Report To: Dr. Herbert W. Dick Date: November, 1965

From: J. Schoenwetter

Title: Pollen Studies at Picuris Pueblo: Preliminary Report

Correction: on Figure 5, Pollen spectrum of Kiva M floor, read Zone XI for Zone IX.

INTRODUCTION

The first palynological work in the area of Picuris Pueblo was undertaken by George Smith in 1961. Mr. Smith analyzed a stratigraphic series of samples from the fill of a kiva at the Pot Creek Ruin, TA-1, under the direction of Katherine Clisby at the Fort Burgwin Research Center. In his unpublished report, Smith established that pollen could be recovered in some quantity from sediments of cultural context in this area, and this prompted Dr. H. Dick to collect a suite of sediment samples at Picuris Pueblo during his excavations in 1961. The collection was made from a deep, well-stratified, trash midden at one-tenth foot intervals.

In 1962, while working in the pollen laboratory at Fort Burgwin on another project, I analyzed approximately 20 of the 167 samples from this midden series and was able to establish clear indications of palynological variation through time. Thus encouraged, Dr. Dick applied for funds for palynological studies in his NSF request for 1963 and collected pollen samples from archaeological contexts as they were uncovered in 1963 and 1964. In 1963, pollen analysis was limited to the long series from the midden deposit, a few samples from a pithouse and some from Test Pit B. When the analysis of the artifactual materials excavated in 1963 and 1964 was sufficiently completed, a selection was made of pollen samples which had been collected during those seasons, and in 1965 the analysis of these samples was undertaken.

The midden deposit had been excavated in one-foot levels, while the pollen samples were recovered in one-tenth foot levels. Age estimates based on ceramic analysis could thus be estimated with some accuracy for any given foot of deposit. By using samples from the later excavations, which were also well dated in absolute time, it was anticipated that specific pollen horizons recovered in the midden sequence could be corroborated by correlation.

Much of the following report is concerned with estimates of absolute age. It is important to emphasize that these estimates are not, and cannot be, deduced from the pollen records themselves. Significant palynological variations are fossil evidence for responses of vegetation patterns to changing conditions in the physical environment. The variations are dated through their associations with datable phenomena such as tree-ring specimens, dated ceramic styles, and radiocarbon samples. All the ranges and types of error applicable to the dating of such phenomena are also applicable to the pollen dates.

Dating, however, was not the only purpose of the palynological studies. We also wished to recover information on prior environmental conditions to which the inhabitants of the site were exposed, with the ultimate objective of recognizing periods when the cultural ecology of Picuris may have been different than that of today. In effect, there are three separate problems with which this report attempts to deal: paleoecology, chronology and paleoclimatology. The three are all interrelated, and it is necessary to recognize that the investigation of one depends on, and at the same time contributes to, the investigation of the others.

The problem of paleoecology is that of a scientific reconstruction of vegetation patterns through the evidence of the pollen statistics of the sediment samples collected in association with ancient artifacts. This objective is served by recovering pollen statistics from known, modern, vegetation patterns and then relating these to those obtained from the old samples. This seems straightforward enough, but it is obvious to even the most casual observer that no two plots of woodland, for example, are precisely alike. It thus stands to reason that a set of pollen statistics from one woodland plot will not be exactly like those from another, and both will probably be different from those of a woodland that became extinct some centuries ago.

It is possible to sidestep this difficulty by dealing with a number of samples from woodlands and working within statistical probability ranges. One can thus learn what frequencies of arboreal pollen characterize a woodland plot most of the time, and use these numbers as an index to woodland conditions. But one thereby imposes a bias on the conclusions that can be drawn from the raw pollen data. One can now tell "woodland" from "non-woodland" but cannot prove that any other ecological phenomena can be recognized from the data. If one wishes to know the number of trees in the plot, or the type of soil present, or the nature of the understory vegetation, he must start all over with a new series of control surface samples and another set of biases.

In this analysis, the paleoecological question investigated was: was tree coverage at Picuris denser or less dense in the past than it is today. There were other questions that might have been posed, but this one offered the most promise of relatively quick resolution, and was considered as most likely to give information of paleoclimatic and chronological value.

The problem of chronology is approached on two levels. First, a series of paleoecological variations through time must be recognized, and these variations must be dated in absolute or relative time. Accomplishment of this yields a series of testable hypotheses, e.g.: tree coverage was less dense than the present between 1275 and 1315 A.D. The second level of approach is to accumulate information which will serve to corroborate or negate any or all of the series of chronological hypotheses.

The selection of relevant paleoecological questions thus becomes vital to the problem of chronology. In the problem of chronology it is necessary to make comparisons between paleoecological reconstructions from one area and those of other areas on the same time horizon as tests of the hypotheses. One cannot select paleoecological problems which might be so limited by local conditions that they yield types of data which allow no comparison between localities.

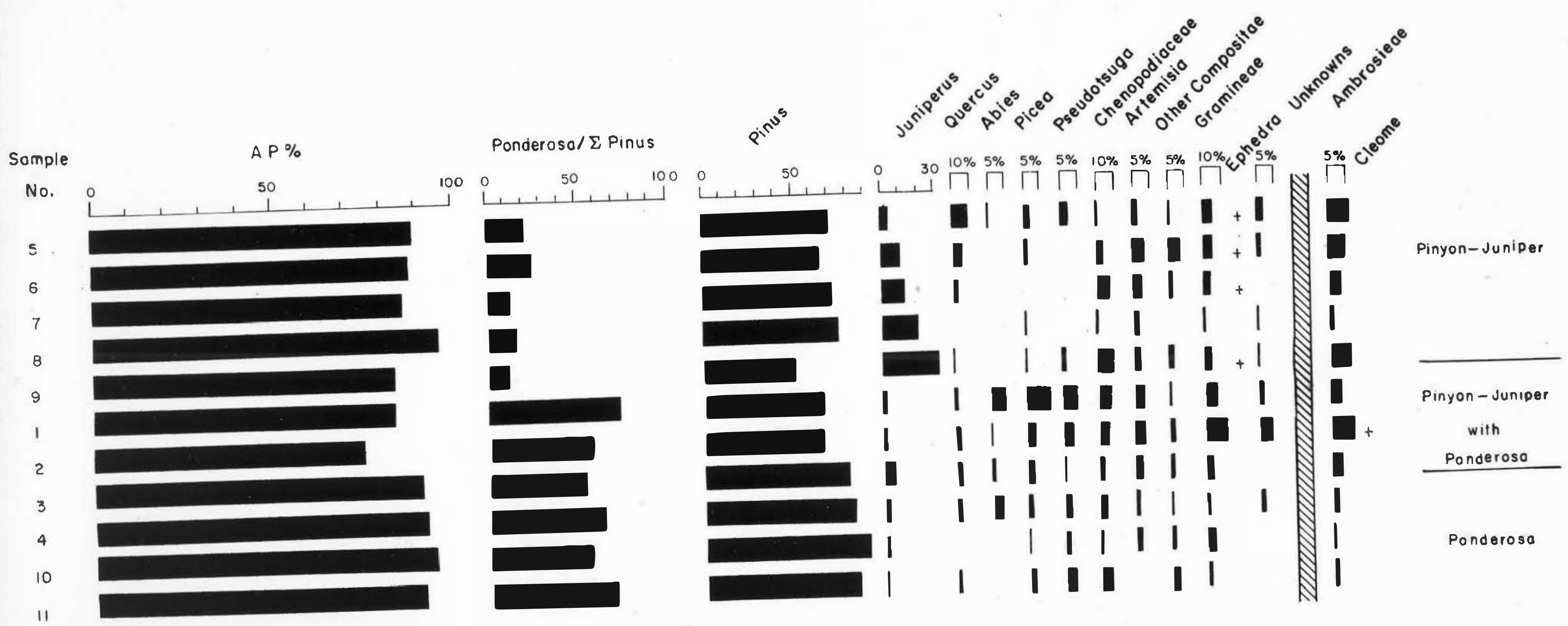
For example, the student of culture history might be very much interested in determining the kinds and numbers of crop plants grown at a site through time. This paleoecological problem could probably be resolved, but would yield no information of value for a problem of chronology, since it is unlikely that any two sites of the same time period would be comparable in their crop production. In this study the posing of a problem of chronology necessitated that the problem of paleoecological reconstruction be one which had some likelihood of comparability with other sites of equivalent age. It was expected that variations in tree coverage would be of regional scope and allow such comparisons.

The problem of paleoclimatology was posed because it was recognized that a simple paleoecological reconstruction of the type undertaken would be insufficient information for the interpretation of such cultural ecological variations as may have occurred at Picuris. In addition, some basis for comparison was necessary between the various types of paleoecological studies being undertaken. Paleoclimatic reconstructions are not directly evidenced in the raw data of a pollen analytic, paleontological, or cultural analysis. Such raw data only forms the basis for paleoecological conclusions. The paleoecological conclusions are then evaluated and interpreted as functions of climatic conditions which may have occurred. One may recognize, for example, that the fossil rocord of the 1300-1425 A.D. period at Picuris has more spruce and fir pollen than later periods. The conclusion is drawn that spruce and fir trees were closer to the site, and this conclusion is evaluated by reference to available data and interpreted as an indication of cooler temperatures at this time.

