REVIEW AND ASSESSMENT OF THE PALYNOLOGICAL EVIDENCE FOR PREHISTORIC WOODLAND REGION MAIZE

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September 1994

ABSTRACT

Palynological evidence of maize cultivation in the Eastern Woodlands Region has been available for the past three decades but has been almost universally ignored in the many recent publications on the question of the origins and development of agriculture in that part of the world. This review deals with (1) the principles and procedures relevant to evaluating the reliability of this type of evidence, (2) the contexts and occurrences of Eastern Woodlands maize pollen records, and (3) some archaeological implications of the existing evidence for pre-Middle Woodland maize cultivation.

Though maize pollen records from Missouri and Illinois may be as much as 5500 rya old, the oldest confirmed palynological evidence for maize cultivation probably dates ca. 4000 rya. Two, perhaps three, occurrences of maize pollen date 2500-2000 rya, and maize pollen is common in early Middle Woodland deposits at Fort Center, Florida, that may also date to this time. Late Woodland and Mississippian Period maize pollen records are known from Tennessee, Illinois and Ontario as well as Mississippi and Florida.

Present models of the development of Eastern Woodlands agriculture recognize non-subsistence role(s) for maize for some centuries prior to the Emergent Mississippian horizon. The palynological evidence extends the time during which maize was cultivated in this area by another one and a half millennia or more, but has no other affect on those models.

Desde las ultimas tres décadas existe evidencia palinólogica del cultivo del maíz en la región de Woodlands Orientales. Sin embargo esta evidencia ha sido universalmente ignorada en todas las publicaciones acerca del origen y desarollo de la agricultura en esa parte del mundo. Este artículo examina (1) los principios y procedimientos relativos a la evaluación de la certeza de este tipo de evidencia (2), los contextos y la presencia de los registros del polen de maíz en los Woodlands Orientales (3) y algunas implicaciones arquelógicas de la evidencia que existe del cultivo del maíz en el período Woodland pre-Medio.

A pesar de que los registros del polen del maíz de Illinois y Missouri datan de 5500 rya, la evidencia palinológica confirmada más antigua del cultivo del maíz data probablemente de ca. 4000 rya. Dos, tal vez tres, presencias de polen de maíz datan de 2500-2000 rya, y el polen de maíz es común en los depositos del inicio del Woodland Medio en Fort Center, Florida, que también pertenecen a esta era. Los registros de polen de maíz de los períodos Woodland Tardío y Misisipiano se conocen en Tennessee, Illinois, y Ontario, así como en Mississippi y Florida.

Los modelos actuales para el desarollo de la agricultura de los Woodlands Orientales identifican funciones para el maíz que no eran para la subsistencia desde varios siglos antes del horizonte Misisipiano Emergente. La evidencia palinológica aumenta el lapso de tiempo en que el maíz se cultivaba en esta área hasta hace un milenio y medio o más, pero sin tener ninguna consecuencia sobre esos modelos.

INTRODUCTION

In 1965, Donald Whitehead reported palynological evidence of the occurrence of prehistoric maize at Dismal Swamp, in southeastern Virginia:

> Initially, a single pollen grain of maize was identified from the 0.49-meter level of a core (DS-1) from beside Feeder Canal, just east of Lake Drummond (Fig.1). A recheck of the slide and of others from the same level revealed four more grains.

> ...A radiocarbon age of 3580 ± 100 years (sample Y-1321) was obtained from the 0.80-meter level of the same core. If one assumes a relatively uniform rate of peat formation (suggested by the homogeneity of the top-most meter of peat) an age of 2200 years can be assigned to the 0.49-meter level (Whitehead 1965:881).
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> ...The meaning of this occurrence of pollen is not clear. At first glance cultivation of maize within Dismal Swamp some 2200 years ago seems unlikely....[However, other palynological] evidence suggests that there was a local clearing in the swamp in which maize could have been grown...Why the people of the Early to Middle Woodland cultures in this region should select forested swamp for farming is a mystery. Perhaps there was no conscious attempt to farm the swamp; perhaps the clearing was made by a spontaneous fire and was cultivated simply because it became available (Whitehead 1965: 881-2).

Though Whitehead's report was not published in an obscure source, an archaeological review of the evidence for prehistoric cultivation and agriculture in the Woodland Region published a few years later (Struever and Vickery 1973) took no notice of its existence. Further, despite reports of the occurrence of similarly ancient maize pollen at other Eastern Woodland locales (Schoenwetter 1974a, 1979; King 1978; E. Sears 1982; Whitehead and Sheehan 1985), subsequent reviews (Ford 1985, 1987; Steponaitis 1985; Fritz 1990; MacNeish 1991; Watson 1989: Smith 1992a, 1992b; Scarry 1993a) fail to recognize the existence of maize pollen records that predate Middle Woodland times. Until the quite recent results of direct AMS dates on earlier Middle Woodland Period maize macroremains were reported (Riley and Walz 1992), Woodland Region archaeologists were firmly committed to the position that maize "--rarely and in small quantities--...appears between ad [sic] 200 and 600 in a few sites in Tennessee, Ohio and Illinois (Watson 1989: 560)."

Two explicit attempts to discredit pre-Middle Woodland Period maize pollen records are unconvincing. Smith's (1986:38) assertion that the association of maize pollen with a radiocarbon date of 450 B.C. ± 105 (I-3556) at Fort Center, Florida, is "tenuous" seems to be based on the fact that maize pollen was not recovered from the sediment lens that incorporated the dated organic material. It was found in four samples of lenses in stratigraphically comparable position, however, and one which is evidently older. The date may be inaccurate, but the association with early Middle Woodland archaeological records seems wholly legitimate.

Conard et al. (1984) employed AMS dating technology to demonstrate that maize macroremains recovered from Horizons 4 and 9 at the Koster site were in fact modern contaminants. Their conclusion that modern maize pollen contaminated the Horizon 6 deposits does not follow from that evidence, and totally ignores the distinct processes involved in the preservation of pollen grains and botanical macroremains. In essence, palynological evidence that maize was cultivated in the Woodland Region prior to AD 200 has neither been successfully discredited nor rejected; it has simply been ignored.

Two questions are thereby raised: First, do such pollen records constitute a credible source of evidence for the presence of maize in earlier times? Briefly, standards for the evaluation of pollen records are based on the natural history of pollen production and dispersal processes and on experimental and empirical evidence of the processes of pollen deposition and pollen preservation following burial. Judged by those standards, there is little likelihood that earlier maize pollen records are any less valid than maize pollen records associated with Hopewellian, Late Woodland or Mississippian Period radiocarbon dates or artifacts.

