

POLLEN STUDIES IN SOUTHERN ILLINOIS

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INTRODUCTION

The potentials of pollen-analytic research are as yet hardly investigated in North America. This is expectable in a science which began less than fifty years ago (Von Post, 1917) and which has little practical application. With the recent introduction of methods for concentrating the pollen of alluvial sediments (Frey, 1955; Kurtz and Turner, 1956; Arms, 1960) whole regions of the continent became potentially open for investigation, for earlier researchers were fairly limited to investigation of either highly organic sediments, such as peat and gyttja, or lacustrine sediments.

The organic and lacustrine sediments of Europe have yielded a great deal of pollen-analytic information on the sequences of postglacial vegetation changes in that region (See Flint and Deevey, 1956, for summary). When, as at Star Carr (Clark, 1953), pollen samples could be collected in association with archaeological materials, the vegetation at the site during the period of occupation could be ascertained from the pollen record as well as a date of occupation in terms of the known vegetation sequence. Radiocarbon analysis of different phases of the vegetation sequence provide an absolute time scale by which both the pollen record and associated cultural materials might be dated.

Cultural materials in direct association with highly organic or lacustrine sediments are far rarer on this continent than in Europe. While pollen chronologies have been available for parts of the United States and Canada for some time (Flint, 1960), and these chronologies were soon dated by C-14, there seemed little prospect that the information would be of direct use to New World archaeologists. As of 1955, the only successful analysis of pollen from an archaeological locality in North America which had appeared in the literature was the Boyleston

Street Fishweir (Banninghoff, 1942). American archaeologists were quite intrigued by the potential value of the technique which had been evidenced in the European studies (witness Taylor, 1956) but were--and mostly still are--quite in the dark about how to go about "doing" the pollen studies they felt were necessary.

The palynologists of the Americas were not quite so hesitant. The excellent archaeological chronologies of the United States offered an exciting opportunity to achieve a pollen chronology which would not be directly dependent on stratigraphy. Hopewellian associations in Ohio, for example; could be assumed to be older than Southern Cult associations in Oklahoma. If such sediments proved polliniferous, a chronology could be developed. Sears (193) attempted such studies, but was generally unsuccessful in recovering pollen from the sediments. The alluvial chronologies developed by Bryan, Antevs, and others in the American Southwest offered prospects to the pollen analyst, as did the alluvial chronology of the Valley of Mexico which was essentially tied together by the artifacts contained in the sediments. Sears investigated the former area in 19 , though the results were not published until recently (Sears, 1962), and he produced a Valley of Mexico pollen chronology effectively dated by cultural materials (Sears, 1956).

But it was not until the University of Arizona's Geochronology Laboratories began intensive pollen investigations in the Southwest, and it was not until efficient methods of extracting and concentrating pollen of alluvial soils were developed, that pollen samples collected in direct association with cultural materials form the basis for a North American pollen chronology (Martin and Schoenwetter, 1960; Martin, Schoenwetter and Arms, 1961). The cultural materials were utilized to date the sequence of vegetation changes; the pollen data, in turn, yielded information re-

garding the variety of vegetation and climatic phases under which the cultures had lived and gave clues through the occurrence of pollen of agricultural plants as to the way of life of the people. This type of research is continuing apace in the Southwest, where late cultural associations can be dated with the precision afforded by tree-ring studies (Schoenwetter, 1962; Hevly, 1964; Schoenwetter and Eddy, 1964) or where early ones are associated with radiocarbon dates (Hafsten, 1961; Martin, 1963; Oldfield and Schoenwetter, 1964).

This study attempts to open up a new area of the United States to palynological investigation. It does not do so with the assurance of prior studies in North America, for on the one hand the amount of stratigraphic detail is quite limited (by contrast to the bog pollen profiles of the Northeast or the Great Lakes area) and on the other hand the absolute dating controls are equally limited. There are a number of radiocarbon dates to act as time-controls, but the time range in which the study is concentrated is relatively short (at most 1500 years) and the overlap of the standard error of the radiocarbon dates leaves the absolute dating quite open to interpretation. The cultural materials with which the pollen samples are associated are not as yet subject to tight time-control. There are a number of hypotheses in the archaeological literature pertaining to the relative and absolute dating of these cultural materials, but considering the total number of known sites, and considering the total area they would encompass, a truly representative sampling is not available in the scientifically analyzed record.

There is a further problem; one which I predict will become of increasing import as archaeologists become more interested and involved in palynological researches. Pollen analysis is a statistical technique. It concerns itself not with vegetation directly but with the numbers of

pollen grains left as fossils by prior vegetation communities. All plants do not pollinate equally, and the prospects for the preservation of one kind of pollen are not the same as for other kinds. Some pollen types are more fragile than others, plants that are not wind pollinated (anemogamous) often do not shed their pollen very far, and in some special instances (as is the case of plants with cleistogamous flowers) the plant never actually sheds its pollen at all. Plants of various species produce and shed quite different amounts of pollen, so those that shed more are relatively over-represented in the fossil record. To overcome such difficulties, the pollen analyst must orient his researches to the resolution of specific problems. He segregates categories within the pollen record, based upon his knowledge of ecological conditions, which have more or less value dependent upon the problem he has chosen to resolve. Those categories which have more value are statistically emphasized--a legitimate operation since the palynologist must perform work with numbers.

The archaeologist is familiar with this procedure, as he employs it in his own researches. It is not unusual for an archaeologist to assign a much lower value to 9,000 plain-ware sherds than to the 200 painted-ware sherds with which they were associated, or to assign an even higher value to ten intrusive sherds. These values are granted because the various categories have different uses and different meanings. Depending on the problems the archaeologist hopes to resolve, the values granted to the categories are determined.

It should not surprise the archaeologist to learn, then, that in Europe it is common practice for pollen analysts to emphasize the value of the pollen of trees over that of the value of pollen of shrubs and herbs. In European pollen chronologies, the problem the analysts have

set for themselves is the composition of the forest at given points in time; pine forest, oak forest, beech forest, etc. It is not unusual, then, for the analyst to disclose that at a certain point in time, a sample evidences 60 per cent beech pollen and 250 per cent non-arboreal pollen. His question--what is the nature of the forest at that point in time--is resolved: it is a beech forest. It happens in this instance that the beech forest did not occur at the locality sampled.

I am quite well aware that the pollen chronology I will present in the forthcoming pages does not "match" other chronologies presented for the Eastern United States (Deevey, Davis, and others). It was never intended to either test or support their work. Paleoclimatologists may object that I did not attempt a longer pollen chronology which would, in this critical region, assist in the resolution of a biogeographic controversy of some importance (Martin, 1958). But I oriented this research toward a quite different set of problems than those which have been traditionally studied by palynologists, problems which were not so much biological as anthropological. My concerns were:

1. What were the vegetation communities in which peoples of Mississippian Culture lived?
2. What changes in vegetation patterns took place, if any, during the period of their occupation of Southern Illinois?
3. What relationship do certain categories of artifacts have to the vegetation sequence, if any?
4. How might the vegetation pattern changes during occupation be explained in terms of causal factors?
5. What would the effect of these causal factors be on the economics of the culture involved?

It was, of course, hoped that if a sequence of changes could be

demonstrated this sequence would be the forerunner of a more complete pollen chronology for the area. And it was hoped that the pollen chronology would prove useful in resolving problems of the temporal placement of cultural events. But it should be pointed out that the methods of analysis utilized to resolve the questions with which I was concerned are not necessarily those best adapted to the problem of building a pollen chronology. There are already some indications that this is the case. The methods of analysis utilized appear to yield information on a quite limited area around the sampled locality. Where vegetation is essentially the same over respectable distances, the "chronology" developed by these methods is adequate; however, disturbance in local conditions as might be expected in such cultural pursuits as excavation of a barrow pit or construction of a mound seem to be overemphasized in the pollen records by the methods of analysis I utilized. For my purposes this was excellent information; for the purpose of building a pollen chronology for Southern Illinois it may well not be.

METHODS OF ANALYSIS

During the field seasons of 1960, 1961, and 1962 a number of archaeologists working in Southern Illinois, including myself, collected the sediment samples here analyzed for their pollen content. The laboratory work began in 1961, so later sampling programs had the advantage of prior experience. In the later field seasons we had some understanding of the percentage of samples that might expectably prove polliniferous, and some leads as to what types of samples might not be expected to yield results. The sampling task was considerably lessened by such information.

The conscientious archaeologist recognizes that in the process of his work he destroys all possibility of further testing. While the

chemist may repeat his experiment with another batch of the same chemicals, no site can be excavated twice. Either the information is obtained the first time or it is not obtained at all. As each shovel-full of earth contains a large number of potential pollen samples, the archaeologist needs some general guides for pollen sampling, and the more specific those guides the more content he will be. At the beginning of this program there were no guides, and samples were collected in some cases almost by whim and fancy. Of the hundreds of pollen samples collected, only a small proportion were actually processed and an even smaller proportion yielded results. In the final analysis these general rules prevailed to guide the sampling program. They are here emphasized as a set of rules-of-thumb for interested archaeologists.

1. The sampling program should be oriented toward the resolution of known problems. If one has some idea of what he is sampling for, decisions about when and when not to sample are largely resolved. In order to formulate a set of problems, of course, some familiarity with the potentials and limitations of pollen analysis is mandatory.

2. The sampling should be done by association wherever possible. If a sample is desired to indicate conditions in existence at the time a specific cultural feature was in existence, the sample (s) should be taken in association with the feature. For example, one may determine the environment in existence at the time of a certain house type by dealing with pollen samples collected from floors of that house type. A series of roof-fall samples from a house type would yield data on conditions in existence about the time of abandonment of the houses.

3. The sampling should include some stratigraphic controls. If one house is superimposed by another a definite stratigraphic sequence is available for sampling. If natural stratigraphy exists at the site and is used as a control on the excavation, the natural units should be sampled in sequence. If arbitrary levels are used as a control on the excavation, samples from the arbitrary levels are linked by association with all of the cultural debris from those levels.

4. Samples should always be taken in association with anything that can be independently dated. If burned roof-fall from a house yields sufficient charcoal for a radiocarbon analysis, a pollen sample from the same provenience is thus dated by the C-14. A vessel which can be dated by association with tree-rings or relatively dated by serriation may contain sufficient soil for pollen sampling. Here, of course, the sample may date to the same period as the vessel or younger, but at least it cannot be older.

When the samples were brought into the laboratory, the first problem was that of extracting the pollen. The first series of samples selected for processing were those collected in stratigraphic sequence from the banks of a slough. These were the most highly organic of the samples available and thus promised the least difficulty. The extraction technique utilized was like that then in use at the University of Arizona, which I had utilized previously for alluvial materials (Schoenwetter, 1962. Appendix B). In that method, the first step of the processing involved preconcentration of organic debris by the technique described by Arms (1960). As there

was less sand in these samples, I substituted for the Arms technique a preconcentration step in which 75-150 grams of sediment were placed in a beaker containing 200-400 ml 10% KOH and, after breaking up the clods of sediment, the whole was stirred rapidly until the sediment was in suspension. After letting the beaker sit at rest for 15 seconds, the supernatant was poured off and centrifuged. This operation tended to remove the lighter particles, including pollen, from the 75-150 gram sample and the bulk of heavier particles was discarded. The rest of the extraction procedure was as described in the source quoted above. As the first series of samples proved analyzable, this extraction technique was used throughout the project.

In the analysis of results, each pollen grain was considered as equivalent in value to each other pollen grain. The figure on which the pollen percentages of a sample were calculated, then, was the total of pollen observed for that sample, or the total pollen sum. Wright (1963) has recently made a strong case for the use of this figure in the analysis of pollen data. No record of observations of materials other than pollen were kept. Spores or various types (moss, fern, algal and fungal) were not recorded, nor were records kept on the presence of various plant tissues observed on the microscope slides.

An attempt was made to record at least 150 pollen grains per sample. Many samples yielded pollen in such small quantity that many hours would have been necessary to achieve a 150-grain count. As the objective was to investigate as many samples as possible in the time at our disposal, such samples were largely ignored. In a few cases such samples were important because of their associations in stratigraphic

columns or their associations with important cultural materials. Then either lower counts were accepted or a great number of slides were doggedly scanned until a reasonable number of pollen grains had been observed. I caution the reader, then, to take note of the pollen sum listed for each sample on the pollen diagrams. This figure is a rough measure of the relative reliability of the statistics of the pollen percentages. When the figure is less than 150, its reliability may well be questioned.

The pollen diagrams are of two types. Where samples were collected in stratigraphic sequence the familiar silhouette pollen diagram is employed. Where the samples were collected by associations, bar diagrams are employed. In constructing the bar diagrams the vertical position of the samples is an interpretation of their temporal position, not a certainty, as it is in the silhouette diagrams.

THE MODERN POLLEN RAIN

As Martin (1963:5) has pointed out, the comprehension of an ancient pollen spectrum is highly dependent on our comprehension on the present pollen rain. In the form of an equation this may be stated as:

$$\frac{\text{modern pollen rain}}{\text{modern vegetation}} = \frac{\text{fossil pollen rain}}{\text{fossil vegetation}}$$

There are various techniques for sampling the modern pollen rain. Hafsten (1961) collected samples from stock tanks, as did Martin (1963). Potter and Rowly (1962) collected pollen on sticky surfaces exposed during the pollination season. Mahr (1964) collected surface sediment. The modern surface samples reported here were obtained by collecting the top centimeter of sediment on the present surface. This technique is probably less effective as a true representation than that proposed by Bent and Wright (1962), but it was the one we began with and maintained throughout the project.

