for storage. _Cucurbita_ flowers are eaten raw or cooked, but the stored portion is the dried mature fruit. Pollen would be expected to remain within the roasted buds of Cylindropuntia in large quantities when stored, but not expected to adhere to the dried rind of stored _Cucurbita_ or to maize cobs and kernels. _Cucurbita_ pollen would be expected to be recovered in large quantities only as a result of flower consumption, and then only in those portions of the occupation area where quantities of _Cucurbita_ flowers were processed for cooking simultaneously. Low, but consistent, values for _Cucurbita_ pollen might be expected where cooking or latrine waste disposal occurred if flower consumption was a customary pattern of behavior. Cooking waste would not expectably contain large quantities of _Zea_ pollen, since the material cooked is flour ground from the seed and the pollen clings to the husk. The area in which corn husks were disposed of would expectably contain quantities of _Zea_ pollen, but dried husk material may have been too valuable as a tinder source to be simply thrown away. Ethnographically, stored roasted cholla buds are ground to coarse flour before addition to stews and meats (Greenhouse 1979). Large quantities of Cylindropuntia pollen would expectably occur in the areas where food was prepared as well as in areas of cooking waste and latrine waste disposal.

The observed distribution of variant quantities of the pollen of these three taxa is consistent with the interpretation that two of the five domiciliary structures studied were locations where corn husks or foliage were stored (F.191 and F.14-L), while the other three houses did not serve such a function. ~~Interestingly~~, ~~these two structures date to the Colonial Period occupation of Los Hornos, while the~~

~~others date more recently~~. The distribution of *Cucurbita* pollen in trash deposits suggests a latrine function for such features. The occasional occurrence of high, but not statistically significant, ratio values for *Zea* and Cylindropuntia pollen in trash deposits samples reinforces this reconstruction and is not consistent with an interpretation of the trash in trash-filled pits as cooking waste.

Though argument from negative data is normally abjured in behavioral reconstruction, certain negative patterns in these data offer hypotheses testable with other research designs. Perhaps the most striking is the lack of correspondence in the pollen aggregate data when comparisons are drawn between the trash records and those of other features. The frequency of Chenopodinneae pollen aggregates in trash samples is consistent with the interpretation that human activities in the site environs created a habitat to which Chenopodinneae pollen producers were extraordinarily well adapted. But if that interpretation applies to the site as a whole rather than the immediate environment of the trash pit features themselves (or the immediate environment of the source of the trash if one assumes it is redeposited), the same pattern should occur in pollen records of other types of features as well. This is not the case. Further, if seeds of Chenopodinneae taxa were harvested for food and stored for later consumption in pithouses, one would expect to observe a significantly large number of Chenopodinneae pollen aggregates in these locales. This also is not the case. The pattern expressed by the Chenopodinneae pollen aggregate data, in fact, compares favorably only to that expressed by the pollen ubiquity values for *Cucurbita* pollen. This suggests that the distribution of Chenopodinneae aggregates is a measure of the latrine function of trash-filled pits rather than a reflection of habitat modification. During the Colonial Period, domiciliary storage of maize husks and cholla buds seems indicated but storage of chenopod and amaranth seeds seems contra-indicated. During later horizons of occupation, the record appears to support the interpretation that domiciliary structures were not used as storage locations for any foodstuffs.

Another interesting pattern is the lack of any significant pollen ratio or pollen aggregate variances from statistical zero in the records of ball court floor samples. One interpretation of this result is that the presumed specialized function of the ball court feature is palynologically reflected in this fashion. However, such an interpretation would not account for the fact that the records from ostensibly contemporary pithouse floors show the same lack of variances. It seems more reasonable to suggest that the distinctive functions of these different sorts of features are simply not reflected in pollen records of 100 and 200-grain magnitude in fashions amenable to univariate analysis.

Two patterns of inter-feature variation occur in the ubiquity data when frequency values are considered. Both may result from the effects of chance upon sampling, but one pattern is stronger than the other. The stronger pattern is the possibly significant constancy of occurrence of Larrea pollen in the canal in-fill records. Since Larrea is a zoophilous taxon, and its occurrence is expectably erratic, it's reasonably constant occurrence in this context may relate to the function of the canals in providing an improved habitat for creosote reproduction. The weaker pattern is the more ubiquitious occurrence of Ephedra pollen in pithouse floor samples than other samples. Ephedra is an anemophilous taxon which would be expected to occur with the same constancy in samples of any provenience category. Since it does not, its ubiquity in pithouse floor contexts suggest a possible localized use. It might have been a construction material for roofed structures.

