# THE TRACK SITE POLLEN STUDY

James Schoenwetter
Palynology Laboratory
Department of Anthropology
Arizona State University

May 1989

ACKNOWLEDGEMENT: The extraction and observation-tabulation phases of research which is reported here were undertaken by Ms. Alice H. Whallin, who also prepared the tables and figure for this report. Her aid and expertise have been much appreciated.

TABLE OF CONTENTS

## Research History

In December 1988, Dr. Mistovich contacted the Palynology Laboratory to discuss a sampling and analysis strategy relevant to archaeological studies soon to begin at the Track Site. At that stage, available information suggested the site had been occupied by Wilmington Phase Late Woodland and Savannah Phase Mississippian populations; the principle question it seemed profitable for pollen studies to address (given time and budget constraints) was whether these occupations took place at roughly the same or roughly different times. Secondarily, the results of the pollen analysis might also provide information on the character of paleoenvironmental conditions during prehistory, and could perhaps support subsistence pattern hypotheses that might be formulated on the basis of independent forms of evidence.

Recovery of pollen samples that would address this variety of questions involved three sampling strategies. First, a vertically organized suite of samples would be collected from one of the profiled walls of each of the 1 x 1 meter excavation units. This set of samples could be related directly to the profile records of site stratigraphy, so relatively earlier and relatively later samples could be isolated by their stratigraphic positions in respect to the site as a whole as well as their positions in a given excavation unit. Second, samples would be collected from the upper surface of each excavated level in each unit. Profile samples contain pollen trapped in the sediment deposited over a relatively small area, and such samples are considered potentially subject to a form of error palynologists refer to as "local overrepresentation" (Faegri and Iverson 1975:173-175). So-called "scatter samples" (Hevly et al. 1965) which represent the pollen trapped as sediment was deposited over a broader horizontal surface are less subject to this error. They thus provide potential means to demonstrate or disprove the existence of local overrepresentation in pollen records obtained from the profile samples, and also provide a potential source of additional information comparable to that provided by some of the profile samples from each unit.

Both profile samples and level-surface scatter samples, however, contain pollen which was deposited at specific points in the continuum of time of sediment deposition. The archeological record of an excavated level in a unit, on the other hand, was included in the deposits over the interval of time required for aggradation of the volume of the level. Though profile and level-surface scatter samples may yield pollen records which are spatially associated with the archaeological assemblege(s) recovered from the sampled excavation unit, they differ from the assemblege(s) to some degree in respect to exact antiquity. This problem can be ignored, for it is reasonable to assume that the pollen record of an interval is effectively approximated as the mean of the pollen records of points in time that bracket the interval. But it can also be controlled by empirical data. A sample representing the volume of the deposit of the excavated level may be collected by a randomly scattered suite of subsamples as excavation of the level progresses. It will represent the pollen which accumulated over the same interval of time as the assemblege(s) with which it is spatially associated. Recovery of volume samples of this sort constituted the third pollen sampling strategy implemented at the Track Site.

In February 1989, Dr. Mistovich informed the laboratory that fieldwork had revealed that certain expectations of the archaeological character of the Track Site were unfounded. The stratigraphy of the site turned out the be assessable only in terms of three strata: the existing surface deposit, a plowzone deposit and a subsoil deposit. The plowzone had been arbitrarily divided into an upper and a lower unit, with depths allowed to vary at excavation units in different portions of the site. The site was shallower than had been anticipated, and most material culture had been recovered from the plowzone. Though it had been expected that some archaeological material would be observed <u>in situ</u>, none of the recovered artifacts could be unquestionably existed in that position. Indeed, historic period artifacts were consistantly associated with prehistoric period artifacts in the excavation units. Given this field situation, the questions the pollen study was originally asked to address seemed unlikely to be answerable. It was possible, however, to employ pollen analysis to suggest an answer to the question of the character of environmental changes that had occurred during the depositional history of the site. Assuming that the subsoil stratum pollen records represented environmental conditions occurring prior to the prehistoric period of occupation, and that the surface stratum records represented conditions occurring at the present time, or at least in quite recent historic time, their differences might identify trends of paleoenvironmental change occurring during the deposition of sediments at the site. It could be expected that plowzone pollen records were affected by vertical and lateral displacements of pollen grains, but statistical pattern analysis techniques offered the potential of identifying and compensating for those affects. Thus trends of paleoenvironmental change might be determinable for the site area.

However, it was also possible that the deposits contained insufficient pollen to support an analysis of this degree of complexity. It was agreed that the Laboratory would undertake the pilot study of a small sample suite to determine the feasabilty of a more elaborate effort focussed on the question of environmental change. Accordingly, Dr. Mistovich submitted a group of 16 samples representing the entire range of stratigraphic units identified at the site and dispersed across the excavated area. They were accompanied by another suite of 16 samples wich could be used to expand the study if productive results were obtained.

Laboratory Work

Palynological laboratory work is basically a three-phase process. In the first phase, a technique consisting of a number of distinct operations is employed to free and recover the pollen of a sediment sample from its organic and inorganic matrix, and to concentrate it in a small volume of "extract". In the second phase, a representative sample of the extract is prepared for microscopic examination and a representative sample of the pollen it contains is observed. Records are maintained of the variety of pollen taxa seen, the numbers of observed pollen grains of each taxon, and the numbers of poorly preserved (fragmentary) grains in each sample. Finally, analysis is performed through statistical evaluation of the pollen counts obtained for populations and subpopulations of samples.

