# PALYNOLOGICAL INVESTIGATIONS OF THE INNUNDATION STUDIES PROGRAM: 1976-77

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## Progress and Character of the Research

During September of 1976, telephone contacts were made with the senior author by staff members of the Innundation Studies Project to determine the capabilities of the Palynological Laboratory to process and analyze the pollen of sediments recovered from archaeological sites proposed for investigation. After some discussion of the requirements of the Laboratory and the probable numbers of samples involved, the senior author agreed to accept a contractual committment to accomplish this work. Purchase Order PX 7029-6-1342 was received on September 30, 1976, requesting the obligation of Palynology Laboratory services for 1-1/3 months prior to April, 1977.

On October 1, 1976, a letter was sent to a Project staff member formally noting the Laboratory's acceptance of the purchase order and making two requests: (a) that arrangements should be made for receipt of sediment samples at the earliest possible opportunity, and (b) that a research design for the palynological work should be identified through correspondence over the following few weeks. Two hypotheses were proposed for testing as a mechanism of initiating the development of a research design. However, telephone communication with the Director of the Innundation Studies Project on October 12 indicated that the proposed hypotheses were inappropriate to fulfill project goals because they assumed forms of archaeological investigation which were not planned. Alternate hypotheses were not proposed at that time.

On November 12, the senior author wrote the Project Director and the staff member he had previously spoken to, noting that no samples had yet been received at the Laboratory. At that time, he advised that the 1-1/3 months of laboratory work required by the purchase order had been scheduled for a

specific period in December, January, and February, because of the requirements of other business of the Laboratory. He pointed out that unless arrangements were changed, which there remained opportunity to negotiate, the Innundation Studies Project would be expected to reimburse the Laboratory for time expended during the scheduled period whether or not physical work was accomplished. He also advised the immediate shipment of a lot of 25 sediment specimens with the remainder to be shipped by January 7, 1977.

The first shipment of 8 sediment samples [illegible] on December 20, 1976. One week of the scheduled period had already passed, which was the entirety of the work period scheduled for that month. The scheduled period resumed on January 10. During the second week of the work period, it was presumed more samples would arrive at the Laboratory. Since they did not, no work was accomplished. On January 13, another telephone conversation was held between the senior author and a project staff member. The Laboratory was advised that another group of samples was being prepared for shipment, but no research design or hypotheses to be tested had yet been established and the staff member was not authorized to make such decisions.

During the third week of the scheduled period, the first shipment of specimens was prepared for analysis. Normally, a group of 24 or 36 specimens would be prepared at once; since only 8 specimens had been received, most of the work week was wasted. During the fourth week no work was accomplished as additional specimens had not arrived.

On January 29, 1977, the senior author wrote the Project Director, advising that he considered the waste of time and effort to date had been a result of the ineptitude and neglect of the Project staff. He further advised that immediate action could stop the Laboratory's work, but if no communication

was forthcoming the Laboratory would continue in its activity as scheduled. During the fifth week of the scheduled work period, a second shipment of 17 samples was received. These were processed immediately. The Laboratory received a research design statement at this time, identifying hypotheses to be tested with the specimens of the second shipment. A general statement was also submitted by the Project Director during this week, outlining the objectives of palynological investigations in the Innundation Studies Project. During the last week of the scheduled work period, opportunity only allowed study of the 25 samples to determine whether or not they contained sufficient pollen for analysis.

Following the scheduled work period, the junior and senior authors spent some time reviewing what had been accomplished and determining efforts that might be made to fulfill Project goals and salvage information of scientific significance. It was decided that even though the Laboratory was not contractually obligated to undertake further efforts, each would volunteer labor and expertise for an additional full work week as a gesture of concern and as a means of maintaining the professional standards and reputation of the Laboratory. Rankin used this period for additional observation and counting of pollen from the most significant specimens. Schoenwetter invested effort in the interpretation and reportage of the results of the work completed.