Summary

Certain patterns of variation in the pollen record suggest reconstructions of feature-specific behavior patterns related to man-plant interactions. Canal embankments, for example, can be argued to represent locations where resource extraction-and-processing activities were undertaken directed towards local concentrations of plants producing Nyctaginaceae and Sphaeralcea pollen. The trash of trash-filled pits yields a pollen record most adequately interpreted as reflecting a latrine function, though other uses of pit features may be evident in fashions not reflected in univariate pollen analyses. The pollen record of presumed domicile floors may be interpreted as reflecting storage of both wild (Cylindropuntia) and cultivated (Zea) resources in the Colonial Period, but relinquishing that function in large part during later horizons of occupation. Though Nyctaginaceae and Sphaeralcea seem to have been collected and processed for use in the same areas of Los Hornos, the record suggests the extracted resources were utilized in different locations (Nyctaginaceae in domiciliary areas but Sphaeralcea elsewhere) and their waste products were disposed of differently (Sphaeralcea in possible latrine waste but Nyctaginaceae elsewhere). Cucurbita flowers seem to have been consumed, but not stored in houses at any period of occupation. The same interpretation may apply to the seeds of chenopods and/or amaranths. The feature-specific character of significantly high numbers of Chenopodinneae pollen aggregates seems better explained in terms of latrine waste disposal than habitat modification.

Such reconstructions are the sort anticipated to result from pollen studies of feature context data according to anthropological theory. Caution should be exercised in accepting them as demonstrated, however, for two reasons. First, these reconstructions are plausible interpretations of the record but not necessarily the only plausible reconstructions that could be made. Second, the theory used to identify palynological records amenable to interpretation in terms of human activity requires assessment of normal and abnormal patterns of pollen production, dispersal and preservation. Such patterns have nothing whatever to do with the presumed use of the features samples.

The combined affect of these cautionary remarks is methodologically significant for archaeologists concerned with the value of pollen records in reconstructing patterned interactions between human populations and plant resources. The archaeologist cannot make the general assumption that features of different function are likely to yield pollen records of different sorts because they are locales of distinctive man-plant interactions. As in the present case, the assumption may prove warranted. But the particular situation will depend on the reproductive biology of the taxa occurring in the pollen record. In many instances the reproductive biology of the taxa observed may preclude analyses which can be interpreted in anthropological terms. Of further relevance is our recognition that interpretable patterns in pollen records only exist in the form of statistically significant data variations. The procedures used to identify such variations, then, and the biological knowledge which justifies the use of certain procedures and not others, condition the use of palynological information in such reconstructions.

POLLEN CHRONOLOGY

Theory and Methodology

The most important problem this study wished to address was that of pollen chronology. Pollen chronology construction is an exercise in biostratigraphy. One independently establishes the relative temporal order of a series of pollen records, seeks to identify biological variation which corresponds to the passage of time, and evaluates the proposition that apparent temporally ordered variation is of stratigraphic value. The classic forms of biostratigraphic analysis are paleontological, and the biological variation identified is the sequential adaptive morphological changes marine invertebrates underwent as a response to evolutionary laws. There is a very significant difference in scale between biostratigraphic analysis of this classical sort and the analyses we would apply to pollen assembleges to discern regional or intra-site variations occurring on the order of decades or centuries. Yet the principle is identical: one seeks to identify the adaptive responses of biological populations which occur as a result of the laws of evolutionary change. At the scale of paleontological studies, adaptations are visible as morphological changes. At the scale of archaeological studies, they are visible as population changes occurring as a result of modifications of habitat.

While all modifications of habitat have temporal referents, all are not of stratigraphic value. The construction of a trash mound at an archaeological site, for example, constitutes a change in habitat. The local population of spermatophyte plants must adapt to it or become extinct. Normally, those taxa whose vitality and reproductive success is benefited in the changed habitat will complete successfully against those taxa whose vitality is adversely affected by the change. The resultant adaptation of the population is a modification in the relative proportions of the taxa it incorporates. This adaptive change, however, may not be clearly expressed in the pollen rain of the affected flora, or it may be expressed at the mound location but not expressed in the fossil records of other parts of the site. In such cases the biological variations one can identify and relate to temporally ordered events have no stratigraphic value.

Pollen chronologies are traditionally developed on the evidence provided by bog and laucustrine sediment cores. The relative stratigraphic positions of samples removed from the cores establishes the temporal order of the pollen records (often reinforced by associated radiocarbon dates). The fact that the depositional context of the sampled sediments is geologically stable is significant, for it lends credence to the assumption that variations which occur in the pollen record over time reflect floristic responses to regional scale variables affecting the evolutionary trajectories of large vegetation populations (e.g. climatic change). Variables of this order have a high probability of stratigraphic value; that is, they are likely to allow correlation from one location to another. But as is apparent from the example of the last paragraph, the principles of biostratigraphic analysis may apply to situations in which human behavior precipitates the existence of chronologically ordered changes in the pollen sequence. The issue is not whether the biological variations identifiable in a series of temporally ordered records are the result of human behavior, forces of nature or some combination of the two. The issue is whether or not the ostensibly temporally ordered variation one can observe at one location can be correlated with the variation observed at another. If it can, a pollen chronology can be established; if it cannot, a pollen chronology cannot be established.