The extraction technique normally employed by this laboratory (Schoenwetter 1979:226-230) was applied to a group of four samples representing the stratigraphic units at different excavation units, with two modifications. One was inclusion in each sample of 60,500 Lycopodium spores to serve as an exotic marker for pollen concentration calculations (see Moore and Webb 1978:29) for discussion). The other was substitution of sodium hexametaphosphate for dilute hydrochloric acid as a defloculating agent. Observation of the extracts revealed very few pollen grains and only 1/3 to 1/2 the expectable numbers of Lycopodium spores. This suggested that inclusions of the size and weight of pollen grains and spores had been eliminated from the extracts by laboratory-induced errors, and further modification of the standard extraction technique was required. Another extraction technique was designed which successfully recovered all the spores included in a different suite of four samples, so probably successfully functioned to recover all the pollen they contained. However, this technique required roughly twice as much time to execute and larger quantities of expendable supplies.

At this juncture, a means of accomplishing the first phase of laboratory work had been developed but much of the time and support allocated to the pilot study had already been expended. Also, both laboratory personnel who had handled the samples began to show dermatological symptoms of a staphylococcus infection that were directly proportional in intensity to the amount of time of

| Excavation Unit | cm depth b.s. | sample volume in cc | *Pinus* | *Quercus* | *Magnolia* | *Platanus* | *Alnus* | *Castanea* | *Ginkgo* | Total Observed AP | Ceralia | Gramineae | Chenopod-inae | *Ambrosia* | Ambrosieae | Tubuli-florae | Coryloid | Total Observed NAP | Total Identified Pollen | Filacales Spores | *Lycopodium* Spores | Unidentifiable Fragments | Total Fragments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 W74 | 0 | 100 | 1 | 25 | 53 | 8 | | | 12 | 99 | 4 | 32 | | | | 3 | 3 | 42 | 141 | | 152 | 83 | 93 |
| S1 W73 | 0 | 100 | 3 | 20 | 51 | 16 | 5 | | 6 | 101 | 2 | 18 | | | | 4 | 9 | 33 | 134 | | 124 | 57 | 71 |
| S3 W73 | 0 | 90 | 1 | 20 | 35 | 27 | 1 | | 5 | 89 | 2 | 24 | | | | 6 | 11 | 43 | 132 | | 97 | 32 | 45 |
| S5 W74 | 0 | 140 | 2 | 61 | 79 | 26 | 5 | | 11 | 184 | 5 | 42 | | | | | 16 | 71 | 255 | | 190 | 123 | 146 |
| S1 W74 | 0-13 | 100 | 4 | 54 | 19 | 13 | 5 | | | 96 | 1 | 20 | 43 | 5 | | 4 | 4 | 77 | 173 | 3 | 93 | 29 | 52 |
| S1 W74 | 13 | 100 | 2 | 32 | 52 | 13 | | 3 | | 102 | 1 | 10 | 12 | | | 1 | 1 | 25 | 127 | | 153 | 32 | 50 |
| S3 W73 | 10 | 100 | 5 | 49 | 17 | 6 | 20 | 2 | | 99 | 1 | 48 | 10 | | | 7 | 1 | 67 | 166 | 6 | 130 | 31 | 48 |
| S4 W74 | 12 | 100 | | 41 | 45 | 13 | 1 | 1 | | 101 | 2 | 8 | 53 | 3 | 7 | 8 | 1 | 81 | 188 | 2 | 158 | 48 | 67 |
| S5 W73 | 12 | 100 | 1 | 42 | 44 | 14 | 1 | | | 102 | 3 | 3 | 14 | 8 | 5 | 3 | | 36 | 138 | | 103 | 58 | 79 |
| S5 W74 | 0-13 | 100 | 1 | 42 | 34 | 9 | 3 | | | 89 | 3 | 20 | 26 | | | 1 | 11 | 61 | 153 | 5 | 118 | 32 | 57 |
| S5 W74 | 13 | 100 | 1 | 37 | 55 | 9 | 3 | | | 105 | | 6 | | 3 | 8 | 3 | 3 | 23 | 132 | 2 | 157 | 83 | 111 |
| S1 W73 | 16 | 50 | 2 | 53 | 26 | 21 | | 2 | | 104 | 2 | 9 | 55 | 3 | 4 | | | 73 | 178 | 1 | 138 | 67 | 127 |
| S1 W73 | 13-30 | 110 | | 65 | 19 | 16 | | | | 100 | 1 | 4 | 65 | | 2 | 1 | | 73 | 173 | | 129 | 22 | 33 |
| S5 W74 | 13-23 | 100 | 8 | 66 | 12 | | 6 | | | 92 | 1 | 23 | 26 | | | | 8 | 58 | 163 | 13 | 183 | 86 | 132 |
| S15 W50 | 20 | 60 | | 78 | 12 | 11 | 1 | | | 102 | | 7 | 195 | 4 | 1 | | 2 | 209 | 311 | 1 | 127 | 176 | 286 |
| S15 W90 | 20 | 100 | | 67 | 19 | 14 | | | | 100 | 1 | 11 | 133 | 2 | | 3 | | 153 | 253 | 1 | 197 | 142 | 196 |
| S15 W90 | 20-30 | 100 | 2 | 61 | 14 | 22 | | | | 99 | | 17 | 89 | 6 | 3 | 1 | 6 | 119 | 218 | 1 | 131 | 52 | 88 |
| S1 W74 | 30 | 100 | | 100 | | | | | | 100 | | 14 | 397 | | 9 | 17 | | 437 | 537 | | 168 | 362 | 582 |
| S1 W74 | 30-40 | 100 | | 94 | 6 | | | | | 100 | | 27 | 123 | 5 | 22 | 5 | | 182 | 282 | 3 | 185 | 93 | 152 |
| S5 W74 | 23-33 | 100 | 11 | 66 | | 9 | | | | 86 | 13 | 35 | 316 | | 39 | 27 | 14 | 444 | 530 | 26 | 286 | 173 | 269 |
| S15 W50 | 30 | 100 | | 100 | | | | | | 100 | | 23 | 342 | 2 | 28 | 7 | | 402 | 502 | 2 | 114 | 375 | 715 |
| S15 W90 | 30 | 100 | 2 | 95 | 3 | | | | | 100 | 2 | 43 | 212 | | 40 | 8 | | 305 | 405 | 1 | 212 | 127 | 123 |
| S15 W90 | 30-40 | 100 | 1 | 96 | | | 2 | | | 99 | 3 | 61 | 190 | 2 | 40 | 13 | 1 | 310 | 409 | | 229 | 175 | 285 |

Table I. Pollen and Spores Observed

human/sample contact. Further laboratory work with additional samples would require additional time and resources to allow sterilization of the bacterial content of the samples and reduce opportunities for reinfection. A decision had to be made about whether to make the larger time investment required to recover pollen record data that would address the research question posed, or to consider the pilot study's achievement of an effective extraction technique adequate to the investigation. Consultation with Dr. Mistovich resulted in a compromise decision: the effort would proceed, but a smaller number of samples would be analyzed than the laboratory would normally be responsible to complete.