## Methods

Extraction of pollen from the sediment samples followed the normal procedure of the Laboratory (Schoenwetter 1975), which is a modification of the method proposed by Mehringer (1967). During the final period of scheduled work, the extracted pollen occurring in each sample was prepared for micro-

scopic examination. One fifth of the total viewing surface of a micro-slide preparation was examined for each of the samples and the observations were tabulated. Counting was halted at the point 200 pollen grains were observed, if this occurred, for the specimens deriving from the Palmetto Bend Reservoir. Counting was halted at the point 200 grains were observed exclusive of those of the Chenopodiineae and Ambrosieae categories, if this occurred, for the specimens deriving from the Abiquiu Reservoir.

Subsequent observation of the six samples considered most significant from the Abiquiu Reservoir series proceeded until 4 hours had been expended per sample or a count of 100 pollen grains exclusive of Chenopodiineae and Ambrosieae pollen had been accomplished, whichever occurred first. Five analyses were completed in this fashion. Pollen frequencies resulting from the additional analysis were then calculated in various fashions to allow maximal comparison with pollen records of presumed similar antiquity in New Mexico.

Results and Inferences: Palmetto Bend Reservoir

Table I provides the pollen record available from Palmetto Bend Reservoir. The low pollen counts produced by seven of the eight samples are of no value for paleoenvironmental interpretation since significant distinctions do not occur amongst the members of the series, and since the statistical credibility of a 7-grain or 6-grain count is no greater than a 1-grain or 2-grain count. Pollen counts of the size obtained at 41JK178 indicate a potential for further investigation, as extrapolation justifies the conclusion that about 30 pollen grains would be garnered if the entirety of a micro-slide preparation were observed. A statistically meaningful pollen count of 100 pollen grains,

| | ARBOREAL POLLEN (AP) | | | | | NON-ARBOREAL POLLEN (NAP) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SITE | Pinus | Juniperus | Quercus | Celtis | Carya | Chenopodineae | Ambrosieae | Tubuliflorae | Gramineae | cf. Leguminosae | Unknowns | Total Observed | cm. Depth Below Surface |
| 41JK163 | 4 | 2 | 44 | 2 | 5 | 7 | 58 | 57 | 6 | 4 | 11 | 200 | 0 - 10 |
| | | | | | | 3 | | 2 | 1 | | 1 | 7 | 20 - 27 |
| 41JK178 | | | | | | | 2 | 4 | | | | 6 | 0 - 10 |
| | | | | | | 1 | 1 | 2 | | | 2 | 6 | 10 - 20 |
| 41JK66 | | | 1 | | | | | | | | | 1 | 0 - 10 |
| | | | | | | 1 | | 1 | | | | 2 | 23 - 33 |
| | | | | | | | | 1 | | | | 1 | 36 - 44 |
| 41JK74 | | | | | | 1 | | | | | | 1 | 15 - 25 |

TABLE I. Palynological Observations of Palmetto Bend Reservoir Sediment Samples

however, would require about one week of work effort to accumulate for each specimen. Unless this level of investment is considered reasonable, the potential of such samples to produce useful data remains a matter of abstract, rather than practical, concern.

The sample from the 0-10 cm level at 41JK163 was collected from an apparently recent deposition to exemplify a "very recent" pollen record. The light brown sandy loam deposit from which the specimen derives is superimposed upon the dark brown sandy loam sampled at the 20-27 cm depth. But field records available to this Laboratory indicate that cultural remains were recovered throughout the stratigraphic column. The possible direct association of the 0-10 cm level pollen sample with cultural materials believed to be 775-975 years old engenders suspicision that the pollen may not actually have been deposited recently. Field records also note the possibility of "very extensive" past rodent activity. This casts a further shadow upon the true antiquity of the geological situation sampled for pollen.

