

PRINCIPAL RESULTS OF  
PALYNOLOGICAL STUDIES AT  
KOSTER: SUMMARY STATEMENT

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## Abstract

The Koster pollen project, begun in the summer of 1971, involved palynological study of samples of midden and "sterile" deposits from the Koster Site; samples collected from drained floodplain lakes in the Koster Site area; and surface sediment samples from the Floodplain, the Hillslope - Talus and the Upland topographic zones between Macoupin Creek and Apple Creek. There are five principle research results:

(1) Pollen density in the Koster Site samples is very low. This leads to complications in paleoecological interpretation due to lack of replicability in the data and it leads to increased problems as regards the data return per invested dollar.

(2) The pollen records of the Koster Site and Calimus Lake clearly document that true and replicate patterns of palynological data occur. Six time-stratigraphic pollen zones, vertically segregate but horizontally replicable, can be identified at Koster. The pollen chronology serves independently to cross-check natural stratigraphic and cultural stratigraphic chronologies derived from other sorts of data.

(3) The ecological study which accompanied the modern surface sampling program provides a perspective of the phytogeography of the district which differs from that provided by Turner (1931) or Zawaki and Hausfater (1969). It suggests that while the earlier classification schemes of vegetation zonation are accurate, they were oriented towards units of regional scale which may be too gross for profitable analysis of the cultural ecological patterns evidenced at a single site or in a specific activity area. The plant resources of a zone such as the Hillslope-Talus Forest are shown to have highly patterned distributions. The zone cannot be thought of as a homogeneous plant mass towards which a uniform resource-exploitation strategy would have been effective.

(4) Various forms of paleoenvironmental analysis of the Square 8 pollen record have been undertaken, each providing somewhat distinctive results. Impressionistic assessment based upon the natural history of the pollen taxa seems to provide conclusions comparable to those approached through geomorphological study. It identifies Horizon IX as a streamside environment at Square 8, Horizons VI-VIII as indicative of prairie conditions, and Horizons I-V as indicative of a successional pattern leading to the development of a forest, then a prairie, soil. Interpretation of the Arboreal Pollen/Non-Arboreal Pollen ratio indicates the wooded or non-wooded character of the site. This agrees with the interpretation drawn from malacological data about as frequently as it disagrees. Comparison of modern and fossil pollen records through multivariate discriminant function analysis provides another format of paleoecological interpretation. This would indicate a minimum of five significant changes in vegetation pattern

through the occupational history of the site. The pollen record suggests that the interpretation of paleoecological stability at the site provided by Asch, Ford and Asch (1972) is valid in the sense they intended but is open to modification.

(5) Maize (Zea) pollen has been observed repeatedly in Horizon VI as well as in samples from Woodland horizons. There is little reason to suspect contamination of the pollen record. There is good reason to accept these records as documenting the occurrence of maize cultivation in the Archaic period of Eastern U.S. prehistory.

## INTRODUCTION

Pollen analysis is a technique for garnering information about vegetation patterns of the past. This information may be interpreted in paleoclimatic, paleoecological, cultural ecological, paleobiogeographic or other terms. Often, the interpretation based upon the data provided by the technique is also referred to as a pollen analysis. But sensu strictu pollen analysis is an information-gathering, rather than an information-interpreting, activity. The information recovered by traditional pollen analysis is only of two sorts. Pollen analysis reveals the variety of pollen types in samples taken to represent vegetation patterns of the past, and it reveals the quantity of pollen of each type in the samples. Because the pollen analyst works perforce with samples and with quantities, pollen analysis is and must be a statistical technique. A given pollen analysis should be structured to provide reasonable prospect of gathering sorts of data which are pertinent to the kinds of interpretations anticipated. Thus pollen analyses should be problem oriented, and they are most effective when they are designed as tests of explicit hypotheses.

However, it is often desirable to undertake exploratory palynological studies which are oriented not so much towards problems as towards problem areas. This is normally true when the palynologist must deal with samples of types which have not seen prior study, or samples from districts where little work has been accomplished which might point the directions of problem orientation. Exploratory studies concentrate on establishing the parameters within which statistically valid pollen analyses may be accomplished, and

only secondarily concern themselves with "results" in the sense of gathering information immediately amenable to interpretation. This is methodologically sound, because in the long run identification of parameters functions effectively to identify means for judging the appropriateness of problem orientations. Thus it is a significant objective of exploratory studies to identify the sorts of palynological data that can be acquired given present technology and the costs of obtaining such data. It is a rather less significant objective to provide statistical data controlled for the solution of specific problems.

Palynological research in the lower Illinois River Valley which had been accomplished prior to 1971 was problem oriented. number of samples from Apple Creek (Schoenwetter, 1962) was designed to demonstrate that fossil pollen records could be obtained from archaeological contexts in the area and that resultant data was significantly patterned and interpretable by reference to specimens reflecting modern vegetation patterns. Study of a larger series of samples from the Macoupin site (Schoenwetter, 1970; 1972) was designed to demonstrate that the patterned character of fossil pollen records from sites in the area could serve the purpose of construction of a fossil pollen chronology.

The present work was designed to be more flexible than the earlier studies. We were concerned with three problems areas: (a) the bases for a pollen chronology covering the period of occupation at the Koster site; (b) the relationship that might exist between a pollen chronology of the Koster site and a lower Illinois River valley regional pollen chronology; and (c) the apparent relationship of paleoecological patterns identified through pollen analysis to those identified through faunal, malacological, geomorphological,

and paleoethnobotanic analyses. The study was designed as exploratory work to identify logistical parameters for pollen analyses that are expected to be forthcoming. Thus the concern was not so much with determining the character of the Koster pollen chronology, or a regional pollen chronology, as it was with determining valid and logistically feasible means for fulfilling such objectives.

One of the research parameters used, and one which strongly influences the results, refers to the amount of time allotted to the analysis of any given sample. Very few specimens indicate that no pollen is present. But the statistical character of the technique of pollen analysis demands a quantity of pollen from each sample if interpretation is to be justified. The recovery of large numbers of pollen grains from most samples is merely a matter of time and patience. Enough sediment may be gathered, and enough pollen extracted, to fulfill given quantitative standards if one works at a sample long enough. There are three difficulties, however. First, where very few pollen grains are encountered in a unit volume of sample it is likely that some mechanisms of pollen degradation have produced this result, or else that some depositional factor active at the time the sediment was laid down was responsible for abnormal exclusion of pollen. If either of these probabilities is valid, there is reasonable prospect that the pollen which is observed is not representative of a "normal" pollen rain of the horizon of deposition, or that it is pollen which has been deposited in the sample subsequent to the loss of the original pollen rain (i.e., that the observed pollen is a contamination of the sample). Second, when the observer is required to spend many hours of unproductive microscopic analysis searching large volumes of sample for the recovery of very few pollen grains, boredom

produces research results of lower quality. Third, the human and fiscal cost per observation tends to rise in this situation to the point that research undertaken within time restrictions becomes more expensive than can be justified.