This paleoclimatic reconstruction, and the others, must be recognized in its proper perspective: i.e., a best available hypothesis based entirely on an evaluation of logical conclusions drawn from a body of raw data which does not, in itself, yield information of paleoclimatic value. It is thus necessary to support paleoclimatic reconstruction from as many independent sources of paleoecological inquiry as possible. This, in turn, necessitates that each reconstruction undergo constant scrutiny as new kinds of data become available, and that those who would make paleoclimatic reconstructions constantly evaluate the premises upon which the various paleoecological conclusions are based.

In order to offer paleoclimatic reconstructions, it is necessary to obtain paleoecological data which has a relatively clear relationship to climatic phenomena. Selection of a paleoecological problem also, then, played a role in this objective of the report. There were other paleoecological problems which could have been selected which offered more clear-cut relationships to climate than that of tree coverage. Certain plants have quite critical temperature and moisture relationships, for example, (Dahl, 1964) and I might have attempted to use their pollen frequencies as the raw data upon which the paleoclimatic interpretations were made. Yet the problem of chronology had to take precedence, and this meant that the paleoecological problem already selected was relatively more important. This was especially so since some paleoclimatic interpretations could be made from an evaluation of the meaning of changes in the density of tree coverage. Unfortunately, there was no time to undertake the completely different types of analyses which might have allowed more detailed information for the paleoclimatic reconstruction. In any case, it would have been premature to attempt them until the paleoclimatic implications of the archaeological, historical and paleontological data forthcoming from Picuris had been evaluated.

In the face of these difficulties it is somewhat surprising that paleoclimatic reconstructions should be offered at all. Yet it is vital to do so. The various paleoecological reconstructions indicate that the environment has undergone change, and how it has changed, but does not define <u>why</u> it has changed. Our understanding of the past must be based on an understanding of cause, not effect, so as to enable determination of which effects are due to the same, or related, causes and which are not. At Picuris changes may occur in the vegetation pattern, the faunal assemblage, and the artifact assemblage at the same time. The simple recognition of parallelism of changes at one point in time does not inform us of the meaning of this occurrence. It is only when it can be recognized that the three changes are due to a common causal phenomenon, or that two are but one is not, or


Sample No.
A P %
Ponderosa/ Σ Pinus
Pinus
Juniperus
Quercus
Abies
Picea
Pseudotsuga
Chenopodiaceae
Artemisia
Other Compositae
Gramineae
Ephedra
Unknowns
Ambrosieae
Cleome
5
6
7
8
9
1
2
3
4
10
11
Pinyon-Juniper
Pinyon-Juniper with Ponderosa
Ponderosa

that one is but the other two are not, that one can understand what the changes mean. Climate is a common controlling variable on both nature and culture. Change in this variable is immediately suspect as a cause whenever cultural and natural changes are recognized in the past. Thus despite the fact that paleoclimatic reconstructions are difficult and untrustworthy they must be attempted in order to allow full scope for the potential for understanding the meaning of such cultural and natural variations as occur through time. While we may well doubt interpretations of the meaning of cultural and natural change which are based on paleoclimatic reconstructions, we cannot afford to limit ourselves by ignoring the potential for making such interpretations.

SURFACE SAMPLES

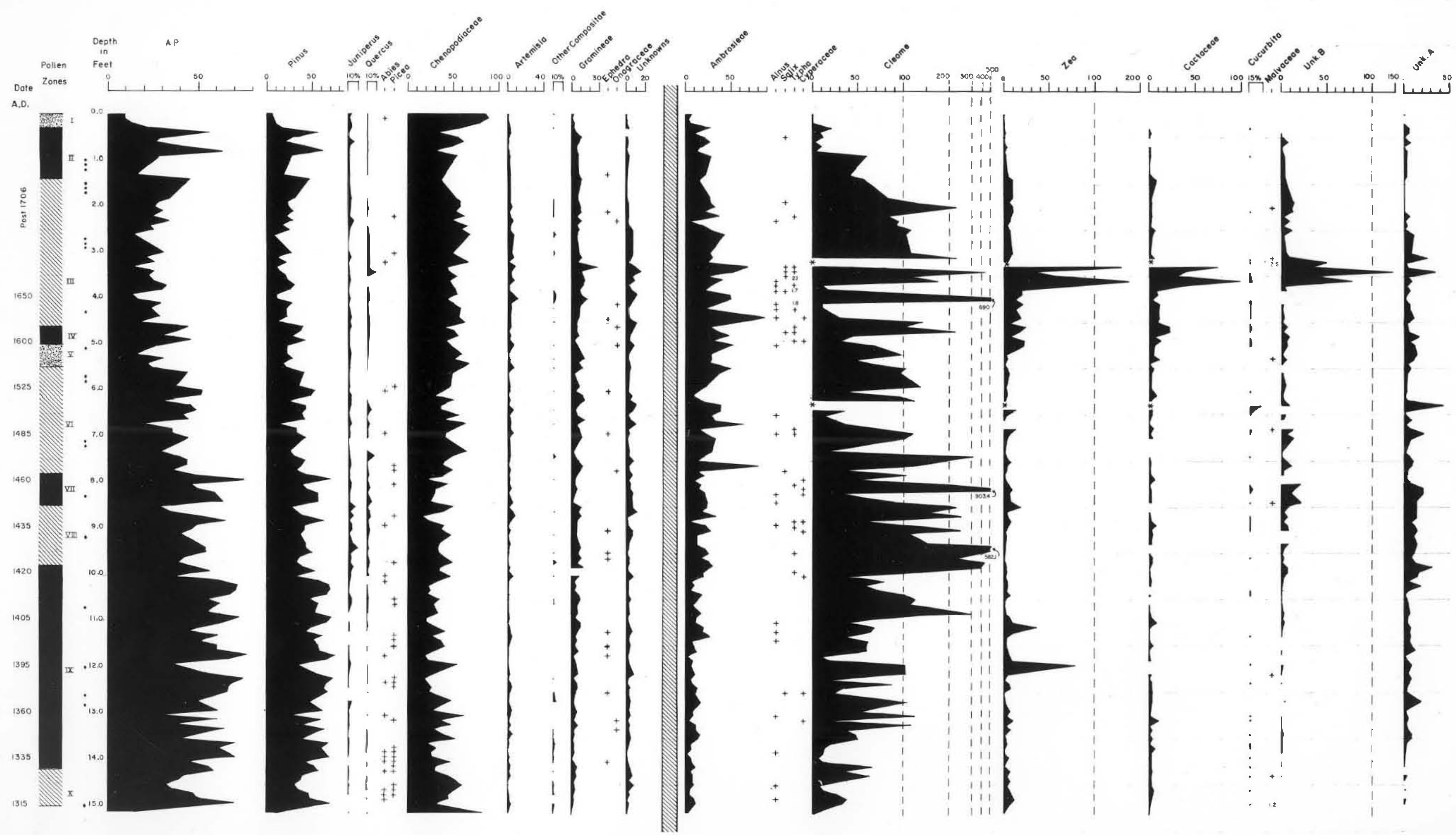
During the course of his investigations of the modern plant ecology of the Picuris area in 1963, Mr. Krenetsky collected a series of surface sediment samples for pollen analysis. These samples form an empirical control from which, along with other surface samples from the Colorado Plateau, information can be obtained on the nature of modern pollen rain-vegetation relationships. By application of the principle of uniformity, similar relationships are assumed to be expressed in the pollen statistics of samples of more ancient sediments. Thus the paleoecological meaning of the pollen frequencies of the ancient samples is deduced by reference to modern controls.

Eleven samples of modern surface sediment were analyzed to yield data on pollen rain-vegetation relationships in the woodlands and forests near Picuris. Samples 5,6,7,8 and 9 were collected from pinyon-juniper woodland; samples 1 and 2 were of a mixed pinyon-juniper-yellow pine ecotone; samples 3,4 10 and 11 were collected from yellow pine forest. The pollen statistics of these samples, and the fossil samples as well, were computed by the standard "adjusted sum" technique this laboratory has found successful in northern New Mexico (Schoenwetter and Eddy, 1964, pp. 69-72).

Total arboreal pollen (AP) values of these samples are quite high, as is to be expected for these dense canopy vegetation types. The very close canopy of the yellow pine community seems to be responsible for the highest AP frequencies, but in general the AP values of these samples are higher than those collected elsewhere in northern New Mexico from similar stands (Schoenwetter, n.d.). The most diagnostic index for distinguishing different vegetation types is the ratio of cf. Pinus ponderosa to cf. pinyon pollen (Martin, 1963, pp. 19-21). As soon as yellow pines become a major floristic component of the vegetation pattern, the frequency of cf. P. ponderosa pollen is greater than that of the cf. pinyon pollen. This parallels the findings of Hevly (1964) in his analysis of curface pollen samples from east-central Arizona. Abies, Picea and Pseudotsuga pollen is more consistently found in the samples from the more elevated vegetation patterns at Picuris and elsewhere, but its mere presence or absence seems not to be a reliable indicator.

All the surface sample data from northern New Mexico (Schoenwetter, n.d.), central Arizona (Hevly, 1964; Schoenwetter, 1962) and southern Colorado (Maher, 1963) now available would indicate that AP frequencies computed on the basis of an adjusted pollen sum yield a reliable index to the amount of arboreal coverage within this area. On a statistical basis, 87 per cent of the population of samples from woodland or forest vegetation patterns will yield AP frequencies above 61.7 per cent; 87 per cent of samples from savannas (trees evident on the landscape but scattered more than 10 m. apart on the average) will yield AP frequencies between 33.0 and 60.0 per cent; 87 per cent of the samples from localities where trees are not evident but are available within a few miles will yield AP frequencies between 22.8 and 54.0 per cent; and where trees are not available within some several miles 87 per cent of the samples will yield between 35.8 and 10.8 per cent AP pollen.