Second, what is the effect of such evidence on existing models of the origins and development of agriculture in the region? When Whitehead's discovery was published, conventional wisdom held that Early and Middle Woodland Period economic systems were based on maize agriculture. In the subsequent two decades, the development and application of techniques for the recovery and analysis of plant macroremains from archaeological sites in the region has provided a body of paleoethnobotanical information demonstrating that the subsistence value of maize was not exploited much before the Emergent Mississippian Period, ca. 1100 rya. Current models of the origin and development of agriculture in the region (e.g. Smith 1992b, Yarnell 1993:22, Fritz 1993: 56) recognize that maize was grown for several centuries during which it apparently played no significant role in Eastern Woodlands subsistence, and exotic cultivars played no obvious role in the establishment of the domestication of local food plants. The palynological evidence extends the period of time in which one or more non-subsistence roles for maize occurred; it does not support or argue for an alternative sort of model.

EVALUATING THE EVIDENCE

General Considerations

Maize is an obligate cultivar. All varieties of maize require human manipulation at some (often many) stages of their life cycles to reproduce successfully. However unlikely, it is of course possible that an individual maize plant -- or a small population of maize plants -- might survive and produce reproductively successful offspring without human assistance. Attributing the occurrence of fossil maize pollen observed in a sediment sample to such an unusual set of circumstances, however, violates the law of parsimony. If fossil maize pollen is the homologue of modern maize pollen, it was produced by maize plants. If ancient maize plants are the homologue of modern maize plants, the ancient plants were obligate cultivars. Lacking evidence to the contrary, the logic of uniformitarianism must here prevail.

Pollen analyses represent the execution of research designs; their evaluation thus begins with consideration of the sorts of questions an analysis attempts to address and the logical relationship between those questions and the means employed to address them. Both the traditional method of Quaternary pollen analysis and more recently developed quantitative methods have been designed to generate data for the reconstruction of paleovegetation patterns and sequences of paleovegetation pattern changes. Some workers (e.g., King et al. 1975; Bryant and Hall 1993) assume that the appropriate application of pollen analysis in archaeological research has this same objective, and that it should use the same techniques and methodology. Analyses of this sort are often based on pollen counts that are sufficient for identification of the significant components of the wind-pollinated paleoflora (e.g., the now-classic 200-grain count) but are not large enough to provide statistical confidence in the presence of floristic elements that disseminate little pollen or rarely occur. Such analyses also tend to offer inductive conclusions based upon appreciation of the natural history and ecology of the plants represented by their pollen types.

Others (Schoenwetter 1970, 1980, 1990; Schoenwetter and Limón 1982; Fish 1982; Williams-Dean 1975) have designed or employed alternative methods of pollen analysis in order to generate data bases more appropriately organized for the pursuit of specifically archaeological objectives. Such non-traditional pollen studies usually use classical palynological techniques to extract, identify and record the pollen of sediment samples. But they assume that the sorts of sample contexts studied, and the character of the archaeological problems of concern, impose demands for different emphases in the routines of analysis and provide different grounds for interpretation of the observed pollen record. The interpretations offered by such studies are often developed deductively through comparison with control data, and the size of the pollen count adjusted to the needs and purposes of the analysis. Paleovegetation reconstruction is not usually ignored, but the conclusions of such efforts often emphasize reconstruction of behavioral patterns based on ethnobotanical analogies or upon archaeological understandings of the formation processes creating anthropogenic deposits (e.g. midden, house floor, storage pit fill).

To my knowledge, the only studies of the latter sort which have been attempted for the Woodland Region remain unpublished, and in any case were also designed to provide paleovegetation reconstructions (Schoenwetter 1974b, 1978). Thus (excepting the work of E. Sears, 1982), the pollen analyses that have generated observations of ancient maize pollen in the region have done so by accident rather than by design. Critical evaluation of those pollen records must take that fact into consideration. Further, their design limits the sorts of interpretations supported by the observed data. Almost all existing Woodland Region pollen studies only allow identification of temporal-spatial contexts in which maize plants constituted a component of the vegetation pattern.

The principle variables affecting the character of pollen records are the suite of processes responsible for the occurrence of pollen in the sediments sampled for analysis. Birks and Birks (1987:177-194) provide the most thorough discussion of the models of the processes of pollen production, pollen dispersal, pollen deposition and pollen preservation evidenced by a variety of kinds of information. Here, it is sufficient to recognize that palynologists measure the reliability of palynological observations through consideration of the likelihood that the observation was created by expected processes of pollen production, dispersal, deposition and preservation in contrast to processes that might act to contaminate the sample with modern pollen, with the pollen of another sample, or with pollen transported to the sample from another paleoflora. The characteristic operation of the processes by which pollen records are normally generated yields replicate samples of statistically equivalent assemblages of pollen grains. Alternatively, none of the processes that result in contaminated samples are likely to yield multiple observations of the same sort in samples representing the same horizon of time at the same locale. Replication of a pollen observation in the same sample or in other samples drawn from the same pollen rain population thus constitutes prima facie evidence that the observation is legitimately interpretable as a product of the natural processes normally responsible for the occurrence of pollen in a sample, rather than the unusual processes of contamination or pollen transport.

Contamination

Discussions of pollen analysis expressly written for archaeologists (e.g., Shackley, 1981, Bryant and Holloway 1983, Holloway and Bryant 1986, Dimbleby 1985, Pearsall 1989) tend to emphasize how pollen samples are collected and analyzed, and offer case studies and cautions regarding archaeological applications. Perhaps as a result, most archaeologists are highly sensitive to the statistical character of pollen analysis and the importance of protecting samples from contamination by modern air-borne pollen or the pollen of deposits other than the one being sampled (cross-sample contamination). Conventional archaeological wisdom (expressed, for example, with respect to small quantities of corn pollen by Berry 1982 and Minnis 1985) is that recovery of a statistically unreliable amount of the pollen of an unexpected taxon may be reasonably interpreted as a chance event attributable to sample contamination.

However, sample contamination is not a likely event if normal field and laboratory procedures are followed. Thus contamination is not a probable explanation for the observation of a small quantity of corn pollen merely because that observation might have occurred as a result of chance. Contamination is a probable explanation for an unexpected maize pollen record only in those cases where the evidence for contamination is more compelling than the evidence for an alternative explanation.

Contamination is often thought to be likely if a wind-pollinated taxon is involved, since even very limited exposure of the sample to air could have that result. However, one must remember that the sediment sample itself normally contains many more times the number of in situ pollen grains than probable contaminants. Unless a sample contains an unusually small number of in situ pollen grains, or remains exposed to polleniferous air for an unreasonably long period, the odds are very low that even one of the air-borne contaminant pollen grains will be observed among the very many in situ pollen grains in any small sample fraction. The likelihood that an observer would find a second contaminant pollen grain of the same type as the first in the same sample is so small that replication of the original observation is generally accepted as effective demonstration that contamination has not occurred.