In light of the above, an arbitrary standard was established: a specimen evidencing no potential for the recovery of 40 pollen grains within two hours of viewing time, or 100 pollen grains within five hours of viewing time, was considered unproductive. When the services of a skilled observer were employed, an average minimal investment of one half hour viewing time was spent on each sample. During this period the observer surveyed approximately twenty percent of the volume of one drop of pollen-bearing matrix extracted from a sediment sample. This was approximately 10% of the area of one  $22\text{mm}^2$  microslide. If extrapolation of the results on a volume:time ratio indicated that the arbitrary standards could be met, the observer proceeded with the analysis. Otherwise the observer halted analysis of the sample at this juncture.

This particular standard was selected for two reasons. First, it was desirable to investigate as many problem areas as possible in the time provided by the research grant. To have expended more time per sample would have led to a substantial reduction in the number of samples investigated, and thus lessened the prospect of exploring more than one problem area in any adequate fashion. Second, in keeping with our primary concern of establishing research parameters, it was desirable to determine the range of variation in such factors as pollen types, pollen density and pollen preservation among samples of as many different sorts as possible.

It is well recognized that the quality of pollen counts of 100 or less observations is considered minimal. With such limited samples, the statistical

strength of many sorts of analyses becomes too low for confidence. However, it was necessary to strike some compromise between the logistic constraints imposed upon data gathering by the pollen density of the samples and the advantages offered by the availability of data of higher inherent quality. The Macoupin study had successfully tested the hypothesis that pollen counts of either 50 or 100 observations were adequate for the development of a pollen chronology in this area. This seems also confirmed by unpublished pollen data from the Cahokia area (Schoenwetter, 1964) and southeastern Missouri (Fish, 1973). A special research program specifically designed to test the hypothesis that 50 or 100 grain pollen counts function to allow identification of vegetation patterns was undertaken as part of the Koster study. It confirmed the conclusion that such counts are adequate to the resolution of the questions presently being asked of the data.

A second arbitrary decision which affects the kind and quality of results was that made to commit the study to the analysis of samples which could be collected by people without training in pollen analysis. There is very little doubt that sediment samples collected by workers well aware of the potentials and limitations of pollen analysis, or by workers whose personal research aims were to be satisfied by the samples, would provide less grounds for suspicion as regards contamination, provenience recording, or appropriateness to the problem under investigation. But the routines of sample collection are not complex, and the basic strategy of a sediment sampling design is not esoteric. It was our decision to teach the routines and strategy to student field workers and field supervisors and to use the samples collected as a normal routine of archaeological field work. Internal consistency indicates that this decision has not created biased palynological data.



The principle "cost" of this decision has been to provoke suspicion that that the maize pollen observed in Horizon VI is contaminant pollen. However, it should be recognized that no technique of sample collection is known which provides samples virtually free of suspicion of contamination. At least, this is true for sediment samples of the size involved here. Also, contamination can occur during the process of pollen extraction or during preparation of the pollen for microscopy. So it is the degree of probability that contamination has occurred in a given case which is at issue, not the possibility or impossibility of contamination. Consistency among samples, each of which is open to different sorts of contamination, tends to be the strongest argument that contamination has not occurred. This is true irrespective of the skill of the sample collector.

#### RESULTS

To date we have undertaken analysis of 85 samples from Square 8 at Koster; 19 samples from other squares representing horizons VI, VII, and VIII at Koster; 10 samples from Calimus Lake (now drained) on the flood-plain just below Koster; and 95 specimens of the modern soil surface in the area east of Illinois River between Macoupin Creek and Apple Creek.

Samples from the Koster site were collected from proveniences which can be associated with specific bodies of artifactual and non-artifactual data. All samples we have analyzed to date were collected from exposed profiles by field supervisors. The samples from Calimus Lake were collected with a two-inch truck-mounted hydraulic soil sampler. Another set of cores was collected from Reddish Lake (now drained) just east of the Macoupin site, but samples of

this series have not been investigated.

The goal of the surface sampling program was the recovery of five samples from each of the plant associations found in the study area. Disturbed and undisturbed, and successional as well as climax associations, were sampled. Numerical data was obtained on the nature of the over-canopy and the under-canopy at each sampling locus and a qualitative assessment of herbaceous ground cover was also made. The size of plot was variable. Plots were no less than 15 x 15 meters but maximal plot size was determined by the requirement that at least 30 over-canopy trees be included in the area of the sample. Surface sediment was collected by the "pinch" method of obtaining a minimum of ten to a maximum of 20 sub-samples dispersed over the plot. Samples were collected at the base of the leaf litter at the upper point of mineralization of humus.

1. Pollen density in the Koster Site samples is very low, while pollen density in the Calimus Lake samples is very high. This is not unexpected. It is probably an effect of more rapid deposition at Koster, with consequent entrapment of less pollen per unit volume of sediment. The greater probability of pollen degradation in a terrestrial (as opposed to an aquatic) also probably plays a significant role. About one third of the Square 8 samples provide sufficient pollen to meet our arbitrary standard of "acceptably polliniferous". However, a significant portion of the acceptable samples from Square 8 are samples from Horizons I-IV. If only Horizons VI-XI are considered, the proportion of acceptable samples is much lower. Only about 25% of the samples of this group provide 40-100

Because of the pollen density problem, even a very large investment of time and energy provides only a few acceptable pollen counts. Working

full-time at extracting and analyzing sediment samples from Horizons IV-XI at Koster, a technician could probably not average an accumulation of more than 20 pollen

2. The samples collected from Horizon VI and Horizon VIII in other squares compare favorably with those collected from these Horizons at Square 8. Since the Horizon VI pollen spectra differ from those of Horizon VIII in the same directions in both cases, it would appear:

(A) true patterns of palynological record exist which are replicable horizontally at specific time-stratigraphic units of the site; and

(B) true patterns of palynological record exist which isolate one time-stratigraphic unit from another vertically within the site.

Thus a pollen chronology can be developed for the Koster site. This serves as an independent cross-check on natural stratigraphic, biostratigraphic and cultural stratigraphic chronologies derived on other grounds.

3. The Calimus Lake pollen records provide a pollen chronology distinct from that of the Koster Site. Calimus Lake seems to offer a palynological record more closely attuned to regional paleoenvironmental events while the Koster pollen chronology seems more a reflection of paleoenvironmental conditions within a limited district of the Hillslope-Talus topographic zone. The differences between the pollen records of the two sites are sufficiently great that the Calimus chronology provides no point of reference for analysis of portions of the sequence missing at Koster by virtue of poor pollen density.

However, pollen density in the Calimus Lake deposits is very high, and pollen preservation far excels that of the samples from the Koster Site.

There is every reason to expect that pollen records from floodplain and upland lakes would be easily obtained and cross-correlated. This would allow development of a regional pollen chronology.