It should be noted that constructing a pollen chronology does not demand an interpretation or assessment of the biological variations which are identified. Recognition of a biological change (for example, a relative increase in the frequency of Chenopodinneae pollen) which can be correlated between two or more locations is sufficient for chronology construction in and of itself. One does not need to comprehend what conditions precipitated the change or what floristic or climatic conditions it may represent. Uninterpreted pollen chronologies are of little general value, of course, and are not a normal objective of pollen analysis. They may, however, be significant for intra-site temporal analysis in archaeological situations. In a large site where logistical considerations demand limited testing, for example, biostratigraphic correlation of provenience units through the medium of a pollen chronology will provide intra-site relative dating which is at least as secure as that one may obtain through comparisons of artifact types or seriation procedures. This is true whether or not the biological variations upon which the chronology is based are interpreted or even interpretable.

The problems which adversely affect pollen chronology constructions based on archaeological context data are not problems of the application of methodological principles. They are logistical. The relative temporal order of the samples used for constructing a pollen chronology must be known independently. Stratigraphic positioning can be used for this purpose as can chronometric dates. The direct association of artifact assembleges whose relative temporal positions are known or estimable can also be used. Intra-site stratigraphic analysis, however, is rarely accomplished in archaeology to the standards a geologist would employ. The normal routine is to select a few exposures within the site (occasionally only one exposure) and use them to characterize the intra-site stratigraphic record. The relative temporal order of the pollen samples collected from the exposures examined would be known in this situation, but the exact relative temporal position of samples collected elsewhere are not assessable from their stratigraphic position. Samples of this latter group might be related to those of the former group by what Dean (1978) refers to as "bridging events." If the samples recovered from a particular stratum in the exposures were associated with a specific chronometric date or the specific assembleqe of artifacts diagnostic of a temporal phase, samples recovered elsewhere which are similarly associated can be considered as having a similar absolute or relative antiquity. The difficulty with this approach is that the samples required to construct a pollen chronology could not be identified until all independent means of dating their proveniences had already been applied. In other words, the pollen analysis could not proceed until all artifactual and chronometric analyses had been completed.

The archaeologist may overcome this problem by the collection and analysis of many pollen column sequences from a number of mapped (i.e. profiled) exposures. However, each sample in a column has a unique temporal position as a result of its stratigraphic relationship to the others. As such it yields a single pollen record representing a specific depositional interval. In a lake or bog, where one can anticipate that natural variables of regional scale condition the nature of pollen records, the results of a single sample may be adequate to characterize the pollen rain of a time interval. But in an archaeological context, where one anticipates that highly localized human behavior patterns may condition the nature of pollen records, it is doubtful if the results of a few samples can be trusted to adequately characterize the pollen rain of a temporal interval. One would prefer to consider the results of a statistically adequate group of samples of any given time interval for this purpose. Thus it is not only necessary to collect and analyze many pollen column sequences. One must also design the collection strategy so that it will be likely to provide numbers of pollen samples of the same stratigraphic position (viz. Bohrer and Adams 1977).

From the perspective of practical archaeological work, pollen chronology construction presents logistical difficulties of some magnitude. Large numbers of sediment samples must be collected during field operations, both as column sequences and from potentially datable proveniences. Sample collection is not difficult or labor intensive, but management and curation difficulties increase dramatically when the numbers of samples collected rise from scores to hundreds and thousands. Once collection ceases, the decision must be made whether or not to undertake the analysis of as few samples as possible for the purpose of chronology construction.

The financial advantage of this strategy must be weighed against the requirement of independent evidence of relative chronological position. The smaller the number of pollen samples analyzed, the more securely the relative temporal position of each sample must be evaluable on independent grounds. Normally, this information will not be available until the bulk of analysis of the site's internal stratigraphy and assessments of the temporal significance of the artifact inventories of provenience units have been completed. To save money, pollen chronology construction should be one of the last analytic jobs performed. But this could constitute false economy, since the character of a pollen chronology may indicate that methodological or theoretical problems exist in the ways the archaeological analyses were accomplished.

