ADDITIONAL POLLEN STUDIES IN MAMMOTH CAVE NATIONAL PARK
(…AND NOW YOU KNOW THE ***REST*** OF THE STORY)
March 2006

ABSTRACT

Pollen samples collected from a second stratigraphic test in the vestibule of Salts Cave, Mammoth Cave National Park (MCNP), were analyzed subsequent to composition of the unpublished report on study of surface sample controls and fossil pollen records from three other archaeological cave sites in the park (Schoenwetter 1978). Though only five pollen records were recovered, the surprising results stimulated further assessment of the univariate and multivariate statistical analyses that had previously been used as the basis for interpretation of MCNP pollen records in terms of patterns of vegetation change. Taken altogether, the ultimate conclusions of my studies of MCNP pollen records are:

(1) The sequence of vegetation pattern changes proposed for the area in Schoenwetter (1974) is contra-indicated by the information obtained through analysis of additional fossil records and control data.

(2) Though the control data is highly variable, multivariate discriminant functions analysis allows one to recognize pollen record data patterns that identify ecological conditions that control the character of vegetation patterning in the park today. However, the statistical strength of the discriminant functions analysis supporting this interpretation depends on the algorithm used for the computer program involved. More robust programs have lower statistical strength. This is probably due to the relatively small number of control pollen records that have been analyzed, but that cannot be known unless additional surface pollen samples are analyzed. A more generalized form of paleoenvironmental interpretation, however, –one that interprets pollen records in terms of the degree of moisture reflected by ecosystem conditions—can be justified.

(3) When applied to the fossil record, this form of analysis suggests that the range of modern ecological conditions occurring in MCNP dates back only to the Middle Woodland occupations. It further suggests that during the Archaic and Early Woodland the paleoenvironment was drier

(4) Late Archaic pollen records from Test E-ext in Salts Cave yielded examples of maize and cucurbit pollen. This data conclusively demonstrates that maize, at least, was cultivated in the MCNP area prior to the cultivation of locally domesticated seed plant foods. It is unlikely that maize was cultivated for its food resource value, however.

PROJECT HISTORY

In April 1978 my laboratory technician extracted a suite of fourteen sediment samples collected in 1974 from the south face of Test E-ext in the vestibule of Salts Cave, Mammoth Cave National Park (MCNP), KY. A year later, I persuaded an undergraduate student seeking research course credits to attempt the analysis of these samples. The resulting paper was deficient as regards both assessments of the stratigraphic positioning and pollen statistics of the observations. Though I sent copies of the student's observations with a letter dated 1 August 1979 to P.J. Watson, I did not send her a copy of that report nor did I keep a copy in my files.

According to the student, only six of the 14 samples contained sufficient pollen to be analyzable. Even those six were difficult to analyze because the Pollen: Debris ratio was very low. When the extracts of these six samples was sufficiently diluted that the pollen was not obscured by debris, fewer than 50 pollen grains were observable on a micro-slide – usually fewer than 10 grains.

I considered analysis of these samples to be particularly important because the series offered prospect to replicate some or all of the pollen sequence previously recovered from Test J-IV in the cave (Schoenwetter 1974). Also, because Watson's (1974:238) assessment of the archaeology of MCNP supported the hypothesis that vegetation change occurring ca. 1400 B.C. in this region had stimulated cultural concern with such locally domesticated plants as chenopod, sunflower and sumpweed. As the archaeological record of the Salts Cave vestibule encompassed deposits of both Late Archaic and Early Woodland antiquity, the pollen sequence from E-ext might offer palynological records to support or negate that hypothesis.

Thus, in late December and early January of 1979-80 I experimented with one of the E-ext extracts to determine if suction sieving the extract through 20 micron mesh screening would significantly alter the Pollen: Debris ratio for these samples. Sieving did make the pollen easier to observe, but it did not appreciably increase the amount of pollen on a micro-slide.

In June 1980, I attempted reanalysis of all fourteen samples. I reported the results of this research to P.J. Watson in a letter on 11 July 1980. In the letter I noted that samples 4 and 5 had yielded pollen of *Zea* and *Cucurbita*. Also, I noted that the pollen frequency values of the E-ext sample were not similar to those I believed to be stratigraphically equivalent samples from Test J-IV in the Salts Cave vestibule.