4. The surface sampling program undertaken in the summer of 1971 was preceded by a qualitative plant ecological study of floral diversity. This work identified the occurrence of about 20 segregate plant associations in the eastern valley area surrounding Koster and Calimus Lake. Once the associations had been identified, quantitative data on the relative frequency of upper and lower canopy trees was gathered at replicate locations where each of the associations could be observed. A statistically valid sample was not the objective of this work, merely a quantified index to the character of the associations which had been subjectively appraised.

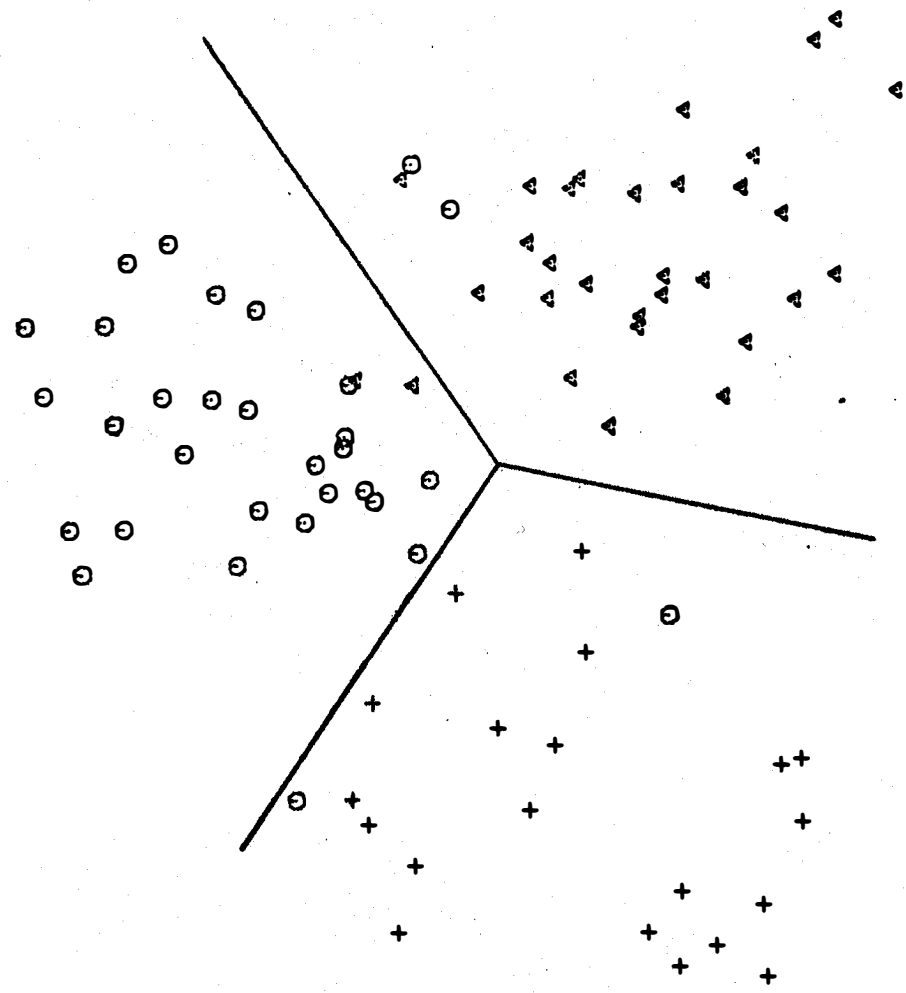
There seems reason to believe that the phytogeographic patterns of the lower Illinois River valley are far more complex than the work of Zawaki and Hausfater (1969) was able to suggest. Many of the plant associations observed are obviously functions of successional sequence or disturbance. On the east side of the valley, the maple-oak plant association is the most widespread climax association of the Hillslope-Talus Zone. But climax associations of prairie, oak-hickory and oak-cedar also occur with consistent distributions in this zone, and there seems to be a segregate pattern for floras of the type that occur with springs or streams tributary to the main creeks. It is likely that yet other climax associations occur on the west side of the valley. Such botanical study indicates that the Zawaki-Hausfater classification of vegetation patterns in the valley area is but one of a series of possible classifications. There may be substantial profit for paleoecological and for cultural ecological studies in consideration of