No surface samples were collected from undisturbed locations at Picuris Pueblo which would inform us of the pollen rain there today. I believe it can be fairly assumed, however, that the surface sample data available from the region as a whole is applicable to this site. The site today supports no trees, but a juniper savanna-sagebrush ecotone exists within a quarter mile. AP values between 54 and 23 per cent would characterize this condition. Any horizon in the fossil record which displays less than 23% AP, then, would be indicative of conditions in which trees were significantly further from the site than they are now. Any horizon with more than 54% AP would indicate conditions in which trees were significantly closer than they are now. Any horizon with more than 60% AP pollen would indicate woodland or forest conditions very near the site, and if 50% or more of the pine pollen was of the cf. P. ponderosa type this would indicate the near presence of a significant quantity of yellow pine in the immediate vicinity. This latter conclusion could be substantiated by consistent occurrence of Picea, Abies and/or Pseudotsuga pollen.


Date A.D.
Pollen Zones
Depth in Feet
A.P.
Pinus
Juniperus
Quercus
Abies
Picea
Chenopodiaceae
Artemisia
Other Compositae
Gramineae
Ephedra
Onagraceae
Unknowns
Ambrosieae
Alnus
Salix
Typha
Cyperaceae
Cleome
Zea
Cactaceae
Cucurbita
Malvaceae
Unk. B
Unk. A
Post 1706
1650
1600
1525
1485
1460
1435
1420
1405
1395
1360
1335
1315
I
II
III
IV
V
VI
VII
VIII
IX
X
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
690
903.4
582

become a major floristic component of the vegetation pattern, the frequency of cf. _P. ponderosa_ pollen is greater than that of the cf. pinyon pollen. This parallels the findings of Hevly (1964) in his analysis of curface pollen samples from east-central Arizona. _Abies_, _Picea_ and _Pseudotsuga_ pollen is more consistently found in the samples from the more elevated vegetation patterns at Picuris and elsewhere, but its mere presence or absence seems not to be a reliable indicator.

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CONVENTIONS OF THE DIAGRAMS

Test pit A, the 16.7-foot stratigraphic profile from which samples were collected in 1961, is considered to have yielded the most valuable of the pollen records. The sediments are polliniferous to a depth of 15.1 feet, at which point the midden matrix gives way to a sand and gravel basal deposit in which some artifacts and charcoal appear.

The pollen record of this series of samples is diagrammed on Figure 2. As a number of conventions are used on this and the other diagrams, it is necessary to explain them clearly before proceeding. A number of natural stratigraphic units were observed in the deep sections, but they have not been expressed on the diagrams as is traditional. This has been omitted because the whole of the pollen-bearing sediment is obviously cultural in origin, because fluctuations in the pollen record do not accord with the stratigraphic boundaries recognized, and because the sediment types were not given special treatments in the program of pollen extraction.

The absolute dates given to certain levels on the diagrams (far left) were provided (Wolfman, pers. com. Oct 14, 1965) on the basis of ceramic and tree-ring associations. Next to them is a column illustrating the division of the pollen sequence into zones on the basis of arboreal pollen frequencies. Black areas indicate zones interpreted as periods of more tree coverage than the present, stippled areas indicate zones interpreted as periods of tree coverage less than the present, and hatched areas indicate zones interpreted as periods of tree coverage like the present. Immediately left of the scale of depth of the stratigraphic profile are a series of dots. These dots illustrate levels from which insufficient pollen was recovered for analysis.

At the left center of the diagram a vertical hatched bar segregates the pollen taxa included in the pollen sum (left) from those excluded. Excluded taxa are either of specialized riparian or economic plants, or have no known or obvious ecological import. It will be noted that since the percentage value for any taxon is computed on the basis of the sum of observations of included taxa for any given level, some frequencies of excluded taxa are well over 100 per cent. Dashed vertical lines illustrate the necessity for log scales in the case of some excluded taxa. The pollen sum for each level on the diagrams is given in appendix A, and this allows calculation of the number of grains actually observed.

Crosses on the diagram indicate a frequency of 1.5 per cent or less. There are two levels (3.2 feet and 6.3 feet on Fig. 2) where asterisks are shown for the taxa *Cleome*, *Zea* and Cactaceae. Asterisks indicate that the data for these levels has been lost for those taxa.

Most of the pollen taxa represented on the diagram will be recognized as common ones found in pollen records from the American Southwest. Those with little knowledge of the ecology of this region and the meaning of these floristic elements are advised to refer to Schoenwetter (1962, pp. 173-177) and Martin (1963, pp. 49-56, 71-75)for comprehensive discussion. "Chenopodiaceae" on these diagrams is essentially the same taxon as "Cheno-ams" in those references. Two distinctive pollen types were recognized which could not be referred to known plant taxa: Unknown A and Unknown B.

Unknown A is a small pollen type, 18 to 25 microns in longest axis. It is sub-prolate to prolate in shape, finely scabrate to microreticulate in sculpture, and provided with a distinctive aperture system. The three colpi are subtended by transverse colpi which often anastomose in the more prolate fossil condition. No pollen in the reference collection of the University of Arizona is like this type, though pollen of members of the Euphorbiaceae approximate it most closely.

Unknown B is somewhat larger, between 20 and 30 microns in longest axis depending on amount of distortion in the fossil condition. The grain is subprolate with characteristic blunt ends, and has a microreticulate sculpturing. The colporate apertures are highly distinctive, as the subtending pore is equatorially elongate and pinched into a peculiar dumbell shape. Fig. 3, which illustrates Unknown B, shows that this aperture system approximates that named as *exitus digitatus* by Potonie (1934, p.22)

In recording pollen data recovered in 1963, no distinction was recognized between the cf. *P. ponderosa* and the cf. pinyon types of pine pollen. This distinction was recognized on data gathered in 1965, so some of the pollen diagrams do show *ponderosa*-pinyon ratios while others do not. Such ratios are graphed to the right of AP values where they are known.

No attempt has been made to relate the pollen zone chronology to the temporal phase sequence established at Picuris through analysis of the ceramic data. This is not an oversight, for the phase sequence is assumed to be of wider areal extent than the Picuris site, while the pollen zone sequence is simply a classificatory device for expressing Picuris data. Also, the phase sequence is a system designed to illuminate aspects of artifactual and cultural history, while the pollen sequence is designed to allow recognition of variation through time in tree coverage at or near the site. While cultural history may prove to vary relative to change in environmental conditions, it cannot be presumed that it necessarily varied relative to the changes this pollen study recognizes as significant.

THE POLLEN ZONE SEQUENCE

On the basis of the AP frequency, the record of the 15.1 feet of deposit at Test Pit A breaks down into a series of ten pollen zones. Pollen Zone I is characterized by significantly low AP values, which are taken as an indication that during the deposition of the upper 0.3 feet of the deposit trees were more distant than they are today. This would seem an erroneous conclusion, since the surface itself was sampled. But the modern surface of this trash deposit is undergoing erosion, and since the samples were collected after the test pit was fully excavated there is some probability that the upper few inches of the deposit became quite disturbed by trampling in the area of the pit. These considerations lead me to believe that most recent times are not represented by the uppermost samples.

Pollen Zone II, which extends from 0.3 to 1.4 feet depth, is characterized by wildly fluctuating AP frequencies between significantly low and significantly high values. Problems are encountered in evaluating these data because a high proportion of the samples collected from this interval did not lend themselves to analysis. One would be justified in setting this interval aside as a zone if only on the basis of a relative lack of available information, but I believe that some true variation or variations in vegetation conditions are responsible for the high AP values in this part of the pollen profile. Perhaps future paleoecological work on this time horizon will be able to resolve the question, but I shall tentatively define Zone II as a horizon which indicates the occurrence of trees closer to the site than they are at present.

Zone III is characterized by AP values within the range (23 to 54 per cent) of those considered to be representative of the modern pattern of arboreal coverage. In the middle part of this zone (3.3 to 4.0 feet) there is an unusual concentration of pollen types indicative of a riparian habitat and a sharply dramatic rise in the frequency of pollen of economic plants (*Cleome*, *Zea*, Cactaceae and perhaps *Cucurbita*). The frequencies of the unknown pollen types A and B also rise sharply on this horizon, and this has led me to the conclusion that these types are also members of the economic flora.

I have hesitated to utilize this rise in frequency of riparian and economic pollen types as horizon markers in the profile. The pollen, flowers, fruits and foliage of economic plants are handled by man in many and various fashions, and the ways in which their pollen might become incorporated into sediments of cultural origin are legion. The riparian elements evidenced may also have had their pollen incorporated into the midden in a cultural fashion, or if this was not the case they might illustrate only an extremely localized ecological condition. Since it is unlikely that these peculiar pollen frequencies would be represented in similar fashion in pollen samples collected elsewhere at Picuris (as from room floors or fill) I have not used them as a horizon marker.