If we presume that the sample does date to the period of recent environment of the locality, its pollen record ostensibly reflects the recent vegetation. There is no necessary direct relationship between the frequencies of pollen producing plants at a locus and the pollen preserved at the locus, however. In the present case, we observe that 57.5 percent of the pollen spectrum derives from the Ambrosieae and Tubuliflorae (tribes of the Compositae family) while only 26.5% derives from prominent tree species of the Blufftop Forest which occurred at the location until recent clearing. This seems a rather extreme difference from the modern flora, though there are a number of plausable explanations. Pursuit of the issue is fruitless, however, because of the nature of palynological reserach. Pollen analysis is a statistical

technique of investigation. While the sample submitted contains many pollen grains, it remains a single sample of the pollen rain of the environmental conditions specified. It might characterize that environment palynologically, but there is no way to demonstrate that it does or does not, since a single sample has no stastical value for this purpose. It is therefore impossible to generate a set of rational expectations regarding the nature of the probable pollen rain, and thus impossible to evaluate the pollen record in such terms.

In fairness, it should be pointed out that the 0-10 cm level sample from 41JK66 was also anticipated to contain a modern pollen rain spectrum. Besides the fact that it contained far less pollen, however, it derived from the plow zone. This introduces the factor of possible mixing with more ancient pollen and/or possible geophysics variables. Even if the sample had contained quantities of pollen, similarities or differences between its record and that of the upper deposit at 41JK163 could not have been confidently evaluated.

Considered as groups, the pollen samples thought to date to different time horizons contain significantly different quantities of pollen. The two samples thought to represent modern pollen rain contain an average record of 500 pollen grains/slide; those thought to date AD 1000-1200 contain an average record of 32 pollen grains/slide; and those thought to date from earlier times produce an average count of 7 pollen grains/slide. Though the standard errors of these values are very great because of the small number of specimens in each group, it may be suggested that the data indicate a loss of pollen from the sediments with age. While this inference is legitimate, it is no more legitimate than other inferences which might be generated from the same information. It is equally possible that environmental conditions occurring

in the area at different times - including, but not limited to, those geochemical and/or geophysical conditions generated by the varying nature of human occupancy of the sites - may have increased or decreased the likelihood of pollen capture and preservation in sediments. Another possibility is that hydrographically-controlled or vegetation factors have affected the pollen preservation or the pollen capture capability of the sediments of archaeological sites along Mustang Creek (41JK74, 66 and 178) to a different degree than they have affected those of 41JK163, on the Navidad River.

Results and Inferences: The Abiquiu Reservoir

The samples submitted to the Laboratory were selected by C. Schaafsma for the specific purpose of testing well-identified and explicit hypotheses significant to the Project. These were:

$H_1$ : sediment samples collected from archaeological features closer to the innundated surface in a site contain more, and/or more well-preserved, pollen than those collected at deeper levels.

$H_2$ : sediment samples collected from archaeological features at different sites which have the same probable antiquity have the same sorts of pollen records.

$H_3$ : sediment samples from innundated archaeological sites contain the same sorts of pollen records as sediment samples from non-innundated sites of comparable antiquity.

The results of the initial study of the samples is provided on Table II. These are statistically adequate to serve as tests of Hypotheses 1 and 2.

| SITE | Pinus edulis | P. ponderosa | Juniperus | Quercus | Ephedra (N-type) | cf. Yucca | Platyopuntia | Gramineae | Chenopodiineae | Ambrosieae | Tubuliflorae | Cleome | Unknowns | Total Observed | PROVENIENCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR32B | 106 | 2 | 49 | 15 | | | | 7 | 46 | 6 | 20 | | 1 | 252 | FS #5 |
| | 95 | | 55 | 13 | 2 | | 4 | | 68 | 19 | 31 | 1 | | 288 | FS #9 |
| | | | | | | | | | 5 | 1 | | | | 6 | Fea. B |
| | 2 | | | | 1 | | | | 20 | 8 | | | | 31 | Fea. L |
| | | | | | | | | | 3 | | | | | 3 | Fea. M |
| | | | | | | | | | 2 | 2 | | | | 4 | Fea. N |
| | | | | | | | | | 1 | | | | | 1 | Fea. Z |
| AR12 | 1 | | | 2 | | | | | 7 | 5 | 1 | | 1 | 17 | Fea. X, fill |
| | | | 2 | | | | | | 15 | 1 | | | 1 | 19 | Fea. X, base |
| | | | 1 | 1 | | | | | 14 | 4 | 1 | | 1 | 22 | Fea. Y, fill |
| | 2 | | | | | | | | 4 | 1 | | | | 7 | Fea. Y, base |
| | 2 | | 2 | 4 | | | | 1 | 30 | 3 | | | | 42 | E 9, 15 cm. |
| | 1 | | | | | | | | 4 | | 1 | | | 5 | E 9, 20 cm. |
| AR8 | | | | | | | | | 2 | 1 | | | | 3 | FS #274 |
| AR23 | 4 | | | | | | | | 4 | | | | | 8 | FS #905 |
| AR9 | | | | | | | | | 3 | 1 | | | | 4 | Hearth C |
| | 1 | | | | | | | | 6 | 1 | 1 | | | 9 | Hearth E |