9.40  
9.20  
9.00  
8.80  
8.60  
8.40  
8.20  
8.00

**LEGEND**

- + FLOODPLAIN
- ▲ HILLSLOPE-TALUS
- ⊙ HIGHLANDS

**FIGURE 1.**



5.00 5.20 5.40 5.60 5.80 6.00 6.20 6.40 6.60 6.80 7.00  
ROOT 1

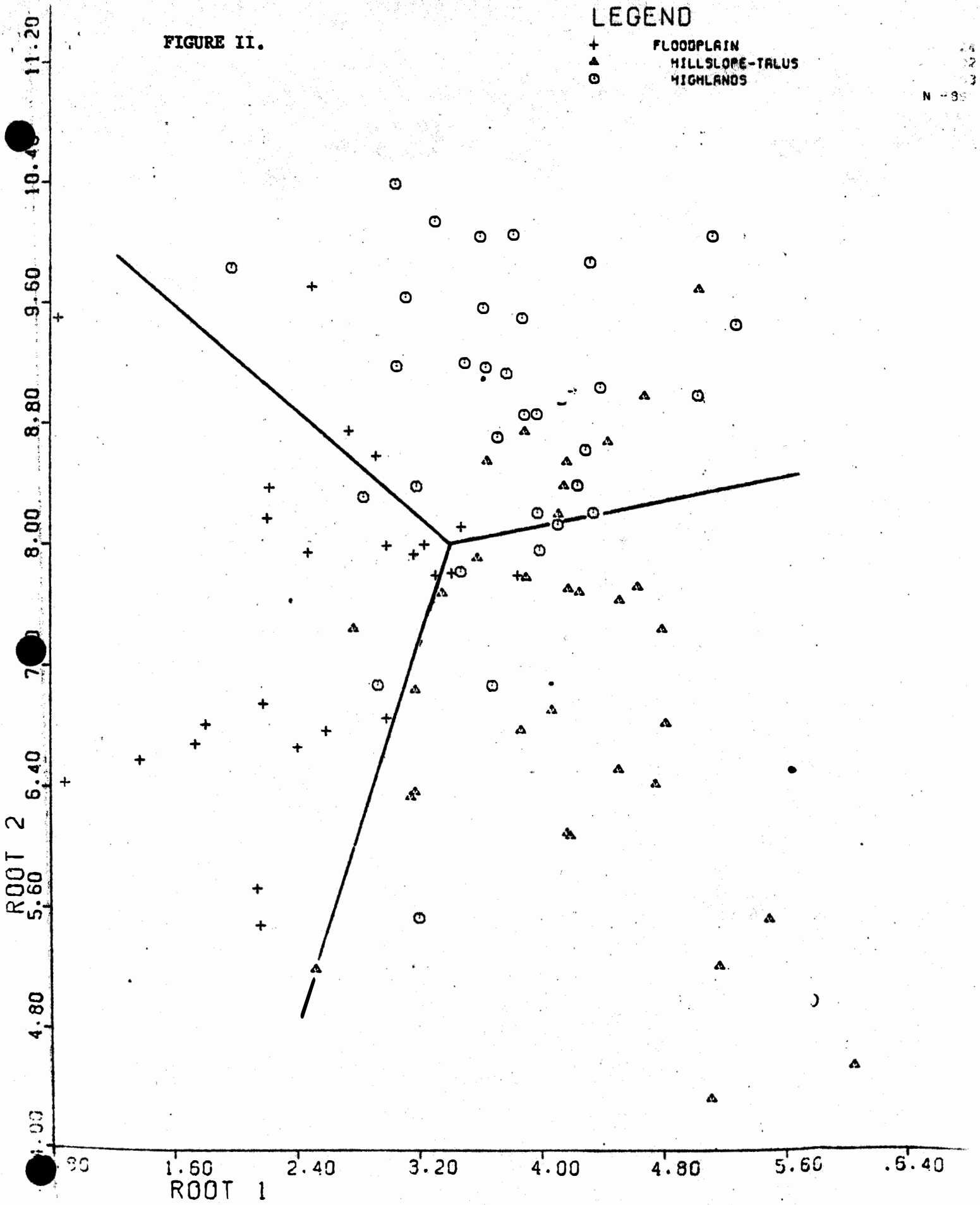
TOPOGRAPHY - SURFACE SPECIES

FIGURE II.

LEGEND

- + FLOODPLAIN
- ▲ HILLSLOPE-TALUS
- HIGHLANDS

N-95



TOPOGRAPHY ARCH SPECIES

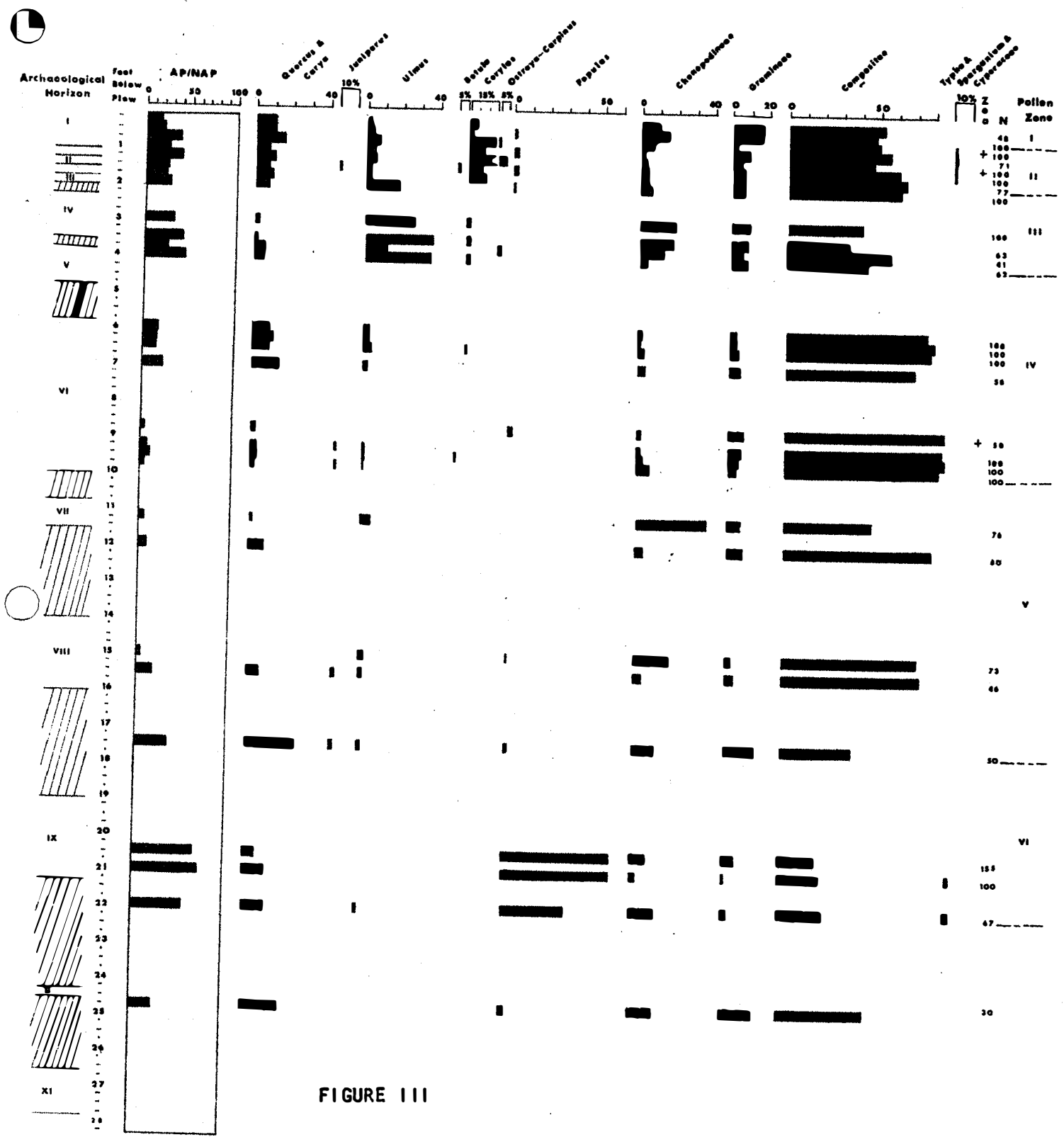


FIGURE III

the Hillslope-Talus Zone as a suite of plant associations having patterned distributions rather than as a fairly homogeneous (though species-variable) plant community.

5. The modern pollen rains of the various plant associations turn out to be generally segregate. Discriminant function analysis immediately serves to identify pollen rains of the three topographic zones from those of other zones, for example (Figure 1). Certain plant associations may be uniquely characterized by their pollen rains; other associations - particularly successional associations - are not easily distinguished. Generally speaking, however, discriminant function analysis allows one to recognize any given modern sample of pollen rain as deriving from a very limited possible series of plant associations. This is true even when one restricts analysis to the eleven pollen taxa most frequently encountered in fossil pollen rains (Figure 2). Application of the principle of uniformity thus allows interpretation of fossil pollen rains by reference to the patterns evidenced in the pollen rains of modern plant associations.

6. The record of Square 8 at Koster is divisible into six pollen zones identified by frequency variations in the pollen types (Figure 3). The lowermost of the productive samples derives from a point 24.75 feet below the base of the plow zone, just below Horizon X. Samples from Horizon XI in Square 8 yield insufficient pollen for analysis.

Paleoclimatic interpretation of the zonal pollen record indicates the following:

(A) The period represented by the deposits of Horizons I-IV was a period of wetter environment than occurs at Koster today.



(B) The period of Horizon VI was drier.

(C) The period of Horizons VII and VIII apparently was one of oscillations in temperature-moisture balance, though the paucity of records and some internal evidence suggest some of these apparent oscillations are effects of cultural practices.