As King _et al_. (1975) noted, sediment samples recovered from the deposits of archaeological sites tend to contain much less _in situ_ pollen than samples from many other sorts of deposits. This is especially the case for Woodland Region sites. Though enough pollen often can be recovered for analysis by concentrating the polleniferous fraction of larger sediment samples, the fact that smaller amounts of pollen occur per gram or per cubic centimeter of sample yet makes the observation of contaminant grains more likely. Two methods have been devised to allow evaluation of the likelihood that a sample contains so little _in situ_ pollen that contamination should be suspected. One involves calculation of the pollen concentration for the sample and acceptance of the 1000-grain/gram or /cc minimum standard for interpretive purposes established by Hall (1981). The other, designed for situations in which pollen concentration values are unrecorded, employs comparisons between the pollen statistics of the ostensibly contaminated sample(s) and those of ostensible sources of the contaminant pollen type (Schoenwetter 1985). This method recognizes the extreme improbability of contamination by a single taxon; the prior probability is that cross-sample or air-borne pollen contamination would occur in the form of an assemblage of pollen types. It assumes that such contamination would skew the statistical expression of the _in situ_ assemblage to a detectable degree.

Long distance transport

Pollen grains have been observed at great distances from the nearest possible sources, and some plant taxa produce pollen that is very efficiently adapted for dispersal by wind. The possibility of long distance pollen transport can never be absolutely denied as the explanation for an unexpected pollen observation. The probability of that explanation, however, is related to the nature of the processes by which pollen of that type is dispersed from its source and deposited and preserved in the kind of depositional environment in which it was found.

Maize ova are contained within the husked ears located where the leaves of the plant join a main stem. They are fertilized by pollen dispersed from tassels at the top of the stem to the silks appended to the ears. One result of this anatomical arrangement seems to be an adaptation that insures maximal probable fertilization: though transported through the air, the great majority of maize pollen grains released from a tassel fall as an enshrouding cloud to the silks and foliage of the same plant. Extremely little maize pollen becomes part of the pollen rain trapped in surface-level deposits even in fields that have been devoted to maize cultivation for many human generations (see Schoenwetter and Smith 1986:187-190), and little maize pollen remains dispersed into the air even a few meters beyond the parent plant (Raynor et al 1972). Maize pollen is thus one of the least likely types of pollen to be observed as a result of long-distance transport.

Vertical transport

Once incorporated in a deposit, pollen grains may be subject to processes which cause vertical movements of particles of similar size and weight. Bioturbation of the sort normal to soil formation processes, cryoturbation, sediment redeposition in cracks, resuspension, etc. all might cause the pollen of a depositional unit to be relocated at a different vertical position. The possibility of vertical pollen transport, however, does not make it probable in a given case. Lacking positive evidence that a maize pollen observation is likely to be a product of vertical transport, claims to that effect are not likely to carry much weight. In any case, processes which cause vertical movement of pollen grains in sediments act on the assemblage, not on individual taxa. Comparison of the character of the ostensible source assemblage for the maize pollen with the assemblage within which it is observed allows evaluation of the occurrence or lack of affect of vertical transport processes.

Misidentification

The morphological characteristics of the pollen of maize and its relatives have been relatively intensively studied (Kurtz and Liverman 1958, Irwin and Barghoorn 1965, Banarjee and Barghoorn 1972, Whitehead and Langham 1965). Maize and teosinte pollen have been found to be distinguishable from the pollen of other grasses on the basis of their larger size and a unique pattern of surface microsculpture. Unfortunately, the latter characteristic is not observable without specialized (SEM or phase contrast) microscope equipment. Though the size ranges of maize and teosinte pollen recovered from modern specimens overlap (Kurtz et al. 1959), the modal size of maize pollen is significantly larger. Thus palynologists can and do recognize modern maize pollen grains on the basis of size alone at a confidence level exceeding 95%. Fossil pollen grains with morphological characteristics identical to those of modern maize pollen grains occasionally occur in sufficiently large populations to allow statistically adequate study of size variation (e.g. Martin and Schoenwetter 1960, Gish 1979, Fish 1982, E. Sears 1982). The modal size of such populations is normally far more similar to that of modern maize pollen than any other grass. Insofar as it is technically possible to document the matter, application of the principle of uniformity allows confident identification of fossil graminoid pollen larger than 60 mμ diameter as maize.

Technically, fossil pollen identifications are recognizable as diagnoses rather than absolutely secure classifications. The probability of diagnostic error, however, is very low for maize pollen because of its unique characteristics. The likelihood of misidentification is normally considered so remote that simple reportage of the occurrence of maize in a pollen assemblage will rarely be challenged. Explicit reportage of the size of the maize pollen grains is considered useful, but not necessary for credibility.

Confirmation

Cultural patterns and institutions are characteristically expressed in a variety of fashions, each of which may have distinctive material culture correlates. Recovery of a second type of archaeological record evidence of a cultural pattern thus acts to confirm the evidence provided by the first sort. The reconstruction of maize production behavior from the evidence of maize food remains may thus be confirmed by the recovery of material evidence of population density changes created by the availability of the food, site proximity to arable lands, remains of irrigation systems, food preparation and storage technology appropriate to the type and size of crop, etc. The situation is different in the case of pollen grains because palynological evidence of a behavior pattern can only exist as a product of the interaction of specific human actions and the processes of pollen production, dispersal, deposition and preservation. Thus, pollen record information can only be confirmed by other pollen record information illustrating the occurrence of those same interactions, and, logically, it can be disconfirmed only by demonstration that alternative processes acted to create that pollen record (contamination, etc.) or on the basis of new or more precise understandings of the botanical/ecological character of the plants or processes involved.

Many archaeologists accept the common-sense argument (Harlan and de Wet, 1973) that the reliability of evidence for a plant's cultivation is properly tested by the recovery of independent forms of evidence. Thus they defer judgement on the credibility of maize pollen records until "verification" is attested by recovery of contextually equivalent maize macroremains, maize phytoliths or artifactual evidence that may be reliably related to maize production (e.g., stone or bison scapula hoes). I have attempted to deal with the question of the value of this argument elsewhere (Schoenwetter 1990b) and shall not review the matter here. Suffice it to note that failure to recover anything other than palynological evidence of the occurrence of maize neither disconfirms the palynological record nor argues the necessity for caution in interpretation of such a record. The processes through which different kinds of plant fossils are created, distributed and preserved are simply too dissimilar to justify the assumption that one type of fossil is likely to occur where another is found. Lack of a charred maize macroremains record, for example, does not weaken the case for maize cultivation evidenced by the occurrence of maize pollen. Among other considerations, it must be recognized that the distribution of charred maize macroremains is controlled by human activities related to food preparation, while the distribution and preservation of maize pollen is not.

However, the confirmation problem is different in cases where the depositional environment of the pollen assemblage has been created by natural processes or (in whole or part) by human behavior. In the former instance, paleontological standards must be employed for confirmation because the primary issue is whether the maize pollen reflects the existence of maize plants at the time, in the place, the deposits were formed. In the latter instance, archaeological standards must be employed because the primary issue is the sort of human behavior most likely to be reflected by the occurrence of maize pollen.

