# POLLEN ANALYSIS OF THE HELMS PROJECT

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## INTRODUCTION

The analysis of pollen from archaeological context deposits was attempted in conjunction with the Helms Project for two principle reasons. On the one hand, pollen analysis offers potential as a relative dating technique when used as a tool of biostratigraphic correlation. Since the relative temporal relationship of the occupation components of the Helms Project sites is roughly known, it was hoped palynological study would refine the available archaeological chronology. On the other hand, pollen analysis offers potential as a technique of paleoenvironmental reconstruction. If the relationship between modern conditions of site environment and those occurring at the time of occupation could be understood, insight might be offered into the character of cultural ecological relationships at different horizons of prehistory and certain explanatory hypotheses regarding cultural change through time might appear evidenced. However, the decision to undertake a pollen analysis had to be recognized as a calculated risk. First, no prior attempt to extract pollen from archaeological context deposits had even been made for such sites or in this area. There was no way to guarantee that fossil pollen records could be recovered from the samples collected. Second, even if pollen could be recovered in adequate quantities from the archaeological samples, other pollen studies accomplished in northern California (e.g. Heusser, 1960) have been generated through limnological research. Since archaeological context deposits are not comparable to the aquatic deposits previously investigated, part of the palynological research associated with the Helms Project would necessarily be that of the development of a set of standards which would allow interpretation of the fossil pollen records. It could not be known if this could be accomplished with the suite of pollen samples available.

The issue, then, was only partly one of the potential of the palynological study to resolve problems relevant to the archaeological investigations. Equally significant was the exploration of the potential of the archaeological context sediments to yield patterned, interpretable, forms of palynological record. If this potential could be realized, an additional pathway to the resolution of archaeological problems would be initially cleared. We would also be in a position to extrapolate our experience to determine the parameters of further desirable research in the area of archaeological pollen analysis in the California Sierras.

The 56 pollen samples submitted were recovered from 8 different sites on the eastern slopes of the San Juaquin Valley at varying elevations. At the initiation of the analysis, nothing was known about the preservation or amounts of pollen in the samples, or even how variability in the pollen record might reflect variations in ecology. Because the sites are situated at a range of elevations, and therefore are located in different vegetation zones, considerable differences between them in contemporaneous pollen record were expected. But it was not known what the most parsimonius indicators of the differentiation would be. Further, preservation of sub-surface pollen would have a strong affect on the amount of pollen observable in a sample and therefore the expenditure required to draw significant conclusions about a sample. But our opportunities for observation and analysis were limited by budget considerations.

## METHODS AND TECHNIQUES

Pollen of the sediment samples was extracted according to the standard Arizona State University Palynology Lab procedure (Schoenwetter 1975). This produced clean samples with the exception of site S-391 and portions of sites FRE-667 and -682, which remained too organic. Most samples had strong reactions in HF and required many rinses after KOH treatment to reduce organic content.

| SITE | Picea/Abies | Pinus | Cupressaceae | Quercus | Juglans | Salix | Carya | Chenopodiineae | Anthemidae | Ambrosieae | Liguliflorae | Tubuliflorae | Gramineae | Onagraceae | Rosaceae | Ericaceae | Leguminosae | Geraniac./ Plumbaginaceae | Unknown Type 7 | Other Unknowns | N | ELEV. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FRE-622 | | 34 | 6 | 7 | | | | 3 | 16 | | | 26 | 1 | | | | | 7 | | | 100 | 640' |
| FRE-682 | | 31 | 1 | 21 | 1 | | | 2 | 2 | | 1 | 35 | | 1 | | | | 1 | | 1 | 97 | 2000' |
| FRE-741 | | 61 | 4 | 23 | 2 | | | | | 2 | | 71 | 5 | | | | | | 1 | 1 | 170 | 2800' |
| | 2 | 60 | 1 | 38 | | 6 | | | 2 | 1 | | 86 | 2 | 2 | | | | | | | 200 | |
| FRE-608 | | 60 | 11 | 16 | | | | | | 2 | | 8 | 2 | | | | 1 | | | | 100 | 4480' |
| | 2 | 132 | 15 | 38 | | | | | 2 | 1 | | 5 | 1 | 1 | | 1 | | | | 2 | 200 | |
| | 5 | 122 | 14 | 32 | | | | | 1 | 1 | | 17 | 5 | | | 1 | | | | 2 | 200 | |
| FRE-756 | 1 | 181 | 8 | 2 | 1 | | 1 | 1 | 2 | | | 3 | | | | | | | | | 200 | |
| | 8 | 168 | 4 | 8 | | | | | | 7 | | 1 | 2 | | | | 2 | | | | 200 | 5640' |
| FRE-661 | 10 | 187 | | 2 | | | | 1 | | | | | | | | | | | | | 200 | 8320' |

Table I. Pollen observed in the surface samples

Pollen preservation was excellent for all surface samples; most 200 grain surface pollen counts are from 3 or fewer rows on the slide. However the amount of pollen per drop of extract declined drastically with increasing depth below surface. Sometimes only 30 or 40 pollen grains were observed on an entire slide from lower stratigraphic levels.