BLUFF LINE

SCALE MILES

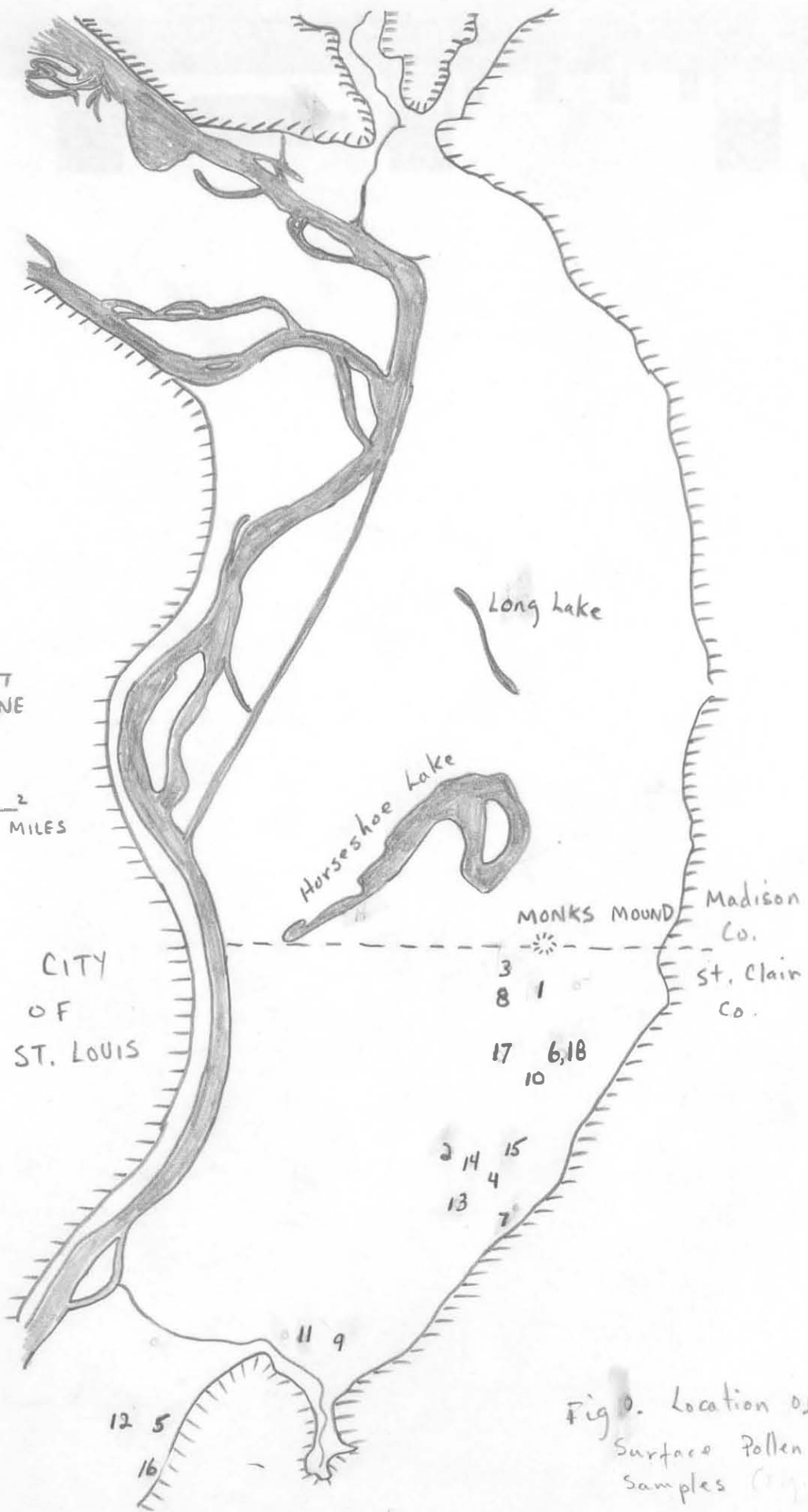
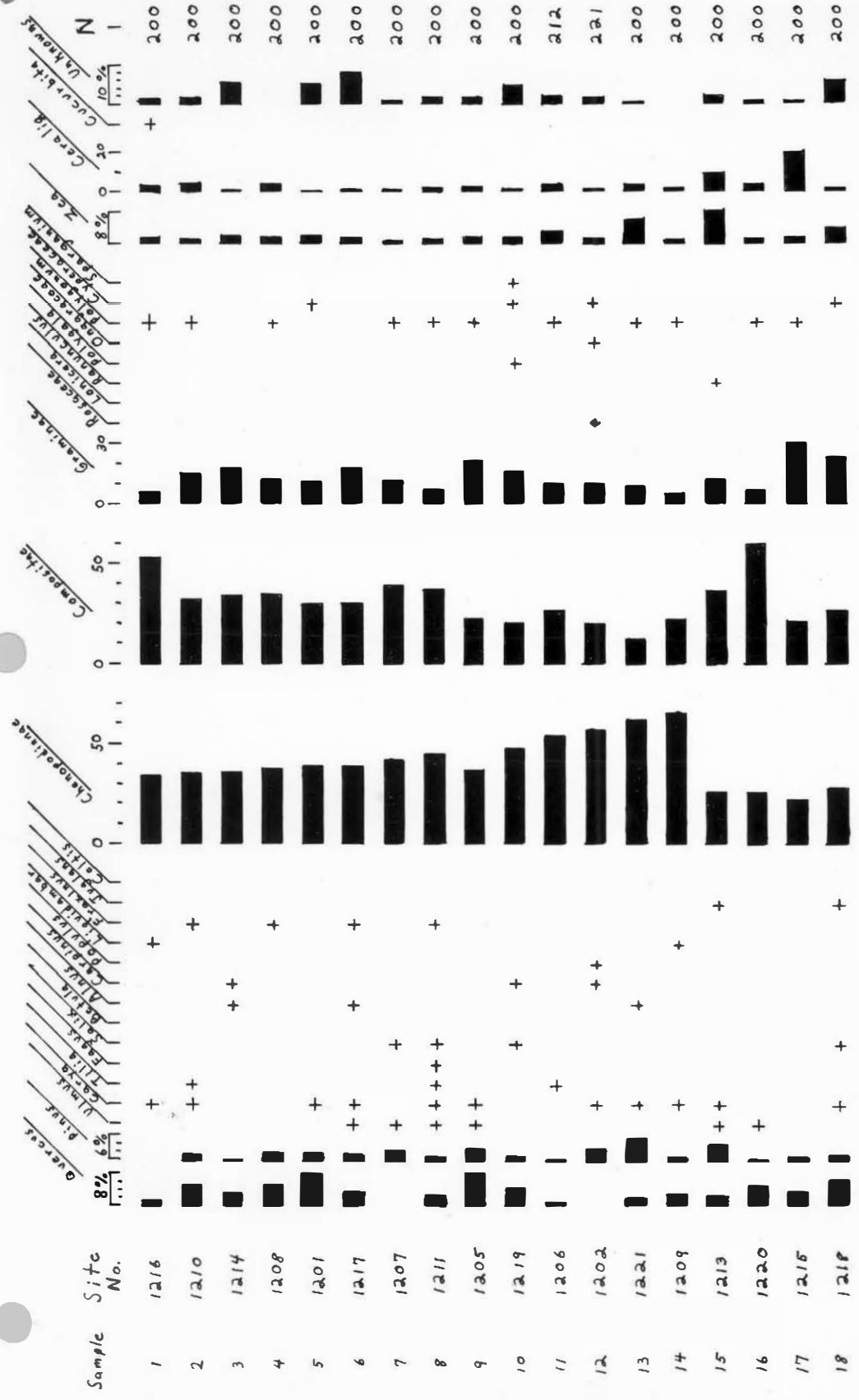


Fig. 2. Location of Surface Pollen Samples (Fig. 3)

SOUTH BOTTOMS AREA



LONG LAKE AREA



Modern surface samples were collected in two of the three areas in Southern Illinois which were investigated for fossil pollen: the Apple Creek Site area in Pike County, and the American Bottoms area in Madison and St. Clair Counties. The positions of these areas in the state are shown on Figure 1.

Figure 2 illustrates the points of collection for 18 surface samples collected in the American Bottoms area south of Monks Mound. The resulting pollen spectra are shown in Figure 3. It is clear that the majority of the pollen in any given spectrum is of the three taxa Chenopodiaceae, Compositae and Gramineae.

In eight of these spectra, both the Chenopodiaceae and Compositae percentages are greater than 30%. In six other cases only the Chenopodiaceae frequency is greater than 30%. Of the remaining four cases, one contains no pollen type in greater frequency than 30%, and two contain only Compositae and one only Gramineae pollen in frequency greater than 30%.

The modern vegetation pattern in the area where these surface samples were collected can only be generally described. Some of the samples were collected in Monks Mound State Park, which is in part forested; the larger number of samples were collected from the surface of farmland; some were collected near swamps or sloughs; and others were collected on industrial or residence land. The American Bottoms for the most part consists of farmland where wheat, maize, and horseradish are major crops. A number of industrial and residential areas occur, and highways and railways cover a substantial acreage. Natural vegetation is fairly limited to lake and slough margins which support Salix (willow), Quercus (oak) and Acer (maple) as the dominant arboreal species and

Cyperaceae (sedges), Typha (cattail), Gramineae (grasses) and Iva (marshelder) as the dominant non-arboreal species and to hardwood woodlots in which Quercus (oak) or Carya (hickory) is dominant. Woodlots are not uncommon on the farmland and a narrow strip of forest extends down the bluff slopes bordering the area. For the American Bottoms as a whole, arboreal coverage is minor as most of the region is either cultivated or too wet for either trees or cultigens.

The lack of tree cover seems well represented in the surface pollen spectra. The two dominant arboreal species in the pollen records are oak, which never amounts to more than 8% of a spectrum, and pine. While the pine record accounts for as much as 4% of the pollen spectrum, pine is extremely rare in the area. A few specimens exist on the bluffs and some are cultivated in the residential areas as exotics. The occurrence of much more pine pollen than is expectable may be attributed to either very high pollen production by these few trees or to long-distance transport of pine pollen from the extensive pine forests some hundreds of miles to the southeast, or both. During the season when the southeastern pine forests are pollinating, the prevailing winds would carry pollen to the American Bottoms area.

Of the three dominant taxa in the pollen spectra, representatives of Chenopodiaceae and Compositae in the area today are mostly rank weeds. Lamb's Quarters and Pigweed are quite common in the cultivated fields for they, like many other species in the Chenopodiaceae, are adapted to disturbed soils. Marsh elder and Ragweed are the most prevalent members of the Compositae in the region; the former preferring the damp soils of the slough and lake margins and the latter adapted to the dry, disturbed soils of the farmland. Almost all of the Compositae pollen recovered can be referred to the subsection Ambroseae of the Compositae, to which the marshelder and ragweed belong. The city of St. Louis, just across the river from the collection

-15-

area, is infamous as one of the worst loci in the United States for persons allergic to *Ambroseae* pollen.

In almost half of the modern surface samples the present vegetation pattern seems excellently presented. Little arboreal coverage is evidenced and greater than 60% of the pollen may be attributed about equally to the weedy plants that infest the disturbed soils of the farmland and the wet soils of the lake and slough margins. In another third of the samples *Chenopodiaceae* pollen is dominant over the other types. In each of these instances the samples were collected from sandy loam or sand sediments where it might be expected that species adapted to somewhat drier conditions might be better competitors. In one of the two samples where *Compositae* pollen is dominant, and in the one sample where grass pollen is dominant, unusually high frequencies of maize and wheat pollen occur. I think it can be confidently assumed that because of local conditions of pollen deposition these samples are not truly representative of the modern pollen rain. The other sample yielding only *Compositae* pollen in greater frequency than 30% was collected only a few yards from a swamp on a clay substratum, where it might be expected that marshelder would be over-represented. The one sample in which no taxon establishes a frequency of greater than 30% is simply an anomalous record.

These surface pollen samples indicate the generally prairie-like structure of the vegetation of the American Bottoms by the low frequency of arboreal pollen. That the prairie is not a grassy prairie is reflected in the fact that in only one instance--and that a probably non-representative record--does the amount of grass pollen amount to as much as the quantity of either category of weedy growth. When it is recognized that cultivation in this region depends upon the use of the tractor for plowing and an extensive use of ditching to drain water from the land, the *Chenopodiaceae* record

takes on significance as an indication of disturbed soils. By contrast of these records where *Chenopodiaceae* pollen is the only type with a frequency of greater than 30% with the majority of records, *Chenopodiaceae* pollen becomes an indicator of dry, loose, disturbed soil habitats while the *Compositae* record becomes indicative of wet, less disturbed, more compact soil habitats.

The lower section of Figure 3 illustrates the pollen spectra of surface samples collected at Long Lake, in Madison County, on the American Bottoms. The upper three samples of this group were collected from the soil surface, about 50 yards apart, on the west shore of the lake; the lower three samples were collections of surface sediment below the waters of the lake, again 50 yards apart near the west shore.

The three soil surface samples are much alike. All contain greater than 30% *Chenopodiaceae* and greater than 30% *Compositae* pollen and thus agree with the majority of surface samples collected in St. Clair County. The three lake sediment samples are variable. All contain more arboreal pollen than the soil surface samples and more types of tree pollen. Only one of the three contains more than 30% of both *Chenopodiaceae* and *Compositae* pollen. By comparison with the other surface samples from the American Bottoms, this series from the sediment of Long Lake would indicate that under the lacustrine condition atypical results are expectable.

Figure 4 shows the results obtained on modern surface samples from various ecological niches in the area of the junction of Apple Creek with the Illinois River, in Pike County. Here the valley is far narrower than at the American Bottoms, and the hardwood forests of the bluff slopes are quite closer to surface collections made on the floodplain. The region is not so extensively cultivated, so many of the sloughs still remain undrained. An ecological study of the area was made by Turner (1934).

Surface samples AA and BB were collected about 100 feet apart on the surface of the present floodplain of Apple Creek. This floodplain is inundated almost annually, but the loci of these samples may not have been flooded in the year or two previous to sampling.

Samples CC and DD were of moss polsters. Both were collected in areas of climax oak-hickory forest on the bluff slope, but the former was collected near the crest of the bluff and the latter was collected at the crest.

Sample EE was collected from the uppermost six inches of sediment in a large slough on the bottoms of the Illinois River Valley, locally known as Brush Lake. The shoreline vegetation is a heavy growth of Populus (cottonwood), Salix (willow), Fraxinus (ash) and Quercus (oak). Sample FF is of sediment from the uppermost foot of another slough bordering the Illinois. It lies about a quarter-mile from Brush Lake and was an old channel of Apple Creek, but this channel was abandoned in 1924. This slough supports a shoreline forest of Acer (maple), Ulmus (elm) and Celtis (hackberry) in addition to the species noted for Brush Lake.

Sample GG was collected from the surface of the Apple Creek Site, an archaeological locality. Until 1962 this was a cultivated field; during the 1962 growing season, some 5 months before the sample was taken, the area supported a dense growth of weeds.