Ultimately, pollen extracts were prepared from 23 of the 32 samples submitted to the laboratory, with one sample processed by the technique that did and the technique that did not include sterilization operations (S5W74, 0 cm.). The pollen counts for the two reveal no differences that cannot be accounted for as a result of the effects of chance on observation.

Table I presents the results of the second phase of laboratory work. Two matters are of particular interest: On the one hand, the table reveals the fact that relatively few kinds of pollen and spores were recovered for the suite of samples, considering the total number of pollen grains observed. Also a number of non-arboreal pollen (NAP) types that appear in earlier pollen sample populations do not appear in the surface sample population, while a number of arboreal pollen (AP) types that appear regularly in more recent pollen sample populations do not appear consistantly in the earliest (subsoil) sample population. On the other hand, the table reveals the regular occurrence of Ceralia pollen (which is produced by Old World cereal cultivars) in the population of subsoil samples. Also, maize pollen was not observed in any sample.

Analtytic Results

The pollen analysis was begun by transforming the observed pollen counts to pollen frequency values, which allows samples of different sizes to be compared more easily. Since the concern was with environmental change, pollen frequency values for arboreal pollen types (*Pinus*, *Quercus*, *Magnolia*, *Platanus*, *Alnus*, *Castanea*, and *Ginko*; produced, respectively, by pine, oak, magnolia, sycamore, alder chestnut and ginko trees) were calculated on the sum of observed AP while pollen frequency values for non-arboreal pollen types (Ceralia, Gramineae, Chenopodinneae, *Ambrosia*, Ambrosieae, Tubuliflorae and Coryloid; produced, respectively, by species of Old World cereals, grasses, goosefoot family and amaranth plants, ragweed, species of the ragweed tribe, species of the sunflower tribe and hazel, birch or myrtle) were calculated on the sum of observed NAP. This allows identification of change trends which may have occurred independently among upper and lower canopy species contributing to the pollen records.

Pollen frequency values must be statistically assessed by non-parametric techniques, since populations of observations are distributed binomially rather than normally (see Mosimann 1965:637-638). Thus a number of the more familiar tests for determining the significance of variability among samples (e.g. standard deviation from the mean or "t" test) do not apply. The most robust univariate statistical test applicable to evaluation of frequency values is the binomial confidence interval test. When the span of 95% confidence intervals overlap for any two frequency values, those values are considered statistically equivalent expressions whose distinction may be an effect of chance. If the confidence intervals do not overlap, the values are recognized as significantly different and the difference is unlikely to be an effect of chance. Though the bioturbated character of the plowzone suggested that much more complex statistical techniques might be required to allow assessment of the variability amongst the Track Site pollen records (e.g. multiple regression, discriminant function or cluster analysis pattern search techniques), they were not in fact required to deal with the question posed for this research.

The first application of the confidence interval test allowed reduction of the raw data set. Since all frequency values that are not significantly larger than zero could occur in a pollen record as a result of chance, any pollen frequency value of that size could be eliminated as a source of clearly interpretable data. The interpretable relevance of all observed Pinus and Castanea pollen was demonstrated to be minimal in this way. The test also may be employed to identify pollen frequency values that are significantly larger than the mean for the population of samples of equivalent stratigraphic position. This allows recognition of pollen record observations which are not likely to be chance events but which may be strongly suspect as local overrepresentations. Removal of such suspect values from the data set eliminated all remaining observations of Alnus, Tubuliflorae and Coryloid pollen from consideration as interpretable data.