The alternative strategy (proceeding with the analysis of relatively large numbers of stratigraphically organized samples soon after sample collection has ceased) creates different, but no less significant, logistical problems. It may be a very costly strategy, depending on the level of statistical adequacy established for identification and delineation of the pollen chronology units. It is also a risky strategy, since there is no guarantee that a statistically satisfactory number of pollen counts of each unit of the chronology will be recovered.

Unless unusual preparations are made in advance, the normal way of resolving those logistical problems is one of compromise. Some, but not many, pollen samples are collected from stratigraphic exposures which, as a matter of field judgement, offer unusual promise as bases for establishing a pollen chronology. Most of the samples are collected from provenience units on the assumption that they can ultimately be securely dated independently through bridging events. Some, but not many, samples are collected in direct association with radiocarbon or archaeomagnetism samples amenable to chronometric analysis. The attempt to construct a pollen chronology will then draw upon samples of all these categories to the numbers possible within fiscal and schedule constraints.

	cm. depth below surf.	Pinus	Juniperus	Quercus	cf. Agave	Sarcobatus	cf. Yucca	Ephedra-N	Cercidium	Papillionoideae	Olneya	Prosopis	Larrea	Chenopodinneae	Artemisia	Liguliflorae	Ambroseae	Tubuliflorae	Gramineae	cf. Tidestroemia	Onagraceae	cf. Kallestroemia	Plantago	cf. Cactaceae	Platyopuntia	Polygonum	Salix	Cyperaceae	Unknowns	N	Zea	Cylindropuntia	Nyctaginaceae	Sphaeralcea	Cucurbita
	50-54			2.0				1.0				1.0		37.2			8.8	29.4	18.6										2.0	102	.01				
	56-58																																		
	60-63			3.0				0.5		0.5				36.3			7.5	28.0	16.0	1.0									2.5	201			.01	.01	
Sand	63-66		0.5	1.0				0.5						32.5			10.5	34.5	18.5										2.0	200		.02	.01	.06	
	71-76	0.5		2.5			0.5			1.5		0.5		29.2			10.4	50.7	21.3										3.0	202			.02	.08	
	92-96							1.0		1.0				8.9			8.9	66.3	12.9										1.0	101					
	105-100			0.5			0.5	0.5		1.5				45.0			5.4	25.7	17.3	0.5	0.5								2.5	202	.01		.02	.05	.01
	124-127																																		
Sand	148-150																																		
	160-166									1.9		3.8		49.0			12.5	16.3	11.5	1.9									2.9	104		.01	.02	.02	

Table VIII. Fature 22 pollen sequence.

Constructing a Los Hornos Pollen Chronology

Two stratigraphic column pollen sequences representing exposures of depositional events unaffected by human behavior had been collected at Los Hornos. One column of samples was collected at 5cm intervals from the deposits which infilled the ball court, Feature 340. This pollen series is potentially datable to any one or more of several archaeological phase intervals subsequent to the last use of the ball court in the Sedentary Period. Unfortunately, the excavation strategy applied to the ball court fill deposits precluded recovery of temporally diagnostic pottery in direct association with the pollen samples, and indirect associations of pottery and the pollen samples are presently too limited to provide adequate dates. The available information thus neither supports nor denies an interpretation of the pollen sequence as of probable Classic Period age.

The other pollen sequence was recovered from banded silt and sand deposits infilling a large feature assessed as a borrow pit (Feature 22). The feature appears to have been excavated through and below the caliche horizon of the local sedimentological sequence from a point stratigraphically related to house floors and other indicators of the Classic Period. Ostensibly, then, the samples were deposited during the Classic Period occupation. In any case, the pollen sequence is capped by deposits containing pottery attributable to the Classic Period.

The Feature 340 sequence (Table VII) documents no significant variations through time in either pollen frequency or pollen ratio values with the exception of the ratio value for Nyctaginaceae pollen in sample 2, which may be an accident of sampling. Though the pollen frequency and pollen ratio values are similar to those representing the upper floor of the ball court feature, which is thought to date from the Sedentary Period, ubiquity values for *Yucca* and *Sarcobatus* pollen are dissimilar.

Three of the ten samples of the Feature 340 sequence failed to yield sufficient pollen for analysis. As two of the three derive from the same ten centimeter interval in the depositional sequence, it seems likely that microstratigraphic distinctions in the depositional history of the infilling process account for this anomoly. One pollen aggregate of Chenopodinneae pollen occurred in samples 6 and 8 and one Ambrosieae aggregate occurred in sample 9. But there is no pattern of significant variation which may be interpreted in terms of temporal ordering or related to other patterns in the aggregates data.