Between 3.2 and 3.6 feet in the sedimentary profile the excavators encountered a layer of animal dung. This was apparently deposited when the area was used as a corral in historic time. One might expect that this sediment would produce an unusual pollen record, influenced by the pollen the domestic animals ingested, but this does not seem to be the whole case. The unusually high frequencies of Zea, Cactaceae, Unknown A and Unknown B pollen might be related to this sediment, but the frequency of other herbaceous pollen types--particularly grass--is no different within the manure layer than above or below it. The high frequencies of riparian pollen types and Cleome continue below this deposit for an additional foot and so cannot be simply explained as pollen from the fodder. The unusual pollen frequencies of middle Zone III may be partly due to the use of the area as a corral, then, but cannot be entirely due to this situation.

Because the upper three feet of sediment at this test pit were collected as one archaeological unit, no better ceramic dating is available than the recognition that all of this part of the profile must be younger than 1706 A.D. Relatively little paleoecological data is presently available on the post-1700 horizon from pollen records elsewhere in the Southwest with which those collected at Picuris might be correlated. Palynological analyses were undertaken on samples dated 1700-1775 in the Navajo Reservoir District (Schoenwetter and Eddy, 1964, p.116) and these yielded AP values within the range of modern coverage patterns. These could well be correlated with the Picuris spectra from Zone III collected between 2.0 and 3.0 feet. There is an undated pollen sample from the Shiprock area (Schoenwetter, MSa) which might be correlative with the samples from Zone II in the Picuris series. This sample was collected from the floor of a Navajo hogan of the forked stick type and is generally conceeded to be datable to some time in the 18th or 19th century. No reliable artifact associations were recovered, but coal was found in the trash midden associated with the hogan, which makes any date before 1800 somewhat dubious. The AP record of this sample (over 70 per cent) indicates an increase in arboreal coverage similar to that postulated for Zone II.

Maps based on tree-ring records (Fritts, Smith and Howard, 1964) indicate that between 1700 and 1940 there were a series of periods when moisture receipts in the northern Rio Grande valley fluctuated sufficiently to allow the formation of significantly wide and significantly narrow tree rings. Between 1700 and 1825 tree-ring widths were not significantly different from those of a selected control period, but between 1825 and 1840 wider rings were formed. Ring width patterns returned to "normal" until the 1891-1905 period when significantly narrow rings were formed. Between 1906 and 1920 wider rings are noted, as they are between 1925 and 1930.

If the increases in moisture receipts and droughts recognized in the dendroclimatic record were to be reflected in the pollen record, one would expect that an increase in moisture would create an increase in tree coverage and an increase in AP, while a decrease in moisture would create a decrease in tree coverage and a decrease in AP. I think it highly likely that Zone II is a palynological reflection of climatic conditions in effect during the 1825-1840 period and that Zone I is a palynological reflection of the 1891-1905 drought. This would suggest that the Zone I-II boundary dates about 1890 and that no deposits as young as 1910 are now evident at Test Pit A. The Zone II-III boundary apparently dates about 1825. This dating estimation is extremely close to that obtained if a constant rate of deposition is assumed for the upper 4.0 feet between 1650 and 1910. Such a constant deposition rate would place the Zone II-III boundary at 1819 and the Zone I-II boundary at 1900.

Zone IV, between 4.6 and 5.0 feet depth, is another admittedly tentative distinction. At this depth AP values rise above the frequencies of those of preceeding and succeeding levels. Though they do not do so to the point (54.0%) where a denser arboreal coverage pattern than that of today is evidenced, I believe that woodlands actually were closer to the site at this time. Studies in the Navajo Reservoir District, the area of the Cochiti Pueblo Reservation (Schoenwetter, MSb) and the Galisteo Basin (Schoenwetter, MSc) show an increase in AP values sometime between 1550 and 1700 A.D. Tree-ring widths in the upper Rio Grande Basin are narrow or "normal" throughout this period except for the 1611-1620 period when they are significantly wide and indicate a period of increased climatic moisture. According to associated ceramic dates, the only period of increased AP values in the Test Pit A profile between 1550 and 1700 is that of Zone IV, and it happens that this zone must date after 1600 but before 1650. The coincidence of all these data is too perfect to be ignored. Though the four samples from Zone IV do not indicate the presence of woodland, I believe that they are correlative with those of the Dinetah Phase in the Navajo Reservoir District, Late Glaze horizon pollen spectra at Cochiti, and Late Glaze records in the Galisteo Basin which do show denser tree coverage patterns. Thus I would conclude that a woodland condition did occur at Picuris some time during the 1600-1650 period.

Zone V, between 5.0 and 5.5 feet in depth, contains AP frequencies below 23 per cent except for the sample at 5.3 feet. I believe this last record to be a statistical error of sampling, and would consider this zone as illustrating a period when trees were significantly further from the site than they are today. Ceramic dating places Zone V between 1525 and 1600 A.D. If a uniform rate of deposition is postulated between the 6.0 and 5.0 foot levels, Zone V would date between 1563 and 1600. The dendroclimatic record of the 16th century indicates that the upper Rio Grande basin was particularly dry between the years 1561 and 1585, and remained no moister than normal between 1586 and 1605. Well dated pollen records for the last half of the 16th century are not available elsewhere, but the agreement between the Picuris pollen record and the dendroclimatic record inspires confidence that Zone V is a real phenomenon which is quite accurately dated by its ceramic associations.

Zone VI, from 5.5 to 7.8 feet in depth, yields AP frequencies within the range of the expected modern coverage pattern. The AP values tend to be somewhat higher between 5.5 and 6.6 feet and somewhat lower between 6.6 and 7.8 feet. The higher values might be indicative of more of a savanna-like condition.

Zone VII, from 7.8 to 8.5 feet in depth, is characterized by AP frequencies within the range represented by modern woodlands and forests, and thus indicates a period when trees were significantly closer to the site than they are today. Zone VIII, between 8.5 and 9.8 feet, yields AP frequencies in the range of coverage conditions expectable for the site at present, and is best interpreted as expressing a vegetation pattern similar to that now occurring at the locality. The high AP value recorded for the 8.8 foot level is probably a statistical error of sampling. Zones VII and VIII tend to contain more cattail and sedge pollen than any zone but Zone III, though the ecological meaning of this datum is unclear and I have not used this characteristic as a horizon marker.

The range of time covered by Zones VI, VII and VIII is estimated to be the period 1425 to 1550 A.D. The published dendroclimatic record extends back only to 1500, but dated pollen spectra from the site of Sapawe (Schoenwetter, MSd) and sites in east-central Arizona (Hevly, 1964) are available for this time range. At Sapawe a number of well-dated pollen horizons are available for the period 1400 to 1525. The absolute dates for the Sapawe pollen sequence are based on a completely different ceramic series than those used for dating at Picuris and thus form a true test of the question of correlation of pollen horizons. If AP values from

Sapawe, dated independently on the basis of biscuit wares, can be seen to match those of similar dates from Picuris, the probability is outrageously low that either the pollen records or the dates do not reflect true conditions which existed in prehistoric times.

AP values below 50 per cent are recorded at Sapawe between ca. 1475 and 1525, with values in the range of 40-50 per cent about A.D. 1500 and values less than 40 per cent between ca. 1475 and 1500. This replicates the situation observed in the Picuris chronology in Pollen Zone VI which is dated between 1465 and 1550. AP values above 55 per cent are recorded at Sapawe from a horizon dated some time after 1425 but before 1475. This replicates the AP records from Picuris observed in Pollen Zone VII which is dated between 1445 and 1465. AP values below 50 per cent occur again at Sapawe on a horizon dated no earlier than 1400 to somewhat later than 1425 but before 1450. This replicates the AP record of Zone VIII in the Picuris chronology which is estimated to date between ca. 1425 and 1445.

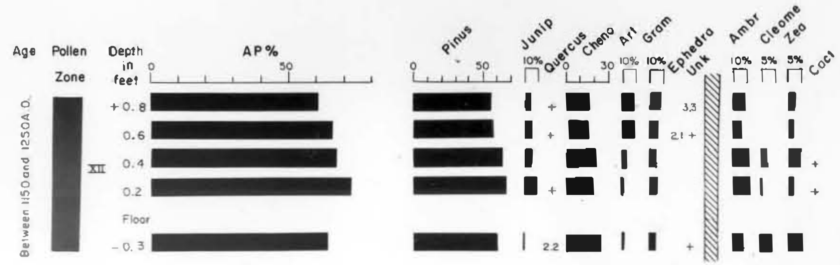
Considering all the errors that both ceramic dating and pollen analysis are heir to, the amazing parallelism of the Sapawe and Picuris pollen chronologies ranges beyond the remarkable to the nearly incredible. Yet the parallelism does exist, and it inspires great confidence for the techniques of ceramic cross-dating and pollen analysis. This is not an isolated case of correlation of AP values from dated horizons. In the area of the upper Little Colorado draingae, pollen samples were analysed from room floors at Four Mile Pueblo by Hevly (1964) and dated by yet another series of ceramic controls (Longacre, 1962). It is difficult to date these pollen samples to the proper quarter-century since no ceramic samples were collected in direct association, but from the surface collection of artifacts and pottery made at the site, dates of 1400-1450 were assigned. Recalculation of Hevly's raw data according to the pollen sum used at Picuris yields AP frequencies for these samples in the range of 50 per cent. Such frequencies correlate well with those obtained from Zone VIII in the Picuris chronology dated 1425 to 1445.