Sample HH is of sediment which was accumulated between July 2, 1962 and March 21, 1963 in a pit dug at the Apple Creek Site. It thus represents only a part of the year: the end of the growing season and the winter months.

The contrast of these pollen spectra with those of the American Bottoms is quickly evident. But one of the samples shows much higher frequencies of tree pollen, even those from the treeless part of the floodplain or the cultivated field. There is far less *Chenopodiaceae* pollen and a generally greater frequency of the unknowns category. These differences seem perfectly

explicable on the basis of the ecological meaning previously ascribed to the pollen spectra of the American Bottoms. Chenopodiaceae values would be expected to be lower in an area where cultivation and draining have not disturbed the soil extensively. Arboreal pollen frequency is expectably higher closer to the forest. Unknowns, primarily representing zogamous flora, are expectably more frequent in a less disturbed vegetation unit.

Making internal comparisons between the samples, those that form the un-forested areas (AA, BB, CC, GG) show the expected pattern of containing less arboreal pollen than those from the forested areas (CC, DD, EE, FF), with the exception of sample BB in which elm pollen is very obviously over-represented. The riparian trees, Populus, Salix, Alnus, and Betula, are better represented at the slough localities, as are the wet non-arboreal plants, Typha, Polygonum and Cyperaceae. The drier trees, Carya and Juglans, are better represented in the upland samples. The cultivated field sample, and the sample which represents only part of the growing seasons, evidence unusual pollen spectra.

In summary, the surface samples act as controls on those collected below the surface by yielding explicit data on the relationship between a vegetation unit and its expectable pollen rain. These general principles seem to hold at present, and may be expected for the past.

1. The closer the sample to forest the more pollen of trees may be expected. As indicated by the surface samples from the Long Lake area, however, there is a critical tree density below which this rule does not apply. Gallery forest which has little extent back from the water edge does not yield sufficient arboreal pollen to mask the generally non-arboreal nature of the vegetation pattern. The arboreal pollen frequency thus seems to indicate arboreal coverage rather than the simple proximity of trees.

2. *Chenopodiaceae* pollen seems best characterized as an indicator of disturbed ground, occurring in frequency greater than any other pollen type only when extensive disturbance is evident.

3. Non-forested bottom lands tend to have a pollen flora dominated by *Compositae* pollen under present environmental conditions when undisturbed. Forested bottom land or upland pollen floras are not necessarily dominated by arboreal pollen, but contain enough more to make their presence recognizable.

4. Pollen of economic plants is not widely disseminated. Its presence, therefore, is a good indication of farming activity in the area, but its absence is not a precise indicator of a lack of agriculture nearby.

5. While the pollen spectrum of any given collecting station reveals more about the vegetation of that station than it does about the general vegetation pattern of a large area, the pollen spectra of a specific vegetation pattern tends to show a general resemblance. If only one or two samples are available, one cannot expect to make definitive statements about the vegetation pattern from which they derive, for they might be more indicative of local than area vegetation conditions. A number of pollen spectra from a locality which yields essentially the same results, however, can be expected to have derived from the same vegetation pattern.

THE POLLEN CHRONOLOGY

Three stratigraphic sequences of pollen samples were collected from the banks of a slough which meanders next to the Cahokia Site. These form the basis of the pollen chronology, as palynologically distinct horizons can be recognized in the profiles and the sequence of these horizons is repeated in various profiles.

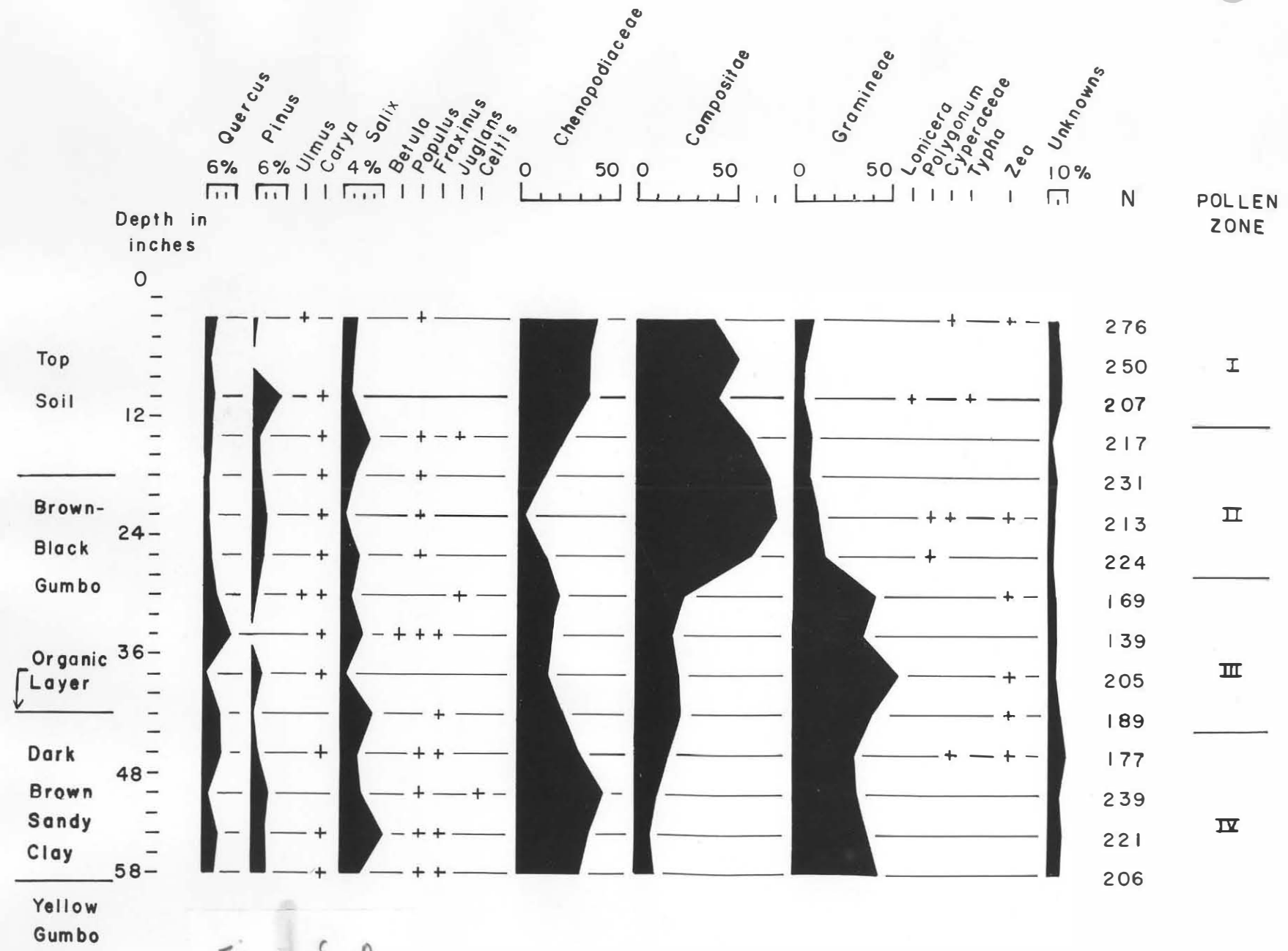


Fig. Sec A

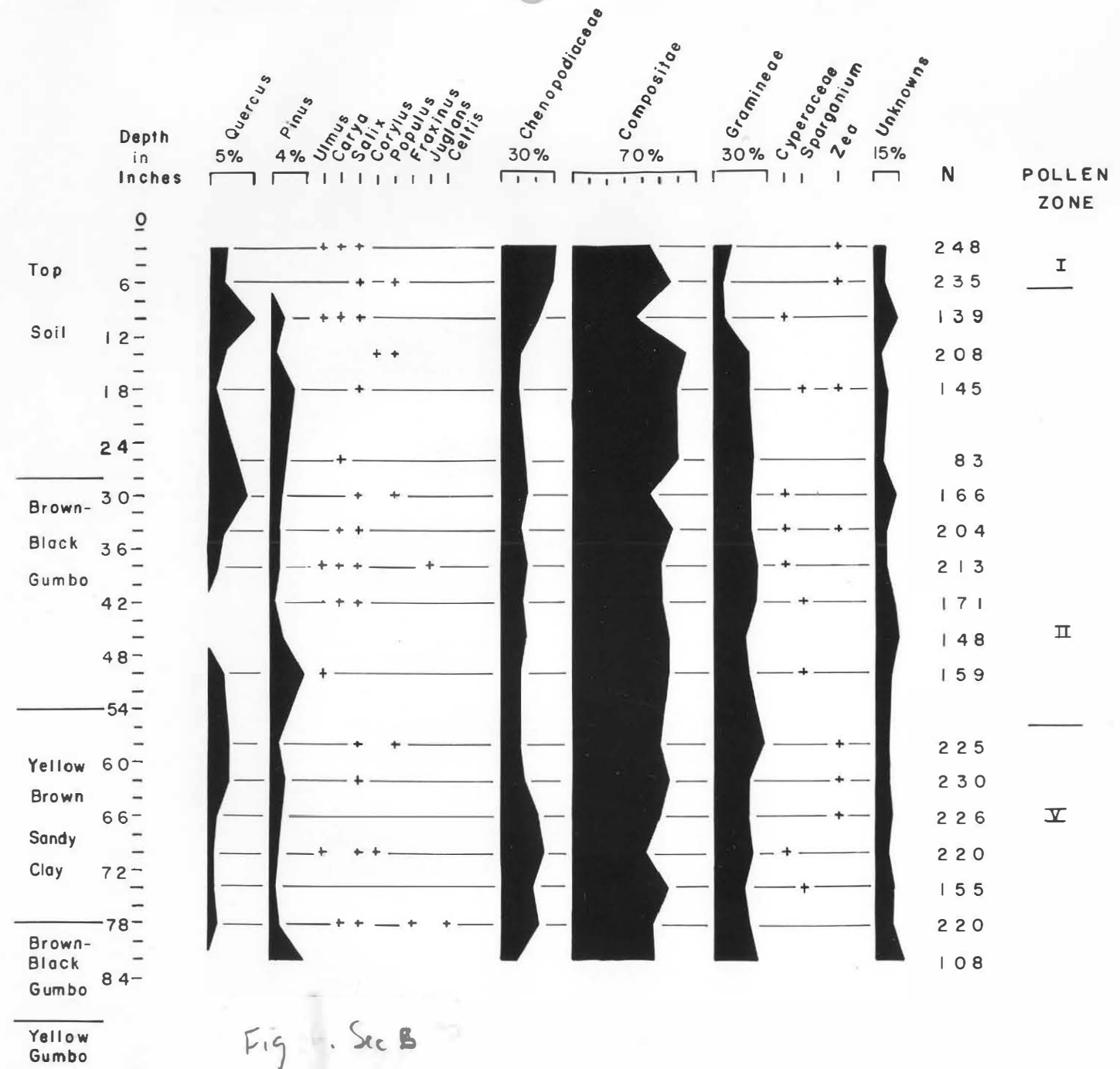


Fig. Sec B

Figure 5 diagrams the results from Locality A on this slough (Field designation 800R160). The uppermost two samples are seen to be like most of those from the modern surface in yielding greater than 30% *Chenopodiaceae* and greater than 30% *Compositae* pollen. Below a depth of six inches only *Compositae* pollen is in greater frequency than 30%. Mississippian potsherds were recovered from the surface to a depth of 24 inches. There were no artifacts in the brown-black gumbo between 24 and 60 inches depth, but more Mississippian sherds were recovered between 60 and 84 inches depth. Maize pollen, which might be attributed to either American or Mississippian culture, was associated with all lithological units.

Figure 6 shows the profile collected at Locality B (field designation MS2-2, T-1) about 2.5 km from Locality A along the same slough. The contrast in lithology of the two sediment sequences is quite striking, yet the sequence of palynological horizons seems maintained at Locality B. The uppermost sample from Locality B is obviously over-represented in pollen of *Salix*, and must be discarded from consideration. The sample collected below it yielded a pollen spectrum containing more than 30% of both *Chenopodiaceae* and *Compositae* pollen, like the majority of those from the modern surface and like those from the upper levels at Locality A. Below this, and extending to a depth of about 36 inches, only *Compositae* pollen is in excess of 30%--just as was the case at Locality A. Below 36 inches a series of pollen spectra occur in which only *Gramineae* pollen has a frequency of greater than 30%.

Artifacts are present at Locality B only between the 12 and 18 inch levels, and these are pieces of metal, brick, and wood attributable to the American occupation. Maize pollen is associated with the artifacts and the levels above them.