Watson's reply (16 October 1980) advised me that her assessment of the stratigraphy of the two sequences differed from my own. Her interpretation was that sample 8 of the E-ext sequence could be the stratigraphic equivalent of any of the 10 levels between level 3 and 13 at J-IV. Also, that samples 4 and 5 from E-ext were stratigraphically positioned to be equivalent to levels 14-17 at J-IV. Further, that there were no pollen records from J-IV that were recovered from stratigraphic equivalents to samples 2 and 11 in the E-ext sequence. Sample 2 was collected from the stratigraphic equivalent of level 7b at Test E and sample 11 was collected from the stratigraphic equivalent of level 5 at Test E. Thus sample 11 was stratigraphically positioned to be younger than any of the pollen records of the J-IV sequence and sample 2 was positioned to be older than any from J-IV

In my reply letter (11 November 1980) I recognized that Watson's comprehension of the stratigraphic relations of samples from the two tests was clearly more informed than my own, since she had observed them first-hand and was familiar with the complex stratigraphy of the sediments of the site. There were, however, archaeological implications to this stratigraphic positioning that begged for her consideration.

(1) If the pollen records were accepted at face value, the *Zea* and *Cucurbita* pollen observed in the E-ext samples, being older than the pollen observed in J-IV level 13, must certainly be older than the botanical remains of J-IV level 6. Yarnell (1974) had interpreted that assemblage as pre-dating the cultivation of local varieties of squash and gourds.

(2) If the uncalibrated radiocarbon date for Test E level 5 is accepted as the stratigraphic equivalent of J-IV levels 7-14 (Watson 1974:236), the pollen record provides evidence that the cultivation of maize, and possibly squash, extends to the second or third millennium B.C in the MCNP area and probably pre-dates the cultivation of local seed plant foods.

My correspondence file contains no response to this letter from Watson. However, it includes most of the draft of a letter I wrote her early in 1981 but decided not to send until I heard her comments on my prior letter. In the draft, I note my thinking that publication of my 1978 report "Surface and Archaeological Sediment Pollen Studies in Mammoth Cave National Park" and the E-ext pollen study should be reserved until Ken Carsten's doctoral dissertation was published.

My files also include the draft of a report (apparently written later in 1981) on the results of discriminant functions studies performed on the total MCNP pollen database. The results of that study, and the interpretations developed at the time are integrated into the report presented below.

RESEARCH REPORT

Pollen study of the fourteen samples collected in 1974 from the south profile of Test E-ext in the vestibule of Salts Cave, Mammoth Cave National Park (MCNP), was undertaken between 1979 and 1981 as opportunity arose at the Palynological Laboratory of the Department of Anthropology at Arizona State University. Successful study of samples from this provenience was particularly significant for resolution of the original objectives of research that had been published in 1974. Samples from Test J-IV at this site had produced a pollen sequence that generated a tenuous interpretation of vegetation changes occurring in the MCNP district during its Archaic and Early Woodland occupations (Schoenwetter 1974:103-105). The palynological record of the E-ext samples offered opportunity to substantiate or contradict that interpretation.

Pollen work on samples from other cave sites in MCNP (Schoenwetter 1978) had not successfully advanced the original research objective because those samples mostly were associated with archaeological contexts of Late Woodland and Middle Woodland occupations. Also, only nine of the 34 site-context sediment samples from three cave sites contained sufficient pollen for cost-effective analysis.

The majority of the pollen extracts of the E-ext samples, however, were unusually bulky. Normally, the laboratory procedures used to extract the pollen of initial volumes of 30-40 cc of MCNP cave site sediment resulted in an extract of ¼ to ¾ cc volume. Those extracts that contained at least 30 pollen grains concentrated in a drop of extract allowed observation of enough pollen for analysis. Most of the Test E-ext samples yielded 1.5-2.5 cc volume of extract, with fewer than 10 pollen grains per drop. Only four samples had provided pollen counts of statistical value, and another had yielded a count of 13 pollen grains. It seemed likely that there actually were a sufficient number of pollen grains in the extracts, but few could be observed in a given drop because of an excess of organic detritus. I therefore designed an experiment to determine if removal of that fraction of the detritus that was smaller than the types of pollen grains normally observed in MCNP cave site sediment samples would concentrate the amount of pollen per drop of extracted sample.