Eight of the 10 pollen samples of the Feature 22 infill deposits (Table VIII) were collected from silt lenses, while only 2 samples were analyzed of the 14 collected from different sand lenses. As a rule of thumb, sandy deposits are somewhat less likely to contain extractable fossil pollen. Our decision to limit major investment in the study of the Feature 22 samples to the silt lenses was justified on those grounds. As it turned out, however, pollen recovery was only slightly less feasible for sand than silt deposits and seems to relate to temporal position rather than depositional context.

The Feature 22 pollen sequence is divisible into two biostratigraphic zones on the basis of pollen frequency values. The older zone is characterized by significantly higher mean Chenopodinneae pollen frequency values in the deposits below 105 cm depth, and coincident low mean Tubuliflorae pollen frequency values. The younger zone is characterized by the reverse of this pattern in the samples collected above 76 cm depth. The sample collected at 92-96 cm depth is anomolous in that it yields a Tubuliflorae pollen frequency value significantly larger than those characterizing the younger zone. Biostratigraphic zones, however, cannot legitimately be established on the basis of single pollen records because the effect of chance cannot be eliminated from consideration in such cases. The two defensible pollen zones of the sequence, then, are separated by a possible--but not demonstrable--third zone.

Though there is no evidence which would indicate that the Feature 22 pollen records date to any other possible interval of time, none of them yield pollen frequency data that can be correlated with other data available for the Classic Period at Los Hornos. The value of the biological variability observed to construction of a Los Hornos pollen chronology, then, seems to be nil.

There are, however, no pollen records from Los Hornos which are independently dated to the Soho phase of the Classic Period on the grounds of associated ceramic types. One interpretation of the Feature 22 sequence is that the pollen zones observed represent the pollen rain patterns of the Soho phase interval. While plausable, this interpretation is unwieldy because it requires adoption of the inference that during part of the Soho Phase adaptive interactions of the local flora were of a totally different nature than occurred in any of the preceeding intervals. Another interpretation of the sequence is that the pollen frequency values observed are strongly influenced by local overrepresentation of the Tubuliflorae pollen producers. This interpretation would be consistent with the inference that the deposits represent not more than a few rapid, seasonally constrained, depositional events.

The original conception controlling the selection of samples for pollen chronology construction was that there was some prospect that the pollen records of these two sequences could be correlated, since one was of post-Sedentary Period age and the other was of the subsequent Classic Period. Presuming that it would be possible to establish a "floating" pollen chronology relevant to the post-Sedentary Period occupation of Los Hornos, it was thought that the pollen records of the trash pits and features selected for study for other problem areas might be related to the chronology on the basis of associated, temporally diagnostic, ceramics. Unfortunately, the original assumption proved unjustified. There is no significant palynological variability at all in one of the pollen sequences, and that which occurs in the other is not of stratigraphic value. An attempt to construct a chronology from the pollen records of trash-filled pits and features which are controlled by associated temporally diagnostic ceramic materials also failed.

Pollen records from trash pit features 16, 99, 75, 218, 430A, and 485 are, with three possible exceptions, derived from mixed deposits according to Abbot and Lindauer's analysis (this volume). The pollen rain they contain cannot, then, be assumed to represent a single interval of time. The exceptions are the sample from the basal deposit of F. 485 and the two lowermost pollen records from F. 218. Associated pottery indicates that the F. 218 records are of the Sacaton phase, but do not identify when the deposits were laid down during that two hundred year interval. There is one Santa Cruz type decorated potsherd directly associated with the pollen sample of F. 485. It is an inadequate basis for dating.

Though a number of the pollen samples analyzed were collected from micro-stratified proveniences in architectural features from Los Hornos, the associated ceramic materials rarely provide usuable dates. Features 140 and 1 are both assigned to the Classic Period on the basis of the occurrence of Casa Grande R/B, Salt Red or Gila Palychrome sherds in the fill or roof fall deposits. The only direct association of temporally diagnostic pottery with the sediments sampled for the pollen study, however, is one Gila Palychrome potsherd on the floor of Feature 140. Again, one sherd is an inadequate basis for dating.

Features 8 and 170 are pithouse structures attributed to the transistion period between the Sacaton and Soho phases. A late style Sacaton R/B vessel fragment lay on the prepared surface sampled for pollen at Feature 8. No temporally diagnostic pottery was recovered in direct association with the stratified hearth sediment samples of this feature which were analyzed. Salt Red, however, was recovered from the pithouse fill. The floor sample from Feature 170 was indirectly associated with Sacaton R/B vessels. No temporally diagnostic pottery was recovered in association with the stratified hearth samples of this feature, but

Casa Grande R/B occurred in the pithouse fill.