Figure 7 is the pollen profile of samples collected at Locality C (field designation 840R260). This locality is only 200 meters from Locality

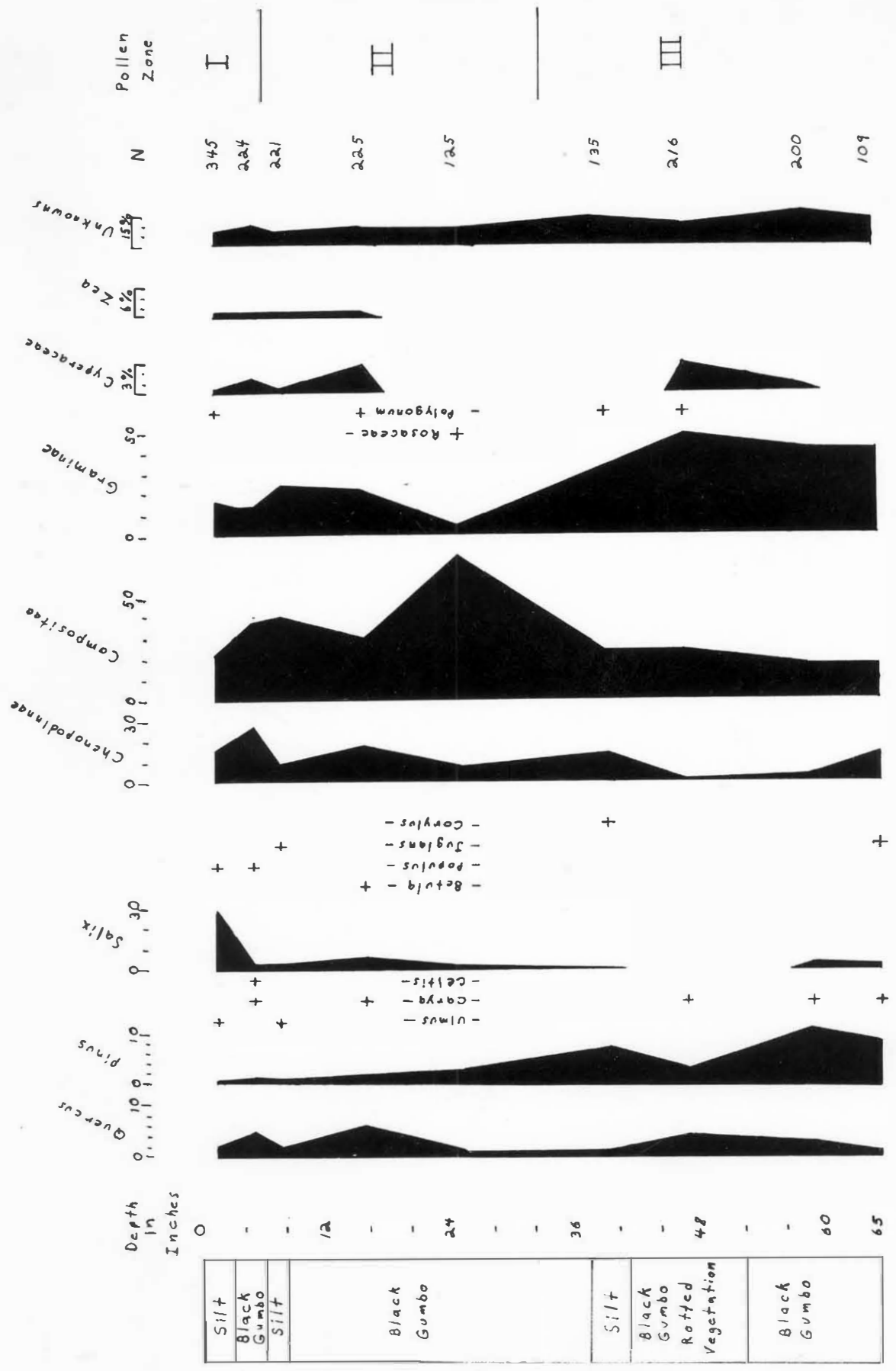


Fig. Sec C

A, and it will be noted that the lithological sequences at Localities A and C are very similar though the thicknesses of the various units are different at the two localities. In the Locality C profile, like the others, the uppermost samples contain more than 30% Chenopodiaceae and more than 30% Compositae pollen and below these are a series of samples in which only Compositae pollen has a frequency greater than 30%. As was the case at Locality B, the series of pollen spectra below this horizon contain only Gramineae pollen in excess of 30%. Below 46 inches, however, are four spectra which contain pollen frequencies unlike those from other localities or the modern surface, in which both Gramineae and Chenopodiaceae frequencies are greater than 30%.

At Locality C artifacts were encountered only below 24 inches. All were Mississippian potsherds. Maize pollen is associated with these artifacts and was also recovered from the uppermost sample.

There appears, then, to be a stratigraphic positioning of pollen horizons. The uppermost horizon (Zone I) at all localities is one in which pollen frequencies are like those of most of the modern surface samples from the American Bottoms, containing more than 30 per cent of both Chenopodiaceae and Compositae pollen. Below this horizon at all localities is one (Zone II) in which pollen frequencies tend to be like those from non-arboreal locales in the Apple Creek area and wetter modern locales in the American Bottoms area, containing only Compositae pollen in excess of 30 per cent. Below this horizon at two localities is one (Zone III) in which pollen frequencies are unlike representative samples from the modern surface, containing only Gramineae pollen in greater frequency than 30 per cent. Below this horizon at one locality is one (Zone IV) in which pollen frequencies are unlike any from the modern surface, containing both Chenopodiaceae and Gramineae pollen in greater frequency than 30 per cent.

This interpretation may be objected to on two grounds: First, all of the pollen horizons are associated with Mississippian sherds. This should not be the case if there is true superposition of horizons, as the Zone II horizon is also associated with American artifacts, known to be later in time than the Mississippian ones. Second, the sequence of lithological units at Localities A and C is in great part identical, but four pollen horizons are represented at Locality C and only two at Locality A.

As to the first objection, it must be remembered that vast areas of the American Bottoms have been disturbed by plowing. Mississippian potsherds brought up from beneath the surface in fields near the slough over the past 200 years could well have been transported into the upper six inches of topsoil at Locality A and thus be emplaced in the uppermost pollen horizon. Since artifacts of American culture are emplaced in the Zone II horizon at Locality B, it would not be unlikely that all of the Mississippian potsherds encountered in the upper two feet of sediment at Locality A were emplaced after the beginning of American Occupation. This would explain the break in artifact deposition at Locality A satisfactorily.

The second objection is much more difficult to overcome, for if the pollen horizons are time-diagnostic, as their stratigraphic positioning would indicate, the sedimentary units with which they are associated thus cannot be in sensu strictu. The brown sandy gumbo, for example, would date to the Zone II pollen horizon at Locality A, but to the Zone III and Zone IV horizon at Locality C.

Though it seems reasonable to assume that such a lithological unit as the brown sandy gumbo was deposited at the same time at both localities (they are only 200 meters apart), there is no a priori reason to do so. The specific factors causing deposition of any given sediment type at any given time in this area have not, to my knowledge, been investigated, so only the

general controls on sediment deposition may be taken into account in this case. Here we have a slough, an extremely slowly moving or stagnant body of water. All of the larger, heavier, sediment particles carried by the water would be expected to have been deposited soon after the formation of the slough and from that time only small particles and organic debris plus the few larger particles washing in from surrounding land. One would expect that after the deposition of the heavier particles the next lithological unit formed would cover the bottom of the slough to a constant level. Any succeeding units would then be of the same thickness over the bottom, except along the shore margins. As deposition continued the marginal deposits would become truncated and late units would not be represented.

As at least the upper three deposits are evident in both profiles, so neither is a shore margin condition, why are the deposits not of the same thickness at Locality A and Locality C? The sandy gumbo is two feet thick at Locality A but not quite 1.5 feet thick at Locality C; the overlying brown-black gumbo is two feet thick at both localities, but the top soil at Locality A, the brown-black gumbo below the sandy gumbo, is missing at Locality C. How could this have occurred under depositional environments in a slough? Finally, why is the sequence of lithological units so very different at Locality B, which is part of the same slough?

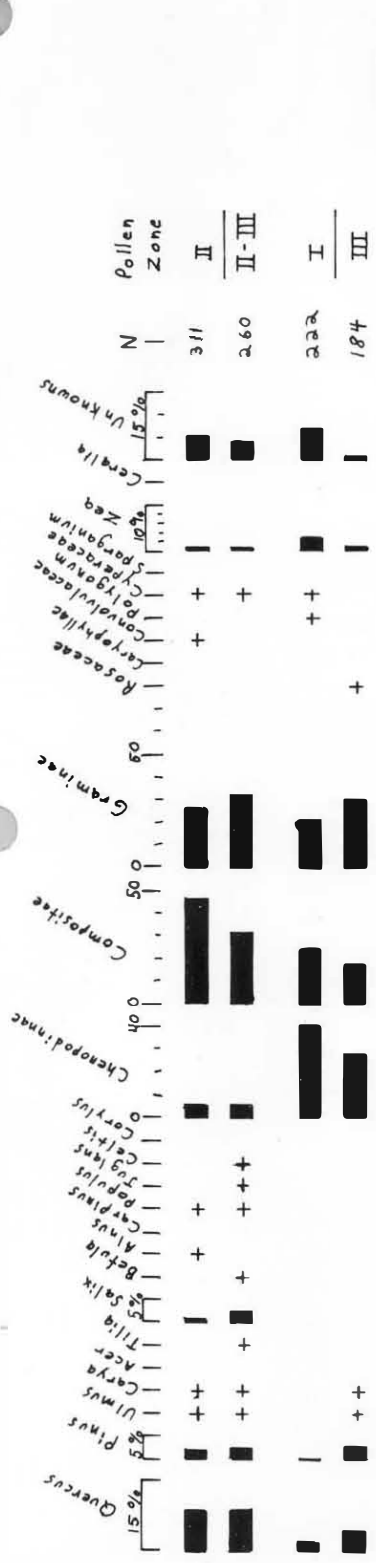
All of these inconsistencies could be resolved by one postulate: that though the water body was a slough at the time of collection of the samples, it was not a slough during all of the deposition history recorded in the sediment sequence. This would also resolve the problem of how, under a slough environment, a sandy layer managed to be deposited between two gumbo layers. If the water body was a stream, a continuously moving body of water, the deposition of its sediment load would depend on the proportion of sediment in

suspension, the gradient and the velocity. Brown sandy gumbo might well have been deposited at one locality while no deposition was occurring at another. Granting that the water body may have been a slough at some times and a faster moving water body at others, the following depositional history can be reconstructed to explain the differences in thickness of deposits, the differences in lithological sequences, and the differences in pollen spectra at the three localities.

During the deposition of the yellow gumbo at localities A and C and the brown-black gumbo which overlies it at A, the water body was a slough. The slough was then breached and a faster moving water body was formed. This deposited brown sandy gumbo at Locality A but not at C. Somewhat later the gradient changed. At Locality B this was sufficiently low that near-slough conditions occurred there and the deposition of black gumbo and black gumbo with rotted vegetation was possible. At Locality C brown sandy gumbo was deposited at this time, but there was no deposition at Locality A. A slough then formed again; a band of yellow silt was deposited at B. At Localities A and C two feet of brown-black gumbo formed on the bottom of this second slough, and at B 2.3 feet of black gumbo formed. The slough was again breached. Bands of silt and gumbo were deposited at B while top soil was deposited at A and C, though deposition at A and C did not occur at the same rate. At the time of sampling the localities were once more part of a slough, but this was entrenched below the areas sampled.

By reference to the cultural materials embedded in these horizons, some dating of the hydrological occurrences of this reconstruction is possible. Mississippian potsherds are found in the brown-black gumbo underlying the sandy gumbo at A and in the sandy gumbo and the overlying brown-black gumbo at C. American artifacts are found in the younger slough gumbo at B, and derived Mississippian sherds--presumably an effect of plowing after the be-

STRATIGRAPHIC
SUPERPOSITIONS



Site	Quercus	Pinus	Ulmus	Carya	Acer	Tilia	Betula	Alnus	Populus	Juglans	Cistaceae	Corylus	Chenopodiaceae	Compositae	Gramineae	Rosaceae	Conyuliacae	Cyperaceae	Polygonum	Zygaceae	Cerales	Unknowns	N	Pollen Zone	20 cm
# 162	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	311	II	20
# 14	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	260	II-III	24
# 35	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	164	II	25
# 269	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	204	II-III	27
# 277	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	225	III	28
# 97	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	108	III	30
# 98	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	174	II-III	30
# 124	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	205	II-III	44
# 102	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	219	III	45

Hsc. 59 B

Pot fill

Site	Quercus	Pinus	Ulmus	Carya	Acer	Tilia	Betula	Alnus	Populus	Juglans	Cistaceae	Corylus	Chenopodiaceae	Compositae	Gramineae	Rosaceae	Conyuliacae	Cyperaceae	Polygonum	Zygaceae	Cerales	Unknowns	N	Pollen Zone	
Hsc. 6, fill	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	132	I	Plow Zone
Hsc. 6, floor	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	257	II	Below Plow
Hsc. 5	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	179	II	Below Plow
Hsc. 2	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	271	II	13-26"

Hsc. 6, fill
Hsc. 6, floor
Hsc. 5
Hsc. 2

Fig 7
2 B Modif

ginning of American occupation--are in the top soil at A. It would appear that at the time of the earliest known Mississippian occupation the water body was a slough. It changed to a faster moving body of water and then became a slough again during the Mississippian occupation. It was still a slough during some early phase of American occupation but was breached, perhaps to drain land and create farmland, later in the American period. At the time of sampling it was a slough for a third time.

According to this reconstruction the two pollen spectra from the lower brown-black gumbo at Locality A, and the pollen spectra from the sandy gumbo above, they are the oldest in the pollen series. These have the same palynological characteristics as the samples from the second pollen horizon (Zone II) which dates, in part at least, to American occupation. It would appear, if the reconstruction of slough events is correct, that there is a pollen Zone V which happens to have the same palynological characteristics as Zone II: only Compositae pollen in excess of 30% frequency.

The presence of a five-zone pollen chronology is supported by results of some samples collected from the culturally sterile horizon at Cahokia. There were six samples collected from culturally sterile sediment at Cahokia and which thus must date either from before Mississippian occupation or during an early period of occupation (Fig. 8). Of the six samples from such proveniences, three yield pollen frequencies attributable to Zone III and two yield frequencies that might be attributable to Zone II or Zone V. As these are supposed to be from an early period of occupation the latter two cannot be from Zone II, since artifacts are associated with Zone IV and Zone III records in the slough profiles. Thus it appears that a Zone V, which happens to look like Zone II, does exist in the pollen chronology.

There was another opportunity to test the hypothesis that a Zone II-like pollen horizon (Zone V) underlay later horizons. At the Collinsville Airport site two pollen samples were collected from house number 6. One sample came

from the floor of the house, and the other from fill a few tenths of a foot above the floor. The lowermost produced only Compositae pollen in excess of 30 per cent; the upper yielded both Compositae and Gramineae frequencies greater than 30 per cent. The data could not be consistent with the hypothesis that the floor of the house was attributable to the Zone II horizon, as the succeeding sample--which still dates to the Mississippian period--would then necessarily yield Zone II pollen characteristics also, and it does not.

In all other cases where pollen samples were successfully analyzed and superposition occurred, the pollen chronology developed from the slough profiles was maintained. Zone III always underlay Zone II and overlay Zone IV; Zone I spectra were never obtained from Mississippian cultural contexts; where samples attributable to Zone V could be distinguished from those attributable to Zone II, the latter were always stratigraphically higher. There were a number of samples which contained pollen frequencies unrecognized in the slough chronology. Such samples contained records of greater than 30 per cent Compositae and greater than 30 per cent Gramineae pollen. I have taken these records as indicating the horizons of transition between Zones III and II or between Zones V and III.