The pollen spectra obtained between 9.8 feet and 14.2 feet in the Test Pit A profile yield AP values above 54 per cent in 31 out of 40 cases, there being four levels where no data was recovered. As there seems no consistent pattern to the exceptions, I have delegated this entire part of the pollen profile to Zone IX and characterize it as a period when high AP values indicate trees substantially closer to the site than they are at present. The AP frequencies reached by seven of the samples from this zone are beyond the 87 per cent probability range of woodland surface samples and would seem to indicate a dense forest coverage pattern. This conclusion is somewhat substantiated by the almost constant occurrence of pollen of fir and spruce in this zone. Frequency values of Ambrosieae pollen become significantly reduced in Zone IX relative to zones which succeed it in time, and this can be used as a horizon marker for differentiating Zone IX from later zones with high values of arboreal pollen.

Zone IX is dated by its ceramic associiations between 1335 and 1425. There are no well dated pollen spectra from other sites in northern New Mexico of the 14th century, except for a single sample from Pueblo del Encierro on the Cochiti Reservation (Schoenwetter, MSb). Pueblo del Encierro is located far enough south of Picuris to be in an area classified as one of different climatic regime (Trewartha, 1954). While Picuris (as well as Sapawe and the sites in east central Arizona) are now in the area of BSh climate, the Cochiti Reservation is on the northern edge of the BWh area. It is not to be expected that the records of vegetation change for these two climatic regions would be identical, but it may be assumed that vegetation changes in the same paleoecological directions would occur in both if the changes were mutually due to environmental shifts which affected the entire Southwest at certain dates. Samples from Pueblo del Encierro which date after 1375 but before 1410 yield pollen spectra indicative of colder conditions and increased arboreal coverage relative to the modern surface samples. These conditions are replicates of those indicated for Zone IX, which incorporates those dates. Samples from Pueblo del Encierro which date after 1410 but before 1450 are indicative of arboreal coverage within the range of present values. This replicates the conditions indicated for Zone VIII of the Picuris chronology which dates 1425 to 1445. Another sample from Pueblo del Encierro was associated with a dendrological specimen which gave a bark date of 1469. This sample has a pollen spectrum indicating lower values of arboreal coverage than presently occur and might well be considered a correlate for the records of lower Zone VI at Picuris which are of the same date.

In the Arizona pollen sequence, samples from Shumway Pueblo (Hevly, 1964) dated as "some time between 1350 and 1450" could be expected to correlate with those of Zone IX at Picuris. In fact, they are good correlates as they yield AP values greater than 54 per cent.

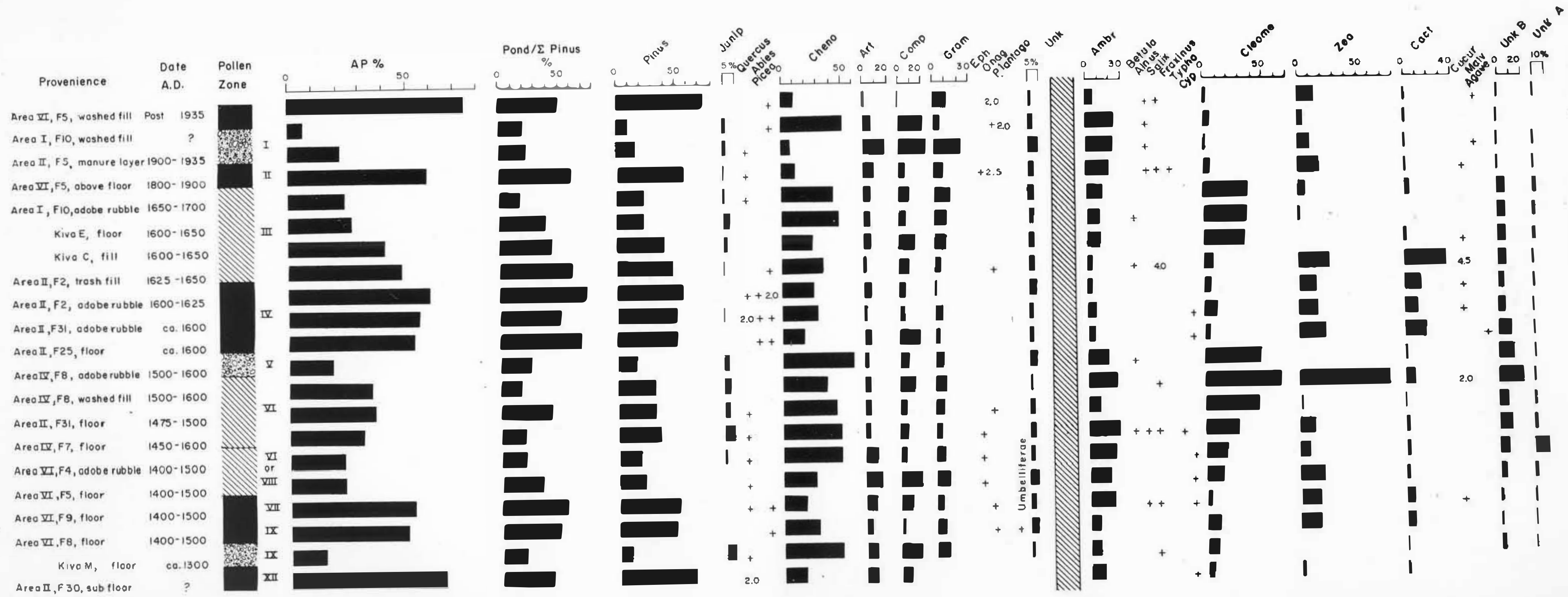
Zone X of the Picuris sequence, between 14.2 and 15.0 feet in depth, is characterized by AP values within the range of those expected under present conditions. This would indicate that trees were about as distant from the site as they are today. However, the persistence of small quantities of spruce and fir pollen indicate the possibility that though arboreal coverage was reduced relative to Zone IX, trees which now occupy higher elevations were located close to Picuris. This is most aptly explained as oocasioned by lower temperatures than now occur. The sample from 14.9 feet seems a statistical anomaly.


Age
Pollen Zone
Depth in feet
AP%
Pinus
Junip
Quercus
Cheno
Art
Gram
Ephedra
Unk
Ambr
Cleome
Zea
Caci
Between 1150 and 1250 A.D.
XII
+0.8
0.6
0.4
0.2
Floor
-0.3
0
50
10%
30
5%
3.3
2.1
2.2
+

From 15.1 feet to a depth of 16.7 feet only two samples yielded much pollen. The sample from 15.1 feet has an AP value of 15.5 per cent, in the range of samples indicating that trees were more distant from the site than they are at present. It would not be reliable to recognize a separate pollen zone on the basis of this one sample, but the sample from the 16.5 foot level, associated with a hearth, also gave some data. Only 79 pollen grains were observed from this level (which is why it was not recorded on Fig. 2) and the statistics are therefore more suspect than those of upper levels. However the AP frequency recorded was only 7.8 per cent, and this would tend to substantiate the conclusion than an older pollen zone, Zone XI, does exist which is characterized by very low AP frequencies.

Ceramic dating allows recognition that no pollen spectra from Test Pit A at Picuris are earlier than 1290 A.D. and that the 15.0 foot level dates about 1315. Zone X, then, must date between 1315 and 1335 and Zone XI ends about 1315 but could extend back in time beyond 1290 to any unspecified date. No other pollen spectra from the Southwest are known to date between 1315 and 1335 which might be used as a check on the recognition of Zone X. Three records are available, however, which may be considered correlates of the observations of Zone XI. A pollen spectrum from site LS-15 analyzed by Hevly (1964) and a series from Hooper Ranch Pueblo (Schoenwetter, 1962) were dated as ca. 1300 by their ceramic associations. Both of these samples yield less than 22 per cent AP as recalculated on the basis of the pollen sum used at Picuris. Samples from Table Rock Pueblo (Schoenwetter, 1962) were associated with a radiocarbon date of 1345 ± 50 A.D. These also yield AP values in the low range and there is no reason to believe that they are not correlates with those of Zone XI at Picuris.