TABLE II. First Observations of the Abiquiu Reservoir Sediment Samples

Site AR32B is a masonry structure believed to date from the 17th century Navajo occupation of the district. Sample FS 5 was obtained from level A, nearer the surface, and sample FS 9 was collected from the more deeply buried level B. The samples from AR12 derive from a site believed to date between 1500 and 500 BC. The specimens from Features B, L, M, N, and Z were recovered from near-surface deposits while those from Features X and Y and from the grid E 9 profile were more deeply buried. The sediment samples from AR32B, irrespective of depth, yielded sufficient pollen for analysis; those from AR12 did not, irrespective of depth, though the potential of the latter series for further investigation was identifiable.

The number of samples submitted from AR32B and AR12 is large enough to provide an adequate test of Hypothesis 1. Clearly, the results of study allow the inference that the hypothesis is false: proximity to the innundated surface is not a predictor variable one may utilize as an index of pollen density or pollen preservation in an archaeological context. The average pollen density of more deeply buried samples is larger than the average pollen density of less deeply buried samples. This statement is demonstrably statistically significant from the data. However, within the set of more deeply buried samples, we also have information regarding relative burial depths. Pollen density is not greater in the more deeply buried sample collected at Feature X than it is in the less deeply buried sample; at Feature Y and grid E 9 the more deeply buried samples have significantly lower pollen densities than the less deeply buried ones. Thus it seems evident that even though buried features produce more pollen than surficial features in innundated sites, depth per se is not the controlling factor.

Hypothesis 2 may be tested through comparison of the pollen records of

the samples from AR12, AR8, and AR23, which are all of the same presumed antiquity. It is clear from Table II that pollen density values are not uniform, though it may be argued that the various samples sort into two pollen density groups: 1-8 grains and 17-42 grains. Samples of the former group are observed at all the sites, and such a group assignment may be positive indication that the hypothesis is accurate. Unfortunately, acceptance of this inference requires the prior assumption that pollen density is a reasonable indicator of temporal horizon. Such an assumption has never been tested with palynological data from archaeological contexts. Considering the number of biological, geological and cultural conditions which could affect pollen density in a sediment sample of archaeological context, it would seem unwise to accept the assumption without a controlled test.

Comparison of the pollen spectra (ie., the frequency values of the different taxa) from the three sites is not productive utilizing these data. First, the statistical value of pollen spectra involving less than 30 grains is so low that inferences drawn from this population would have little credibility. Second, the proportion of Chenopodiineae pollen in all of the samples is very high (41.1 - 100.0%). This introduces a mathematical factor called constraint into the analysis which, in combination with the low pollen counts, effectively precludes the generation of credible interpretive statements from the observed variation in the frequency values of other pollen taxa.

Essentially, then, Hypothesis 2 turns out not to be testable from the palynological data provided by the initial analyses. This is not due to any defect in the sampling design or the design for identifying which sediment samples would be investigated as a test of the hypothesis. It is due to the nature of the data obtained. Confirmation or rejection of the hypothesis

using these data demands analysis in terms of assumptions which cannot be judged credible from prior knowledge.