The pollen record, then, seems adequate for dating associated cultural materials if the spectra are attributable to Zones I, III, or IV. Zones II and V cannot be clearly differentiated unless there are a series of stratigraphic samples, and samples dating to the transition periods are similarly undistinctive.

THE ENVIRONMENTAL CHRONOLOGY

The sequence of environmental conditions represented in the pollen chronology can be reconstructed by reference to the modern pollen spectra to which the pollen zones are equivalent and by reference to the general principles derived from the study of the surface pollen records. Zone I pollen spectra match the majority of those found today from the surface of the American Bottoms, and thus may be interpreted as indicative of the present disturbed prairie environment. Zone II spectra match those from prairie locales at Apple Creek and from relatively undisturbed wet prairie locales in the American Bottoms. Thus Zone II spectra may be interpreted as indicative of wet prairie, as was encountered by the American Settlers.

Zone III spectra are unlike those obtained from the modern surface, and thus apparently represent an environment not now known. This would be one in which the present ecological factors encouraging Compositae or Chenopodiaceae pollen production are absent. As was pointed out, the Compositae pollen is almost all of the Ambroseae type, indicative of either wet prairie or disturbed prairie environments. Chenopodiaceae pollen is indicative of disturbed locales. As the Zone III spectra do not contain high frequencies of arboreal pollen, the structural condition represented is prairie, and as it cannot be either disturbed or wet prairie it must be dry prairie.

Zone IV records, which contain high Chenopodiaceae and high Gramineae frequencies, by the same token, would be attributable to a disturbed dry prairie environment. But the evidence of the modern surface samples indicate that disturbance is well recorded in the pollen spectra only near the disturbed locale. Some distance away from the disturbance the Chenopodiaceae values decrease. We might expect then, that the Zone IV record at Locality C only indicates disturbance at a nearby area, and that at some distance

from Locality C the Chenopodiaceae values would be decreased and a Zone III record would result during the same time-period in which Zone IV records were being deposited at Locality C. Thus, we must speak of Zone IV in different terms than the other zones. It can only be expected to occur in a limited area and so though it has value, as a zone, for placing associated cultural records in relative time it exists on the same general horizon as Zone III. I have elected to call Zone IV the Period IV Interlude henceforth to so distinguish it.

Zone V records indicate the same environmental conditions as those of Zone II: a wet, relatively undisturbed, prairie environment.

Transition records indicate environmental conditions during the periods of fluctuation from one environmental condition to another. They thus represent neither dry prairie nor wet prairie but something in-between. As the Period IV Interlude exists on the Zone III time-horizon, one of the transition periods occurs between Zone V and Zone III, not between Zone V and the Period IV Interlude. The other transition period exists between the Zone III and Zone II horizons. Since Zones V and II are similar in palynological characteristics, the V-III transition and the III-II transition appear similar also.

ABSOLUTE DATING OF THE POLLEN CHRONOLOGY

Absolute dating of the various zones of the pollen chronology is extremely difficult. Absolute dating depends upon association of pollen spectra of a horizon with confident radiocarbon-dated, dendrologically-dated or historically-dated artifacts or features. As there are no historically or dendrologically dated materials, and as the available radiocarbon evidence is insufficiently critical (as is discussed in detail in a later section), only guesses based on other sources are possible.

The critical questions are the absolute dates on the shift from wet to dry prairie occurring between Zones V and III and the reversal of this condition between Zones III and II. The transition from Zone II to Zone I conditions took place in historic time and has nothing to do with climatic changes. Thus, it is unimportant in explaining the culture history of Mississippian culture.

Griffin (1960) has proposed that a number of cultural events, presumably due to migrations, in Mississippian culture history are explainable on the basis of a change in climatic regime from cooler-moisture conditions to warmer-drier ones. There is a climatic shift in this direction known historically from Europe beginning about 1200 A.D., and one in the opposite direction is known from Greenland which can be placed on this time horizon. In the American Southwest more arid conditions are postulated for the 13th century than preceding centuries on the basis of the dendrological record and the alluvial record, though recent pollen studies (Martin, 1963; Leopold, Leopold and Wendorf, 1963; Schoenwetter, 1962; Hevly, 1964) seem to indicate that the transition was not to more arid but to more moist conditions. In any event, some changes in the atmospheric physical system of the northern hemisphere seem to have taken place in the 13th century.

The radiocarbon evidence from the American Bottoms would not negate the conclusion that one of the changes in the pollen record, if not both, fall into the 13th century time range. The shift from wet prairie to dry prairie (the Zone V-III transition period) might be considered correlative with the moister to drier shift known from Recurrence Horizon RY I in the European pollen-geologic record. If one preferred to stay on this side of the Atlantic, the shift from dry to wet prairie (the Zone III-II transition period) might be correlated with the drier to moister shift in the Southwestern pollen record.

At the present state of knowledge there are two quite severe limitations to making successful correlations of the types noted in the last paragraph. First, the climates of the areas which have been investigated on prior ~~time~~ horizons are now under quite different, though related, atmospheric control systems. When one approaches the question, as Griffin has done repeatedly (Griffin 1960, 1960, 1961, 1961) it appears quite obvious that the relationship of all climates in the Northern Hemisphere is close enough so that during a century of climatic change in one area there probably is some change occurring in the other areas. But since our understanding of this relationship is as yet rather nebulous, we are unable to confidently predict exactly what kind of change will occur in Area A when a change of a known type occurs in Area B. There is also a question of time-lag in effect between areas, so if we do make correlations we are as yet not at all positive that the absolute dates are precisely the same.

Second, if pollen chronologies are utilized for correlation between the areas, as the American Southwest and the American Bottoms, the recognition of drier or moister conditions depends to a great extent on the way in which the pollen analyst undertook his studies. In both the European and Southwestern chronologies the recognition of a moister condition is dependent to a great extent on the proportion of arboreal pollen in the records. In this chronology the proportion of tree pollen is always so small as to be statistically meaningless, and it certainly does not undergo dramatic change in quantity as in the Southwestern records (Leopold et. al. 1963; Hevly, 1964; Schoenwetter and Eddy, 1964; Schoenwetter, 1962), nor does it change in internal composition as in the pollen records of eastern North America and Europe.

It cannot be said, then, that we can confidently correlate the environmental sifts observed in the American Bottoms pollen chronology with those

known from elsewhere, even though they appear to be in the same directions as others of known date. Yet some kind of absolute dating of the chronology is expected of the palynologist, and the matter has become of such archaeological interest through the theories of Griffin that I feel rather obliged to offer some opinion, weak as I believe it to be.

Recognizing the limitations on such a correlation as noted above, I tentatively would correlate the Zone III-II transition period with the environmental shift recognized in other areas as beginning in the 13th century. Evidence will be presented below that dates this transition horizon between 1385 and 1465 A.D., and I feel that this is very probably a true date on the transition as it occurred on the American Bottoms, but I would suspect that there was a lag effect involved and the beginning of the change in the atmospheric control systems of the Northern Hemisphere more probably occurred in the 13th century than the 14th.

On an even more tentative basis, I would date the Zone V-III transition period to the eighth or ninth century A.D. by correlation with a quite evident fluctuation in the pollen record of the Southwest which dates between 700 and 800 A.D. (Schoenwetter and Eddy, 1964). There is another transition in the Southwestern pollen record in the 10th century (Schoenwetter, 1962) with which it might also be correlative, but the 10th century shift is in the opposite direction from that evidenced in the American Bottoms chronology.

In summary, the pollen chronology is tentatively estimated to begin before the eighth century A.D. during a period when wet prairie conditions were in existence. This would have been a prairie much like that known at the time of American entrada, with a number of ponds, lakes, and sloughs and a scattering of woodlots with extensive open areas of grassland. In the eighth or ninth century the bodies of standing water apparently dis-

appeared in large part, though there was plenty of water in the through-flowing drainages. It seems hardly likely that the occupants of the region could have accomplished this by draining the area, so it seems to have been an effect of a true change in climatic factors.

Sometime before the last half of the 14th century and after the beginning of the ninth century, local environments were disturbed and one would have noted fairly limited areas of weedy growth on the prairie. In all probability this was due to the action of man in constructing earthen mounds and destroying the natural ecological balance by earth removal. This disturbance was not on a par with that noted for the historic period, when the tractor was available, however, and so though it did occur it can only be recognized in the regions where it was locally of major importance.

Most of this disturbance activity seems to have been completed by the end of the first half of the 14th century. At that time or somewhat later another climatically-induced environmental shift seems to have occurred which resulted in the re-instatement of environmental conditions which occurred before the eighth or ninth century: wet prairie. While the Mississippian peoples existed in this environment for an unknown length of time, they abandoned the area before conditions changed again. When the American Settlers entered the area, they encountered the same environmental conditions which the Mississippian peoples had abandoned some time before. With the advent of the tractor, the Americans set about to change the environment to suit their needs. By draining the ponds, lakes and sloughs they could have effected a reversal to the conditions known during most of Mississippian time: dry prairie. But their objective was to construct a dry prairie environment for maximal crop production and the ensuing use of the tractor for cultivation has today turned the region into a disturbed partially wet prairie.

TABLE I

SAMPLE PROVENIENCE	NUMBER PROCESSED	NUMBER ANALYZABLE
Mound fill	10	1
Pits and post-pits	9	2
Wall trenches or floors	13	7
Walking surfaces	16	12
Muck from lake	9	7
Others	4	2

THE FOSSIL POLLEN STUDIES

1. The American Bottoms Area

Mitchell Site and the Fill Site

The Mitchell site was the first in which the pollen chronology developed on the basis of the slough samples was tested. At this site relatively few samples were collected in superposition because of the shallow depth of architectural features below the plow sole. There were some samples collected in stratigraphic sequence from mounds, however, and it was hoped that these would substantiate and possibly enlarge the chronology. Samples collected in association with cultural debris were expected to be utilized to date the cultural materials in terms of the chronology.

Sixty-one samples from the Mitchell site and eight from the Fill site were processed for pollen analysis, but the majority contained too little pollen for reliable interpretation. In such cases, after the extraction process and subsequent reprocessing for removal of additional organic and inorganic matrix, the ratio of pollen to debris found on the microscope slides was still so low (less than 75 pollen grains/slide) as to preclude useful analysis. In the minority of cases the pollen to debris ratio was high enough to make analysis worthwhile.

None of the Fill site samples, for example, yielded to analysis.

Table I shows the distribution of analyzable samples by provenience category of the Mitchell samples. It becomes obvious that some sorts of samples were almost invariably low in pollen yield at this site, and others almost invariably high. Mound fill and pit and post-pit fill samples produced no significant results; those from house floors and walking surfaces dating to the time of occupation were almost invariably analyzable.

Why this should be the case is a perplexing problem. Mound fill, for example, is earth that has been scraped from some surface in aboriginal times and deposited by the basket-load in the mound. One would expect that the pollen it contained at the time it was scraped up would still be trapped in the earth, even if the earth was not exposed long enough during the mound construction to entrap more recent pollen. We cannot assume that the earth of which mounds were constructed never contained any pollen, as numerous plant tissue fragments were encountered in these samples and most of the samples are deeply stained by other sorts of decaying organic debris.

Somehow, it appears, pollen has been removed from such samples during the process of redeposition of the sediment. The same principle seems to hold for the pit fill samples, which are also intentionally redeposited sediments.

This at first seemed like an extremely odd occurrence, but on reflection it can be recognized that it may be a general condition. Pollen samples from inorganic sediments have only recently been intensively investigated because techniques of extraction of pollen from such sources have only recently been developed. But by and large it is the rule that such sources do not appear to contain large amounts of rebedded pollen. Pollen analysis in the Southwest has been successful on far more inorganic matrices than those investigated here, yet little rebedded pollen has been recognized.

Now the inorganic matrix is obviously rebedded in any alluviated area. The question of why pollen is not rebedded in intentionally rebedded sediments seems to be applicable as well to the naturally rebedded sediments. To my knowledge it has always been simply accepted as a stroke of good

fortune that relatively little rebedding of pollen occurs, and the question of why this is the case has not been raised. I have turned over a number of possible answers in my own mind but find none very satisfactory. The introduction of decomposing micro-organisms seems a good probability, but in the case of mound fill one would suspect that deposition occurred so rapidly that few such organisms would have become incorporated. Also, such organisms need an aerobic environment in which to survive, and it seems unlikely that enough oxygen would be entrapped in the sediments during mound construction. In the case of sediments deposited by water there would also be little oxygen entrapped.

While the question remains an intriguing one, my personal bent is to follow the lead of other pollen analysts and simply be relieved that intentionally redeposited sediments actually contain as little pollen as they do. Whatever the causes for this occurrence, it makes the pollen analysts' lot a little less complex.

Lake muck samples (top of Fig. 9) were dredged from Long Lake along with a number of artifacts. Stratigraphy was impossible to control in such an operation as the samples can be utilized only to give some general associations of pollen spectra with artifacts from this site. In two of the seven samples only Compositae pollen is in greater frequency than 30 per cent; in the remaining five both Gramineae and Compositae frequencies are greater than 30 per cent. According to the slough chronology, two samples may date either to Zone V or Zone II, and the others may date either to the V-III transition or the III-II transition periods. Without stratigraphically controlled data one cannot select from these alternatives.

There were only a couple of instances of stratigraphic sampling at Mitchell where the samples yielded data. In one case the floor of Feature 9 was sampled and another sample was collected 10 cm below the floor. The

floor sample contains only Compositae pollen in excess of 30 per cent; the sub-floor sample contains more than 30 per cent Gramineae and more than 30 per cent Compositae pollen. The lower sample may be either of the V-III transition or the III-II transition, but the upper sample cannot be Zone V as it is superimposed on a sample which must date later than Zone V. Hence, the floor sample must date to Zone II.

In the second case of stratigraphy a sample was collected from above the plow sole and another sample was collected below the plow sole. The uppermost sample contains only Chenopodiaceae pollen in greater frequency than 30 per cent; the lower one contains only Gramineae pollen in greater than 30 per cent. There seems to be a Zone III sample overlain by one in which the modern disturbance of the area is evident.