Though fossil pollen samples yielded less well preserved pollen than surface samples, the pollen of deeper levels was not more poorly preserved than that of upper levels. In order to assess the labor requirements of the analysis, a count of the first 200 pollen grains was attempted for every sample, but if more than one hour was needed to count 200 grains, only 100 were counted. If one drop of extract (= one slide) yielded less than 100 grains, the count was halted after those observations were recorded. A few samples had so little pollen they were not deemed worth counting at all. In these cases the proportion of organic debris to pollen was the critical factor.

The research design was oriented towards identification of pollen record variations likely to have resulted from climatic or natural vegetation changes and those likely to have resulted from changes in human adaptive strategies. The suite of surface pollen samples served as the primary control series. These samples ostensibly yield pollen records reflecting the response of pollen rain to modern climate and vegetation and are uninfluenced by human behavior patterns. Insofar as the fossil pollen records are comparable to the pollen spectra of the surface samples, they may be interpreted as similar reflections of climatic and vegetation patterns. Differences that can be shown to exist between modern and fossil pollen records, however, could reflect the effect of human actions since the samples are recovered from an archaeological context. We presume that such human actions as affect the pollen records of an archaeological context are likely to indicate adaptive strategies of plant resource procurement and processing subsystems.

One difference that occurs between modern and fossil pollen records, however, is not likely to result from human action. Pollen preservation in terrestrial deposits is influenced most significantly by the physio-chemical character of the deposits; particularly by the rapidity with which the deposits are formed and the opportunities they provide for the introduction of aerobic organisms which feed on pollen grains. But if preservation of pollen occurs differentially--that is, if some pollen types are destroyed when others are not--the frequency values of the pollen record will be affected. This may produce fossil pollen records which mimic those reflecting natural or cultural processes but are not true indicators thereof. Since the factors influencing pollen preservation seem to be highly localized for the most part, one does not expect differential preservation of pollen to affect many samples in exactly the same way. Our working assumption is that replication of results in different levels of a site or at different sites indicates that differential preservation of pollen has little or no influence on the record. Thus we hold that replicated, patterned, pollen statistics are reflections of natural or cultural processes which affect vegetation, and that differential preservation is indicated by stochastic variation.

## RESULTS OF ANALYSIS: SURFACE SAMPLES

The surface sample pollen records (Table I) clearly document pollen rain variations at different elevations which are apparent responses to distinctions in vegetation pattern and climatic parameters. If one assumes that the sample collected at 0-10 cm depth at site FRE-534 (elev.=7100') provides the sort of pollen record a surface sample from this location would produce, the varying proportions of pine, Cupressaceae, oak and Compositae (mostly Tubuliflorae) pollen which are predictors of vegetation pattern are identifiable as in Table II. Other species do not contribute to the surface pollen rain in statistically significant amounts. The frequency

| Site | Picea/Abies | Pinus | Cupressaceae | Quercus | Anthemidae | Tubuliflorae | Geraniaceae/ Plumbaginaceae |
|---|---|---|---|---|---|---|---|
| FRE-661 8120' Elev. | 5% | 33.5% | | 1 % | | | |
| FRE-534 7100' | 1.5 | 94 | | | | 1.5 | |
| FRE-756 5640' | 4.5 | 87.3 | 3 | 2.5 | | 5.3 | |
| FRE-608 4480' | 1.6 | 62.8 | 6 | 17.2 | | 6 | |
| FRE-741 2800' | 0.5 | 32.7 | 1.4 | 16.5 | | 42.7 | |
| FRE-682 2000' | | 32 | 1 | 21.6 | 0.7 | 36 | 0.3 |
| FRE-622 640' | | 34 | 6 | 7 | 16 | 26 | 7 |

Table II. Frequency values of statistically significant components of the surface pollen record

values of the indicator species clearly depends on the elevation of the site. Pine is highest in the high elevations and Compositae (combined Tubuliflorae and Anthemidae and Ambrosieae and Liguliflorae) are highest in the lower elevations.

Site FRE-661, elevation 8320', is located in the red fir vegetation zone. Abies magnifica and lodgepole pine are the dominant trees at the site. The precipitation of this zone is high; more than 25 inches falls in the average winter. Temperatures are cool; the hottest summer months being only a little above 70°. Little shrubby undergrowth occurs in this vegetation pattern. The surface pollen rain fits this pattern. Pine, Abies and Picea represent 98.5% of the pollen in a 200 grain count. Quercus and combined non-arboreal pollen represent 1% of the total. It should be pointed out that even though Abies is the dominant species of the vegetation zone, the pollen rain is overwhelmingly dominated by pine pollen (93.5%). Other pollen types do not even appear in statistically significant quantities.

At site FRE-534, at 7100' elevation, annual average values for rainfall and temperature are approximately those encountered at the higher elevation locality. We would expect a slightly altered pollen rain because different species of pines are observed, there is some distrubance due to logging, and about half the non-arboreal species are different from the high site. No surface samples were submitted from this site, but the fossil pollen record from the 0-10 cm level does not vary significantly from the surface pollen record presented for site 661, in spite of the differences in vegetation.