Sample 2 had produced over 3.5 cc volume of extract and had therefore been stored in two roughly equal one-dram shell vials. I labeled these 2a and 2b and generated pollen counts on one drop from each:

POLLEN TYPE	VIAL 2a	VIAL 2b
Pinus	1	
Quercus	7	8
Carya	1	
Chenopodiineae		3
Ambrosieae	2	5
Tubuliflorae	11	29
Polygonum cf. *amphibium*		1
Unknowns		2
N observed	22	48

Because of the small number of observations, the difference between the two pollen counts is not statistically significant with p set at .05.

The extract in vial 2a was then suction sieved through 20-micron mesh screencloth with 95% ethanol. This reduced its volume by 2/3. It did not, however, significantly improve the Pollen: Debris ratio, since three one-drop slides of the sieved extract consistently yielded 19 pollen grains each. A 48-grain count of the pollen of the reduced volume sample compares favorably with that of the unreduced volume sample:

POLLEN TYPE	SIEVED 2a	VIAL 2b
Juniperus	1	
Quercus	5	8
Carya	1	
Magnolia	1	
Chenopodiineae	2	3
Ambrosieae	7	5
Tubuliflorae	25	29
Gramineae	1	
Caryophyllaceae	1	
Polygonum cf. *amphibium*		1
Unknowns	4	2
N observed	48	48

Again, there is no significant difference in the observations. Sieving, then, did not prove to be a meaningful way to increase the number of pollen counts from the E-ext sample series.

Table I details the pollen observed in the four analyzable Test E-ext samples. Comparison of the pollen frequency values of these samples with those of the J-IV series (Schoenwetter 1974:103) documents no comparability between the two. Biostratigraphic correlation of the two series is thus contra-

POLLEN	TEST E-EXT LEVEL/SAMPLE NO.				
TYPE	11	8	5	4	2
Pinus	13	2		2	1
Juniperus	7			1	1
Quercus	7	2	3	8	20
Fagus		1			
Carya		6	3	3	2
Magnolia				1	
Celtis	2	1		2	
Juglans		2			
Ulmus	1	2		4	
Betula	1				
Alnus			1		
Chenopodiineae	9	2	1	39	6
Ambrosieae	3	14	3	16	14
Tubuliflorae	3	51		15	64
Liguliflorae		16			
Gramineae		1	1	4	1
Caryophyllaceae		3		1	1
Umbelliferae				1	
Polygonum cf. *amphibium*					1
Cucurbita				1	
Zea			1		
Unknowns	2	1		2	6
Total observed	48	104	13	100	117

TABLE I: POLLEN OBSERVATIONS

indicated if undertaken by the method normally applied to bog, alluvial and lacustrine pollen sequences. On the other hand, comparability of the root 1 discriminant function values (Table II) suggests that pollen sample/level 8 at E-ext is the biostratigraphic equivalent of level 3 at J-IV, sample/level 6 at E-ext is the biostratigraphic equivalent of upper level 5 at J-IV, and sample/level 2 at E-ext is the biostratigraphic equivalent of level 13 at J-IV.

The lithological stratigraphy of the deposits of Salts Cave Vestibule, however, has been well studied (Watson 1974:74-81). From that perspective, level 11 at E-ext is superpositioned upon any of the levels observed at J-IV, and level 8 at E-ext is the stratigraphic equivalent of levels 3-13 at J-IV and levels 6 and 7 at Test E. Levels 4 and 5 at E-ext are stratigraphically positioned *below* level 14 at J-IV, and are arguably the lithostratigraphic equivalent of level 7b at Test E. Level 2 at E-ext, from the cave breakdown deposit, being positioned below level 5, is evidently significantly older than any of the levels from which pollen was obtained at J-IV.

Lithological stratigraphic relationships are recognized as a superior basis for discrimination of the relative age of deposits than are biostratigraphic relationships. The palynological similarities of certain E-ext and J-IV samples identified through discriminant functions analysis, then, cannot be relied upon to index temporal equivalency. The *lack* of palynological similarity between levels that are lithological stratigraphic equivalents in the two pollen sequences, however, is significant information. It provides strong evidence in support of the position that the pollen records of the two sequences are not expressions of the types of forest vegetation responsible for the existence of the pollen observed.