Now the Mitchell site is recognized as being one of short occupation. The architectural evidence for this is clear in a number of instances, and the available radiocarbon data would tend to show agreement with such a conclusion. We can indicate from the stratified pollen samples associated with cultural features that the site was being occupied in pollen Zones II and III. As it is a short occupation it seems reasonable to conclude that the samples which might be interpreted as either belonging to the V-III or the III-II transition periods probably date to the III-II transition and not the earlier one.

Other unstratified samples also seem to support this conclusion. During the excavation a number of samples were collected from the cultural horizon at the site. These samples were not directly associated with artifacts, but were collected in areas and at depths at which artifacts occur. They thus represent surfaces which were in use at the time the site was occupied. There are a series of nine such samples collected along grid-lines L180 and L185. They all come from a strip of territory 200 meters long and 5

TABLE II

SAMPLE NUMBER	DEPTH	POLLEN ZONE
162	20 cm	II
14	24	transition
35	25	transition
269	27	transition
277	28	III
97	30	III
98	30	transition
124	44	III
102	45	III

meters wide at the site. Thus, the sample collected 20 cm below the surface within this strip is quite probably younger than the one collected at 30 cm below the surface, as the surface is quite level and sediment deposition appears always to have been relatively even to judge by the soil stratigraphy. No doubt the accretion of sediment has been by water deposition and natural sod formation.

Table II shows the pollen zone attributes by depth of samples from this series. The sample from 20 cm depth, by this analysis, must be attributed to Zone II and those of the transition period must be of the III-II transition period. There is too much regularity of Zone III occurrences below 28 cm depth for the stratigraphy to be far off. Again, the only reasonable conclusion is that the occupational period is in the Zone II to Zone III range and not earlier.

There were five analyzable samples collected in association with houses. As floors of these houses are hard to define, the samples from features 9, 2, and 1 were collected from what probably was the floor area. Samples were collected from wall trenches of features 46 and 55, and from a definable floor in Feature 7. The sample from Feature 9 yields a typical Zone II or Zone V pollen spectrum. Those from features 2, 1, 46, and 55 yield spectra attributable to either the V-III or the III-II transition periods. The sample from Feature 9 cannot be Zone V in age as it overlies a transition period sample. The transition period reflected in any of the spectra from features 2, 1, 46, or 55 could be the V-III transition. However, this seems contrary to all of the available evidence so far discussed, so it appears most probable that the spectra from these features are of the III-II transition period.

There is no pollen sample of the Zone III horizon which is associated with a house. The presence of maize pollen in Zone III pollen spectra at

the site, however, substantiates the conclusion that occupation occurred in Zone III times. Another indication of this comes from two samples collected from Feature 10, a pit. Both are Zone III, and as they represent fill of the pit the pit must have been dug on the Zone III horizon or earlier.

Of the remaining 10 analyzable samples, eight give Zone II records, one is most probably of the III-II transition period, and one is Zone III. This last sample was the only one collected from a mound which yielded to analysis. It contains a greater number of arboreal pollen types than is usual and lacks maize pollen, but otherwise seems a reasonable Zone III spectrum. It may or may not actually be attributable to the Zone III horizon, as the pollen it contains may have been deposited at an earlier time when Zone III environmental conditions were also in effect.

The Cahokia Site

The Cahokia site produced two of the three slough profiles (Figs. 5 and 7) on which the pollen chronology was based, and the five samples of the precultural and early cultural horizon (Fig. 8) on which basis Zone V was inferred.

When the selection of samples from the Cahokia site came under consideration the results of the Mitchell samples were already known. It was determined from that analysis that the samples most likely to yield information were from wall trenches, house floors, and the aboriginal surfaces. No samples in the latter category were available from the Cahokia site, so most of the samples selected for processing came from the former categories.

There were also special categories of samples. The occurrence of circles of posts at this site, apparently ceremonial construction features, was so unusual that a concerted effort had to be made to try to date their

TABLE III

SAMPLE PROVENIENCE	NUMBER PROCESSED	NUMBER ANALYZABLE
Post-pits	28	0
Sterile soil	13	6
Humus line	1	1
Wall trenches	30	6
Above floor level in houses	10	2
On " " " "	7	6
Pot fill	3	1

construction through the pollen chronology. A series of 28 samples from the pits in which the posts were emplaced was processed to see if sufficient data could be garnered. There was also a sample from a humus line at the base of an artificial mound. Dating of this sample would yield a maximal date for the construction of the mound. Samples were also processed of the fill from buried vessels.

Table III shows the yield of analyzable samples. The yield from wall trench samples was far lower than had been anticipated on the basis of the Mitchell data, and was one of the most disappointing aspects of the American Bottoms Pollen Research Program.

Though none of the samples from post-pits yielded statistically relevant results, one of the sterile soil samples has bearing on the pollen-dating of a circle of posts. The sample of sterile soil (Fig. 8) number 52-4 was collected 0.2 feet beneath the pit in which a post was emplaced. Thus, it dates to a period before this post and, presumably, before the post circle of which it is a part. The pollen spectrum of this sample is typical of Zone III. The post circle, then, does not date as old as Zone V or as old as the Zone V-III transition period, though it may date any time thereafter.

The sample of pot fill (Fig. 10) which was successfully analyzed yielded a typical Period IV interlude pollen spectrum. This pot was recovered lying on the floor of house 89B. Presumably the house also dates to the Period IV interlude horizon. This house was superimposed by house 59B, which yielded two pollen spectra. Both of the spectra from 59B are attributable to Zone III. The stratigraphic superposition of Zone III above the Period IV interlude thus seems again evidenced.

The sample from the humus line at the base of the mound yielded a spectrum typical of Zone III. The mound itself, then, probably was con-

structed in Zone III or Zone II times. It must be remembered that the Period IV interlude is an interlude in Zone III time. Zone III may be expected to extend in time both before and after the Period IV interlude, thus accounting for the V-III transition. The construction of the mound may have been either before or after the Period IV interlude and yet still be on the Zone III horizon.

Eight of the samples analyzed were associated with houses which had been dated by the radio-carbon method. In the case of two houses, two samples came from each house; either from two different wall trenches or from the floor and the wall trench. The two samples from one house always agreed in pollen zone designation.

The samples from the radio-carbon-dated houses were treated somewhat differently than the others. Because the possibility existed that the C-14 dates would give absolute dating to the pollen chronology, it was considered worthwhile to work with the samples until a statistically reliable count was achieved even if the pollen yield per slide was extremely low. In the case of three of these eight samples there was less than 75 grains per slide but counting was continued until 150 or more grains were observed. In one instance this involved scanning 15 slides for a 165-grain count.

Of the six houses, four yielded spectra attributable to Zone III, one had a transition spectrum and so could be designated to either the V-III or the III-II transition periods, and one yielded a spectrum in which only Chenopodiaceae pollen was in greater frequency than 30%. This last spectrum is not typical of any pollen zone, but by reference to the modern surface samples it appears to be indicative of an area of local sediment disturbance. On the prehistoric horizon the Period IV Interlude indicates conditions of sediment disturbance, though not as extreme as those represented in this spectrum. It seems most likely that the sample

from house 74A belongs on the Period IV interlude time horizon and simply represents a locality where more than usual disturbance was prevalent.

The house that yields transitional spectrum can be confidently placed on the III-II transition horizon rather than the earlier one. The house, house 35A, overlies house 32A. As house 32A yields Zone III spectra, and house 35A must be younger, the transition represented in the sample from 35A must be the III-II transition. Since there is a radiocarbon date for the transition period between Zones III and II from House 35A, there should be no difficulty in assigning an absolute date to this horizon in the pollen chronology. There is no difficulty, but the precision of the date so assigned is qualified.

A radiocarbon date, because of the factor of imprecision in laboratory measurement, must be given in terms of a probable range. The traditional practise, which at least some radiocarbon experts deplore (Godwin, pers. comm.), is to present a central date in terms of a number of years before present and a plus-or-minus figure of one standard deviation. The probability that the central date is the true date is extremely low. The probability that the true date lies within the range of one standard deviation on either side of the central date is 66.6%, i.e. the odds are 2 to 1 that the true date falls in this range. The probability that the true date lies within the range of two standard deviations on either side of the central date is 95.0%, i.e. the odds are 19 to 1 that the true date falls in this range.

Table IV presents the radiocarbon dates in terms of the "1-sigma" and "2-sigma" ranges for the six radiocarbon-dated houses on which pollen data is available. The range of dates is given in the Christian calendar. It must be remembered that the true date of the house may fall anywhere in the range. It will be recognized that if the 1-sigma range is accepted house 35A must be older than house 59B, since if this range is accepted, house 35A cannot be

TABLE IV

HOUSE	POLLEN ZONE	"1-sigma" C-14 range	"2-sigma" C-14 range
35A	III-II	1165-1365 AD	1065-1465 AD
59B	III	1475-1655	1385-1745
43B	III	1335-1535	1235-1635
32A	III	1125-1325	1025-1425
77A	III	985-1385	885-1485
74A	IV	815-1035	705-1145

younger than 1365 AD and house 59B cannot be older than 1475 AD. This, in turn, would indicate that the transition pollen zone III-II of house 35A is not younger than pollen Zone III of house 59B.

But in accepting the 1-sigma range for the radiocarbon dates, one is limited to only a 66.6% probability that the range encompasses the true date. Two-to-one odds are not very good ones. Ordinary procedure in scientific investigation is to demand statistics which are significant at the 0.5% level of confidence, i.e. the 95.0% level of probability. When this level of reliability is utilized, the 2-sigma range, the ranges of radiocarbon dates for houses 35A and 59B overlap by some 80 years.

Now it is not possible to state with confidence when, in the range of time covered by the 2-sigma range, the true dates of houses 35A and 59B actually occur. Any one date within that range is as probable as any other. It is therefore as probable that the true date of house 35A falls in the 80-year overlap as it is probable that it occurs at any other time. It is as probable that the true date of house 59B occurs before the true date of house 35A as it is probable that it occurs after that date.

Thus use of the 0.5% level of confidence for the radiocarbon dates of the houses, the level of confidence ordinarily accepted as standard in scientific research, does neither justify nor dismiss the possibility that pollen horizon III-II follows pollen horizon III in absolute time. The stratigraphic positioning of the former horizon above the latter at both Cahokia and Mitchell, however, would tend to support the original chronology.

If the 0.5% level of confidence is accepted, and if it is assumed that the III-II transition period is later in absolute time than the Zone III horizon, the radiocarbon dates on houses 35A and 59B would necessitate that the III-II horizon occurs between A.D. 1385 and 1465. This is the 80-year overlap range in which the true date of house 35A would have to fall. This

TABLE V

HOUSE	TYPE	POLLEN ZONE
35A	Late Mississippian	III-II transition
59B	Late Mississippian	III
43B	Late Mississippian	III
32A	Early Mississippian	III
43A	Early Mississippian	III
85A	Early Mississippian	III
69A	Early Mississippian	V-III or III-II transition
156A	Early Mississippian	V-III or III-II transition
157A	Early Mississippian	V or II
77A	Bluff	III
74A	Bluff	IV
146A	Unidentifiable	III
89B	Unidentifiable	IV

Mississippian houses, defined as such primarily on the basis of their ceramic content, probably are the youngest at Cahokia. At the lower end of their time range they may or may not overlap with the Early Mississippian type; the serriational data would indicate that they do not do so by much if at all.

Early Mississippian houses probably existed for a time as the only house type at the site, but on the lower end of their time range they overlap with Bluff houses. In fact, Early Mississippian houses seem likely to have been in existence at the site from the earliest period of occupation as one of them appears to date from Zone V times. Yet it is not impossible that, as the serriation would suggest, some Bluff houses were actually at the site before the Early Mississippian style developed.

There is no data from the pollen record at the site which would indicate that the Bluff house-ceramic styles were retained until the period when Late Mississippian styles occurred. Though the possibility exists that this was the actual case, one imagines that somewhere in the stratigraphic superpositioning of houses there would be some independent evidence if it did occur. All of the available evidence from this site, then, points to an extinction of the Bluff styles before those of Late Mississippian developed.

This interpretation would modify that presented by Vogel (this volume) somewhat. Because one Early Mississippian house (157A) appears to have been in existence at a very early period of the occupation of the site, the length of time during which both Early Mississippian and Bluff styles were being manufactured side-by-side seems respectable. The lack of close relationship between these styles thus becomes a particularly interesting archaeological problem, and one which may have import on other time-horizons.

There is one very interesting contrast of the pollen data from the Cahokia site with that obtained from Mitchell. A glance at Figures 9 and 10 will allow quick recognition that the samples from Cahokia offer a very

TABLE VI

POLLEN ZONE	CAHOKIA			MITCHELL		
	Number of Spectra	Number with Maize	Av. % Maize	Number of Spectra	Number with Maize	Av. % Maize
II	0	0		6	6	1.5
III-II	1	0		7	5	3.0
III	11	9	3.1	7	5	1.8
IV	4	3	1.6	0	0	
V-III	3	0		0	0	
V	3	0		0	0	

different record of maize pollen. Almost all of the samples from the Mitchell site contain some maize pollen, but this is not the case at Cahokia. The samples from the lake muck at Mitchell are not, of course, comparable to the samples associated with cultural debris at Mitchell and Cahokia because of the type of sediment involved, but if the remaining samples are considered comparable, and grouped by probable pollen zone, the average frequency of maize pollen through time occurs as in Table VI.

Now the frequency of maize pollen in the horizons on which it occurs is not a very relevant statistic. It is invariably such a low number that one cannot say with confidence that 3% of maize pollen occurring on one horizon means something different than the 1.5% occurring on another horizon. Yet there does seem to be some clue offered by these data that another research program might find worthwhile to investigate more intensively.

The presence or absence relationship, in the case of the Cahokia data, does seem significant. Of six samples older than the Period IV interlude horizon none yielded maize, though we may be assured that the site was occupied. The absence of maize pollen does not indicate that maize was not being grown in the area of the site, for maize pollen is not widely disseminated from its source and its absence thus does not invariably indicate that no maize was present. But I think that there should be some explanation. One would suspect that the difference between the earlier and later horizons would be a reflection of cultural practices of some sort relative to maize. Perhaps the relative amount of maize grown at the site is the factor, perhaps the relative import of the plant to the people through time.

Before turning to the pollen records from other sites, a word on the pollen dating of ceremonial activities. The Cahokia site is an obvious ceremonial center. Wittry (this volume) has investigated this aspect of the site

intensively and has pointed out that both circles of posts and mounds were ceremonial equipment. The pollen record does yield some information on the age of construction of these features.