The Feature 170 and Feature 8 pollen records are significantly different from each other in respect Chenopodinneae pollen. Both hearth fill pollen records from Feature 170 contain significantly greater amounts of Chenopodinneae pollen than the mean value of the population of pollen records which may be attributed to the transition horizon, and the lower hearth fill and the floor pollen records of Feature 8 contain significantly smaller amounts. Statistically significant variability is also observed in the frequency values for Tubuliflorae and Gramineae pollen, though this is likely to be a function of reduced constraint. Statistically significant variation is also documentable for the Zea pollen ratio of two samples from Feature 170, and the ubiquity values for Quercus, Yucca, Kallestroemia, and Plantago in the Feature 8 records exceed those of the general population of Los Hornos samples.

The character of independent temporal controls for this population of samples precludes judgement on the question of whether or not the pollen record variability observed is time dependent, however. It is tempting to argue that absolute temporal distinctions account for the pollen rain variation, and thus the two hearth records from Feature 170 reference a time horizon relatively late in the transition period, the floor sample from Feature 170 and the upper hearth sample from Feature 8 reference a middle temporal horizon of the transition period, and the basal hearth sample and prepared surface sample from Feature 8 reference an older temporal horizon of the period. The relative stratigraphic relationship of the samples from the hearths and those from the floors of these features, however, is not really known. It is reasonable to suggest that the pollen of floor deposits is relatively older than that of basal hearth deposits but this cannot be demonstrated independently. These data, then do not meet the necessary requirements of pollen chronology construction.

Ball courts of the style recovered at Los Hornos are dated to the Sacaton

Phase at other sites. The few pieces of pottery found directly associated with the floors of the ball court ~~floors~~ at Los Hornos, however, were not temporally diagnostic. The only other feature sampled for pollen was Feature 191. The stratigraphic relationships of this pithouse to pithouse features 89 and 190 are complex but neither their analysis nor the results of ceramic study achieve a phase temporal diagnosis for the sampled deposits. All that can be presently inferred is that these pollen records are older than any others of unmixed strata from Los Hornos, and date to the Colonial Period.

Clearly the independent temporal control available for the pollen records of the trash pit fill deposits and the samples from features is inadequate to satisfy the requirements of pollen chronology construction. Had it been possible to delay selection of the pollen samples to be analyzed until the ceramic studies and the study of trash pit deposition were completed, the story might have been different.

OVERVIEW

The Los Hornos study represents the most extensive, intensive and systematic palynological effort yet undertaken in Hohokam archaeology. Certainly, Los Hornos is the single most extensively sampled site (446 samples) and the single site yielding the largest number of samples submitted for pollen extraction (108). A respectable proportion of Los Hornos pollen samples have produced analyzable data (72.2%), for comparison with a comparatively well examined modern (9 studies) and fossil (18 studies) pollen record. The decision-making process which justified the procedures used in collecting, selecting and analyzing the samples was explicit and closely related to a specified research strategy linked to the demands of both professional standards and Federal law and regulation.

Yet the Los Hornos pollen study yielded more archaeological disappointments than results. The two problem areas that were given highest research priority were not resolved at all. The two conclusions which were most effectively demonstrated by the study are (a) trash-filled pits at Los Hornos are likely to have served latrine functions, and (b) pollen record variations can sometimes be interpreted as indices of the differential use of associated architectural features. The former is hardly earthshaking news. The latter has been demonstrated previously a number of times. Clearly, the value of the Los Hornos pollen study does not lie in what it has provided by way of discoveries about the times and culture of Hohokam populations.

But that is not to say that the Los Hornos pollen study has failed to yield information of importance to prehistory. Though it was designed to produce information important to our comprehension of the Hohokam, and did not, it did produce information of methodological significance in archaeology. Interestingly, it is assessment of the study's failures that have had positive results. If the work had been more successful in its original intentions, its methodological lessons would probably have been ignored.

What, precisely, are those lessons? First, and most important, is the lesson learned from the failure of the data to prove information about temporally ordered ecological or climatic changes:

1. Archaeological context deposits can produce the kinds of palynological records open to biostratigraphic analysis and chronology construction. But they may not do so in particular cases because

(a) logistical constraints or the character of the site precludes recovery of adequate independent temporal controls;

(b) anticipated correlations between data sets do not materialize (the Los Hornos case);

(c) the localized effects of human behavior on pollen records drown, mimic or modify the palynological responses of district vegetation to regional ecological or climatic changes;

(d) the format of analysis is ineffective; or

(e) no adaptive vegetation change occurred during the time period for which samples are available. It should be noted that no one of these reasons is inherently more probable than any other. Explaining the failure of a suite of pollen records to produce a chronology, then, is not a matter of asserting that one of the options is plausable. The alternatives should also be explained away.