Samples collected from the only pit house recovered at Picuris all contained high frequencies of arboreal pollen, indicating that trees were closer to the site at the time these levels were deposited (Fig. 4). These samples were associated with ceramics yielding an archaeological date of 1150-1250 A.D. and this precludes the possibility that these pollen spectra relate to the chronology recovered from Test Pit A. I have therefore relegated these samples to Zone XII. In the Shiprock District of New Mexico, pollen records with AP values above 54 per cent are associated with ceramic dates of 1225-1240 (Schoenwetter, MSd). In the upper Little Colorado drainage Hevly's data yields AP values between 23 and 54 per cent for samples dated ca. 1250, and AP values in the Shiprock chronology for the period between 1250 and 1275 are of the same range. The 1225-1240 record from the Shiprock chronology correlates well with those of Zone XII from Picuris, and the other records would indicate that the entire period between 1240 and 1315 was not one in which AP values were unusually low--as might be surmised from the meager data of Zone XI in the Picuris series. In all probability the 1276-1299 period was one with low AP records,


Provenience
Date A.D.
Pollen Zone
AP %
Pond/Σ Pinus %
Pinus
Junip
Quercus
Abies
Picea
Cheno
Art
Comp
Gram
Eph
Onag
Plantago
Unk
Ambr
Betula
Alnus
Salix
Fraxinus
Typha
Cyp
Cleome
Zea
Cact
Cucur
Malv
Agave
Unk B
Unk A
Area VI, F5, washed fill Post 1935
Area I, F10, washed fill ?
Area II, F5, manure layer 1900-1935
Area VI, F5, above floor 1800-1900
Area I, F10, adobe rubble 1650-1700
Kiva E, floor 1600-1650
Kiva C, fill 1600-1650
Area II, F2, trash fill 1625-1650
Area II, F2, adobe rubble 1600-1625
Area II, F31, adobe rubble ca. 1600
Area II, F25, floor ca. 1600
Area IV, F8, adobe rubble 1500-1600
Area IV, F8, washed fill 1500-1600
Area II, F31, floor 1475-1500
Area IV, F7, floor 1450-1600
Area VI, F4, adobe rubble 1400-1500
Area VI, F5, floor 1400-1500
Area VI, F9, floor 1400-1500
Area VI, F8, floor 1400-1500
Kiva M, floor ca. 1300
Area II, F30, sub floor ?
I
II
III
IV
V
VI
VI or VIII
VII
IX
XII
Umbelliferae

as would be indicated by the famous "Great Drought" tree-ring series. For further substantiation of the existence of Zone XII, it might be noted that a short term environmental fluctuation from dry to wet conditions is known for the mid 13th century near Fort Sumner in east-central New Mexico (Jelinek, pers. comm.).

Occupation at Picuris is recorded for the period 1150 to 1225, but no sediment samples of this horizon were submitted for analysis. On the basis of pollen statistics of samples dated to the 12th century from the Shiprock area and the upper Little Colorado drainage, one might assume that this period yields AP values between 23 and 54 per cent and indicates conditions of tree coverage like those of the present.

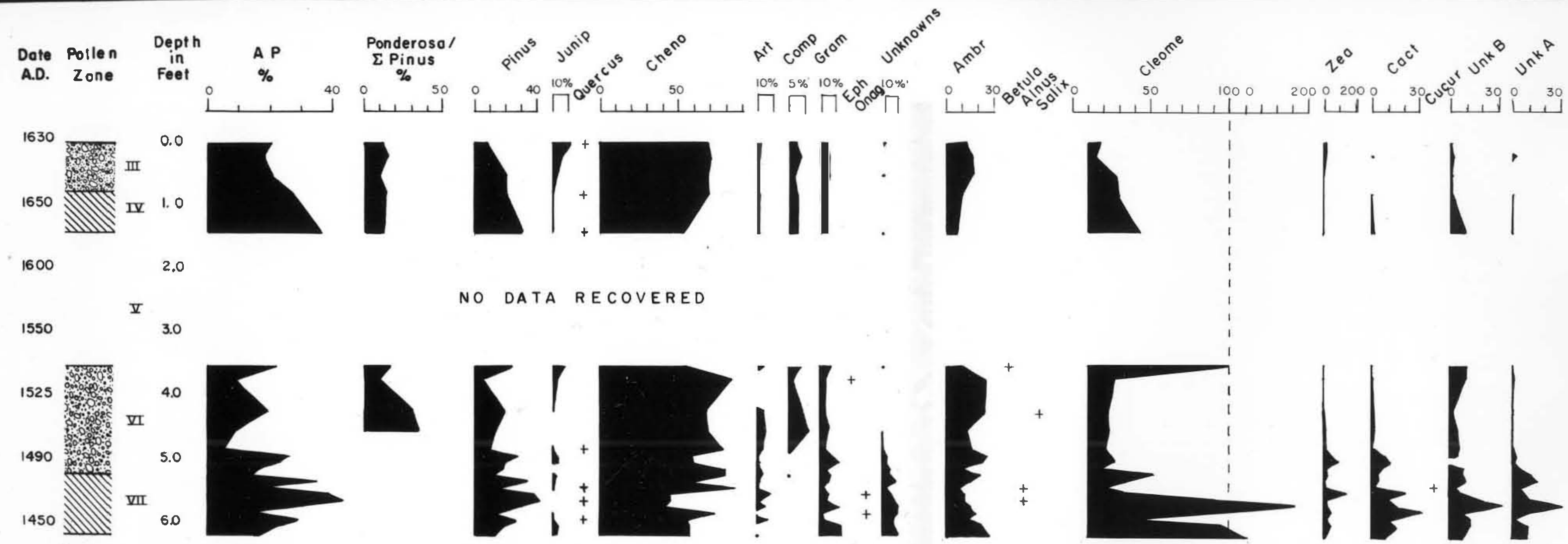
CORROBORATORY EVIDENCE FROM PICURIS

The pollen zone sequence is wholly the result of analysis of data from Test Pit A (Fig. 2) and the pithouse (Fig. 4) at Picuris. It has been shown that other sites in New Mexico and Arizona yield comparable palynological data for the time horizons of the zone sequence, but there is also a set of corroboratory evidence for the zone sequence from Picuris itself.

Primary corroboration of the sequence is yielded by the data recorded on Figure 5. Here a series of sediment samples were collected in various associations with datable artifacts at a number of locations on the site. Most of the samples were not datable with the same precision as those from Test Pit A, but approximate dates yield sufficient information to allow a test of the zone sequence.

Of the 36 samples collected from such proveniences, 15 did not lend themselves to analysis. Some of these came from particularly sandy matrices which contained very little pollen per unit volume of sediment; others were particularly organic and pollen on the slides was obscured by charcoal and large fragments of organic matrix. Seven of these recalcitrant samples clearly did not contain sufficient pollen for analysis; analysis of the other eight was not attempted because a preliminary scan indicated little pollen and time committments required that more promising samples be investigated. The proportion of analyzable samples, then, about 60 per cent, was rather lower than had been hoped. Possibly this was due to the fact that most of the samples came from fill proveniences, while most successful samples from cultural contexts in the Southwest come from floor and midden proveniences.

It was expected that there would be difficulties in recognizing proper pollen zone correlates among these samples. A sample of adobe rubble, for example, might be postulated to contain pollen



Date A.D.
Pollen Zone
Depth in Feet
A P %
Ponderosa/ Σ Pinus %
Pinus
Junip
Quercus
Cheno
Art
Comp
Gram
Eph
Onag
Unknowns
Ambr
Betula Alnus Salix
Cleome
Zea
Cact
Cucur
Unk B
Unk A
1630
1650
1600
1550
1525
1490
1450
III
IV
V
VI
VII
0.0
1.0
2.0
3.0
4.0
5.0
6.0
NO DATA RECOVERED

incorporated in the original sediments of the adobe, pollen incorporated into the wall plaster when it was applied, and pollen which rained down onto the collapsed wall when it finally tumbled. A sample of washed fill might be postulated to contain pollen of the source sediment, perhaps an ancient floor, as well as pollen which rained onto the wash sediment as it accumulated. Such situations would produce a blending of pollen of various horizons which would result in unusual and erroneous pollen statistics. But the fact is that the entire series of samples from such proveniences does yield pollen statistics which are correlative with the zonal sequence defined at Test Pit A. It would appear that the expected blending of pollen horizons does not occur for some unknown reason, for in each case the pollen statistics of a datable horizon are precisely those of similarly dated levels at Test Pit A. The adobe rubble samples from Area II, Features 2 and 31, yield AP values in the same range as those from the floor sample of Area II, Feature 25, which is of the same approximate age: ca. 1600 A.D. These statistics are comparable to those of Zone IV in the Test Pit A sequence which dates between 1600 and 1650 and indicates tree coverage conditions equivalent to those recognized in the dendroclimatic record between 1611 and 1620.

This does not mean that on the basis of pollen statistics alone any sediment sample can be dated in absolute time. The pollen statistics of the various zones are similar, and one can only say that a given sample is more probably of some zones than others. Other kinds of dating are needed to determine which zone is the most probable. For example, between 1400 and 1500 A.D. zones VI, VII, VIII and IX are recognized. The AP values of zones VI and VIII are similar to each other, while those of zones VII and IX are similar. If the AP value of a sediment sample known to be deposited between A.D. 1400 and 1500 is less than 54 per cent, the most probable date is either in Zone VI or Zone VIII, but the pollen record does not allow clear evaluation of which date is more probable. This is the situation expressed in the case of the samples from Area VI, Features 4 and 5.

Another attempt to corroborate the pollen zone sequence was allowed through the analysis of samples from Test Pit B (Fig. 6). Samples collected at one-tenth foot intervals in this stratified trash midden were dated by their artifact associations as at Test Pit A, and it was shown that a shorter period of time was involved.

The success of this attempt at corroboration of the pollen zone sequence is almost a matter of personal opinion. The pollen statistics of dated horizons at the two test pits are not directly comparable. At Test Pit A the horizon dated A.D. 1485 to 1525 yields AP values between 23 and 54 per cent; at Test Pit B the horizon dated between 1490 and 1525 yields AP values below 23 per cent. Other dated horizons at the two locations show the same situation: when Test Pit A yields AP values indicative of dense tree cover, Test Pit B yields values indicative of "average" tree cover; when Test Pit A pollen statistics indicate average tree cover, Test Pit B statistics indicate minimal coverage; when Test Pit A statistics indicate minimal coverage, Test Pit B yields no data.