From the analysis of the sample of culturally sterile soil into which one of the post circles was emplaced, and from the analysis of the sample from the humus line beneath one of the mounds, it can be confidently stated that these ceremonial features--if not others--are not as old as the oldest occupation at the site. Both Bluff houses and Early Mississippian houses had been constructed at the site before some of the ceremonial structures were built.

The Period IV interlude, which indicates a period of sediment disturbance at the site, seems to me to be the most likely time horizon for the construction of the ceremonial structures, especially of earthen mounds. It is improbable that all of the ceremonial construction at the site was concentrated on one time horizon, but the Period IV interlude pollen record is the sort one would expect in an area where earth was being excavated for the construction of the post circles and/or being heaped up as mound fill. While ceremonial construction probably occurred throughout the history of the site in one form or another, the Period IV interlude horizon seems to me the period when maximal effort in this regard were going on.

Site ABR/1 (Fig. 11)

Only one sample from this site was processed. It came from the plow zone and thus was expected to yield a pollen spectrum typical of Zone I or Zone II. The spectrum recovered yielded less than 30 per cent of any pollen type and so cannot be dated by the pollen chronology. Wheat pollen (Poa) was recovered, however, so placement of this sample on the proper time horizon is possible.

Site S34/7 (Fig. 11)

Of the five samples processed from this site, only the one from the plow zone gave results. Again, this was expected to yield a Zone I or Zone II record, but the pollen spectrum contains greater than 30% Chenopodiaceae and greater than 30% Gramineae pollen, and thus would be dated to the Period IV interlude time horizon. The occurrence of wheat pollen allows proper placement on the present time horizon, however.

The Powell-Zurkhlen Site (Fig. 11)

This site was the provenience of slough profile B, which was utilized in the construction of the pollen chronology (Fig. 6). Other samples from the site were processed after the work on the Mitchell and Cahokia sites had been completed. It was thought that the experience so gained would allow some recognition of the most likely samples to achieve results. Table VII shows, however, that at this site hardly any sediment source was productive of pollen.

Of the five productive samples one is from the plow zone, two were collected just below the plow sole, and one was from a sedimentary horizon 13 to 26 inches below the surface. The one from the plow zone contains only Chenopodiaceae pollen in greater frequency than 30% and also contains wheat pollen. The other three yielded pollen Zone II spectra, which is consistent with their stratigraphic positioning.

The fifth productive sample, from house fill, yielded a pollen spectrum in which only Chenopodiaceae pollen was in greater frequency than 30 per cent. This sample cannot be accurately positioned in the pollen chronology, though it is similar in many respects to the pollen spectrum from house 74A at the Cahokia site, which was attributed to the Period IV interlude

TABLE VII

SAMPLE PROVENIENCE	NUMBER PROCESSED	NUMBER ANALYZABLE
Stratigraphic series	16	3
House fill	11	1
Above house floors	4	0
On " "	4	0
Below " "	2	0
Wall trenches	8	0
Pits	3	0
Others	7	1

horizon. Such a time placement would be dubious for the sample from the Powell-Zurkhlen site, as the Period IV interlude is posited as a local phenomenon in the area of the Cahokia site. This sample was collected at a depth of 60-75 inches below the surface and is possibly older than any other sample from the American Bottoms. It could conceivably be representative of an even older pollen horizon than Zone V, but one sample does not a pollen zone make.

The Collinsville Airport Site (Fig. 11)

Eight samples were processed from this site, of which four yielded results. All four were associated with houses.

The two samples from house 6 were discussed in the section on the pollen chronology. The sample from the floor of this house yielded a record attributable either to Zone V or Zone II. A sample from the fill one-tenth foot above the floor yielded a spectrum attributable to either the V-III transition or the III-II transition horizons. This superposition allows confidence that the earlier sample is actually of Zone V and the younger of the V-III transition periods.

The sample from house 5 is from the stratigraphically oldest house at the site. The pollen spectrum contains only Chenopodiaceae pollen in greater frequency than 30% and thus would not be datable according to the pollen chronology. The sample from house 2 contains both Chenopodiaceae and Compositae pollen in excess of 30%, and thus would date to the historic horizon (Zone I) according to the established chronology.

There is a known complicating factor. Near the Collinsville Airport site there is an ancient barrow pit--apparently aboriginal in date. At the time this barrow pit was being utilized one would expect that the consequent earth disturbance would create an unusually good habitat for producers of Chenopodiaceae pollen. Thus if houses 2 and 5 were constructed at the time the barrow pit was

in use, they might be expected to yield pollen records with higher Chenopodiaceae frequencies than normal for the time horizon. I believe that the reason the records from these houses will not "fit" the pollen chronology is due to this phenomenon.

Assuming this to be the case, the available data would indicate that the site was primarily occupied during the Zone V time horizon. During the earlier period of occupation at the site, there was a period when the barrow pit nearby was being utilized more extensively than later.

It will also be noted that if the above interpretation is correct, the barrow pit near the Collinsville Airport site was not being utilized extensively during the period when major disturbance is evidenced at the Cahokia site (the Period IV interlude) as far as is evidenced from the meagre pollen record, but before that period. Assuming the barrow pit was being utilized for a source of earth for mounds, there seems to be evidence here of mound building activity in the American Bottoms before that shown at the Cahokia site.

The Kane Village Site (Fig. 12)

Nineteen samples were processed from this site but only two yielded results. Both were collected quite near the surface. The sample from the topmost fill of Feature 1, a pit, gave a Zone II spectrum; the sample from above house 1, collected at the base of the plow sole, also gave a Zone II spectrum. As the latter sample contains wheat pollen it can be relegated to the most recent horizon and therefore does not relate to the age of the house.

These pollen data are of no assistance in dating the Kane Village site, as both are quite probably of the post-occupation period.

THE CARLYLE AREA

During the summer of 1962 a number of salvage excavations were undertaken in the area to be flooded by Carlyle Reservoir. Pollen samples were collected from a number of Mississippian sites, and it was felt that the American Bottoms

project could legitimately investigate them as part of its research on Mississippian culture, even though they were outside the main geographic area of interest. Samples from the Galley Pond, Toothsome, Sandy Tip, and Semper Fidelis sites were processed, of which two samples from Sandy Tip and three from Semper Fidelis were successfully analyzed. (Fig. 13)

The area of these sites is one of topographic diversity. On the topographic highs, where vegetative cover has not been removed for agriculture in recent times, one encounters oak-hickory climax forest or grassy swales. The topographic lows are inundated by sloughs whose shorelines fluctuate seasonally. In the spring the sloughs are at their highest; in the summer they are at their lowest.

By reference to the American Bottoms pollen chronology, all of the samples from the Carlyle area date to the Zone II or Zone V horizons. There is more arboreal pollen in the Carlyle records than those of the American Bottoms, but this is expectable as there are more habitats for trees in the former area. Dating of the Carlyle materials on the basis of ceramic content would yield a relatively late age, as Cahokia Cord-marked is present. On this grounds the pollen horizon is probably Zone II rather than Zone V.

THE APPLE CREEK AREA

The surface sediment samples collected from this area were discussed in the section on the modern pollen rain. A series of 16 samples from the prehistoric horizon was also collected and, since the site is considered to have been occupied before the American Bottoms, these samples were analyzed in hopes of obtaining another, more ancient, pollen horizon to add to the chronology.

Of the 16 samples submitted, seven were productive. Six of the seven were associated with the cultural horizon while one was a plow zone sample. One sample is of a house floor, one sample is from trash midden and four

samples are from intentionally deposited fill in pits. It will be immediately noted that the pollen spectra of these samples (Fig. 14) are all much alike in containing very high frequencies of Compositae pollen. This would indicate that they were all deposited on the same time horizon, as is also indicated by the associated pottery.

It will also be noted that none of these pollen spectra are much alike those from the American Bottoms, either surface or subsurface. While they could be considered as Zone V or Zone II samples, since only Compositae pollen is in excess of 30% frequency, the amount of pollen of all other types is so low as to be distinctive. As they all may predate the American Bottoms chronology this in itself is not too important.

Turning to the modern surface samples from the Apple Creek area, it is seen that there is a remarkable similarity between these prehistoric samples and that collected from the Apple Creek area which represents only part of the growing season (sample HH of Fig. 4). One of the pit samples, in fact, is practically identical to sample HH.

By the principle of uniformity, it would appear from these data that the prehistoric records also represent only part of the year and thus present the conclusion that the site was actually occupied only in the late summer and winter. The house floor and the trash midden samples are so similar to those from the pits that they must all represent the same period. This conclusion has been independently reached by an analysis of the faunal remains (Streuver, pers. comm.). Waterfowl bones are all of the age of birds on a fall migration, and no deer bones are of animals younger than six months. As the fawns are born in the spring, this would indicate that the animals were killed in the fall and winter months.

The hope of adding an older pollen horizon to the chronology has been frustrated by the apparent fact that the oldest pollen records available are

not yearly but seasonal records. Until other pre-Mississippian horizons are investigated we shall have to content ourselves with a five-zone pollen chronology extending back less than 1500 years.

CULTURE HISTORY AND ENVIRONMENT ON THE AMERICAN BOTTOMS

The conclusions and interpretations drawn in this section rely only on the data available from the pollen record and the archaeological record as I know it. As this paper is being composed the archaeologists who have been investigating the region for the past few years are independently forming their own conclusions and most of their information is unavailable. These interpretations may well, then, be shown to be grossly in error in some cases by archaeological data. I am basing my archaeological record on published information on Mississippian culture, my own field impressions, and personal communications in regard to occurrences at the Cahokia site and elsewhere.

Archaeological chronology

The chronology of Mississippian culture periods has been developed on two bases. First, Griffin (1949, 1952) divided Mississippian into two foci, Old Village and Trappist, on the basis of pottery styles. The American Bottoms area was not known to yield pure component sites with either the Old Village ceramic complex or the Trappist complex, but various American Bottoms sites did yield differing percentages of the two complexes and pure component sites were recognized elsewhere. Griffin (1949:46) considered the chronological division of Mississippian on this basis "suggestive and valid but not definitive".

The second basis was stratigraphy. Wittry's extensive excavations at Cahokia yielded no instance in which features containing pottery of the Trappist complex were superimposed by those containing pottery of the Old

Village complex. There were, however, instances of Trappist over Old Village. In addition, there were materials of the Bluff complex recovered, and where superposition occurred Bluff was always at the base of the sequence.

By far more refined techniques of analysis, Vogel reinvestigated the ceramics of the Cahokia site and postulated a different set of style characteristics than those Griffin utilized. Vogel has urged abandonment of the terms Old Village and Trappist and replacement of them by the terms Early Mississippian and Late Mississippian, for the latter terms refer to ceramic horizons based on more refined analysis and more data.

Wittry's excavations indicate a sequence of house styles at Cahokia. It appears that houses increased in size through time, though this pattern is not absolute, and that at one point in the sequence semi-subterranean houses of single pole construction were replaced by houses on the surface with wattle and daub walls set in wall trenches. The earlier construction technique appears to be correlative with ceramics of the Bluff complex and the later technique with those of the Early Mississippian complex (when smaller houses are involved) and the Late Mississippian complex (when larger houses are involved).

It would seem that the Mississippian chronology is on a pretty sound archaeological basis at this point, and all that remains is to discover the absolute dates that relate to this sequence. This is the contention of Vogel in this volume, and he attempts to apply to available radiocarbon dating to resolve the final question.

But there is a very major defect in this line of reasoning. Griffin's original ceramic chronology was not principally based on data from the American Bottoms, as he recovered no pure components there. Vogel refined this chronology on the basis of one site from the American Bottoms. Now it is true that there appear to be a number of pure components from the stratigraphy at the Cahokia site, but this is not necessarily the only interpretation

of these data. It is at least possible, let us say conceivable, that the ceramic-house complexes that exist at Cahokia are not time-diagnostic units but subcultural units. These may

1) happen to occur in time sequence at different areas of the Cahokia site but not be actually time-segregate,

2) happen to occur in time sequence at the Cahokia site but not in time sequence at other sites.

Salzer (n.d.) has recovered information from Mississippian sites in the Carlyle area which indicates that Trappist and Old Village ceramic complexes exist in different parts of the site on the same time horizon.

In any case, it seems vitally necessary to seek ceramic information from other sites than Cahokia to modify Griffin's original formulation if it needs modifying, and any independent mechanism of chronological determination would certainly seem worth considering. Through the pollen studies we have such an independent mechanism.

Unfortunately, as of present writing only the ceramic analysis of the Cahokia site has been completed. Though pollen records from the Mitchell and Collinsville Airport sites can be compared with those from Cahokia, the pollen-ceramic associations at the three sites cannot be compared. However, there is some data which can be brought to bear on the problem at this time. At Cahokia the house style and the ceramic complex appear to be related. If Vogel's modification of Griffin's chronology holds true, one would expect that the house styles and ceramic complexes would be similarly related at other sites on the American Bottoms. Thus, the house style-pollen associations at the Mitchell and Collinsville Airport sites should be correlative with the house style-ceramic complex-pollen associations known from Cahokia.

The pollen-dating of the houses at Cahokia was presented in **Table V.**

It was shown that Vogel's formulation was not contradicted by the pollen record, and that it did indeed seem most probable that Early Mississippian preceded Late Mississippian at the site and that Bluff was an early horizon complex which overlapped the lower end of the Early Mississippian sequence.

Turning to the data from the Collinsville Airport site, there were three houses yielding pollen data, and all seem attributable to early pollen horizons (Zone V and the V-III transition). All of these houses are of wall trench construction, and would probably be classed as Early Mississippian. One which is definitely attributed to Zone V (house 6) appears to be superimposed on a Late Mississippian style house, but this may be a misinterpretation of the field data. From the results at this site, then, we cannot dispute Vogel's formulation, but there does seem additional evidence that the Bluff-Early Mississippian overlap was of respectable length: through much of the Zone V period and through a good part of the Zone III period, including the Period IV interlude.

The Mitchell data, however, would tend to dispute Vogel's formulation. There are house styles at Mitchell that would be attributable to Bluff, Early Mississippian, and Late Mississippian. Both the archaeological and the pollen data would indicate a short period of occupation, and it would appear that this period was in the latter part of Zone III, through the III-II transition, and into the early part of Zone II. On these pollen horizons only Late Mississippian is recognized for the Cahokia site, but at Mitchell all three house styles appear to be present.