| Excavation Unit | cm depth b.s. | Quercus | Magnolia | Platanus | Ginkgo | Ceralia | Gramineae | Chenopod-innae | Ambrosieae | AP/NAP Ratio | Unidentifiable Fragments/TLP Ratio | pollen Concentration per c c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 W74 | 0 | 25.25 | 53.53 | 8.08 | 12.12 | 9.62 | 76.19 | | | 2.357 | .588 | 565 |
| S1 W73 | 0 | 19.80 | 50.49 | 15.84 | 5.94 | 6.06 | 27.27 | | | 3.060 | .425 | 655 |
| S3 W73 | 0 | 22.47 | 39.33 | 30.34 | 5.62 | 4.65 | 55.81 | | | 2.070 | .242 | 915 |
| S5 W74 | 0 | 33.15 | 42.93 | 14.13 | 5.98 | 7.01 | 59.15 | | | 2.591 | .482 | 1360 |
| MEAN OF 4 | | 25.16 | 46.57 | 17.09 | 7.41 | 6.81 | 54.60 | 00.00 | 00.00 | 2.519 | .434 | 875 |
| S1 W73 | 0-13 | 56.25 | 19.79 | 13.54 | | 1.30 | 25.97 | 55.84 | | 1.247 | .107 | 1145 |
| S1 W74 | 13 | 31.37 | 50.98 | 31.37 | | 4.00 | 10.00 | 48.00 | | 4.080 | .251 | 505 |
| S3 W74 | 10 | 49.49 | 17.17 | 17.17 | | 1.49 | 71.64 | 14.93 | | 1.478 | .187 | 825 |
| S4 W74 | 12 | 40.59 | 44.55 | 12.87 | | 2.46 | 9.88 | 64.20 | 8.64 | 1.249 | .255 | 725 |
| S5 W74 | 12 | 41.17 | 43.14 | 13.73 | | 8.33 | 8.33 | 38.88 | 1.38 | 2.833 | .429 | 815 |
| S6 W74 | 0-13 | 47.19 | 38.20 | 10.11 | | 4.92 | 32.79 | 42.62 | | 1.459 | .209 | 810 |
| S5 W74 | 13 | 35.24 | 52.38 | 8.57 | | | 26.09 | | 34.78 | 4.565 | .629 | 515 |
| MEAN OF 7 | | 43.04 | 38.03 | 15.36 | 00.00 | 3.21 | 30.67 | 37.78 | 7.46 | 2.416 | .303 | 765 |
| S1 W73 | 16 | 50.96 | 25.00 | 20.19 | | 2.74 | 12.33 | 75.34 | 5.48 | 1.425 | .376 | 1570 |
| S1 W74 | 13-20 | 65.00 | 19.00 | 16.00 | | 1.37 | 5.48 | 89.04 | 2.74 | 1.370 | .127 | 7025 |
| S5 W74 | 13-23 | 71.74 | 13.04 | | | 1.72 | 39.65 | 44.83 | | 1.586 | .528 | 550 |
| S15 W50 | 20 | 76.47 | 11.76 | 10.78 | | | 3.35 | 93.30 | .48 | .488 | .508 | 2495 |
| S15 W90 | 20 | 67.00 | 19.00 | 14.00 | | .65 | 7.19 | 86.93 | 1.96 | .654 | .561 | 785 |
| S15 W90 | 20-30 | 61.61 | 14.14 | 22.22 | | | 14.28 | 74.79 | | .832 | .239 | 1020 |
| MEAN OF 6 | | 65.46 | 16.99 | 13.87 | 00.00 | 1.08 | 13.71 | 77.37 | 1.78 | 1.059 | .309 | 2240 |
| S1 W74 | 30 | 100.0 | | | | | 3.20 | 00.85 | 2.05 | .228 | .674 | 1935 |
| S1 W74 | 30-40 | 94.00 | 6.00 | | | | 14.84 | 67.58 | 12.09 | .549 | .330 | 950 |
| S5 W74 | 23-33 | 76.74 | | 10.46 | | 2.93 | 7.88 | 71.17 | 8.78 | .191 | .328 | 1190 |
| S15 W50 | 30 | 100.0 | | | | | 5.72 | 77..03 | 6.96 | .249 | .747 | 2685 |
| S15 W90 | 30 | 95.00 | 3.00 | | | .66 | 14.10 | 69.51 | 13.11 | .328 | .313 | 1160 |
| S15 W90 | 30-40 | 96.97 | | | | .97 | 19..69 | 61.29 | 12.90 | .212 | .428 | 1085 |
| MEAN OF 6 | | 93.78 | 1.50 | 1.74 | 00.00 | .76 | 10.90 | 72.91 | 9.32 | .298 | .470 | 1500 |

Table II. Interpretable Pollen Statistics

| Excavation Unit | cm depth b.s. | Quercus | Magnolia | Platanus | Ginkgo | Ceratia | Gramineae | Chenopod-innae | Ambrosieae | AP/NAP Ratio | Unidentifiable Fragments/TLP Ratio | pollen Concentration per c c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 W74 | 0 | 25.25 | 53.53 | 8.08 | 12.12 | 9.52 | 76.19 | | | 2.357 | .588 | 565 |
| S1 W73 | 0 | 19.80 | 50.49 | 15.84 | 5.94 | 6.06 | 27.27 | | | 3.060 | .425 | 655 |
| S3 W73 | 0 | 22.47 | 39.33 | 30.34 | 5.62 | 4.65 | 55.81 | | | 2.070 | .242 | 915 |
| S5 W74 | 0 | 33.15 | 42.93 | 14.13 | 5.98 | 7.04 | 59.15 | | | 2.591 | .482 | 1360 |
| MEAN OF 4 | | 25.16 | 46.57 | 17.09 | 7.41 | 6.81 | 54.60 | 00.00 | 00.00 | 2.519 | .434 | 875 |
| S1 W73 | 0-13 | 86.25 | 19.79 | 13.54 | | 1.30 | 25.97 | 55.84 | | 1.247 | .167 | 1145 |
| S1 W74 | 13 | 31.37 | 50.98 | 31.37 | | 4.00 | 40.00 | 48.00 | | 4.080 | .251 | 505 |
| S3 W74 | 10 | 49.49 | 17.17 | 17.17 | | 1.49 | 71.64 | 14.93 | | 1.478 | .167 | 825 |
| S4 W74 | 12 | 40.69 | 44.55 | 12.87 | | 2.46 | 9.88 | 61.20 | 8.64 | 1.249 | .255 | 725 |
| S5 W73 | 12 | 41.17 | 43.14 | 13.73 | | 8.33 | 8.33 | 38.88 | 1.38 | 2.833 | .420 | 815 |
| S5 W74 | 0-13 | 47.19 | 38.20 | 10.11 | | 4.92 | 32.79 | 42.62 | | 1.459 | .209 | 810 |
| S5 W74 | 13 | 35.24 | 52.38 | 8.57 | | | 26.09 | | 34.78 | 4.565 | .029 | 515 |
| MEAN OF 7 | | 43.04 | 38.03 | 15.36 | 00.00 | 3.21 | 30.67 | 37.78 | 7.46 | 2.416 | .303 | 765 |
| S1 W73 | 16 | 50.96 | 25.00 | 20.19 | | 2.74 | 12.33 | 75.34 | 5.48 | 1.425 | .376 | 1570 |
| S1 W74 | 13-30 | 65.00 | 19.00 | 16.00 | | 1.37 | 5.48 | 89.04 | 2.74 | 1.370 | .127 | 7025 |
| S5 W74 | 13-23 | 71.74 | 13.04 | | | 1.72 | 39.65 | 44.83 | | 1.586 | .528 | 550 |
| S15 W50 | 20 | 76.47 | 11.76 | 10.78 | | | 3.35 | 93.30 | .48 | .489 | .5[illegible] | 2495 |
| S15 W90 | 20 | 87.00 | 19.00 | 14.00 | | .65 | 7.10 | 86.93 | 1.96 | .654 | .541 | 785 |
| S15 W90 | 20-30 | 61.61 | 14.14 | 22.22 | | | 14.28 | 74.79 | | .832 | .239 | 1020 |
| MEAN OF 6 | | 65.46 | 16.99 | 13.87 | 00.00 | 1.08 | 13.71 | 77.37 | 1.78 | 1.059 | .309 | 2240 |
| S1 W73 | 30 | 100.0 | | | | | 3.20 | 90.85 | 2.05 | .228 | .674 | 1935 |
| S1 W74 | 30-40 | 94.00 | 6.00 | | | | 14.84 | 67.58 | 12.09 | .549 | .330 | 950 |
| S5 W74 | 23-33 | 76.74 | | 10.46 | | 2.93 | 7.88 | 71.17 | 8.78 | .191 | .320 | 1190 |
| S15 W50 | 30 | 100.0 | | | | | 5.72 | 77..03 | 6.96 | .249 | .747 | 2685 |
| S15 W90 | 30 | 95.00 | 3.00 | | | .66 | 14.10 | 69.51 | 13.11 | .328 | .313 | 1160 |
| S15 W90 | 30-40 | 96.97 | | | | .97 | 19.68 | 61.29 | 12.90 | .212 | .428 | 1085 |
| MEAN OF 6 | | 93.78 | 1.50 | 1.74 | 00.00 | .76 | 10.90 | 72.91 | 9.32 | .298 | .470 | 1500 |