Maize pollen records recovered from non-anthropogenic deposits can be confirmed in two ways. The simplest is through replication by examination of larger samples of the same population of pollen grains or examination of additional equivalent populations of pollen grains. Attempts to confirm a pollen record through replication that do not succeed do not <u>disconfirm</u> the original record, but they weaken reliance upon that record for interpretive purposes. A somewhat more complex method relies upon recognition that vegetation patterns are organized and operate as systemic entities, so may produce pollen records in which the existence of a particular ecosystem variable or relationship is expressed in more than one way. McAndrews (1988), for example, noted the fact that palynological evidence of plant succession accompanies the maize pollen observed at Dismal Swamp. The co-occurrence of this second palynological index of vegetation subject to human modification acts independently to argue for the existence of cultivation activity, so serves to confirm the evidence of maize cultivation indexed by the recovery of maize pollen.

Replication of maize pollen records from anthropogenic deposits confirms the existence of the cultivar, but does not identify maize plants as members of the local flora at the time the deposit was created. The maize pollen of a pitfill sample, for example, may have been transported to the locale from some distant place by human action, consciously or unconsciously and with or without accompanying parts of maize plants. In anthropogenic deposits the local cultivation of maize is most strongly suggested by the recurrence of maize pollen in different populations of pollen grains; specifically, in samples from different types of cultural contexts of the same antiquity. As is true for many types of artifacts, local production is more strongly expressed by ubiquity than by frequency.

Depositional Environment

Pollen deposition and preservation processes vary as a result of differences in the ways sediment deposition occurs. Both the organic deposits of peat bogs and the largely inorganic deposits of permanent ponds or lakes, for example, usually provide better environments for the preservation of pollen grains than alluvial, colluvial, terrestrial soil or anthropogenic deposits. The size of the basin of deposition affects the character of preserved pollen assemblages, and such factors as sediment particle size and geochemistry. Evaluating the probability that a maize pollen observation occurs as a product of contamination or transport processes is thus first guided by understandings of the environment of deposition of the analyzed sample.

Such understandings are far more easily achieved for non-anthropogenic deposits. The varieties of plausible human actions that could have affected the palynological characteristics of anthropogenic deposits, and even non-anthropogenic deposits laid down in the immediate environs of loci of human behavior, is so great that the pollen records of such depositional environments must be assumed to reflect cultural behavior in some ways and to some degree. The paleontological standards palynologists employ to verify interpretations of pollen records from non-anthropogenic deposits, then, must be amplified by archaeological standards when the issue is interpretation of such records from anthropogenic or site-context deposits.

Summary

Evaluation of maize pollen records begins by identifying the purpose(s) and methodology of the analysis involved. A research program designed to provide information on the floristic character of ancient vegetation, for example, cannot be faulted if it fails to yield another sort of information. The second step is identification of the sorts of deposits in which the pollen has been found. This allows assessment of the nature of pollen production, dispersal, deposition and preservation processes which could result in that observation. Evaluation of the likelihood that the observation represents the existence of cultivated maize in the paleoflora that produced the assemblage, or that it represents an assemblage affected by modern or cross-sample contamination, by long distance pollen transportation or by vertical transport, is made from assessment of the formation processes normal to pollen assemblages recovered from deposits of that type. Since the former processes generate replicate pollen assemblages and the latter processes normally do not, recovery of multiple grains of maize pollen in the same pollen assemblage or in equivalent samples acts to confirm the original observation.

Maize pollen recovered from non-anthropogenic deposits identifies the presence of maize -- thus the cultivation of maize -- in the local environment at the time the deposit was formed. The frequency of maize pollen in such samples suggests the plants' prominence in the local flora. In anthropogenic deposits, however, the frequency of maize pollen is not as secure an index of its local cultivation as its ubiquity in samples representing a variety of cultural contexts.

CONTEXTS OF WOODLAND REGION MAIZE POLLEN RECORDS

Peat Deposit Maize Pollen

Peat deposits form as the product of the submergence and compaction of dead vegetation in a saturated anaerobic environment, usually in a shallow and limited basin of deposition. There are rarely more than a very few types of plants represented by the macroscopic plant fossils contained within a peat deposit. The traditional interpretation is that the plants which contributed fossils to the deposit represent a death assemblage of the plants which grew immediately adjacent to, or within, the basin from which they are recovered. Peat deposits are thus often characterized by the sort of flora they identify, e.g. forest peat, sedge peat, etc.

Pollen samples collected from peat deposits normally yield large quantities of very well preserved pollen. The variety of taxa occurring in small peat sample pollen assemblages, however, is usually quite limited because most of the pollen was dispersed by the very localized vegetation of the death assemblage. Long distance transport is thus an unlikely explanation for pollen types observed in peat samples. Indeed, peat sample pollen counts which reach only minimal standards of statistical adequacy (150-200 grains) are rarely undertaken, as larger counts make confirmation of relatively rare pollen types more likely. Even then, however, the pollen of a few taxa often dominate the assemblage and constrain the pollen frequency values of taxa that may have been quite common in the district flora.

The occurrence of even a very small quantity of the pollen of a taxon in a peat sample, therefore, is considered most likely to be the product of growth and pollination of that taxon in the immediate environs of the sampling location at the time that sample of peat was laid down. The most probable alternatives to this interpretation are that the pollen was transported upwards or downwards within the deposit to the position in which it was found.

King (1978) recovered a single maize pollen grain from a fibrous peat deposit at Phillips Spring MO, stratigraphically superimposed upon, and stratigraphically superimposed by, non-polleniferous clay deposits. This situation obviates the possibility of vertical transport of the Phillips Spring maize pollen.

In the case of Dismal Swamp, maize pollen occurs in forest peat as a member of an assemblage characteristic of the uppermost pollen zone of the local sequence (Whitehead 1972). This particular sample, however, contains significantly less Nyssa (sweetgum) pollen than those stratigraphically superimposed upon it and significantly more Taxodium (bald cypress) pollen than samples of the deeper pollen zones of the sequence. The sorts of pollen distributions that expectably occur as a product of vertical transport, then, do not occur. Further, as McAndrews (1988:680) pointed out, the samples that contain the maize pollen present slight maxima in the percentages for Graminae, Corylus, Myrica and Ilex pollen, suggesting shrub succession following field abandonment.

Whitehead was able to replicate the maize pollen observation in the same subsample of peat and in other subsamples from the same level. Given that situation, he dismissed the possibility of contamination by modern maize pollen. King searched for other occurrences of maize pollen in a number of subsamples from the same level at Phillips Spring but was unable to observe any more. He concluded, correctly, that cautious interpretation was appropriate because the chance of contamination could not be excluded. However, he noted that maximum efforts had been expended during field and laboratory activities to reduce the likelihood of contamination. He concluded:

> ...it is my opinion that this grain is not the result of contamination and therefore probably reflects aboriginal agriculture (King 1978:10).