Perhaps of equal significance is the lesson which can be learned through evaluation of the relationship between the pollen record and the functionally distinctive features of Los Hornos:

2. Anthropological expertise, particularly knowledge of the ethnobotanic activities of human populations, is a poor basis for generating expectations about the character of behaviorally-influenced pollen rains. It is unlikely that the numbers and types of pollen preserved at a locus will depend in a direct way on the human behavior undertaken specifically at that location. A pattern of customary behavior performed at loci of a particular type, however, or a pattern

of behavior affecting regional ecosystem relationships, may be discernable palynologically. The judicious practice is to identify anomalies in the records of particular kinds of archaeological context records on palynological grounds, not to seek their existence on anthropological grounds. Once identified, however, anthropological argument is quite powerful in providing an explanation of the anomaly phrased as a reconstruction of man-plant interaction.

Taken together, these lessons justify recognition of a more encompassing methodological principle of some import in archaeology. It is neither new nor surprising, but it is a principle which has been more recognizable in areas where archaeological concern overlaps the interests of other disciplines, such as chronometric dating. Concisely stated, we are thus advised that simple and straight foreward application of diverse scientific techniques and methods to archaeological problem areas may be good science but poor archaeology. That is, it may produce meaningfully interpretable data of the sorts those techniques and methods are designed to provide, without generating bodies of information that significantly address archaeological research problems or allow us to discover characteristics of the prehistoric human condition. We have been rather prone to assume that any of the variety of forms of scientific data we can recover from archaeological site contexts will prove of archaeological value, if an archaeological research design has been employed in the recovery and analysis process. At Los Hornos, that assumption proved unfounded.

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	Foa. No.	Field Spe	Context	Pinus	Juniperus	Quercus	cf. Agave	Sarcobatus	cf. Yucca	Ephedra-N	Cercidium	Papilionoi-	Olneya	Prosopis	Larrea	Chenopodinne	Artemisia
ad 140;	340	4017	45-47 cm above floor													59	
		4016	40-43 "					3	1	2				1		95	
		4015	35-37.5 "	2			1									56	
		4014	30-32 "							1						58	
		4013	25-27.5 "			3		1	1		1					118	
		4012	20-22 "	2		1		4	2			2				118	
		4011	15-16.5 "													3	
		4010	10-11.5 "													2	
		4009	5-7 "					2	3			1				128	
		4008	0-2 "	1												2	
		4060	E-22 floor													49	
		4035	E-11 floor													55	
		4034	Level 2									2				129	
		4057	Level 3	1					1							68	
		4055	Between floors			1										176	
	22	2055	Soil Col.1, 50-54 cm b.s.			2				1				1		38	
		2053	" 56-58 "														
		2049	" 60-63 "			6						3				73	
		2052	" 63-66 "		1	2				1						65	
		2050	" 71-76 "	1		5			1			3		1		59	
		2044	" 92-96 "						1	1						9	
		2046	" 105-109 "			1			1	1		1				91	
		2048	" 124-127 "													10	
		2076	" 140-150 "														
		2074	" 160-166 "							2					4	51	
ıd 23	218	4127	Level 17, base		1								1			58	
		4128	Level 18, base			1				2						116	
		4129	Level 19, base													60	

Field Spe	Liguliflorae	Ambroseae	Tubuliflorae	Gramineae	cf. Tidestroemia	Onagraceae	cf. Kallestroemia	Plantago	cf. Cactaceae	Platyopuntia	Polygonum	Salix	Cyperaceae	Unknowns	Zea	Cylindropuntia	Nyctaginaceae	Sphaeralcea	Cucurbita	N
4017		15	6	14	2			1						2		1	4	3		107
4016		8	5	24	3			1						8			1			152
4015		7	9	18	2									6		1	2	1		105
4014		14	7	17	2						1			5			1			106
4013		19	15	36	4									3			2	4		207
4012		9	21	31	1									5	1					205
4011				3																6
4010		3	1																	6
4009		15	18	30	5		1							3	1		17	3		227
4008		1		1																5
4060		10	19	20										4			3	1		106
4035		12	13	17										3			2	1		104
4034		12	18	30	2		2							5		1		4	1	205
4057		7	5	16	1									1		1				101
4055		6	6	11	1									13		3	1	3	1	224
2055		9	30	19										2	1					103
2053																				0
2049		15	58	38	2									5			2	2		205
2052		21	69	37										4		3	1	12		216
2050		21	62	43										6			3	15		220
2044		9	67	13										1						101
2046		11	52	35	1	1								5	1		4	30	1	218
2048		7	22	7	1									1				2		50
2076																				0
2074		13	17	12	2									3		1	2	2		109
4127		7	11	18							1			5	2	1	1	8	1	115
4128		18	31	26										6	1	2	6	12	2	223
4129		5	15	17				1						3		1	6	15		123