Though the statistics are not comparable, the sequence of change occurring in the AP values from both test pits is comparable. AP values rise or fall past significant levels in the Test Pit A sequence and they similarly rise and fall past significant levels in the Test Pit B sequence. Though the levels of significance are different, with Test Pit A fluctuating from minimal to maximal tree coverage while Test Pit B fluctuates from minimal to average tree coverage, the changes occur in the same directions at the same points in absolute time.

The discrepancy between Test Pit A and Test Pit B pollen statistics might be considered to have sufficient import to discredit the zonation sequence worked out at Test Pit A. But the correspondences between the two sequences in dates of occurrence of variation and variation in the same direction seem to me to far outweigh the discrepencies in actual frequencies of arboreal pollen grains observed. Also, the correspondence of the Test Pit A sequence with all the other records from Picuris, and its correspondence with the pollen statistics of independently dated and independently analyzed samples collected elsewhere on the Colorado Plateau, should weigh heavily in this consideration.

It seems most probable that the discrepancy is a special function of localized floristic conditions occurring at Test Pit B during the deposition of these samples. Whether this was occasioned by a local over-abundance of some producer of herb pollen better adapted to these sediments, the actual distribution of trees relative to this location, or some other natural or man-induced condition I cannot say. Yet I doubt that the pollen zone sequence is threatened by the data from Test Pit B, and have had few qualms in alloting pollen zones to the Test Pit B record which I feel are correlates of the true sequence.

PALEOCLIMATIC RECONSTRUCTIONS

The prospects of a reliable paleoclimatic reconstruction for the Picuris area are enhanced by the relatively large amount of immediately and potentially available corroboratory data. The pollen records alone would afford little basis for a good reconstruction, but the paleoecological information derived from the pollen zone sequence can be shown to be highly correlative with pollen data from elsewhere on the Colorado Plateau and with tree-ring variations in the region. There are also historical accounts for much of the time period involved, and a wealth of paleontological data which is now being analyzed.

The following reconstruction is offered as the best available hypothesis from data immediately at hand, as mentioned in the introductory section. Thus it may serve as a starting point for the evaluation of the other paleoecological and cultural records from Picuris, and it is expected that it will be modified and amplified as more relevant information is recovered. This paleoclimatic reconstruction rests on the evidence of the tree-ring record of the past 400 years, the conclusions drawn from the paleoecological record of the pollen zone sequence, and the record of alluviation and degradation of river and arroyo deposits on the Colorado Plateau during the past ten centuries.

The excellent correlation of pollen records from the Colorado Plateau area indicates that conditions of tree coverage for the whole region tend to change simultaneously when they change. As there are few or no other ecological variables which could be simultaneously operable over this region of more than 10,000 square miles, it seems most likely that climatec causes must be postulated for these variations in vegetation patterns. Judging by the distribution of more and less dense arboreal coverage on the landscape of the Southwest, it becomes apparent that the major controlling variables on coverage are temperature and precipitation, slope exposure, height of water table, soil characteristics and perhaps mountain mass. Only temperature and precipitation values, among those mentioned, are climatic variables.

Temperature and precipitation are related and mutually dependent, with a significant change in one creating a significant change in the other. From the record of changes in arboreal coverage alone, it is impossible to determine the relative quantity of change in either variable. One can only say that if arboreal coverage values increase for a specific elevation that it was either colder or wetter or both than it is now.

The dendrological record is similarly limited in the interpretations that can be drawn, but to a somewhat different degree. Tree-ring width is the simultaneous expression of a host of biological and climatic variables (Fritts, Smith and Howard, 1965; Fritts, 1965), but work is progressing on attempts to discover just what roles each of these plays. Most recent analyses indicate that when ring growth records over a large area agree in being significantly high or significantly low, the most probable cause is a variation in total annual precipitation values. Since we can indicate that significant variations in AP values are correlative with significant variations in ring growth records, it follows that most of the variation of AP values is a function of the climatic variable of annual precipitation.

The causal factors for aggradation and degradation of alluvial sediments in the Southwest is a topic of much debate. It is generally conceeded that regional climatic factors are responsible when periods of alluviation and periods of degradation are widespread, but there is much controversy over which climatic factors. My own research along these lines (Martin, Schoenwetter and Arms, 1961; Schoenwetter and Eddy, 1964) biases me in the direction of explaining aggradation as a function of lessened summer rainfall, relative to present values, and degradation as a function of summer rainfall values like those of the present or higher.

It is well known (Bryan, 1954; Hack, 1942; Cooley, 1962) that during most of the time that there has been occupation at Picuris--i.e., through most of the time of this pollen sequence--Southwestern floodplains were undergoing aggradation. Specifically, aggradation seems to have begun before 1400 A.D. and to have ceased at most localities only within the past 100 years. Prior to that date, for some hundreds of years, degradation of floodplain alluvium was the rule, as it has been since the mid-19th century.

On these bases, it can be recognized that there are periods of time within the pollen zone sequence when annual precipitation values are higher, lower, and "normal" relative to those of the dendrological control period of 1625 to 1940 A.D. We may assume that the climatic conditions of the Southwest today accord well with the "normal", judging by the pollen records of modern surface samples. In addition, within the range of time covered by the pollen sequence at Picuris, there have been variations in rainfall periodicity patterns. A summer-dominant rainfall pattern like that which has been in effect since the mid-19th century also occurred before some date prior to 1400 A.D. Between at least 1400 and 1800, however, a winter-dominant rainfall pattern may be assumed.

By playing the fragments of information from geology, palynology, and dendroclimatology off against each other one can sometimes arrive at interpretations that no one source of information could yield. For example, the tree-ring and pollen chronologies indicate low precipitation values in the later 1500's. The geological record indicates that this was a period of aggradation, so apparently winter precipitation values were higher than summer values. Under such conditions, summer temperature values probably were not very high. High summer temperatures lead to heating of air masses with consequent convection storms. If we grant that this was a preiod of drought, and most rainfall occurred in the winter, there must have been few summer convectional storms and thus low summer temperatures. Alternatively, winter temperatures could not have been too much lower than they are today, and perhaps were higher. Low temperatures result in the condensation of moisture from clouds and this results in a winter rainfall increase. Since we recognize this period as one of annual drought, it is doubtful that more winter rainfall was occasioned than is presently received, so winter remperatures were probably no lower than they are at present. The 1550-1600 period, then, seems likely to have been one in which summer temperatures were lower than they are today, winter temperatures were like those of today or somewhat higher, most rainfall was received in the winter, and total annual rainfall values were significantly reduced relative to the present. This would allow a growing season as long as that of today, perhaps longer, but one drastically affected by drought.

In such fashion, I offer the following reconstruction of paleoclimatic conditions for each of the pollen zone time periods:

Zone XII (1225-1240): Rainfall receipts higher than those of the present are likely, under a rainfall periodicity pattern similar to that of today. The increased rainfall was probably occasioned by orographic storms during April and October consequent upon higher temperature values than are now observed. Such conditions would allow a long wet growing season, less affected by the spring and fall droughts which are now standard.

Zone XI (1240-1315): Very little data of paleoecological conditions is yet available for this time horizon, but present indications are that rainfall values like those obtaining at present occurred during the earlier part of this period (1240-1275) and low rainfall values occurred during the later part of the period (1275-1315). The early part of this period seems to have been one of climatic conditions like those now occurring, while the later part of the period saw lower rainfall value in all seasons consequent upon higher winter and lower summer temperatures.

Zone X (1315-1335): Total annual rainfall values for this short interval seem to have been no higher than those occurring today, though there are indications of lower temperature values in the record of spruce and fir pollen frequencies. Lower summer temperatures would account for the indications that spruce and fir were located closer to Picuris if rainfall values were no higher than those now received, but this would in turn reduce the summer rainfall receipts. To account for annual rainfall values as high as those of the present, a period of low winter temperatures and increased winter precipitation must be postulated. It would thus seem that a winter-dominant rainfall pattern was in effect during this period. Since low summer temperatures are postulated for the later part of Zone XI but not for the earlier part, it would appear that the change in periodicity pattern from summer-dominant to winter-dominant occurred after 1240 and before 1315. The last half of the 13th century is as accurate a placement as can be made at this time. The growing season during the period of Zone X would have been somewhat shorter than it is now because of the longer colder winters, and plants responding to summer moisture, such as annual weeds, grasses and crop plants, may have been affected by summer drought.

Zone IX (1330-1425): Annual rainfall receipts were apparently quite high, and annual temperatures significantly lower than today. A winter-dominant rainfall pattern was in effect, so winters seem to have been very long and wet, followed by cool relatively dry summers. The growing season must have been quite short, but evident was not so short that maize agriculture was not possible. Deep snow accumulations and cool springs probably allowed soils to retain sufficient moisture to carry agricultural plants through the summer season without being subject to critical water deficiency.

Zone VIII (1425-1445): Annual rainfall receipts equivalent to those of the present are indicated during a period of winter-dominant rainfall. Thus annual temperature values were probably lower than those of today, but apparently not so much lower than they had been during the preceeding century. The growing season was probably shorter than that of today, but it is unlikely that spring and fall droughts occurred.

Zone VII (1445-1465): Climatic conditions like those reconstructed for Zone IX seem most probable, with the exception of somewhat higher summer temperatures.

Zone VI (1465-1550): Climatic conditions like those reconstructed for Zone VIII seem most probable. In the earlier part of this zone (1465-1500) rainfall receipts on the low side of present averages may have predominated, while in the later part (1500-1550) rainfall may have been on the high side of present averages.