King reported that the maize pollen from Phillips Spring was not directly associated with any radiocarbon date or datable cultural material, but radiocarbon dates on charcoal from other sedimentary units bracket deposition of the peat between 1990 ± 50 B.P. (SMU-234) and 3050 ± 60 B.P. (SMU-235). These indirect associations suggest the maize pollen was probably deposited during the thousand years between 2000 and 3000 rya. Kay, however, subsequently reported a date of 5306 ± 91 (SMU-539) for organic materials from the deposit that contained the maize pollen (Kay, 1979).

Inorganic Subaquatic Deposits Maize Pollen

Pollen of inorganic subaquatic deposits is usually well preserved, and its abundance in a given sample tends to be inversely related to the deposition rate of the sediment involved. Thus, sediments that accumulate more slowly tend to be more polleniferous than those that accumulate more rapidly. Pollen sequences recovered from such deposits incorporate pollen dispersed from plants throughout the whole of the basin of deposition. Larger lakes, then, are more likely to yield sequences of pollen assemblages that reflect both the character and the variety of the regional flora. Since pollen sequences of larger lakes provide evidence of paleovegetation changes occurring at large geographic scale, they are the sorts of sampling locations preferred by pollen analysts engaged in studies of the vegetational changes that have occurred in the Woodlands region.

Conversely, the pollen assemblages of sediment samples from small bodies of water are more likely to reflect the localized floras of small basins of deposition. Thus pollen sequences from smaller basins are more likely to provide evidence of the sort of vegetation changes responsive to human landuse and other human impacts on localized vegetation patterns (e.g.Burden et al. 1986, Delacourt et al. 1987).

Pollen samples are normally recovered from subaquatic deposits through use of coring devices and techniques designed to minimize the probability of vertical transport or contamination. The most probable alternative explanation for recovery of an unexpected pollen type in such sediment samples is long distance transport. However, the probability of long distance pollen transport is significantly lower for small basins, and the probability of local overrepresentation is higher.

Maize pollen records recovered from samples of subaquatic inorganic deposits are known from basal deposits of Crawford Lake in southern Ontario (Burden et al. 1986), from slough deposits at Cahokia (Schoenwetter 1962), from ponds in the Little Tennessee River valley (Delacourt et al. 1987), and from B.L. Bigbee Swamp in the Tombigbee valley in eastern Mississippi (Whitehead and Sheehan 1985).

Relatively intensive palynological research in the Western Great Lakes district has failed to identify maize pollen more ancient than the Late Woodland horizon of local prehistory. The slough deposits at Cahokia also contain Mississippian pottery, and correlation of the pollen sequences suggests that none of that maize pollen is older than the Mississippian occupation of the American Bottoms (Schoenwetter 1963, 1964)[1]. In the Little Tennessee Valley the pollen sequence from Black Pond includes maize pollen dated to the Mississippian occupation horizon and pollen from a core recovered from basal sediments in Tuskegee Pond provides evidence of the continuous presence of maize in the local flora throughout the past 1600 years. Finally, two single maize pollen grains from the 0.48 and 1.05 cm levels of the B.L. Bigbee Swamp core are bracketed by 14C dates of 2310 and 2680 B.P. (SI 4187 and 4188).

Because small basins were sampled, there is some likelihood that maize is more consistently represented in the pollen record than it was in the flora surrounding Crawford Lake, the slough at Cahokia, or Tuskegee Pond. But replication of these maize pollen records strongly suggests that maize plants existed in the immediate environs of those locales when the sediment samples containing maize pollen were deposited.

The B.L. Bigbee Swamp maize pollen records are not replicates because they were observed in stratigraphically separated samples. Each, then, is a member of a temporally distinct pollen assemblage. Since neither observation is palynologically confirmed, the suggestion that each maize pollen grain is an independent contaminant, or represents a separate instance of long distance pollen transport, cannot be denied on statistical grounds.

These alternatives do not seem too likely, however. As at Phillips Spring, the analyst considers early maize cultivation the appropriate explanation for the observations.

Five samples containing maize pollen were collected from "midden" lenses in-filling ditches marginal to and within the Great Circle Ditch at the Fort Center site, Florida. Two maize pollen grains occurred in two samples, 20 and 24 maize pollen grains were observed in two others, and a single maize pollen grain was observed in sample P 68. Given their map positions, samples P 47, P 51, P 52 and P 69 must be the ones from midden lens deposits "that accumulated in the ditch [surrounding the Great Circle] while the midden [at Mound B] was forming rather than being washed in from an already existing midden (Fairbanks 1967, quoted by W. Sears 1982:178)." W. Sears (op cit.) notes that these four lenses are from "about the same stratigraphic position" as another which produced a radiocarbon date (I-3556) of 450 B.C. ± 105. The fifth sample, P 68, was collected 100 feet south and almost 400 feet west of the others, from the basal deposit of a recognizably earlier ditch:

> several sherds of semi-fiber-tempered plain and two steatite sherds [were found] in the top of the subsoil at the base of the earlier ditch...An estimate of age for this earlier ditch would be in the transitional period, not later than 500 B.C. (Fairbanks 1967, quoted by W. Sears 1982:178).

P 68 sampled a deposit referred to as midden but characterized by "an extreme scarcity of sherds or bones."

What is communicated by the term "midden"? Dictionary definitions suggest midden deposits are principally composed of dung or kitchen waste; common archaeological usage suggests they are composed of household garbage and refuse, including worn or broken items. In my experience, however, the deposits prehistoric archaeologists normally call middens are rarely diagnosed on the basis of strict definitions. At Fort Center, the term seems to have been applied to deposits that were not in fact anthropogenic. Sears' field observations clearly identify the "midden" lenses which produced maize pollen as (originally) subaquatic deposits that accumulated through natural processes. The artifactual material and the maize pollen they contain apparently were simply dispersed in places and fashions that would lead to their deposition as inclusions in those sediments. These "midden" maize pollen records are thus fully comparable to the maize pollen records of the deposits from Crawford Lake, the slough at Cahokia or Black Pond, Tennessee.

The fact that the exact age of the five maize pollen records is controlled solely by a single radiocarbon date obviously leaves the matter of their true antiquity open to interpretation. Overall, however, the stratigraphy and artifactual record of the site leaves no room for doubt that the ditch samples were deposited prior to the construction of the Hopewellian pond-charnel platform complex deposits or the Historic Period housemounds and linear earthworks that served as other sources of samples containing maize pollen. Given the archaeological evidence for Early Woodland occupation of the site and the stratigraphic position of the deposit from which the radiocarbon date was recovered, evaluation of the date depends upon whether the associated St. Johns Plain sherds could have that antiquity. I lack the regional expertise to judge the matter. However, even if the radiocarbon date is the consequence of an "Old Wood" problem or represents some other source of error, the maize pollen of the basal deposits of the circle ditches is stratigraphically older than that of the samples from other Middle Woodland contexts, and at least one sample (P 68) is as old as the Early Woodland occupation of the site. Only a single maize pollen grain from a single sample, then, can be attributed to the Early Woodland occupation of the site. It does not meet the replicability test, but the consistency with which maize pollen occurs in the earliest Middle Woodland deposits strongly suggests it should be accepted as a credible record.