Table II. Interpretable Pollen Statistics

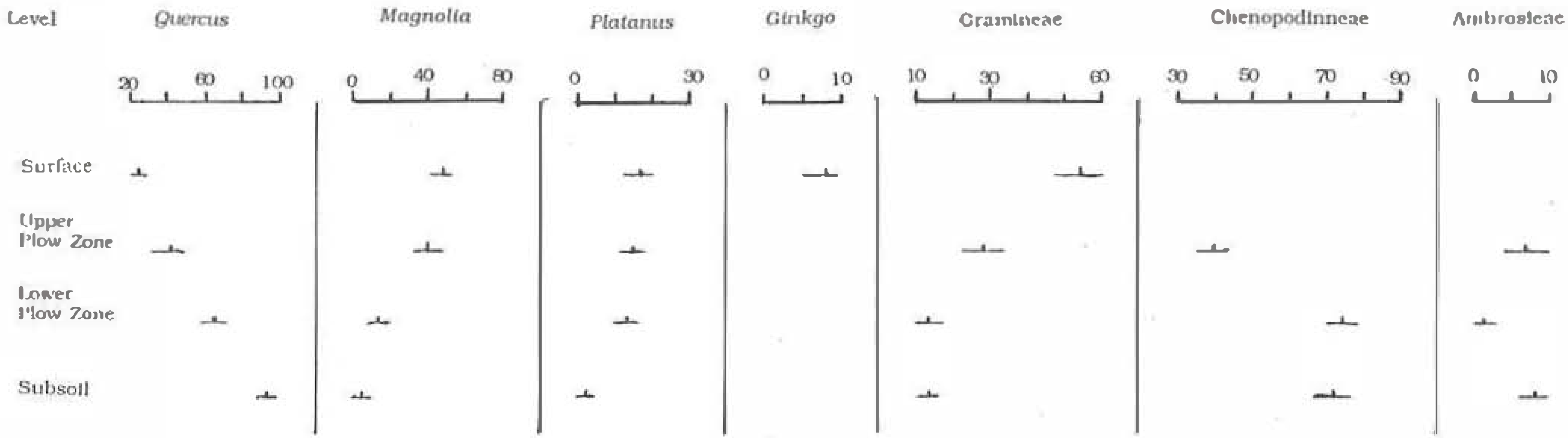


Figure 1. Sequence of Sample Population Means and 95% Binomial Confidence Intervals

Table II expresses the pollen frequency values of the simplified data set as well as other interpretable pollen values. It also presents mean values for the populations of samples of equivalent antiquity -- as that is expressed by equivalent stratigraphic position. As illustrated by Figure 1, certain very clear data patterns emerge when the means are plotted by relative antiquity. There is a decreasing trend in the value for Quercus pollen through time which is compensated by an increasing value trend for Magnolia pollen, and a decreasing value trend for Chenopodinneae pollen which is partly compensated by an increasing value trend for Gramineae pollen. Ambrosieae pollen, which occurs in significant frequency in the youngest population, occurs in a frequency which could be a result of chance in any younger population. Alternatively, Ginko pollen, which occurs in significant frequency in the youngest population, does not occur at all in any earlier population. Though Platanus pollen does not occur in significant frequency in the oldest population, it occurs in a statistically comparable significant frequency in each of the younger populations.

Other pollen statistics are also organized as interpretable patterns. The mean pollen frequency of Ceralia pollen does not reach statistically significant proportions in any sample population, but increases substantially in the two youngest populations. The mean ratio of arboreal to non-arboreal pollen increases through time. The mean value for pollen concentration varies significantly in the different populations but presents no time-dependent trend. The mean ratio of unidentifiable pollen fragments to the total of observed land pollen (TLP) does not vary significantly from population to population.