Zone V (1550-1600): As discussed above, this period probably saw cool summers and winters which were no colder, and perhaps warmer, than modern ones. A marked summer drought seems evidenced and winter precipitation was probably no more than present values. This would have constituted a winter drought relative to preceeding and succeeding periods.

Zone IV (1600-1650): Climatic conditions like those reconstructed for Zone VII seem most probable.

Zone III (1650-1825): Climatic conditions like those reconstructed for Zone VI seem most probable. In view of the length of time of stable climatic conditions expressed by this period, it seems highly unlikely that a rainfall periodicity shift occurred on this horizon.

Zone II (1825-1890): Judging by the tree-ring record, this period of time saw rainfall values higher than those of the present between

1825 and 1840, and rainfall values similar to those of the present between 1840 and 1890. Some time within the range of this horizon, the rainfall periodicity pattern seems to have shifted to that presently observed. I believe it is not improbable that the 1825-1840 period saw climatec conditions like those reconstructed for Zones VII and IV, while the 1840-1890 period saw climatic conditions like those of the present.

Zone I (1890-1910): Lower annual rainfall values than those of today seem to have been occasioned during a period of summer-dominant rainfall pattern. This would indicate the occurrence of a period of cooler summers but winters like those of the present.

It should be possible to check and/or modify these paleoclimatic reconstructions by reference to the paleoecological data offered by faunal remains from Picuris. Indeed, it is preferable that this reconstruction not be published until such supporting or conflicting evidence has been evaluated. There is also every reason to believe that the artifact record should lend some measure of support or conflict to these reconstructions. The insulation properties of structures built during supposed warmer and colder periods might be compared, for example, or the number of woodworking tools compared for horizons when more wood and less wood is presumed available.

EFFECTS OF PRE-EXISTING ENVIRONMENTS ON CULTURE

It is an anthropological dictum that environmental change influences cultural history, just as it is a biological dictum that environmental change influences natural history. But the recognition of environmental change itself allows no comprehension of the kinds of cultural change that might have occurred, and even if one might postulate certain changes as likely, evidence must be accumulated to verify that these cultural changes did, indeed, take place.

Changes in agricultural patterns of placement of crop lands, development or loss of irrigation systems, introduction of new crops, and the like may well have occurred as environmental fluctuations allotted economic advantages to new patterns of agricultural technology. But the economy of a society is as much controlled by cultural values as it is by technology and environmental conditions. One cannot hope, without a reconstruction of both the agricultural technology and the socio-cultural factors of economic patterns, to accomplish a valid economic reconstruction from simple knowledge of environmental conditions.

Such reconstructions of the effect of environment on prehistoric agriculturesas have been proferred (Schoenwetter, 1962; Schoenwetter and Eddy, 1964) have dealt with the socio-cultural factor by interpretation of the relevance of changes in settlement pattern through time, and have shown evidence of the fashions in which agricultural technology underwent change. In the case of Picuris no data is presently available on population size through time or on patterns of site distribution in the area. The only matter that can be reasonably investigated, then, is that of the potential of the environment for agricultural productivity. Whether such variations in agricultural productivity as might be reconstructed are relevant to the culture history of Picuris must remain a problem for those who have analyzed the cultural data.

The growing season at Picuris today is long enough, on the average, to allow substantial yields of maize. But in many years the crop fails because of early killing frosts, and in others it fails because of protracted spring and fall droughts. Modern plots are located on the floodplain of the nearby stream and obtain their water from rainfall, from the water table, and from a poorly kept irrigation system. Irrigation is known to have been introduced to Picuris by Spanish missionaries in the 18th Century, and seems never to have been of much importance.

In view of the paleoclimatic conditions reconstructed for Picuris, it should not be surprising that irrigation systems did not figure predominantly among Picuris agricultural practises at the time of the Spanish missions. For the five centuries preceeding the date of 1840 A.D. indications are that spring and fall droughts were almost unknown, and the only period of critical water shortage was a short-term one on the 1550-1600 horizon. Floodplain farming could be assumed to have been adequate for such maize production as was undertaken, and it is poxsible that under the conditions reconstructed irrigation might actually have been somewhat detrimental to maize cultivation. Maize seeds require warm soils (55°F) in which to germinate, so irrigation undertaken at the beginning of the growing season could well retard the germination process by lowering soil temperatures. Maize yields are higher when night temperatures are high during the growth period, and irrigation during the summer could tend to lower night temperatures in the fields. So long as drought conditions were non-existant, particularly spring droughts which would deprive the germinating seedlings of soil moisture at the beginning of the growing season, irrigation may have been more of a hindrance than a help.

Between 1300 and 1825, it is probable that maize agriculture at Picuris was subject to more consistent crop failure than it is at present, for during almost all of this period the growing season seems to have been shorter than it is now. From 1315 to 1425 colder temperatures would have adversely affected crop potential, as would droughts in the periods 1275-1315 and 1550-1600. The most promising periods for maize agriculture at Picuris would have occurred at 1225-1240 and then again between 1825 and 1840. The latter period was one in which Picuris economy was already well influenced by domestic animals and trading post supplies. It is possible, however, that an early population increase at Picuris was partly due to an increase in the crop potential of the area in the mid 13th century.

Appendix A

The original count made on the Test Pit A samples was to a fixed pollen sum of 300 grains. This sum included the taxa Ambrosieae, *Alnus*, *Salix*, *Typha* and Cyperaceae. After the research on surface samples and modern pollen-vegetation relationships done in 1963, 1964 and 1965 was completed, I recognized that these taxa should be excluded from the pollen sum. The resultant sums are shown on the following table.

Level	N	Level	N	Level	N
0.0 feet	283	2.9 feet	0	5.8 feet	0
0.1'	287	3.0'	237	5.9'	241
0.2'	285	3.1'	232	6.0'	262
0.3'	244	3.2'	236	6.1'	273
0.4'	274	3.3'	178	6.2'	256
0.5'	247	3.4'	200	6.3'	218
0.6'	237	3.5'	239	6.4'	217
0.7'	257	3.6'	213	6.5'	235
0.8'	265	3.7'	236	6.6'	228
0.9'	234	3.8'	242	6.7'	172
1.0'	0	3.9'	202	6.8'	261
1.1'	0	4.0'	200	6.9'	245
1.2'	0	4.1'	220	7.0'	230
1.3'	327	4.2'	245	7.1'	0
1.4'	260	4.3'	0	7.2'	0
1.5'	0	4.4'	159	7.3'	234
1.6'	0	4.5'	200	7.4'	249
1.7'	0	4.6'	239	7.5'	262
1.8'	238	4.7'	220	7.6'	167
1.9'	233	4.8'	203	7.7'	262
2.0'	222	4.9'	235	7.8'	253
2.1'	252	5.0'	195	7.9'	274
2.2'	219	5.1'	0	8.0'	258
2.3'	236	5.2'	235	8.1'	262
2.4'	252	5.3'	233	8.2'	246
2.5'	233	5.4'	239	8.3'	0
2.6'	210	5.5'	194	8.4'	242
2.7'	0	5.6'	216	8.5'	249
2.8'	0	5.7'	0	8.6'	242

Level	N	Level	N	Level	N
8.7'feet	225	11.4'feet	276	14.1 feet	269
8.8'	258	11.5'	275	14.2'	285
8.9'	245	11.6'	269	14.3'	275
9.0'	235	11.7'	292	14.4'	278
9.1'	267	11.8'	278	14.5'	274
9.2'	0	11.9'	281	14.6'	286
9.3'	266	12.0'	0	14.7'	287
9.4'	246	12.1'	272	14.8'	274
9.5'	241	12.2'	285	14.9'	266
9.6'	260	12.3'	280	15.0'	0
9.7'	240	12.4'	267	15.1'	294
9.8'	237	12.5'	269		
9.9'	251	12.6'	0		
10.0'	250	12.7'	258		
10.1'	262	12.8'	0		
10.2'	278	12.9'	276		
10.3'	285	13.0'	276		
10.4'	260	13.1'	291		
10.5!	267	13.2'	269		
10.6'	276	13.3'	272		
10.7'	0	13.4'	259		
10.8'	256	13.5'	263		
10.9'	270	13.6'	285		
11.0'	269	13.7'	282		
11.1'	252	13.8'	293		
11.2'	253	13.9'	286		
11.3'	268	14.0'	281		

Pollen sums for samples from the Pithouse are based on 1963 data originally counted to a 100-grain sum. With the exclusion of Ambrosieae pollen from the sum the percentage statistics of Fig. 4 were calculated on the following base sums:

Depth	N
+ 0.8	92
+ 0.6	94
+ 0.4	89
+ 0.2	88
- 0.3	92

Pollen frequencies for all surface samples (Fig. 1), for all samples from Test Pit B above the 4.5 foot level (Fig. 6), and for all the samples on Fig. 5 were based on 200-grain pollen sums. Pollen sums from below the 4.5 foot level at Test Pit B were calculated on the basis of data recovered in 1963 as follows:

Depth	N	Depth	N
4.8 feet	279	5.5 feet	89
4.9'	79	5.6'	88
5.0'	81	5.7'	86
5.1'	90	5.8'	84
5.2'	22	5.9'	85
5.3'	86	6.0'	81
5.4'	92	6.1'	78

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