Maize Pollen in Soil

Pedogenic processes affect the distribution of pollen grains recovered from soil profiles in very specific ways (Dimbleby 1985:1-18). Basically, pollen falling on the surface of a soil is transported beneath that surface -- and buried pollen returned to that surface -- through the bioturbation normal to the soil formation process. This destroys a significant fraction of the pollen deposited on the surface and mixes the remainder with previously deposited pollen. Pollen samples collected from deposits subject to soil formation processes thus contain assemblages which incorporate pollen invested in the deposits continuously as soil formation continues, as well as the pollen trapped and preserved within the deposit before soil formation began.

As pedogenesis proceeds, pollen continues to rain onto, and be trapped within, the accumulating topsoil (A Zone) deposit. Some mechanism, probably rain water percolating downwards through the soil profile, causes progressive downward vertical displacement of pollen in soils (pollen downwash). The displacement is of such character, however, that the entire pollen assemblage is transported systematically to ever deeper levels of the subsoil (B Zone) of the soil profile. As a result, older pollen assemblages occur at greater depth, and younger and younger assemblages occur at successively lesser depths. In addition, the absolute quantity of pollen recoverable from a unit weight or unit volume of the deposit decreases with depth, and the pollen of deeper samples is degraded. The pollen originally contained in sediments subject to soil formation processes is normally totally destroyed.

E. Sears (1982:122) refers to three sediment samples from the eastern side of the Great Circle at Fort Center, Florida, that contain maize pollen as "topsoil". The context of her discussion and that of W. Sears (1982:176) suggests these samples were collected at the surface and various depths below the surface within the A Zone of a soil profile developed on spoil deposits created at the site by the construction of circular ditches that pre-date A.D. 200. W. Sears (1982:176) insists that at least two of the samples could not have been contaminated with more recent maize pollen, but he may have based his opinion on their stratigraphic position and not have been aware of the potential for pollen downwash through soil profiles. E. Sears (1982:122) does not present sufficiently complete analyses of the samples which contain maize pollen to evaluate whether they do or do not illustrate the expected affects of pedogenesis. It does seem probable, however, given the sub-tropical environment of the southern half of the Florida peninsula. Since Middle Woodland, Late Woodland and Historic Period occupations are also evidenced for the site, there is substantial probability that the "topsoil" samples maize pollen is significantly younger than the date the ditches were excavated.

In the course of a pilot study of the pollen of samples collected from the Square 8 test pit excavated at the Koster Site in 1969, two maize pollen grains were recovered from separate samples collected from occupation Horizon II and another single maize pollen grain was recovered from a sample collected from occupation Horizon VI (Schoenwetter 1971a). Analysis of the material culture recovered from the test pit (Houart 1971) argued for the temporal placement of Houart's Horizon II during an Early Woodland occupation and dated her Horizon VI to the Helton Phase of the local Middle Archaic. Subsequent studies (Brown and Vierra 1983) recognize deposition of Houart's Horizon II during the period of time that spans both Early and Middle Woodland occupations and places the Helton Phase occupation at approximately 5500 rya.

Discussion of the maize pollen was not warranted in the 1971 report, since its discovery was not pertinent to the research objectives of the pilot study and no attempt had been made to replicate any maize pollen observation with additional study of the same or comparable samples. In 1972 expansion of the archaeological research program at Koster provided opportunity for the collection of many additional samples. As I reported (Schoenwetter 1974a), analysis of an additional six pollen samples from Brown and Vierra's Horizon 6A and 6B deposits collected from different parts of the site resulted in recovery of single maize pollen grains from 6A samples at Squares 117 and 122 -- each, like that from Square 8, observed in the context of a 50-100-grain pollen count.[2]

A meaningful alternative to the inference that maize pollen was deposited during the Helton Phase occupation of the Koster site is suggested by the fact that nature of the depositional environments of Horizons 6B, 6A, 4 and 3 have been re-identified. Houart (1971:7) defined the occupation horizons represented in the 1969 test pit profiles on the basis of vertical variations in the density of cultural debris. The artifact density, charcoal content and organic stains of the occupation horizons were significantly higher than in the deposits that normally segregated occupation strata, suggesting the occupation horizons were represented by sheet midden accumulated during the course of residency. Hajic's study of the deposits (Hajic 1981, discussed in Wiant et al 1983) recognized the evidence leading forcefully to the conclusion that subsequent to the deposition of the colluvium within which the artifacts, faunal remains and botanical macrofossils were embedded, a number of occupation horizon surfaces were stabilized and true soil profiles were developed. The surface of the Helton Phase occupation stratum was one of those subject to pedogenisis. The amounts and distributions of pollen in the Horizon 6A and 6b samples are wholly consistent with those expected for pollen records affected by pedogenic processes, and the conservative interpretation is that they display those effects.

Since the sediments deposited during the Helton Phase were subsequently subjected to soil formation processes, the pollen of occupation horizons 6A and 6B is not necessarily the same age as the artifacts, macrofossils and datable charcoal the deposits contain. The pollen assemblages of the deposits could be younger than 5500 rya -- even as young as the date that soil formation ceased and subsequent colluvium buried the archaeological record of Helton Phase occupation. Radiocarbon dates ISGS-329 and ISGS-202 bracket the possible alternative antiquity of the maize pollen between 3950±75 and 4880±250 rya. Hajic (1985:134) suggests a drastic reduction in the rate of colluviation of fan deposits occurred in the Koster area about 4000 B.P. That date, then, is the one he would adopt for the formation of the paleosol on the Horizon 6A deposit. Replicated palynological evidence thus argues for maize cultivation in the vicinity of the Koster site late in the period of its Helton Phase occupation <u>or</u> during the time it was deserted between its late Middle and Late Archaic occupations.

<u>Anthropogenic Deposits Maize Pollen</u>

To my knowledge, Woodland region prehistoric maize pollen has only been recovered from anthropogenic deposits sampled at sites on the American Bottom, at Shell Bluff (Site 22Lo530) in the Tombigbee Valley 5 km south of B.L. Bigbee Swamp, and at the site of Fort Center. The maize pollen records from archaeological features at Cahokia and the Mitchell site (Schoenwetter 1962, 1963, 1971b) occur in floor, pitfill, vessel fill, barrow pitfill and occupation stratum deposits as members of pollen assemblages correlated to the pollen sequence obtained from the slough deposits near Cahokia. The validity of that sequence is reinforced by pollen studies performed by more than one investigator (Bardwell 1980). Direct association with Mississippian material culture suggests these maize pollen records support the inference of maize agriculture generated by charred macroremains (Johannessen 1984).