Interpretations

Interestingly, the most clearly evidenced interpretation of these data is the one that was least expected. Field observations confirm that the sediments of the plowzone stratum have been bioturbated as a result of human technology, and lead to the expectation of a number of affects on the pollen record they could contain. First, repeated vertical displacement of soil particles and inclusions by systematic plowing would expectably homogenize and randomize the distribution of pollen grains trapped in the deposits as the stratum aggraded; so one would expect a lack of sequential patterning in the pollen records of samples recovered from the stratum. Second, aeration of the deposits resulting from plowing would expectably introduce the oxygen and water required by organisms that feed on pollen grains; so one would expect pollen concentration values (which normally decline with depth anyway) to be substantially reduced in plowzone stratum samples. Third, the friction and abrasion of soil particles one against another engendered by plowing would expectably cause sufficient breakage that plowzone stratum samples would contain a larger fraction of unidentifiable pollen fragments. None of these expectations match the reality of the observed pollen records. Indeed the maintainence of pollen frequency trends initiated in the subsoil stratum through the plowzone stratum which terminate in the surface stratum sample populations cannot be reconciled with a presumption of significant bioturbation of the plowzone deposits.

Given the field evidence that plowing has actually occurred, two alternative interpretations can account for the trends illustrated on Figure 1. The pollen which was originally trapped in the deposits of the stratum may have been destroyed as a result of plowing, and the observed pollen invested in the stratum since its surface was stabalized. Alternatively, plowing may have occurred so rarely that it afforded no opportunity for significant displacement, destruction or breakage of the pollen it trapped while aggrading.

The first alternative is attractive, and could theoretically occur through the process of pollen downwash (see Dimbleby [1985: 1-17] for a thorough discussion). This process is thought particularly to affect the pollen content of terrestrial deposits in regions of temperate climate at localities where soil formation is takes place. However, pollen downwash appears to follow a predictable and specific pattern. As pollen assembleges which accumulate on the surface of a stratum are forced to progressively deeper levels by the leaching action of rainwater, pollen destruction also takes place. Thus though the pollen assembleges of deeper levels are more ancient than those of higher levels, pollen concentration decreases with depth and the fraction of damaged pollen grains in the assemblege increases with depth in downwashed pollen records. As Table II documents, the samples collected at greater depths at the Track Site have higher pollen concentration values and do not contain a distinctive pollen fragments ratio. Thus though pollen downwash could theoretically have created the sort of data patterns expressed on Figure 1, the evidence before us suggests it did not. The alternative interpretation is therefore more acceptable.

A second interpretation that is quite clearly evidenced by the palynological record relates to the question of the nature of paleoenvironmental conditions occurring at the site since deposition of the oldest (subsoil) pollen sample population. The site today is occupied by a softwood (pine) plantation of approximately ten years antiquity. Yet there is no significant quantity of pine pollen in the surface stratum samples which are presumably exposed to the pollen rain produced by this vegetation type. This may occur because the plantation's trees do not produce and disperse sufficient pollen, or because the surface stratum samples do not trap or preserve it. But if either of those conditions prevailed one would expect the pollen observed in the samples to index the sort of vegetation that occupied the site prior to the plantation's existence. That vegetation type is not precisely known. It is thought that the site was a cultivated area prior to its use as a plantation, but if not it was probably a district of mainland or mixed hummucks vegetation dominated by species of Gramineae, Chenopodiaceae, and Tubuliflorae with Magnolia, Pinus, Quercus and Myrica (which produces Coryloid pollen) in the open upper canopy. Neither sort of vegetation pattern is suggested by the pollen records of the surface or upper plowzone sample populations.

Traditionally, the significance of palynological research in paleoenvironmental interpretations undertaken in Quaternary studies lies in the opportunity pollen analyses provide to allow reconstructions of the vegetation patterns that existed in ancient times. As Faegri and Iverson (1975:123-127) recognize, and as Dean has commented upon recently (Dean 1988:143), the theoretical basis for such reconstructions is acceptence of the argument that a definable mathematical relationship exists between the numbers of plants at a locus which produce pollen of a given type and the number of preserved pollen grains of that type which are recoverable in a sample of the pollen rain deposited at the locus. It seems intuitively obvious that if two plant taxa (for example *Pinus* and *Quercus*) produce quantities of pollen of even roughly similar orders of magnitude, and if one taxon is very much more abundant than the other at a location, the abundant taxon will necessarily contribute more pollen to the locale's pollen rain. The preserved index of that pollen rain recovered from a sample of sediment which aggraded at the time the pollen rain was deposited might contain a relatively lower frequency value for the more abundant taxon because its pollen is less widely dispersed or less easily preserved. Yet a mathematical relationship would still occur, and awareness of the pollen dispersal mechanisms of the taxa and awareness of the potential of the sampled deposits to preserve pollen types should allow reasonable vegetation pattern interpretation of the observed frequency and ratio values of pollen samples and sample populations.

The controlled data of the Track Site samples and sample populations belie this theory. *Pinus*, *Quercus*, Gramineae, Chenopodinneae and Ambrosieae pollen are all dispersed widely by very prolific pollen producers; *Magnolia*, *Platanus*, Ceralia and *Ginko* pollen are dispersed over narrow ranges by moderately prolific pollen producers. If the theory is applicable and pollen preservation processes did not differentially affect the former suite of pollen types, they should always occur more prominantly in the most recent

Track Site pollen samples than they do.

The evidence that differential preservation of those pollen types has <u>not</u> occurred in the surface and upper plowzone deposits is particularly clear. First, there are sufficient numbers of examples of samples in each of these populations to document that no statistically significant variations occur in the pollen frequency or ratio values within a population that are not attributable to local overrepresentation error, despite the horizontal dispersal of members of a population. This could only occur if the process of differential pollen preservation was occurring in a fashion which would have statistically identical effect throughout the site locale. Since differential pollen preservation would be an effect of highly localized geochemical and geophysical conditions, such an occurrence is not very likely. Second, the ratio of pollen fragments to total identified pollen is generally acknowledged as an index of pollen preservation, as is the pollen concentration value (see Hall 1981). The former value is not significantly increased in the upper plowzone sample population relative to the less ancient surface sample population, and the latter value is not significantly decreased. Both would be expected, since more ancient samples have been exposed to the destructive action of differential preservation processes for a longer time.