Of the pollen-dated houses at Mitchell the largest (house 7) should be Late Mississippian. It dates to Zone III and therefore is not in direct conflict with the data from Cahokia, as Late Mississippian houses there also date to Zone III. But houses 55, 46, 2, and 1 at Mitchell are smaller than house 7 and would be classed as Early Mississippian. These houses pollen-date

TABLE IX

POLLEN ZONE	BLUFF HOUSES	EARLY MISSISSIPPIAN HOUSES	LATE MISSISSIPPIAN HOUSES
II	X		
III-II		X	X
III	X	X	X
IV	X		
V-III		X	
V		X	

to the Zone III-II transition period and thus are quite later than any Early Mississippian houses at Cahokia and time-equivalent to some of the Late Mississippian houses at Cahokia. The smallest pollen-dated house at Mitchell, house 9, might be considered of Late Bluff style since it was constructed of wall posts set into a wall trench. This house pollen-dates to Zone II and thus becomes the youngest house known from the pollen studies of the American Bottoms.

Table IX presents the results of the pollen-dating of houses from the three sites considered together. To this table should be added the comment that Bluff houses probably exist on the Zone V and Zone V-III horizons at the Cahokia site, and a Late Mississippian house possibly exists on the Zone V horizon at the Collinsville Airport site.

If the house-ceramic style association is relevant, then the pollen dating of houses attributable to different chronological horizons is in conflict with the formulation of chronology Vogel offers. Bluff appears to occur as a recognizable house-ceramic style entity throughout all of the sequence; Early Mississippian exists throughout almost all of the sequence; Late Mississippian at least overlaps with Early Mississippian on the late part of the latter's range, and possibly exists throughout all of the range encompassed by Early Mississippian.

If the results from other sites indicate that the house-ceramic association is not consistent, as it is at Cahokia, the pollen data do not necessarily conflict with Vogel's formulation. But for the time being let us assume that the house-ceramic association observed at Cahokia is typical.

Even in this case the conclusions from the pollen data do not effectively dismiss Vogel's formulation of Mississippian chronology. The time sequence of the ceramic styles at Cahokia is apparently evidenced in the stratigraphy of that site. It is reasonable to expect that ceramic traits of Mississippian culture did change through time. There are at least 500 years of occupation

at Cahokia, and to maintain that pottery styles underwent no change over that range of time makes little anthropological sense. The question is, are the traits selected by Vogel or Griffin representative of change in pottery through time, or change in pottery due to some other aspect of Mississippian culture?

To ignore Vogel's analysis would be to throw out the baby with the bath water. There is far too much regularity evidenced in his data to be due to mere chance. But that does not mean that his interpretation of ceramic change through time at Cahokia must be accepted as representative of ceramic change in Mississippian culture history. The pollen record indicates that Cahokia is not a typical site; the presence of unusual ceremonial features indicates that Cahokia is not a typical site; the very size of Cahokia indicates that it is not a typical site. Perhaps, in this atypical site, there is a typical sequence of pottery horizons. As yet I think the question is quite open.

It is not at all improbable that Vogel's ceramic seriation is roughly time-diagnostic. That Cahokia Cord-marked is late in the sequence and that rim height increased through time. Certainly it appears to be the case at the Cahokia Site, and it is difficult to understand how pure components of "Old Village" and "Trappist" could be found if it were not the case. But Vogel's formulation is based on the assumption that the Cahokia ceramic sequence is typical of the Mississippian ceramic sequence, and that the Cahokia site is composed of a sequence of pure components. The pollen data would indicate that Cahokia is not typical and that though it may be composed of a sequence of pure components this is not yet proven.

Granting that the pollen-house associations are equivalent to the pollen-house-ceramic complex associations on American Bottoms sites, the

pollen record would indicate that Vogel's proposition that Mississippian is the late part of a continuum which began with Bluff is probably correct for the Cahokia site but not for the American Bottoms in general. Bluff does not seem to have died out sometime after the introduction of Early Mississippian, but seems to have continued as late as, and possibly later than, Late Mississippian. Late Mississippian probably was a development out of Early Mississippian, but it may have begun quite early in the Early Mississippian range and it may not have "outlasted" Early Mississippian by many years, if at all.

Agriculture

That Mississippian peoples were agriculturalists has been amply illustrated in the recovery of maize pollen and cobs associated with the cultural debris. It is also recognizable in the hoes found among the tool inventory and in the evident complexity of their social organization, which must have necessitated a stable food resource sufficient to maintain large populations and ceremonial specialists.

The agricultural potential of the American Bottoms must have been affected by the environmental fluctuations occurring at the end of the Zone V and at the end of the Zone III horizons. How much that potential was affected in absolute terms cannot be reconstructed, as the genetic nature of the maize and the agricultural knowledge of the people cannot be precisely known. But from a general knowledge of the effects of environmental factors on maize growth and crop yield, it is possible to comprehend when conditions were relatively better for agriculture and when conditions were relatively worse.

The technique of analysis utilized in this pollen study does not allow us to make critical interpretations of the climatic factors responsible

for such changes as occurred in the record. We do not have the pollen of sufficiently critical species represented in sufficient quantity to conclude that the environmental shifts involved so many degrees of temperature or so many inches of rainfall. Most of the pollen record is composed of pollen of annual plants which respond only to climatic conditions in effect during the growing season (roughly March to October), and even then they respond to edaphic conditions as well, so our record becomes one not of climate but of effective environment. Trees are much more responsive to yearly or decade averages of temperature and precipitation, but in these analyses the arboreal pollen record is not statistically significant. The type of analysis used here was purposefully selected, however, to yield maximal data on agricultural potential. Maize is also an annual plant which responds much the way the annual weeds do to effective environment. While this analysis did not yield critical information of the climatic conditions which occurred throughout the year, it did critically relate to the environmental conditions during the period of maize growth.

The Zone V horizon indicates the same sort of environment as that of the Zone II horizon, and the Zone I (present day) conditions are posited as being like those of Zone II with the additional factor of disturbance by man. Present day climatic records, then, should be fairly much like those of the Zone V and Zone II horizons. The Zone III horizon, thus, becomes the "unknown" which must be reconstructed.

Today the St. Louis area has an average growing season of 210 days, from about mid-March to mid-October. During this period it receives about 25 inches of its total annual average precipitation of 36.8 inches. The soils of the American Bottoms area range from sands through loams to clays, but the latter predominate. Clay soils hold moisture more effectively than others, once soaked, but are harder to cultivate and contain less free oxygen than the others.

The distribution of rainfall within the growing season is as critical a factor for plant growth as the total annual precipitation. This is especially true for maize. Maximal yields of maize are obtained when moisture is received in all of the months of its growth, with moisture sufficient to maintain steady growth being essential during the initial two months (Delont and Ahlgren, 1953). Bowman and Crosly (1911) found that there was a close correlation between the August precipitation value and the yield. Closer, in fact, than the correlation between yield and rainfall over the entire growing season.

There are a number of other critical limitations on maximal maize yield. Germinative processes in maize are slow in cool soil, and the seedlings are highly susceptible to injury from parasitic fungi in cold soil (Dungan and Ross, 1957). The roots of maize are also quite sensitive to low concentrations of oxygen in the soil (Delont and Ahlgren, 1953:49). Thus, maize should be planted after the soil temperature reaches 55°F, and it will do best on a well aerated soil. Maize is a poor competitor against weeds, especially during cool wet weather in which weeds may become well established before the maize has emerged and on heavy soils (Delont and Ahlgren, 1953:65). Low yields of maize are expectable in cool cloudy weather. Such conditions result in heavier vegetative growth and less reproductive (seed) growth. Not only are sunny days necessary for maximal yields, but warm nights as well (Delong and Ahlgren; 1953:41).

Under present climatic conditions there is plenty of moisture for maize growth in most years, but the seeds cannot be planted until late June or early July when the soil is warm enough. If the first killing frost occurs as little as two weeks before its average date, much of the crop is destroyed. In addition, extensive cultivation is necessary to aerate the soil and expose it to sunlight to warm it up earlier, and further

cultivation is needed to reduce weed competition. These limitations would also have been in effect during the Zone V and Zone II horizons when Mississippian peoples were living in the area.

The shift in environment evidenced in the V-III transition period was one which produced drier prairie conditions. Swamps and ponds dried up or became through-flowing, and the soils of the region were better drained. This occurrence would probably be correlative with a change from a cooler-moister to a warmer-drier overall climate, but at the very least it can be postulated that during the growing season there was respectably less moisture available in the soil for plant growth. Such a change would also probably increase the length of the growing season. Even if the number of frost-free days was not increased the warmer-drier weather would heat up the soil more quickly, and thus cause an effective change in the length of the growing season.

During the Zone III period maize growth would be less limited by low concentrations of oxygen in the soil, it could be planted earlier to take advantage of more of the growing season and lessen the risk of crop loss due to frost, it would be subject to less competition from weeds, and it would tend to produce less vegetative growth and higher yields of grain. The amount of moisture it received, and the periodicity of rainfall, would be critical.

There are varieties of maize which survive with remarkably little rainfall. Dry farming is practiced in the arid Southwest on as little as ten inches per growing season, and is profitable if the rains occur at the proper times during the period of maize growth. Maize is also a remarkably versatile plant in the matter of genetic adaptability. Agronomists estimate that within ten one-year generations maize will adapt itself by natural selection to the environmental conditions of the field on which it is grown; less than ten years are necessary if the farmer will take the trouble to

plant seed from the best of the previous year's crop.

It is obvious that there was sufficient moisture, and sufficiently critical periodicity of rainfall, available on the Zone III horizon for maize growth, as it can be observed that maize was grown at this time. It is therefore reasonable to conclude that the maize was able to adapt itself to the environmental conditions in effect and produce relatively high yields. Considering the greater number of probable limitations on the maize yield for the Zone V and Zone II horizons, it would appear that the Zone III period was the one in which maize agricultural potential was greater.

But because of cultural devices the potential actual yield of the maize crop may have been as good during Zone V and Zone II times as during Zone III. Increased cultivation would aerate the soil and expose it to sunlight to warm it up somewhat earlier, as well as reduced weed competition. Pruning could reduce vegetative growth and stimulate ripening of the grain. But these devices would necessitate increased expenditure of time and energy in the fields on the Zone I and the Zone II horizons relative to Zone III. Mississippian peoples may not have been able to accept or afford the burden of an increase in human labor per unit of yield.

After the transition to Zone II conditions, when maximal yields could be obtained by greater expenditure of labor, slavery may have been an economically profitable institution. Slavery would, of course, have been even more profitable when agricultural potential was maximal, but after the change in environment occurred it would have been an effective means of keeping the food surplus at a high level.

The effect of the fluctuations in environment on the American Bottoms on Mississippian agriculture in that area seem to have been as follows: During the earliest period, when a wet prairie condition was in existence, the agricultural potential of the region was relatively low without fairly

great expenditure of human labor. In the 8th or 9th century, when a drier environment came into existence, the agricultural potential of the region was appreciably increased. Around the ^{end of the} 13th century, when the earlier conditions reoccurred, the natural agricultural potential of the region was decreased but cultural practices could have been instituted to maintain high crop yields at the expense of human energy.

At the Cahokia site, it appears that it was only during the period of maximal agricultural potential that maize had much of a direct impact. The Mitchell and Collinsville Airport sites seem to have been oriented towards maize much more directly throughout the periods of their occupation.

It is suggested from meager data that during periods when maize was harder to grow, the occupants of the Cahokia site were more dependent on the outlying villages for their supply. When maize was easier to grow the occupants of Cahokia were more inclined to produce a measure of their own supply. This conclusion is, of course, quite highly speculative.

Migrations

Griffin (1960) proposed that much of the available data on Mississippian culture could be explained on the basis of migrations from a central area in the Cahokia region. He suggested that northerly movement would be correlative with a climatic change to a warmer-drier condition, which would allow a greater number of frost-free days and warmer summers in the north, and thus effectively open territory to the north to Mississippian agriculturalists. Griffin postulated that about A.D. 1000 the peoples who ultimately migrated north and west were still in the Cahokia area, but that their migration had been completed by, and was not reinforced after, A.D. 1200.

The shift to warmer-drier conditions in the American Bottoms is tentatively estimated to have occurred in the 8th or 9th centuries A.D.

There is thus no reason to dispute Griffin's hypothesis on the grounds of this study and every reason to support it in general terms, with the possible modifications that migration from Cahokia as a response to climatic change may have begun as early as the 8th or 9th century. The reversion of cooler-wetter conditions in the 13th century would certainly explain satisfactorily a lack of further northward expansion of Mississippian peoples after that date who might have brought specific later traits to the northern area.

By the same reasoning as that Griffin employed, the shift from warmer-drier to cooler-moister conditions which occurred in the 13th century (perhaps as late as the late 14th century at Cahokia) should have made migration south from the Cahokia area a probability after that date. On the Zone II horizon, similar environmental conditions to those experienced during Zone III times would probably have been present to the southeast and southwest as well as further south along the Mississippi Valley. The relationship of late cultural patterns in the Cahokia area to those further south, as in Oklahoma and Tennessee, is as yet rather confused. Part of this confusion may be due to the fact that there is still some question of which cultural traits are definitely attributable to the late horizons in the American Bottoms area, so it is hard to recognize such traits as occurring to the south.

Also, it would appear that in the northerly areas into which Mississippian culture penetrated the reversal of climatic conditions precipitated not a southerly retreat but an adaptation to the new environment, which incorporated selection of traits from "Woodland" peoples who originally lived there. This pattern may have also occurred in the American Bottoms area.

The whole problem of the decline and fall of Mississippian culture

on the American Bottoms is an intriguing one. The pollen record does not carry Mississippian much beyond the 14th century, but the pollen record may be truncated at this point simply because such a small proportion of the samples analyzed gave reliable results (about one-third). Are the sites in the Carlyle area later than the Late Mississippian sites on the American Bottoms? Did Mississippian peoples migrate from Cahokia to sites such as Hiwasee Island and Kincaid before or after the 13th century? Pollen studies may help to resolve these matters, but it will take a lot of time and a great deal of money to accomplish the job in proper fashion.