(D) The period of Horizon IX was wetter. However, this may be a function of local stream conditions in the vicinity of Square 8 rather than general climate.

(E) The single sample below Horizon X appears much like one of the samples of oscillating conditions in Horizon VIII. But climatic interpretation cannot be justified on the basis of a single specimen.

7. One form of paleoecological interpretation of the Koster record is accomplished through a multivariate discriminant function analysis. This involves comparison of modern surface samples representing known ecological patterns with the samples of the fossil record. The results are no doubt biased by the small number of surface samples representing any specific modern plant association. However, the conclusions derived may be considered well-justified hypotheses for future testing. Present indications are that:

(A) The uppermost pollen records from Horizon I reflect a Floodplain Forest or Riverside Forest plant community.

(B) The remainder of samples from Horizons I through IV represent plant associations not sampled in the modern series. Presumably these would be some associations of Floodplain Forest or very mesic Hill-Talus plant associations. They could be successional associations precedent to Floodplain Forest.

(C) The samples from Horizon VI at Square 8, and also from Horizon VI at Square 122, represent the sorts of plant associations today found along

streams tributary to Apple Creek or Macoupin Creek in the Upland topographic zone.

(D) The samples from Horizons VII and VIII are much like those collected at present from fallow field (highly disturbed) or tributary stream plant associations.

(E) The samples from Horizon IX are most like those collected at the margins of floodplain prairie environments where brushlands occur transitional to floodplain forests.

Discriminant function analysis of the Calimus Lake record indicates:

(A) Pollen records of the upper 50 cm. reflect relatively open conditions around the lake, such as are today observed in brushland associations marginal to floodplain prairie or successional precedent to Floodplain Forest. Three of the four samples involved were collected from the plow zone.

(B) Pollen of the 60-100 cm. levels reflect the local occurrence of Hillslope-Talus Forest.

(C) Pollen of the 120 and 140 cm. levels reflects the local occurrence of Floodplain Forest of a wet variety.

(D) Pollen of the 160 cm. level is like that of the 60-100 cm. level.

(E) Pollen of the 178 cm. level is like that of the upper 50 cm.

Comparison of the two pollen chronologies indicates paleoecological correlation of the 60-100 cm. level at Calimus with the samples from Horizon VI at Koster. This is presented as a hypothesis for testing, not as a conclusion from the data available.

8. More traditional forms of pollen analysis provide alternate conclusions to those derived from the discriminant function study. These analyses are

more impressionistic, and refer to other types of paleoecological reconstruction. Thus they are a poorer source of hypotheses for testing. However, they provide conclusions of the orders provided by geomorphology, archaeomalacology and paleoethnobotany.

Impressionistic assessment of the Koster pollen record based upon the natural history of the taxa observed seems to provide conclusions of the sort approached through geomorphology. This procedure identifies the high frequencies of cottonwood, walnut and willow pollen of Horizon IX as indicative of a streamside environment involving continuous flow in the immediate area of Square 8. It identifies the high frequencies of Compositae pollen in Horizons VI, VII, and VIII, and low frequencies of tree pollen, as indicative of prairie conditions. It identifies higher frequencies of tree pollen, with a shift from elm-chenopod to oak-hazel in Horizon III, as indicative of a successional pattern leading to a climax forest at Koster in the Horizon V-I interval. This would be consistent with the development of a Horizon IV soil zone. Also, this approach would identify the six inches of Horizon I just below the base of the plow zone as a prairie horizon.

Another format of interpretation involves analysis of the Arboreal Pollen/Non-Arboreal Pollen (AP/NAP) ratio for identification of horizons of wooded or non-wooded character. This provides conclusions comparable to those of the archaeomalacological series. However, the pollen record of Square 8 was collected in three inch intervals beginning at the base of the plow zone while the malacological series (Jaehnig, 1973) is measured from the ground surface.

Assuming 12 inches of plow zone, the principal wooded horizon evidenced

at Square 8 would be that located between 258 and 294 inches below the surface. This is the series of samples in which cottonwood pollen predominates. Snails from this level are too few for confident interpretation (three per liter), but those that are available may be taken in the context of snail samples of apparently contemporary deposits from other squares. The resultant interpretation is not inconsistent with a pollen interpretation of moist forest edge conditions. An AP/NAP ratio consistent with an interpretation of an opening in a forested area (such as occurs today on ridge top prairies within the Hillslope-Talus Forest) occurs at 212 inches depth. Snail data from this level are ambiguous. AP/NAP ratios indicative of non-wooded conditions occur between 84 and 198 inches. This is a horizon on which snails indicative of dry forest conditions are quite frequent. Snail data is ambiguous in the upper 72 inches of deposit, in which the AP/NAP ratio reflects reoccurrence of forest opening conditions at Square 8.

Thus there is about as much disagreement between the paleoecological reconstructions provided independently by snails and pollen as there is agreement, and much of the record is ambiguous or open to multiple levels of interpretation. It seems likely, however, that a good deal of the ambiguity and discrepancy is more apparent than real. It may derive from the different frameworks of malacological and palynological study rather than differences in evidenced interpretation.

There is a clear discrepancy between the paleoecological interpretation of the Koster paleoethnobotanical record (Asch, Ford and Asch, 1972) and that of the pollen study. Asch, Ford and Asch reconstructed a picture of essential stability of the vegetational resource zones of the lower Illinois valley

during the Archaic occupation. They recognized that climatic fluctuations might have affected the relative proportions of the resource zones, and might have varied their distributions to a degree. But they argued that no zones were likely to have been eliminated, because the zones are not so much dependent on local conditions of climate as they are functions of the topography, hydrography, and the characteristics of the district's soils. The record from Calimus Lake would appear to indicate that the distributions of resource zones have in fact varied in the past. This is also indicated by the record from the Koster site, whether interpreted through the discriminant function analysis or the assessment of the varying frequency of indicator taxa. The pollen record indicates that the kinds of plant resources in a zone have not appreciably changed to the present time. But it is unlikely that the proportions of resources to one another in any given geographic area have remained unchanged. Also, it seems that plant associations occurred in the Koster area that do not now occur in the Hillslope-Talus topographic zone.

A phytogeographic reconstruction of Horizon VI would see the plant associations now characteristic of the Hillslope-Talus Forest narrowly distributed along the base of the talus and extending onto the floodplain along drainage ways. At Koster itself, the flora of the Square 8 area seems to have been that of a streamside environment of the sort now observed in the Upland topographic zone. Trees of this habitat (ash, boxelder, hackberry, willow, cottonwood) were not common in the Koster site area, however. Most of the site seems to have been a disturbed prairie or very open brushland.