The objective of analysis of the pollen samples collected at E-ext in the Salts Cave vestibule was to exploit their potential to provide replicate examples of the results obtained from the samples that had been collected from Test J-IV. Though only four of the E-ext pollen samples yielded sufficient pollen for comparison, the analysis documented that such replication could not be achieved. That being the case, the reconstruction of vegetation changes during

POLLEN TYPE	TEST E-EXT LEVEL/SAMPLE NO. 11	8	4	2
Quercus	-.0044	-.0003	-.0012	-.0027
Carya	-.0255	-.0013	-.0007	-.0003
Ulmus		-.0115	-.0261	
Juglans		-.0047		
Liriodendron				
Fagus		-.0037		
Chenopodiineae	+.1220	+.0064	+.1351	+.0174
Gramineae		-.0007	-.0038	-.0008
Magnolia			-.0066	
Compositae	-.0001	-.0004	-.0001	-.0003
Spectrum Discrim. Score	-9.20	-1.62	+9.66	+1.33

TABLE II: ROOT 1 DISCRIMINANT SCORES

(COMPARE WITH Schoenwetter 1978:29)

the human occupation of MCNP that had been advanced on the basis of the J-IV pollen sequence is contra-evidenced. Since the prior analysis of surface control pollen records (Schoenwetter 1978) produced evidence that the method used to generate the vegetation reconstruction was not supported, it is clear that the reconstruction is untenable, and should be abandoned.

When this conclusion became obvious, I questioned the possibility that the result might be more of an artifact of the statistical manipulations of the pollen data than a true expression of prior conditions. I thus initiated consideration of (a) what alternative means of dealing with the data might exist, and (b) why a multivariate discriminate functions analysis was superior to the traditional method of analysis based on univariate analysis of pollen frequency values.

The answer to (b), above, turned out to be straightforward. The surface control samples data documented the fact that there is a good deal of variability in the pollen spectra produced by any given vegetation type. So much variability, in fact, that no or few pollen types actually dominate the spectra of any given vegetation pattern. The traditional method of analysis assumes that the single or few pollen types that dominate a spectrum identify the kinds of plants that dominated the vegetation producing the spectrum. Since the control sample spectra demonstrate that the assumption is invalid for the vegetation types that exist in MCNP, another sort of analytic method is called for. Multivariate discriminate functions analysis is the sort of factor analysis that is designed to allow recognition of the degree of statistical similarity between a defined data category (in this case the observed pollen records of a vegetation type) and an "unknown" that might or might not be equivalent to the defined data set. It is thus meets the needs of a form of analysis that will identify the match of any fossil pollen spectrum with any category of pollen spectra produced by MCNP vegetation types, if such matches occur.

The answer to (a), above, turned out to be particularly interesting. The computer program I had used for the 1978 study, stored in the Arizona State University Statistical Library under the title "DISCRIM", employed only one of the possible algorithms that could be used to achieve multivariate discriminant functions analysis. The Statistical Library also contained two other programs to accomplish the same sort of analysis: a BDMP program and an SPSS program. All three utilized a step-wise analysis, but the BMPD and SPSS programs added a “jackknifed” or “backward-stepping” routine to the analysis that made them statistically more robust than the DISCRIM program.

Application of <u>any</u> of the programs to the surface control samples data, using the ten ecologically sensitive pollen types, generates a graph on which the centroid for Riparian Woods is on the opposite side of the root 1 axis from the centroid for Oak Woods. The DISCRIM program, however, separates these two data sets more widely than the other programs. Root 1 accounts for 72% of the variance among the pollen records with a probability of .02 using the DISCRIM program and it accounts for 55.8% of the variance with p = .05 using the BMDP program. Using the SPSS program, opposition between Riparian Woods and Oak Woods occurs on the Root 1 axis, but Riparian Woods and Successional Woods are not separated, nor are Oak Woods and Mixed Woods. Even so, the separation of Riparian and Oak Woods accounts for only 45.8% of the variance, and p =.12. Apparently, the root 1 axis represents the degree of moisture in the ecosystem irrespective of the program employed. But the results of the more robust programs argues that classifying any given fossil pollen record in terms of any particular vegetation pattern existing in MCNP today is not justified. If a much larger number of surface control samples data was available, so the statistical strength of more robust forms of discriminate functions analysis was higher, the result might be different. At this juncture, however, the relatively small number of fossil pollen records we seek to interpret in vegetation pattern terms does not justify collection and analysis of additional surface control pollen samples.