A test of Hypothesis 3 requires comparison of the pollen records of innundated sites with those from contemporary non-innundated sites. No samples from non-innundated sites of comparable antiquity were submitted in the AR series, but pollen records from the Navajo Reservoir District (Schoenwetter and Eddy 1964) may be comparable to those from AR32B and samples from the Arroyo Cuervo locality (Schoenwetter, n.d.) may be comparable to those from AR12. The non-innundated site pollen records, however, are not 200-grain pollen counts. The Navajo Reservoir District pollen frequency values are calculated in terms of an "adjusted pollen sum" (Schoenwetter and Eddy 1964:69-72) which express the values of pollen taxa thought to be influenced by cultural, hydrological and edaphic factors as ratios to the sum of other pollen. The Arroyo Cuervo pollen frequency values are calculated in terms of a pollen sum which excludes the taxa Chenopodiineae, and Tubiflorae in addition to those excluded by the adjusted pollen sum (Schoenwetter, n.d.). In order to draw the necessary comparisons, the Abiquiu pollen records must be cast in those analytic frameworks.

There are two problems which must be overcome before this can be accomplished. First, a statistically adequate number of pollen grains must be observed of the set of taxa included in the pollen sum used to calculate frequency values from each sample. The samples from AR32B posed no difficulty in this regard, but additional analysis was necessary for samples from AR12. Second, each of the pollen sums used for the non-innundated series is justified through analysis of the character of modern surface pollen spectra in the district or locality from which the fossil samples derive. No modern surface pollen records were analyzed from the Abiquiu Reservoir District, nor would time have allowed their study if

they had been submitted. Thus though we may draw the comparisons of Abiquiu Reservoir fossil pollen records with presumably contemporary records obtained elsewhere, we cannot be confident that the similarities, or differences, observed reflect innundation effects. It is possible that modern Abiquiu Reservoir pollen rain is quite different from that of the Navajo Reservoir or Arroyo Cuervo locations. If that is true, the comparisons sought would require a distinctive framework of analysis.

Since there was no reason to presume that a distinctive framework of analysis was required, however, we proceeded to assess the comparability of records from AR32B and AR12 with those of the other districts. Time precluded study of more than five of the AR12 records, so we analyzed only those which seemed most likely to provide significant information. The results of this study are illustrated as Table III.

The pollen statistic of primary value for comparision of the AR32B samples with those of the Navajo Reservoir is the adjusted AP frequency. In the Navajo Reservoir District pollen records attributable to the Navajo occupation form two groups (Schoenwetter and Eddy 1964; Eddy 1966). The adjusted AP values of samples associated with Gobernador phase Navajo Period archaeology range from 35.0-59.5%. The adjusted AP values of samples associated with other Navajo Period archaeological data, once assessed as Dinetah phase (Dittert et al 1961), range from 63.5-85.0%. By virtue of biostratigraphic conclation with dated pollen records from Cochiti and Picuris area sites, and by correlation with tree-ring indices of dated moisture variations, Schoenwetter (1966:24-25) attempted to demonstrate that the records containing more arboreal pollen dated between AD 1600 and 1650, while those containing less arboreal pollen dated to the Gobernador phase (AD 1700-1775). The adjusted AP frequency of the samples

| | SAMPLE | Adj. AP % | Pinus edulis | P. ponderosa | Juniperus | Quercus | Ephedra (N-type) | cf. Yucca | Gramineae | Chenopodiineae | Tubuliflorae | Onagraceae | cf. Leguminosae | Unknowns | Pollen Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR32B | FS #5 | 69.09 | 43.08 | .01 | 19.91 | 6.09 | | | 2.84 | 18.69 | 8.13 | | | .00 | 246 |
| | FS #9 | 61.26 | 35.71 | | 20.67 | 4.88 | .01 | | | 25.56 | 11.65 | | | .01 | 266 |
| AR12 | Fea.X,fill | | 57.89 | | 19.73 | 9.21 | | | 11.84 | | | | | .01 | 76 |
| | Fea.X,base | | 46.29 | | 27.77 | 7.40 | 3.70 | | 5.55 | | | | 1.85 | 7.40 | 54 |
| | Fea.Y,fill | | 53.96 | | 14.28 | 15.88 | | | 3.17 | | | | 1.59 | 11.11 | 63 |
| | Fea.Y,base | | 80.95 | | 4.76 | | 4.76 | | | | | 4.76 | | 4.76 | 21 |
| | E 9, 15 cm. | | 35.13 | | 12.16 | 31.08 | | 5.40 | 5.40 | | | | 6.75 | 4.05 | 74 |