Within a one-half mile radius of the Koster site, the same kinds of plant resources and resource zones would have occurred as occur today. But their proportions would change with their distributions. The dense and extensive stands

upland oak-hickory forest that occurred directly east of the site in the 19th century probably were reduced to the status of gully margin stands at the top of the dissected slopes of the Hillslope-Talus. Oak-hickory barren was probably the most extensive resource zone of the uplands. The oak-maple association of the Hillslope-Talus forest, and the many food resources of its rich woods, would have had very limited distributions in scattered patches of terrace lands where shallow soils discouraged competition by alluvium-adapted hardwoods. The floodplain area below the site would have been the heavily wooded district, not the upland zone above. The arboreal plant associations of the immediate area of the site were probably more varied than they are today and at the same time more limited in extent. The undissected slope areas supported prairie. Gully bottoms and gully margins probably supported different strip floras, with the trees of a stand highly differentiated as adapted to greater or lesser runoff trapped by the particular gully and its heavier or lighter colluvial mantle.

Thus the pollen data both confirms and modifies the paleoecological reconstruction proferred on the basis of macrofossil remains. It confirms the reconstruction of plant resource stability in the sense that it also indicates that no kinds of plant resources or vegetation resource zones now found in the lower Illinois Valley were not found there in the past. The pollen record modifies the reconstruction of stability, however, in that it indicates that climatic changes had significant effects on the relative proportions of one resource zone to another and the relative distributions of the zones. These changes affected the proportions of one plant resource to another within a resource zone, relative to the situation we observe today. Climatic changes also affected the relative distance of given types of

vegetation resource stands from the site. Further, it is evident that phytographic patterns which existed early in the Archaic occupation changed over the period of Archaic residency at the site. Resource availability was thus quite different at different points in time.

In my opinion the difference between the reconstructions based on paleoethnobotanical and on palynological data are differences of analytic level. The paleoethnobotanical reconstruction of paleoecology was essentially directed towards the question of the character of the floras of the resource zones in the past, relative to those of today. The floras were reconstructed as essentially identical in the past to those of today. This justified the conclusion of paleoecological stability. The pollen record also indicates that the floras are essentially unchanged. There appear to have been some plant associations which existed in the past which do not exist today, but there is no indication that any resource zones were eliminated, or substantially changed, through the addition of these associations.

The pollen record offers opportunity to investigate other matters than that of the general character of the floras. It offers information about the effects on the individual taxa of the floras which resulted from climatically-induced change in the environment. At this level of analysis the general picture of stability gives way to a more particularized record of variation over space and time. The availability of hickory as a resource, for example, changed greatly over space and time though the availability of floras yielding the hickory resource did not.

Whether this difference does or does not affect the conclusions to be drawn regarding cultural ecology will depend to a great degree upon the level of analysis one is concerned with. Asch, Ford and Asch were concerned with the cultural ecology of the Archaic period population of the Koster site,

taken as a whole. In their analysis, the cultural ecological relationship at issue at the site level was whether sufficient differences occurred through time in the kinds of resources and resource zones to stimulate behavioral change in food collecting strategy. It was obvious that food collecting strategy had not in fact changed over time, but stimulus to change might have occurred as a result of major climatic changes affecting the flora of the area. Asch, Ford and Asch showed how the effect of the changes in larger climatic pattern might have been damped by local conditions so that great floristic change need not have occurred.

The pollen record indicates that climatic changes did affect the distributions and quantities of plant resources to a great degree even though it affected the floras from which they derive only slightly. The inference that must be drawn is that the adaptive relationship between the people and the floras was behaviorally maintained even though the human energy "cost" of the relationship varied over time. Thus the adaptive relationship was not a simple one in which an energy consumer (the population) undertook a direct and efficient behavior pattern for extraction of energy (plant resources) from the environment at any given time. Instead, it would appear that the energy consumers undertook a standardized behavior pattern for extraction of energy which might have been efficient under the long-term pattern of environmental conditions but was not necessarily efficient at the time the behavior was implemented. It was efficient enough for survival, of course. If it were not, there would be no record of the population. But it would seem that the real value of the behavior was not that it worked to allow survival. Rather it seems that it had value because it worked to allow survival in a particular fashion which had importance throughout the Archaic occupation.



Looked at from this perspective, we are considering the cultural ecology of the population at a quite different level of analysis. We are now not concerned with the credibility of a reconstruction of a subsistence strategy. We are concerned with the cultural significance of that strategy, having granted its credibility. The differences between what the pollen record and the paleoethnobotanical data tell us about prehistoric paleoecology and prehistoric cultural ecology, then, are not differences which arise because the one leads to conclusions contradictory to those of the other. The differences arise because the two data forms tell us about these things at different levels of analysis.

9. Zea (maize) pollen has been observed in five separate samples from the Koster site. One of these, from Square 8, occurred 0.75 feet below the base of the plow zone and a second occurred at the 1.25 feet depth. Both these samples appear to represent Woodland time horizons. The other three samples are from Horizon VI. One is from Square 8 at a depth of 8.75 feet. Zea pollen was also observed in sample 6 from Square 117 "three inches above green datum", and was observed in sample four from Square 122 "two feet above white datum". Only one maize pollen grain has been observed in each sample.

I am satisfied that the corn pollen from Horizon VI does not represent modern contamination. Every field precaution was taken when the samples were collected from Squares 117 and 122, for the discovery of corn pollen in the Square 8 series the previous year had made field personnel well aware of the contamination problem. There also seems to be little reasonable prospect that the corn pollen is a laboratory contamination, and there is no possibility of misidentification in these cases. Though about 20% more samples have been observed from Horizons IV-V and VII-X than have been

observed from Horizon VI, it is only in Horizon VI that Archaic period samples yield maize pollen. However, these constitute about 25% of the Horizon VI samples. I find it incredible that maize pollen could so selectively contaminate the fossil pollen record.

#### IMPLICATIONS OF THE RESEARCH RESULTS

1. The pollen density of samples from Horizons VI-XI at the Koster site is sufficiently low that even a very large investment of time and energy provides only a few acceptable pollen counts. Alternatively, the pollen density of the Calimus Lake deposits is high. The work at Apple Creek, Macoupin and the Woodland deposits from Koster yielded moderate to high pollen density samples. It would seem most efficient to program future palynological study in the Illinois Valley area broadly and opportunistically. Though pollen work on the Archaic horizons at Koster should be continued for the resolution of problems that can be specifically resolved at that site, it would seem logistically preferable to plan substantial palynological investment at that site in analysis of the more geologically recent deposits. Until other Archaic sites provide samples with higher pollen density, it would seem that palynological study of the Archaic horizon should be principally explored through a regional pollen chronology based upon sediment cores from lacustrine deposits in the study area.

Such a research plan probably would necessitate ancillary limnological study, and it would surely require substantial investment in radiocarbon assays ultimately. However, the plan is consistent with the regional-level concerns and goals of the overall project. Also, the palynological interests of paleobiogeographic studies underway at the Illinois State Museum are

more in line with region-oriented than site-oriented research. Research attuned to the regional format should thus make for effective cooperation to mutual benefit.