The way in which all three programs agree, however, provides justification for recognition that a pollen record’s position on the Root 1 axis reflects the degree of moisture in the ecosystem of the plant population that produced that pollen spectrum. Since it provides the widest separation, use of the discriminant score values of the DISCRIM program is most useful for assessing the relationship between the modern surface control samples and the fossil samples in this fashion. Figure 5 in Schoenwetter (1978:24) illustrates that the discriminant scores of the MCNP control samples lie in the range between –2.0 (dry) and –6.0 (wet) when this program is used. The discriminant scores of the E-ext samples (Table II, above) and the other samples from archaeological sites (Table I in Schoenwetter 1978: 28), that lie <u>within</u> this range may be reasonably interpreted as reflecting prehistoric conditions of ecosystem moisture <u>within</u> the range of those that exist in MCNP today. Scores that lie above this range, then, may be reasonably interpreted as reflecting drier conditions than exist in the Park today, and those that lie below –6.0 as reflecting moister conditions. The resulting sequence of paleoenvironmental conditions prevailing during different prehistoric occupations of MCNP, then, would be:

OCCUPATION	SITE	ECOSYSTEM MOISTURE REGIME
Late Woodland	Blue Springs Cave	Within modern range
Prior to Late Woodland	Blue Springs Cave	“
Middle Woodland	Crump’s Cave	“
Post-Early Woodland	Salts Cave E-ext	Drier than modern range
“	Salts Cave J-IV	“
Early Woodland	“	“
Late Archaic	Salts Cave J-IV & E-ext	“
Pre-Archaic	Salts Cave J-IV	Within modern range
Earliest Record	Salts Cave E-ext	Drier than modern range

ANTHROPOLOGICAL IMPLICATIONS

The pollen records of samples/levels 4 and 5 at Test E-ext include one pollen grain, respectively, of squash and maize. The size and the pore: annulus size ratio of the Graminoid pollen grain positively identifies it as Zea pollen. The squash pollen may represent either a cultivated or a locally collected wild species. Since maize is an obligate cultivar, however, i.e. cannot grow to maturity without human assistance, the existence of its pollen can only be explained as either a contamination of the record by corn pollen produced more recently or a product of human cultivation at the time that the sampled sediment was deposited. – ostensibly during the Late Archaic occupation of Salts Cave

Though the possibility of contamination cannot be denied, the probability that the occurrence of the maize pollen is so explained is extremely low. The samples were collected in March, and were subject to field and laboratory precautions to minimize contamination. In addition, it is almost impossible for a pollen sample to be contaminated by pollen of only a single type. Whether the contamination source is air-borne or another sample, contamination must occur in the form of a suite of pollen grains, not a single grain or grains of a single pollen type. Further, unless the suite is large enough to elevate the original population of pollen grains in the sample in a significant way, members of the suite of contaminant pollen grains have a very low probability of being observed in the sample of that population that makes up the pollen count. If so large a suite of contaminant pollen grains did occur, its presence would probably be recognizable by its distorting effect on the pollen frequencies of the record. There is essentially no question, then, that the existence of the maize and cucurbit pollen in the E-ext deposits documents cultivation of corn, and possible cultivation of squash, by Late Archaic occupants of MCNP.

There are two anthropological implications of this finding. First, the evidence provided by analysis of charred botanical macrofossil remains in the deposits of Salts Cave vestibule led Yarnell (1974:117) to the conclusion that sunflower and sumpweed were the first crops cultivated in central Kentucky. Though he acknowledged that additional studies were needed to make the case, he argued that the absence of cucurbit remains below level 5 [at Test J-IV] was the telling datum for this inference. The palynological record is clear that at least maize was cultivated in the MCNP area previously.

Second, the pollen record cannot and does not identify either the intensity or the reason(s) for cultivation of one or both of these plants. The results of both pollen and botanical macroremains studies of Late Archaic and Early Woodland paleofeces from Salts Cave are sufficient to demonstrate that maize was **not** a normal member of the diet of the people who entered the cave as miners. And the results of flotation studies of the vestibule deposits demonstrate that maize was not a dietary item for those who occupied the entrance to the cave.