However, deposits of the sort analyzed from the Track Site are not the sort of deposits that produce pollen records normally interpreted through application of this theory, nor are they deposits of the sort that have produced such experimental proofs as are presently accepted to support the theory (see Birks and Birks 1981:

177-192). Also, an alternative theory exists. The alternative is nowhere more explicitly stated than in my own work (Oldfield and Schoenwetter 1975:158-163; Schoenwetter and Smith 1986:181-182), but is implied in a number of palynological studies and interpretations concerned with identification of human impacts on vegetative landscapes (e.g. Hevly 1981; Behre 1981; Edwards 1982). The alternative -- which accomodates and incorporates the traditional theory -- holds that pollen records index a wide variety of ecosystem variables and ecosystem relationships of local and regional scale simultaneously. The pollen production capacities of vegetation patterns constitute an ecosystem variable which is often strongly indexed by relative pollen frequencies. But other variables and relationships are indexed as well, and may be strongly displayed by records recovered from kinds of deposits which are not traditional sources of palynological data. The pollen records of samples recovered from archaeological context deposits -- that is, from deposits at loci displaying material culture evidence for the prior occurrence of cultural behavior -- are particularly likely to display strong indices of human impacts on the local or regional ecosystem; certainly, they are likely to display such indices more strongly than samples collected from deposits which aggraded at locations where no direct evidence of local cultural activity is observable.

Acceptance of this alternative theory of the nature of palynological records supports assessment of sequential pollen record changes at a locality in ecosystem terms. Basically, one considers the frequency value for a pollen taxon to be a reflection of the taxon's relative capacity to adapt to ecosystem characteristics which existed at the time of deposition of the record. A sequential trend in which the proportion of arboreal pollen increases relative to non-arboreal pollen would be interpreted by traditional theory as an index of progressive canopy closure. It would be interpreted by the alternative theory as evidence that the direction of ecosystem change over time increasingly favored the adaptive requirements of upper canopy taxa relative to lower canopy taxa. Vegetation at the location may have exploited the ecosystem advantages so provided. But evidence for that conclusion is not provided by the AP:NAP ratio.

Application of the alternative theory for interpretation of the results of the analysis of the Track Site samples suggests that as aggradation of the sampled deposits proceeded, the ecosystem of the locale progressively diverged from that today represented by mixed and mainland hummock plant communities towards one represented by areas that support mixed (perhaps successional) mesophytic forest communities. Also, it progressively diverged from conditions favorable to the requirements of lower canopy species adapted to disturbed habitats towards those which favored lower canopy species adapted to stable soil surfaces. The nature of the record argues against the interpretation that these ecosystem change trends were induced by climatic, weather or sea-level modifications with the passage of time. The two taxa occurring in the records which are most specifically adapted to elevations of water table are Alnus and Coryloid (potentially Myrica) pollen. Neither taxon is represented by a statistically significant presence in any population.

There is a body of palynological evidence generated by the analysis which addresses the question of the interval of time during which the sampled deposits aggraded and trapped the pollen records observed. Though <u>in situ</u> evidence for prehistoric occupation of the site is minimal, both the numbers and wide distribution of prehistoric archaeological remains suggest the deposits of the plow zone stratum probably aggraded prior to or during Late Woodland and/or Mississippian times, when prehistoric occupation occurred. It would be reasonable to hypothesize that plowing occuring during the historic period invested much more recently manufactured items to relatively deep positions within that stratum. Plowing may also have maintained an unstable, erodable, surface from which soil particles and pollen would be washed and blown away, producing an unconformable contact between the modern surface and the plowzone strata.

The observed pollen record cannot be reconciled with such a reconstruction. It suggests deposition has been continuous and vertical displacement of sediment particles or inclusions has been minimal. The common and intimate association of historic and prehistoric period material culture at the site is thus more likely to be a result of aggradation of the plowzone stratum within historic time, with artifacts of both prehistoric and historic occupations transported to the site from another location. This interpretation is suggested by the consistant presence of Ceralia pollen throughout and below the plowzone stratum and the absence of maize pollen, and by the potential probability that the decline in palynological indices of habitat disturbance has resulted from a decline in agricultural land use in the area during the past 50 - 100 years.

Palynological evidence to address the question of the calendric position of the oldest population of pollen records is not very substantial. The statistical insignificance of _Ambrosia_ pollen suggests, however, that those samples trapped a pollen rain which post-dates the "_Ambrosia_ rise" phenomenon occurring in many regional pollen sequences (e.g. Cridlebaugh 1984), which is thought to be a product of original forest clearance. The implication is an 18th century date. The fact that the subsoil samples population is the only one which contains statistically significant quantities of Ambrosieae pollen and the surface samples population is the only one to contain significant quantities of _Ginko_ pollen may also be relevant to the dating question. From an ecosystem perspective, the Ambrosieae data (potentially produced by _Xanthium_, the cocklebur) may evidence the habitat disturbance occasioned by large-scale construction activities initiated during this century for emplacement of airport facilities. The _Ginko_ data may evidence effective reforestation of a substantial portion of the area by tree plantings in recent housing developments.

## Summary and Conclusions

The pollen sampling strategies employed at the Track Site maximized opportunities to examine the palynological record in a variety of archaeologically significant ways. When excavation revealed that the site had characteristics which were not predicted at prior stages of archaeological work, use of the additional strategies generated suites of sediment samples that were relevant to the study of a different palynological problem than had been originally identified as the purpose of the pollen analysis.

The research focus of the pollen work changed from concern with the relative and/or absolute antiquity of prehistoric occupations at the site to production of evidence allowing interpretations of paleoenvironmental change. It was anticipated that research on this problem might be complicated by the potential for stratigraphic pollen displacement in the plowzone stratum, so a series of samples was selected for analysis that would allow the character of such difficulties to be clearly assessed. A population of samples recovered from the modern surface stratum was also selected, to allow evaluation of the degree of variability among samples of a singular interval of time and to provide empirical documentation of the relationship between a known vegetation pattern and the preserved pollen rain which ostensibly represents it.