Site-oriented palynological research should be undertaken where two forms of benefit can be anticipated. First, when it is desirable to identify an intra-site chronology. As was documented in the Macoupin study, palynological patterns may provide discrimination of temporal units of a finer order than are identified through artifact type analysis. Even if such discrimination is not relevant to cultural analysis, pollen may be a useful mechanism for independently verifying the chronological relationships of horizontally stratified site components.

Second, pollen study should be employed when it is desirable to identify paleoecological conditions specific to the site environs. As at Apple Creek, it may be possible to identify seasonality of occupation. But primarily, I imagine that the pollen record would provide significant input for subsistence-settlement pattern analysis (especially if taken in the context of paleoethnobotanical and faunal analyses). Comparison of the local paleoenvironments of a series of contemporary Woodland sites through pollen analysis should prove particularly enlightening, for example. Research along these lines would be consistent with an overall archaeological program that samples a wide variety of sites in the study region. This seems one direction in which the general research program is headed, so an opportunistic strategy of palynological study seems reasonable.

2. The identification of a number of climax plant associations within certain phytogeographic zones recognized by earlier investigators opens real issues of anthropological concern. One of the principal purposes of the lower Illinois Valley research program involves testing of hypotheses

regarding man/environment relationships. Especially as this investigation demands analysis of plant resources, it is vital to our understanding of the prehistoric situation that we become knowledgeable about the nature and distribution of the ecological variables that control the frequency and distribution of those resources. For example, the hickory resource (which accounts for such a large portion of the plant food used through the Archaic at Koster) is not uncommon in the Hillslope-Talus Forest. But within one-half mile of the Koster Site today, hickory is not common as a dominant or co-dominant tree in the upper canopy. It so occurs only at upper elevations in the NE quadrant of a one-half mile radius circle centered on the North Field.

Partly, this is true because of modern land clearance, successional regrowth relative to lumbering practices over the past decades, and other cultural phenomena. But partly it is a function of the soil, slope and light qualities of plots within this circle. These qualities persist regardless of cultural practices, and over such limited spaces they are in large part slow to vary in response to all but major climatic changes. Mapping of modern plant associations provides strong evidence of the distributions of these ecological factors. Analysis of the requirements of the taxa involved provides significant clues to the nature of the habitat conditions represented. We are thus provided a means of assessing variability in the frequency and distribution of resource plants given modern environmental conditions.

The zone and forest distribution maps provided by Zawaki and Hausfater fulfill this role at present. But they do so on a regional scale. Sites as members of a settlement type may relate well to resource distribution

maps of such a scale. But individual residency areas at which tasks were performed probably do not relate to such large-scale phytogeographic units. One presumes that the resident of the Koster site who was intent on hickory harvesting directed his harvesting behavior relative to the distribution and frequency of hickory stands, not relative to the frequency and distribution of hickory as a member of a forest in the abstract sense. If we desire to deal with that behavioral system or subsystem at a site which relates to plant resources we must know in some detail not only what those resources were but in what directions and at what distances and in what frequencies they occurred.

It would seem we are in fact quite interested in such a level of detail, for the organization of the program tends to select sites for study which are believed to characterize or typify behavioral systems of certain orders. For example, Horizon VI of the Koster site seems due to serve for some time as the data base for models of the man/environment relationship during this part of the Archaic in the lower Illinois valley. It is thus of some importance that the ecological qualities of the environment of the Koster Site area (say within a two mile radius) should be observed in detail through plant association mapping. The area involved is roughly north as far as Dayton Hollow and south across the floodplain of Macoupin Creek. This kind of work should be a normal aspect of the research design of each site investigated.

3. The present is the key to the past in paleoecological research of any sort. Investigation of the nature of variability in modern pollen rains is the best tool available for modelling analyses of the meaning of pollen rains preserved from the past. The discriminant function analysis performed

for this project is the first application of this statistical technique to archaeological pollen records. The interpretations which have been drawn must be recognized as insufficiently substantiated. A far more sophisticated and statistically satisfactory program of modern surface sampling must be pursued to overcome criticism, and a more thorough and considered analysis of the applicability of the inherent assumptions of the technique must be made.

It presently appears, however, that a particularly powerful and useful technique for archaeological pollen analysis of Midwestern and Eastern pollen records has here been used for the first time. A major drawback to surface pollen sampling in these areas has been the fact that most of the territory shows the floristic result of over a century of land use. It has been generally conceded that there was little purpose to the collection of modern surface pollen records if the objective was interpretation of past pollen floras, because the disturbance factor would mask analysis of those interrelationships among the pollen types and pollen frequencies which reflect the undisturbed, "natural", condition occurring in the past.

The discriminant function analysis of surface samples of topographic zones indicates that certain identifying regularities of the pollen spectra can be isolated whether the vegetation of the collection locus is disturbed, in one of two or three successional stages, or in a climax state. Further, the "power" or "characterizing value" of these regularities are statistically evaluated by the procedure. For example, the pollen variables Ostraya-Carpinus, Quercus and Juniperus are statistically significant in discriminating the Hillslope-Talus Forest from other forests. Juniperus and Quercus

consistently have high values only in the Hillslope-Talus Forest, even though only 1/5 of the samples were collected where juniper is a common member of the stand, and 1/3 of the samples were collected at stands where oak is not a dominant or co-dominant tree. Only 1/4 of the samples were collected from the "climax" oak-maple association. Ostraya-Carpinus pollen values aid significantly in discriminating Hillslope-Talus Forest from forests of the upland topographic zone, but do not aid in discriminating this forest from those of the floodplain topographic zone.

Why these taxa should be the ones which serve to discriminate the Hillslope-Talus Forest is a difficult question to answer. Juniperus is only found in this forest, so its significance seems appropriate. But neither Ostraya nor Carpinus seem to have been as common in the flora of the Hillslope-Talus Forest as the pollen data would imply, and neither was commonly observed at the sampling localities. The higher values of oak pollen in this forest may be a function of the greater density of trees in this forest. But this issue really should be reserved until more substantial work is done.

In any case, those are the pollen data that do in fact discriminate the Hillslope-Talus Forest as represented by 24 modern surface samples. If it may be presumed that a fossil pollen record of similar order will characterize an ancient Hillslope-Talus Forest, there would appear no evidence that a Hillslope-Talus Forest occupied the Koster Site during the millenia represented below the plow zone. Such a forest does seem evidenced in the record from Calimus Lake, however, at depths of 60, 100 and 160 cm. below the modern surface. Thus Hillslope-Talus Forest cannot be said to be

excluded from the Koster record because it did not occur in the general area prehistorically. It would seem that the inhabitants of Koster specifically chose a residence location within the Hillslope-Talus topographic zone which did not support Hillslope-Talus Forest.