TABLE III. Pollen Frequencies from AR32B and AR12 Calculated for Comparison with Contemporary Pollen Records Elsewhere

from AR32B is comparable to the Navajo Reservoir specimens believed to date AD 1600-1650, but not comparable to those associated with Gobernador phase Navajo Period archaeological records. The estimated antiquity of AR32B (17th century) is also comparable. The inference that the Abiquiu Reservoir Navajo period pollen records are biostratigraphic correlates of those from the Navajo Reservoir is defensible from these data, which indicates a positive test for Hypothesis 3. A secondary inference is that the true date for Navajo occupancy of AR32B lies in the first half of the 17th century rather than the last half.

The pollen statistics which are most significant for comparison with the records of the Arroyo Cuervo locality are the combined P. edulis and Juniperus value, the Gramineae value and the Artemisia value. Though variations occur within the 1400-800 BC period in the pollen sequence of the Arroyo Cuervo locality, P. edulis and Juniperus values range from 7-20%, Gramineae values range from 25-85%, and Artemisia values range from 5-40%. P. edulis and Juniperus values in the samples from AR12 are very much higher than any encountered in the Arroyo Cuervo series, Artemisia values are never as high, and the Gramineae values are lower than the general trend. These data do not allow biostratigraphic correlation, which leads to the conclusion of a negative test for Hypothesis 3.

The occurrence of a positive result for one test of the hypothesis and a negative result for a second test may be explained in a number of fashions. The Arroyo Cuervo locality is, for example, geographically placed in a different biome than Abiquiu Reservoir, while the Navajo Reservoir is not. The two perhaps may not be comparable because the pollen producers had different ecological parameters in the different regions. Without surface sample comparisons, it is difficult to evaluate this position. It may be noted, however, that pollen

records of this horizon from the Bloomfield area and from the Llano Estacado are biostratigraphic correlates of those from Arroyo Cuervo (Schoenwetter and Rankin 1976), and those from Utah and the Llano are geologic-climatic correlates with the Arroyo Cuervo series on an earlier horizon (Schoenwetter 1974). This tends to indicate that biome distinctions observed today may have less effect of fossil pollen rains than can be casually presumed. In any case, the outcome of the test of Hypothesis 3 is best evaluated as equivocal. In particular, the tests performed neither positively nor negatively address to any effect the question of the role of innundation in modifying archaeological context pollen records.

Two further comments on the palynological records of the Abiquiu Reservoir are appropriate here, though they have no relationship to the hypotheses tested. First, the samples from AR9 derived from hearth features located close to the innundated surface which are of uncertain antiquity. Associated archaeological data indicates a possible assignment to the horizon of 19th century Ute occupation or, more probably, Archaic occupation of the district. The pollen recovered provides no immediate clues to the resolution of this problem because of the low pollen density of the specimens. The results obtained may be taken as additional confirmation of the negative test for Hypothesis 1, but this is insecure as more deeply buried specimens were not submitted for comparison with those collected near the surface.

Second, the number of specimens and the amount of pollen observed is adequate to demonstrate that pollen of Artemisia is lacking in the fossil pollen record of innundated sites in the Abiquiu Reservoir District. This result was wholly unanticipated, and to our knowledge it represents the only such situation on the Colorado Plateau. Today, Artemisia (sagebrush of all varieties) is a

constant - and frequently dominant - member of the district vegetation. It produces quantities of pollen, it is anaemogamous, and its pollen morphology is very distinctive. It seems wholly unlikely that the genus was not represented in the prehistoric vegetation at all, though its present density and distribution is not a necessary index of its significance or occurrence in the fossil pollen rain.