The single maize pollen grain from the Shell Bluff site (Schoenwetter 1987) was recovered from a sample of midden attributable to the Miller III Late Woodland occupation (Futato 1987:86). A carbonized maize macrofossil recovered in a flotation sample from another Late Woodland feature at the site Smith 1987:221) provides supportive evidence of maize cultivation. A single example of a maize phytolith is reported (Robinson 1980) for the same site from a stratum tentatively dated 2000 - 3500 B.P.

Maize pollen has been recovered from a number of kinds of anthropogenic deposits at the Fort Center Site, Florida. Three samples containing maize pollen were from human coprolites recovered from a deposit superimposed upon the collapsed remains of a charnel platform built over an artificial pond (W. Sears 1982:165-167). Four samples were of white pigment associated with wood carvings from the charnel platform. W. Sears (1982:186) dates both deposits to the A.D. 200-600 interval on the basis of radiocarbon dates and associated Middle Woodland Period pottery. Four samples were recovered from linear earthworks accompanying Mounds 1 and 8.

Though the earthworks seem to be made up of spoil dirt created by constructions associated with house mounds of the Early Woodland occupation (W. Sears 1982:130-132, 137), the maize pollen they contain is attributed to agricultural use of the earthwork surfaces during the Historic Period occupation (W. Sears 1982:200). Finally, maize pollen was recovered from a sample collected in the upper foot of a test pit placed within the Great Circle. W. Sears discussion (1982:176) suggests the sample was recovered from sand spoil created by excavation of one of the early (Early Woodland ?) circle structures at the site. When the corn pollen became incorporated into the sample is, unfortunately, impossible to estimate.

Summary (Table 1.)

The maize pollen records from Phillips Spring and the B.L. Bigbee Core have not been replicated in local contemporary populations of pollen grains. The observers recognize the lack of confirmatory evidence, yet suggest the observations are valid and evidence the existence of maize in local floras in the first millennium B.C. A radiocarbon date suggesting an early second or late third millennium B.C. date is reportedly associated with the Phillips Spring observation, however.

The situation at the Koster Site is clear with regard to the Archaic Period presence of maize, but ambiguous with regard to its date. The Koster pollen record meets both the archaeological standard of ubiquity and the palynological standard of replicability in contemporary samples. It is unclear, however, if the maize pollen became incorporated in the colluvium which accumulated at the site during the Helton Phase occupation, in the third millennium B.C., or if it was invested in that deposit when the site was abandoned and soil formation occurred, about the beginning of the second millennium B.C. The former alternative seems anthropologically more reasonable, as it places maize cultivation behavior within a cultural context. The latter alternative, however, is the more likely because pedogenic processes normally act to destroy older pollen grains in deposits subject to soil formation. Paradoxically, then, acceptance of the more conservative, less ancient, date for the Koster maize pollen record requires the conclusion that maize was grown there during a period when other evidence of human use of the locality is absent.

A single maize pollen grain from a non-anthropogenic deposit of Early Woodland age at Fort Center constitutes insecure evidence of Early Woodland maize cultivation at the site in and of itself. Well replicated maize pollen records from other non-anthropogenic deposits at the same site dating to its earliest Middle Woodland occupation, and associated with a date ca. 2400 rya, however, suggest maize may have been cultivated in peninsular Florida in the first millennium B.C.

Replicated observations of maize pollen in core samples from Dismal Swamp, Virginia, are consistent with the inference that maize was cultivated in a clearing in forested swamp approximately 2200 rya. Sampling and analysis programs have been adequate to demonstrate that maize pollen occurs in a variety of anthropogenic deposits of Mississippian Period sites on the American Bottom and Middle Woodland and Historic Period components at Fort Center. The occurrence of a single maize pollen grain in a single sample from Shell Bluff leaves the question of credibility of that record open, but macroremains analysis suggests maize was known to and used by the Miller III occupants of the site. The antiquity of the oldest maize pollen recovered at Crawford Lake, Ontario, is established through varve counts at A.D. 1360.

Overall, the present distribution of palynological evidence for maize cultivation in the Woodlands Region suggests the possibility of maize cultivation in Missouri and Illinois by 5000 rya and confirms the practice by 4000 rya in Illinois. Tree ring calibrations for these dates thus suggest maize cultivation in the region by 4500 B.C., possibly before 5500 B.C.

Credible maize pollen records of the 2500 - 2000 rya period have been recovered from Mississippi, Georgia and Florida -- the latter apparently related to the Early Woodland and earliest Middle Woodland occupation of Fort Center. Maize pollen attributable to Middle Woodland cultural activity is presently also known from Tennessee. Maize pollen has been recovered in Late Woodland contexts in Ontario, Tennessee and Mississippi, Mississippian contexts in Tennessee and at sites on the American Bottom, and Historic Period context in Florida.

THE ROLE OF PRE-MISSISSIPPIAN MAIZE

So far, two cultural reconstructions have been drawn from a knowledge of the maize pollen record. E. Sears (1982:129) and W. Sears (1986:178, 145-6) suggested the maize pollen recovered from topsoil samples within the Great Circle argued for use of that portion of the Fort Center site for maize farming during its Early and early Middle Woodland occupations, with similar use of the linear mounds surfaces during the Historic Period occupation. Whitehead (1965, 1972) suggested the evidence indicated the occurrence of agriculture in the region at least by the time of Christ.

While both reconstructions seem reasonable, neither is in fact well supported by palynological and other archaeological information. The maize pollen records the Sears's relied upon came from deposits subject to soil formation processes. It is difficult to establish the antiquity of pollen in sediments of that sort. Also, the empirical evidence we presently have regarding maize pollen distributions in the soil of maize fields (Martin and Schoenwetter 1960, Schoenwetter and Smith 1986:187-190) suggests that maize pollen is quite ubiquitous in such deposits. E. Sears analysis notes having scanned "several hundreds" of samples for pollen of cultivars, with recovery of maize pollen from only twenty.

Whitehead's Dismal Swamp maize pollen record, and the records from all other non-anthropogenic deposits, evidence the occurrence of maize cultivation because the existence of maize plants requires that behavior. Although agriculture is in part characterized by the practice of cultivation, it is not defined by that practice alone. Agriculture is a complexly organized cultural subsystem; at least some direct or indirect archaeological evidence of behavior patterns normal to an agricultural economy should be associated with evidence of cultivation for credible reconstruction of such a subsystem. No such evidence has been generated by archaeological surveys of the Great Dismal Swamp (Kirk 1979). Indeed, the maize pollen record is the only available secure evidence of <u>any</u> human activity in the district for the ten centuries centered on the time of Christ. Though the term "agriculture" is often loosely defined, and archaeologists accept a variety of weak forms of evidence for its occurrence, Whitehead seems here to have relied more heavily than was wise on the then-current belief that maize agriculture was the economic support of all expressions of Early and Middle Woodland culture.[3]

Most of the Middle Woodland maize pollen records from Fort Center were recovered from samples of pigment, coprolites and midden associated with the use and collapse of a charnel platform. Obviously, the presence of maize pollen in human fecal remains resulted from its ingestion. But it need not represent use of maize for food. Maize pollen was observed in only three of 100 coprolite samples examined. Further, the fairly large quantities of maize pollen observed in two of the coprolite samples and one of the four pigment samples are more consistent with incorporation of the pollen as a (possibly inadvertent) ingredient of one or more recipes than with use of maize for subsistence. Two of the maize pollen records from the Great Circle ditch considered contemporary with the fourth century B.C. radiocarbon date also contain unusually large numbers of maize pollen grains. I suspect they are more likely to be products of cultural patterns that affected maize pollen dispersal than products of food preparation refuse dumped into the ditch.