Analysis of 23 samples was achieved within the temporal constraints of the study. The evidence suggests:

(1) There has been no vertical displacement of pollen rain assembleges trapped during the aggradation of the sampled deposits. The most probable interpretation of this situation is that the plowzone stratum was rarely plowed prior to the recent establishment of the pine plantation which now occurs at the site. The historic and prehistoric period artifacts observed in this stratum, then, are not associated one with another because of vertical (downward) displacement of younger cultural materials. Both the historic and prehistoric items seem to have been transported to the site with the aggrading sediments, and were trapped (like the pollen) as inclusions within historic times.

(2) There is no statistically significant variability among the pollen records of the population of surface stratum sediment samples, and no obvious relationships between the proportions of observed pollen types and the proportions of taxa in the vegetation patterns likely to be represented by the surface and upper plowzone pollen records. To the degree that the present is the key to the past, these observations strongly suggest that each sample population represents the pollen rain of a specific interval of time. Also, that the pollen values of those populations are not likely to be interpretable as indices of the types of vegetation patterns which previously occurred at the site.

(3) Application of a non-traditional theory of the significance of pollen record attributes allows interpretation of pollen record characteristics in ecosystem, as contrasted with vegetation pattern, terms. The interpretation suggested is that the observed trends in the pollen sequence index successive modification of the ecosystem of the site area with the passage of time to the adaptive advantage of a lower canopy flora which normally occupies less disturbed and more stable habitats and an upper canopy flora which normally occupies territory inland from the site's location. These changes seem unlikely to have been induced by modifications of climatic, weather or sea-level patterns, however; the evidence is more consistant with the hypothesis that they are products of changing human land use.

(4) The consistant occurrence of pollen produced by Old World cereal grasses in all sample populations provides strong evidence for the inference that all the deposits sampled at the site aggraded in historic times, and the nature of the <u>Ambrosia</u> pollen record suggests

deposition occurred after the early-to-mid 18th century. The high level of ecosystem disturbance indicated for the subsoil samples provides weak evidence for the interpretation that the upper level of subsoil at the site aggraded during the middle quarter of this century, when the Air Station was developed. The lack of pollen taxa adapted to disturbed habitat conditions, the appearance of significant quantities of Ginko pollen and the AP:NAP ratio displayed by the population means for the surface stratum samples all is consistant with the hypothesis that this stratum has been deposited since the development of residential housing districts in the site's environs. The plowzone stratum, then, may date to the 1940 - 1980 A.D. interval.

## REFERENCES CITED


Behre, Karl-Ernst
1981 The Interpretation of Anthropogenic Indicators in Pollen Diagrams. Pollen et Spores 23 (2) :225-245.

Birks, H. J. B. and Hillary H. Birks
1980 Quaternary Palaeoecology. University Park Press. Baltimore.

Cridlebaugh, P. A.
1984 American Indian and Euro-American Impact on Holocene Vegetation in the Lower Little Tennessee River Valley, East Tennessee. Ph.D. Dissertation. University of Tennessee. Knoxville.

Dean, Jeffrey S.
1988 Dendrochronology and Paleoenvironmental Reconstruction On the Colorado Plateau. In The Anasazi in a Changing Environment, edited by George J. Gumerman, pp 119-167. Cambridge University Press. Cambridge.

Dimbleby, Geoffrey W.
1985 The Palynology of Archaeological Sites. Academic Press. London.

Edwards, Kevin J.
1982 Man, Space and the Woodland Edge - Speculations on the Detection and Interpretation of Human Impact in Pollen Profiles. In Archaeological Aspects of Woodland Ecology, edited by Martin Bell and Susan Limbrey, pp 5-21. B A R International Series 146.

Faegri, Knut and Johannes Iverson
1975 Textbook of Pollen Analysis (third revised edition). Hafner Press. New York.

Hall, Stephen A.
1981 Deteriorated Pollen Grains and the Interpretation of Quaternary Pollen Diagrams. Review of Paleobotany and Palynology 32 (1) :193-206.

Hevly, Richard H.
1981 Pollen Production, Transport and Preservation: Potentials and Limitations in Archaeological Palynology Journal of Ethnobiology 1 (1) :39-54.

Hevly, Richard H., Peter J. Mehringer, Jr. and H. Yokum
1965 Modern Pollen Rain in the Sonoran Desert. Journal of the Arizona Academy of Science 3 (1) :123-135.

Moore, P. D. and J. A. Webb
1978 An Illustrated Guide to Pollen Analysis. Hodder and Stoughton. London.

Mosimann, James E.
1965 Statistical Methods for the Pollen Analyst: Multinomial and Negative Multinomial Techniques. In Handbook of Paleontological Techniques. pp 636-673. W.H. Freeman & Co. San Francisco.

Oldfield, Frank and James Schoenwetter
1975 Discussion of the Pollen-Analytical Evidence. In Late Pleistocene Environments of the Southern High Plains, papers assembled by Fred Wendorf and James J. Hester, pp 149-178. Fort Burgwin Research Center Publication 9. Ranchos de Taos.

Schoenwetter, James
1979 Appendix I: Archaeological Pollen Analysis of Copan Reservoir Sediment Samples. In Susan C. Vehik and R.A. Pailes, Excavations in the Copan Reservoir of Northeastern Oklahoma and Southeastern Kansas. Research Series No. 4, Archaeological Research and Management Center, The University of Oklahoma.

Schoenwetter, James and Landon D. Smith
1986 Pollen Analysis of the Oaxaca Archaic. In Guila Naquitz: Archaic Foraging and Early AgricultureIn Oaxaca, Mexico, edited by Kent V. Flannery, pp 179-237. Academic Press. Orlando.