Summary and Generalizations

According to the information provided us by the Project Director, the principal goal of these palynological investigations was held to be a preliminary evaluation of the impact of immersion on the pollen of archaeological contexts. It was anticipated that such pollen as occurs at the innundated and subsequently re-exposed surface of an archaeological site would be affected through (a) removal from context as a result of flotation from the deposit resulting from flooding, (b) mixture with ancient pollen washed in from other contexts, and/or (c) reflective of the pioneer plant associations invading the surface upon re-exposure. Under such conditions surficial sediment samples recovered from archaeological contexts would be valueless as controls for the analysis of the pollen from more deeply buried contexts. This would be a matter of some import, since surface control samples reflecting modern pollen rain and its variation under known ecological conditions are a significant aspect of archaeological pollen analysis. Surficial sediment samples from site locations frequently constitute these controls.

It was also considered likely that immersion would adversely affect pollen from archaeological contexts as results of the geochemical and geophysical effects it might have upon the sediments. Changes in the chemical equilibria of the deposits might affect the preservation of pollen, either generally or

selectively. Redeposition or loss of context as a result of erosion or slumping and other forms of physical displacement could cause the displacement of pollen - either generally or selectively - creating alterations in the relative pollen values recovered from strata laid down under specific paleoenvironmental conditions.

These anticipations might have served as the basis for generating hypotheses regarding the effects of immersion upon archaeological context samples. Such hypotheses might, in turn, have served as the logical structure which supported a research design for the palynological investigations. That logical structure could have identified guidelines for the selection of sediment sampling opportunities during the course of appropriate field investigations. It could also have identified guidelines for the selection of samples already obtained which had the greatest likelihood to serve to test significant hypotheses. Unfortunately, no hypotheses of this order seem to have been generated by the Project staff or, if they were generated, they were never communicated to the Laboratory. No research design which would allow appropriate selections of pertinent sediment samples or sampling opportunities seems ever to have been established either, despite the early and frequent warnings provided by the senior author that this was necessary to successful functioning of the palynological investigations. The consultation services of the Laboratory (a means of developing a research design) were contractually obligated, and the senior author attempted to establish such a design and offerred to confer with the Project staff to resolve difficulties in developing a research design before scheduled laboratory work was initiated. But no advantage was taken of these opportunities.

As a result of these problems, and as a result of the evident lack of concern to provide the Laboratory with adequate numbers of samples at appropriate times,

the identified goal of the palynological investigations was neither achieved nor adequately investigated. The contractual committments of the Laboratory were fulfilled, but not to the purposes and ends established by the Project.

The samples submitted from the Palmetto Bend Reservoir constitute too small and too variable a series to provide justifiable indications of the impact of immersion upon archaeological context pollen records. This would be the case even if all of the samples contained abundant pollen. The implicit hypotheses this sample series seems to have been collected to represent are:

$H_1$ : pollen is sufficiently dense and sufficiently well-preserved at Palmetto Bend Reservoir archaeological contexts to allow analyses comparable to those obtained in Southwestern sites (eg., Schoenwetter and Eddy 1964, or Hill and Hevly 1968), or mid-western sites (eg., Schoenwetter 1962 or James and Nichols 1967).

$H_2$ : pollen spectra of distinctive temporal horizons illustrate either paleoenvironmental change or paleoenvironmental stability through the period of aboriginal occupancy.

Unfortunately, neither of these hypotheses can be either rejected or confirmed from the available data because the number of samples submitted is not an adequate sample of those potentially available for analysis which are pertinent to either issue. Our position is that this state of affairs has resulted from carelessness of the Project staff. The field party responsible for collection of sediment samples for palynological investigation seems to have been given inadequate guidance for appropriate behavior. The possibility that the carelessness may derive from incompetance and a lack of comprehension of the nature of palynological research has also occurred to us.