If the Late Archaic and, possibly, subsequent populations of MCNP cultivated maize, but did not incorporate it in their normal diets, what was their reason(s) for such behavior? Ethnographic analogy is the crux of archaeological behavioral reconstruction, and there are no human populations existing in the ethnographic present that cultivate maize but do not eat it on a regular basis. Does the palynological record, then, argue that ethnographic analogy is an inadequate basis for reconstruction of the behavior of past populations? Not at all, but it does suggest that total reliance upon ethnographic analogy may limit behavioral reconstruction in unnecessary ways. At the moment, archaeologists have no more sophisticated and reliable methods of behavioral reconstruction than ethnographic analogs. But that doesn't mean that other methods do not exist or that archaeologists should not be interested in identifying them.

SUMMARY

In Schoenwetter (1974:103-105) I offered an interpretation of vegetation changes occurring during Late Archaic and Early Woodland occupation of Mammoth Cave Nation Park (MCNP) based on the pollen sequence recovered from the deposits of Test J-IV in the Salts Cave vestibule. The interpretation was recognized as tenuous, but presented as an hypothesis amenable to testing on the basis of surface sample control pollen records from the park and additional fossil pollen records from archaeological site contexts.

Study of surface sample control pollen records and fossil pollen records from three other sites in MCNP was reported in a 1978 manuscript submitted to P.J. Watson and a number of others for review. Soon after it was written,

opportunity arose to analyze an additional 14 samples from Test E-ext in the Salts Cave vestibule. Two of the results of that analysis were particularly surprising and unexpected: First, the fossil pollen records recovered from Test E-ext were not statistically comparable to those from nearby Test J-IV; second, pollen of *Zea* and *Cucurbita* (corn and squash) were recovered in samples of deposits that were ostensibly laid down during the Late Archaic occupation of the cave.

Taken together, the pollen studies performed subsequent to publication of Watson's *Archaeology of the Mammoth Cave Area* (1974) suggest three conclusions.

(1) The tenuous reconstruction of vegetation and environmental changes I presented as a hypothesis for testing is demonstrably unsound and unreliable. Additional fossil pollen records from comparable archaeological contexts of equivalent antiquity do not yield comparable data, and the information recovered from the controlled data of modern surface pollen samples demonstrates that the apparent vegetation reconstructions offered for the J-IV pollen sequence were not justified.

(2) The reason the reconstruction was invalid is that the method of pollen analysis used to obtain the 1974 reconstruction (though the traditional means employed for the purpose) was inadequate to the task. Study of the surface control samples data set shows that pollen records of the vegetation patterns that exist in MCNP today are actually very variable. So variable, that differences in the pollen frequency values of different kinds of trees cannot be relied upon to reflect differences in vegetation patterns at different times. Application of an alternative method of pollen analysis – one that uses multivariate discriminant functions statistics rather than the traditional pollen frequency values – provides a means to demonstrate that the apparent variability in the pollen records masks data patterns that do allow interpretation of the pollen samples dated to different periods of human occupation of the park. The interpretation, however, cannot be justifiably presented in terms of the vegetation patterns available for human exploitation in the park at different times in the past. The most justifiable

interpretation can only be presented in terms of regional paleoenvironmental change from horizons of time that were wetter, drier, or more or less similar to the range of moisture variation reflected in the ecosystems of MCNP today.

(3) Though palynological evidence for the existence of corn and squash plants is minimal (only one pollen grain of each taxon was observed), it is absolutely conclusive. The probability of modern pollen contamination is too low to be afforded credence, and the integrity of the samples is beyond reproach. Since maize plants cannot survive without human assistance, the occurrence of its pollen can only be explained as the product of human cultivation of corn (if not also of squash) at the time Late Archaic populations inhabited Salts Cave and MCNP. The botanical macrofossil record recovered through flotation of charred seeds and study of the seed remains of paleofeces from Salts Cave documents two significant aspects of the behavior of Late Archaic populations in the park in relation to plant food resources. First, that though the technology of cultivation was known since Late Archaic times, locally developed cultivars did not become prominent in the diet before the end of Early Woodland times. Second, that corn was **not** one of the plant foods actually cooked and eaten during either Late Archaic or Early Woodland times. The anthropological inference to be drawn from these findings is that corn was not cultivated in MCNP during either the Late Archaic or Early Woodland horizons of occupation for its value as a dietary item. The palynological record offers no clues to the *reasons* it was cultivated, and no ethnographic analog exists that identifies a modern society that cultivates maize but does not also exploit its food resource value.

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