4. The antiquity of maize cultivation at Koster (and, by extension, in the Eastern Woodlands area) certainly is a surprising discovery. In the present state of archaeological knowledge and theory regarding the Eastern Woodlands, acknowledgement of human familiarity with maize during much of the Archaic demands that we closely question existing reconstructions of cultural adaptations and culture historical relationships. This is a great deal to ask, particularly of those who have developed coherent synthesis (e.g., Caldwell, 1958; Griffin, 1967; Willey, 1966) which are in part predicated on the assumption that direct knowledge of maize cultivation did not occur in the area until some millenia later. It must be expected that the conclusion I have drawn will be viewed with suspicion, if not outright antagonism, until most archaeologists become convinced that the case has been made air tight. Probably, this will not occur until maize or maize pollen of such antiquity has been found at other sites in the area.

A more effective case, so far as archaeologists are concerned, could be made without recourse to botanical data of any sort. The issue is a behavioral one: the behavior of cultivation. Cultivation behavior is directed towards maize in the present case, but the species towards which it is directed is less critical than the fact of the behavior itself. If evidence derived from analysis of the characteristics and the distribution of the artifactual record could be found to demonstrate the hypothesis that cultivation behavior occurred during Horizon VI, the conclusion would



be immeasurably strengthened. I recognize the challenge to archaeology of devising a means to test this hypothesis independent of the botanical record. I realize that it would be simpler to await the discovery of a carbonized seed of maize, or a cob fragment, by the paleoethnobotanist.

But archaeologists determined to relinquish the analysis of cultivation behavior to botany, because it is easier, should be content with the behavioral conclusion drawn on the grounds of the pollen record. Botanically speaking, there is no less reason to acknowledge the credibility of discovery of one grain of maize pollen than one fragment of a maize cob or one seed from such a cob. In fact, the pollen discovery is more credible. Pollen grains have genetically inherent qualities which adapt them to preservation as a fossil. No other parts of the maize plant, possibly excepting phytoliths, are so favored. Thus it is more likely that pollen which is diagnostic of maize will be recovered from an archaeological locality than any other fossil.

5. It may surprise some workers that various formats of palynological interpretation may be applied to offer means of substantiation or contrast to other forms of paleoecological analysis. This sometimes generates the charge that pollen analysis is so flexible as to be useless as a way of deriving informed conclusions about the nature of prior ecological events. But such charges ignore the fact that pollen analysis is not an information-interpreting activity; it is an information-gathering activity. It has the potential for gathering information about prior ecological and vegetation conditions at different levels of abstraction and in different formats. The proper question to ask of a pollen analysis is not whether its results tend to substantiate a conclusion. The proper question to ask is whether the technique of analysis used is appropriate to test the specific hypothesis

at issue, and (if it is appropriate) whether it is desirable to place confidence in this particular test.

The reconstruction that the environment of Square 8 at Koster during Horizon IX times was a streamside environment is plausible granting the assumptions basic to the format of analysis used. These are, essentially, that the presence of large quantities of cottonwood and willow pollen indicate the prior occurrence of large numbers of these trees. Whether this is an appropriate test of the hypothesis that the Square 8 environment was a streamside environment remains to be seen. If the geomorphological data also indicates this reconstruction, we shall probably be satisfied with its validity. But if the geomorphological record indicates that an alternative characterization of the Square 8 environment is credible, we should not be surprised or discouraged. We must remember that in point of fact the pollen study of Horizon IX at Square 8 was not problem-oriented towards the test of this hypothesis. The assumptions subtending the reconstruction may be appropriate in a general sense, but not appropriate to this case. Even if they are appropriate, it may be desirable to place more confidence in a geomorphological test of the hypothesis than in the palynological test because the assumptions basic to the geomorphological test may be better justified.

The implications of the above paragraphs are two. On the one hand, it would appear that the time has arrived to formulate specific hypotheses about the character of the paleoenvironment in the lower Illinois Valley and to design paleoecological research programs as tests of these hypotheses. On the other hand, it would appear generally profitable to so coordinate the different forms of paleoecological study that they work to test a given set

of hypotheses for which they are mutually effective.

Till now, the malacological, geomorphological, palynological, paleo-ethnobotanical and faunal analyses have been generally exploratory. Each investigator has been working at the task of determining the potentials of a given format of data to provide kinds of information about the past. Some investigators have explored certain of those potentials rather fully in order to provide paleoecological reconstructions which are well-evidenced from their data. So far, though, the tendency has been to present these paleoecological reconstructions as hypotheses for testing. Since the various analytic procedures can serve to substantiate each other, each investigator expects that another format of paleoecological research will serve to reinforce the hypotheses he has put forward.

I believe that further exploratory studies have their value in the overall research program, but the time has come to commit the general pattern of paleoecological study to the more restricted concerns of effectively testing hypotheses already established. It seems reasonable that this should be accomplished through a coordinated research design developed by those who will accomplish (or direct the accomplishment of) the work. The logistics and the funding of such a program might be so great as to obviate its inauguration for some time. But there is every reason to believe that this sort of organization would make an enormous difference in the quality and credibility of paleoecological research. In the present palynological study we have seen that the paleoecological reconstructions offered by paleoethnobotanical study and by palynological study deal with the same phenomenon (vegetation resources and resource zones) at different levels of analysis. Our future objective should be to so coordinate our studies that such

multiple levels of analysis may be explored simultaneously, and feedback routines would allow mutually advantageous encouragement to comprehend the same phenomena from different perspectives at the same time.

6. The research implications of the relationship between the paleoecological reconstructions of the paleoethnobotanical and palynological record first of all emphasize that no one form of paleoecological inquiry takes precedence over another in "revealing" the nature of the past. Each provides something that others cannot provide at all, or can only provide in another way. Second, it illustrates that the phenomena we are concerned with, the "natural" conditions of the past, are comprehensible on a series of levels of abstraction and analysis. All are certainly not appropriate to all problems. Most importantly, it argues to the position that though an integrated paleoecological reconstruction must be attempted, we are presently far from that goal.

Primarily, we are yet dependent on the organization of our data in terms of the associated archaeological record. That is, the one thing that allows comparisons amongst the forms of paleoecological record are their associations with the archaeological deposits of the Koster site. Unfortunately, substantive knowledge of Koster archaeology is yet minimal. Horizons have been delineated only by the very rough sorting device of debris frequency evaluation. Once delineated, Horizons are identified through the presence of diagnostic artifact types. This must be admitted as a very coarse screen for the sifting of systemic processes of behavior. There seems every likelihood that Horizon diagnosis will ultimately be based on quite different behavioral criteria. Before more can be done, it is essential

that correspondences among the paleoecological records are identified in terms of the three-dimensional location of the samples from which they derive.

Once the paleoecological data can be considered independently of their archaeological associations--that is, once the stratigraphic placement of sediment, faunal and floral records can be identified without regard to archaeological horizon but in regard to lithological stratigraphy--the relationships among these records may be explored. Contrasts among the interpretations should be identified and situations where level of abstraction or level of analysis is at issue may be considered. Research designed to deal with the questions generated by these discussions should be begun and implemented. Only then will the goal of an integrated paleoecological reconstruction be within view. And only then will the archaeologists be in a significant position to propose hypotheses regarding man/environment relationships which are open to rigorous testing.

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