	Fea. No.	Field Spec	Context	Pinus	Juniperus	Quercus	cf. Agave	Sarcobatus	cf. Yucca	Ephedra-N	Cercidium	Papillionoid	Olneya	Prosopis	Larrea	Chenopodinae	Artemisia	Liguliflorae	Ambroseae	Tubuliflorae	Gramineae	cf. Tidestromia	Onagraceae	cf. Kallstroemia	Plantago	cf. Cactaceae	Platyopuntia	Polygonum	Salix	Cyperaceae	Unknowns	Zea	Cylindropuntia	Nyctaginaceae	Sphaeralcea
1,	16	419	Level 2, 73-78 cm b.d.			2						4				82			8	59	47	5									2	1	3	6	4
71		420	Level 3, 78-83 "	4									1	4		101			41	31	18										2	5	6	6	2
		421	Level 4, 83-88 "													129			30	31	18										3	10	19	16	11
	430A	3693	Level 13, 57-63 cm b.s.	8					1			3				139			27	9	19		1								7				
		3679	Level 14, 63-68.5 "	2					1			4				125			20	12	30										3	1			
		3691	Level 15, assoc. w/vessel	1					1			1		2		115			15	18	38										4	13	4	3	7
0	485	3981	Level 21, base	1							1					103			32	29	26					1					10	4	8	7	3
		3978	Level 22	2					3							50			15	14	13		1						1		5	1	1	1	
		3980	Level 23, base at caliche surf.	1					2			1				124			12	16	30										10		1	4	4
	75	4302	Level 21B, base													100			21	45	33	1	2								2	3	10	14	3
		4308	Level 22, base			1					2		1			91			21	55	29										1	2	2	10	1
	99	2289	Level 7, SW section	1							1					117			26	38	11	1	1	1		1					1	6	15	11	7
		2290	Level 7, SE section	10		4						1				106			36	20	21		2								5	3	6	3	5
		3176	Level 12	1		2						2				102			23	39	28	1		1							2	5	33	13	3
		3561	Level 13, E Test Pit	1		2						1				117			33	19	21		1	1							5	3	16	12	4
		3562	Level 14, "	2												71			6	16	12		2								4	4	4	5	1
3	140	1271	Hearth lens 1	3					1		1	1				125			11	24	33	2								1	3		20	4	3
		1282	Hearth lens 2			2			1		1					126			12	20	22	1									9	1		1	
		1159	Floor, below metate													61			10	15	16										4		11	6	
		1274	S. edge of hearth		1						1					4			2	1	4														
		1204	Under metate fragment													12			4	2	0									1			5		
2	1	703	Hearth fill	1							3					109			87	17	11		1								2	1	2	1	3
62		704	Base of hearth fill	1				4			1					98	2		41	29	26										3		1		2
		319	Floor, under sherds	1				4			3					107			21	30	32	1		1							6	1	3	7	4
		320	Floor	1						2					1	116			9	32	31	1									8		2	4	4
		401	Floor, under sherd	2							1	1				112			10	34	35	4									5		5		3
		318	Floor													49			11	16	17						1				6			2	1

	Fea. No.	Field Spec. #	Context	Pinus	Juniperus	Quercus	cf. Agave	Sarcobatus	cf. Yucca	Ephedra-N	Cercidium	Papillionoid	Olneya	Prosopis	Larrea	Chenopodinne	Artemisia	Liguliflorae	Ambroseae	Tubuliflorae	Gramineae	cf. Tidestroemia	Onagraceae	cf. Kallestroemia	Plantago	cf. Cactaceae	Platyopuntia	Polygonum	Salix	Cyperaceae	Unknowns	Zea	Cylindropuntia	Nyctaginaceae	Sphaeralcea	Cucurbita
14	170	2085	Hearth fill													129			7	47	28	2									7	2		3	3	
4		2086	Hearth base							1						127			4	31	30	1		1							6	8	3	8	3	
		2025	Under vessel #8			1								1		106			11	135	35	4	1				1				6	10	4	4	5	
38	8	1048	Hearth, Stratum 1	1		2			2	1		3		2	1	105			19	43	10	2		3		1						4		2	5	6
188		1049	Hearth, Stratum 2			2			6			1			3	62			19	67	35	5		1		1						9	1	1	4	5
		755	Below vessel fragments			7			2			4		2		83			34	35	27	1		1		1						6	1	4	5	6
7	191	3233	Test 6, Lower Fill		1							1				121			13	31	25		2	1				2				5	20	7	5	2
37		3240	Test 7, floor contact	1		1			1	2						112			12	29	42	3	1			3						6	41	23	11	
		3222	Floor, under large rock																																	