Scarry (1993:90) has noted that the contexts in which Middle Woodland maize macroremains have been recovered suggests the hypothesis that maize played a ceremonial role at that time, and it is tempting to interpret the Middle Woodland palynological record from Fort Center in similar terms. Unfortunately, presently available maize pollen records for the region are far too limited to support that proposal. Only one Woodland Region site has yet been systematically sampled and subject to a pollen study designed to provide evidence with respect to maize cultivation and use. Until information is available from scores, if not hundreds, of other pre-Mississippian Period sites too many equifinal interpretations of maize pollen records will remain plausible.

There is, then, little support for interpretations of the pre-Mississippian maize pollen record that have been offered to date. It is clear, however, that the distribution of presently available maize pollen records presents no information inconsistent with recent models of the origin and development of agriculture in the Woodland Region. The palynological evidence extends the period during which maize was cultivated in the region substantially. But neither the distributions and amounts of maize macroremains nor the frequency and ubiquity patterns of the maize pollen record suggest that maize played any economic or subsistence role prior to the Mississippian Period, nor suggest that prior knowledge of maize cultivation was relevant to the development and ultimate domestication of native cultivars for food.

Testable hypotheses that account for maize production for some other purpose than human consumption may, unfortunately, prove difficult to develop for a number of reasons: First, the obvious sources of evidence are not unbiased. Charred maize macroremains, by and large, are products of food preparation activities. Their occurrence, therefore, will probably rarely prove informative with respect to cultural patterns that are only indirectly linked to subsistence practices. The presence of maize pollen in a non-anthropogenic deposit can denote nothing other than the fact of the plant's cultivation in the soil or basin of deposition at the time the sampled sediment was created, so study of the sorts of pollen samples that most clearly denote paleoenvironmental conditions is not likely to provide much information significant to the problem. The distribution, ubiquity and frequency of maize pollen in anthropogenic and site-context deposits of different sorts and antiquities is likely to be most informative when conjoined with interpretations of the characteristics of the associated archaeological record. But construction of that sort of data base will require significant investment. Presently, such investment is justified by the opportunities pollen study offers for reconstructions of paleoenvironmental conditions. Ultimately, however, palynological study of human behavior patterns will require the development of palynological research methods more appropriatly designed for analysis of man/plant interactions.

Second, such hypotheses cannot be fully satisfactory if they do not account for the question of why maize consumption might have been generally avoided for so long. The answer to this puzzle is likely to be fairly complex, and may be related to the question of why the earliest maize pollen records from Tropical America, Mesoamerica and the American Southwest (Piperno et al. 1985, Monsalve 1985, Schoenwetter and Smith 1986, Irwin-Williams 1973, Schoenwetter 1993) are also much more ancient than macrofossil indices of use of maize for food.

Finally, it is necessary to recognize that one hypothesis is often only more or less attractive than another because it conforms to paradigms familiar to its author and/or biases favored by its audience. Archaeologists are most comfortable with hypotheses that are grounded on ethnographic analogy, and the advances made in paleoethnobotanical research during the past quarter century in this region illustrate the value of that approach most handsomely. However ethnobotanic analogy may in this case require more caution than archaeologists normally employ when constructing testable hypotheses on such grounds. To the best of my knowledge, all ethnographic groups known to grow maize prepare at least some of the harvested grain for consumption in ways that result in production of charred macroremains. Ethnographic analogues likely to prove fruitful sources of information for the construction of pertinent hypotheses, then, may not exist at all.

Acknowledgements. Barbara L. Stark, Alice B. Kehoe and Virginia L. Betz kindly reviewed earlier versions of this manuscript. Their critiques and comments have been very helpful, and are much appreciated. My thanks also to Luz Maria Aguilar for her Spanish translation of the abstract.

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NOTES

[1]. The slough at Cahokia had been drained; samples were collected from an

exposed profile rather than by coring.

[2]. Chomko and Crawford (1979) suggested that the palynological evidence for Helton Phase maize cultivation at Koster is unconvincing because it has never been presented in the form of a published text available for critical evaluation. This sort of criticism of reports of pollen records seems sound, but, as in this case, may be beyond the ability of the palynologist to control. Critical evaluation of all relevant information would not be satisfied by publication of my report to the project director (Schoenwetter 1974a) or my public presentation (Schoenwetter 1974b). Critical evaluation also demands review of the field records supporting the claim that the sediment samples containing maize pollen were in fact collected from Horizon 6 deposits; review of the argument that the sampled deposits were stratigraphically equivalent to the Horizon 6 deposits which yielded C14 dates ranging from 4880±250 to 5725±75 rya (Hajic 1990:17); and review of the evidence that the degree of asssociation between the samples containing the maize pollen and diagnostic Helton Phase artifacts is sufficient to infer contemporaneity.

In short, critical evaluation of the palynological evidence requires either the long-awaited monographic Koster site report or access to field and laboratory records now almost a quarter century old, as well as the patience and opportunity to follow paper trails confirming or contradicting claims about the provenance of the samples in which maize pollen was observed. I have taken the provenance claims transmitted to me as personal communications by the project director at face value. One reason a report on pollen studies undertaken at Koster remains unpublished is that I am in no position to verify those claims to the total satisfaction of possible critics.

[3] . Though palynological research designs could be developed to explore the hypothesis of maize's ceremonial significance to Middle Woodland Populations, technical and logistical factors may deny Woodland archaeologists much opportunity to implement them. Systematic study of anthropogenic deposits pollen samples from this region is not presently cost effective, because the pollen is normally too poorly preserved to allow confident interpretation of frequency values in paleovegetation terms. Many such pollen samples must be studied, however, to develop the data base needed to design and test behavioral hypotheses palynologically. The issue is complicated by the fact that much of the archaeological research undertaken in the region today consists of cultural resource mitigation efforts. It is unethical (and possibly illegal) to undertake expensive studies for the purpose of providing a body of palynological information that might (but might not) some day be determined to be useful to the study of the region's prehistory. As I understand the law, scientific research legitimately supported by funds intended for the mitigation of adverse impacts to cultural resources must be <u>demonstrably</u> <u>likely</u> to contribute to a positive understanding of their significant qualities.