The samples submitted from Abiquiu Reservoir constitute a rationally selected series adequate to serve as tests of the identified hypotheses. The equivocal character of some test results is a function of the nature of the pollen records obtained, not a function of the sample series. The hypotheses tested bear directly upon the goal identified for the palynological study. In addition, the data available in these samples offer a further source of inferences significant to that goal.

The negative test for Hypothesis 1 provides a basis for the inference that the phenomenon of immersion plays a less specific role than was anticipated. That is, changes in geochemistry and geophysics of the deposits may be more likely closer to the sediment water interface and they probably in fact occur more dramatically near that surface. But they seem to affect the pollen content of the deposits - whether for good or for ill or at all - no differently near the interface than they affect it at more deeply buried positions. The equivocal outcomes of the tests of Hypotheses 2 and 3 do not threaten this inference. In fact, their very equivocal character tends to lend credence to the secondary inference that each segregate and distinct archaeological context tends uniquely to contain or not contain adequately preserved pollen in response to the equilibrium obtaining at present or at any time in the past among a variety of biological, cultural and geological variables. Immersion seems to be one of these variables, but it is likely to be a controlling variable only in certain circumstances. It would appear that something affected pollen density of the archaeological context deposits at AR12, AR8, AR23 and AR9 to a greater degree than it affected pollen density at AR32B. Further, it affected pollen density more severely in certain AR12 contexts and less severely in others. But we cannot yet comprehend the conditioning variables which act to create the effect

observed. These could be cultural, eg., the occurrence of masonry walls confining the sediment samples; they could be functions of antiquity; or they could be functions of the hydrographic histories of the sites involved.

The data recovered from the Abiquiu series, and also that of the Palmetto Bend series, provides fairly strong evidence that innundated archaeological context deposits suffer selective destruction of certain pollen taxa. Because there was no opportunity to compare the pollen spectra of comparable innundated and non-innundated locations within the same reservoir in a statistically adequate fashion, such evidence must be viewed from the perspective of expectations rather than in light of controlled information. But the modern floras of both reservoir areas are characterized by taxa one would expect to recover in the fossil pollen record which were not in evidence. The 23 pollen grains which comprise the total available fossil pollen record from Palmetto Bend Reservoir constitute a small sample, and so do not allow us to draw many inferences having a very high degree of confidence. But the proportion of arboreal pollen in that sample is so extremely low that a confidence interval test confirms the inference that no more than 25% of the fossil record would be arboreal pollen if these samples are representative of the total fossil record. We would expect that whatever the nature of prehistoric climatic conditions might have been, they would not have been so different from those of the historic past that the site locations were not wooded, or clearings within a wooded district. The low values of arboreal pollen, then, seem likely to be due to selective destruction of pollen taxa. Innundation of the site location is, at very least, a probable variable to produce this effect. Judging by the results obtained in the "recent" sample from 41JK63, Ulmus and Celtis pollen may be particularly affected in the Palmetto Bend Reservoir area.

A similar situation obtains in the Abiquiu Reservoir series with respect to Artemisia pollen. Selective destruction of pollen taxa, of course, leads to misanalysis of pollen spectra since such study is based upon frequency variations. This, in turn, leads us to draw inadequate comparisons with pollen records collected from non-innundated sites and consequent development of false inferences and conclusions. Because of its statistical character, mechanisms and procedures of palynological investigation exist which can control for and alleviate the interpretive difficulties consequent upon selective destruction of pollen taxa in sediments. Carefully selected control specimens identifiably related to specific environmental parameters, for example, can be analyzed exclusive of the taxa which do not occur in a depauperate fossil record or which occur in superabundance as a result of the effect of some conditioning variable. Comparison of the fossil and the control series will then allow interpretation of the former in terms of the environmental parameters known to control the latter. Such analyses are now commonly supported through multivariate statistical evaluations of the prospect that the inferences are results of chance events or sampling errors.

Procedures of this sort were fully appropriate to the palynological investigations undertaken for this report. They were not applied because appropriate control samples were not submitted and because the timing of shipment of samples to the Laboratory did not allow opportunity for their accomplishment.

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