Site FRE-756 lies at an elevation of 5640 feet. Annual rainfall values are similar to those of higher elevation though summer temperatures average in the high eighties. The site has been logged. Incense cedar, black oak and ponderosa pine are observed at the locale, with buckbrush and manzanita. A wider variety of non-arboreal species is present in this vegetation zone. However, the pollen record is not statistically distinct from that of the 7100' or 8320' contours. Pine pollen is numerically decreased and oak and Tubuliflorae pollen values are numerically increased, but the differences are not statistically significant. In other words, the environmental conditions present at sites 661, 534, and 756 cannot be distinguished palynologically. As the three sites have only average winter rainfall as a common environmental variable, it would appear the very high values for pine pollen observed at all three are indices of that ecological parameter.

Site FRE-608 lies at the 4480' contour. A portion of the site has been disturbed by logging. Available vegetation records locate the site in a meadow--open snowbush (Ceanothus) habitat of the oak forest vegetation zone. The surface sample pollen record at this site shows statistical change relative to those of higher elevation sites. The pine pollen value decreases to 60-66% and Quercus and Cupressaceae (cf. cedar) values are significant for the first time. Thus the environmental zone occupied by site 608 can be distinguished from those at higher elevations on the basis of its palynological record.

Site FRE-741 lies at the 2800' contour line at a grassy clearing surrounded by chaparral and foothills woodland. Several hardwoods and only one pine species are observed. Pine pollen frequency is down to 30-35%, the Quercus pollen values is not significantly different from the 4480' elevation, but Tubuliflorae pollen frequencies have risen significantly. The pollen record at site 741 is distinctive from that of sites of higher elevation in that the frequency of Tubuliflorae pollen is higher than the frequency of pine pollen.

Site FRE-682 is at the 2000' contour in oak chapparal vegetation. Rainfall and temperature are similar to site 741. A greater variety of arboreal and non-arboreal species is observed at the site of collection of the pollen sample but the surface pollen record of site 682 is statistically indistinguishable from that of site 741.

Sites 608, 741, and 682 are not similar as regards vegetation zone or local vegetation pattern, but they all receive about the same amount of winter (November

| Sample | Abies | Picea | Pinus | Cupressaceae | Quercus | Juglans | Chenopodiineae | Anthemidae | Tubuliflorae | Ambrosieae | Liguliflorae | Graminae | Onagraceae | Leguminosae | Total Pollen |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface | 3 | 7 | 187 | | 2 | | 1 | | | | | | | | 200 |
| 10-20 cm | 2 | 3 | 192 | | | | | | 3 | | | | | | 200 |
| 30-40 cm | 2 | 2 | 192 | | 2 | | 1 | | 2 | | | | | 1 | 202 |
| 40-50 cm | | | 198 | | | | | | 2 | | | | | | 200 |

Table III: Pollen observed in samples from FRE-66?

| XIX-386 | Abies | Picea | Pinus | Cupressaceae | Quercus | Juglans | Cercocarpus | Chenopodinneae | Anthemidae | Tubuliflorae | Ambrosieae | Liguliflorae | Graminae | Onagraceae | Unknowns | Total Pollen |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-10 cm | 3 | | 188 | | | | 1 | | | 3 | | | | | | 200 |
| 30-40 | 4 | | 184 | | 3 | | 5 | | | 4 | | | | | | 200 |
| 50-60 | | 1 | 96 | | | | | | | 1 | | | | | 2 | 100 |
| 70-80 | | | 94 | | 1 | | | | | 2 | | | | | 3 | 100 |
| 90-100 | | | 91 | | 4 | | | 1 | | 3 | | | | | 1 | 100 |
| XIX-81B | | | | | | | | | | | | | | | | |
| 10-20 cm | | 7 | 174 | 12 | 5 | | | 2 | | | | | | | | 200 |
| 40-50 | | 6 | 182 | | 4 | | | 1 | | 3 | 1 | | | | 3 | 200 |
| 50-60 | | 5 | 189 | | 1 | | | | | 4 | | | | | 1 | 200 |
| 70-80 | | 10 | 190 | | | | | | | | | | | | | 200 |
| 80-90 | | 2 | 192 | | 2 | | | | | | 1 | | | | 3 | 200 |

Table IV: Pollen observed in samples from FRE-S34

| | Abies | Picea | Pinus | Cupressaceae | Quercus | Juglans | Carya | Chenopodinneae | Anthemidae | Tubuliflorae | Ambrosieae | Liguliflorea | Graminae | Onagraceae | Legumfnosae | Unknowns | Total Pollen |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SURF | 1 | | 181 | 8 | 2 | 1 | 1 | 1 | | 3 | 2 | | | | | | 200 |
| SURF | | 8 | 168 | 4 | 8 | | | | | 1 | 7 | | 2 | | 2 | | 200 |
| 15 cm | 2 | | 89 | 3 | 2 | | | 2 | | | | | | | 1 | 1 | 100 |
| 45 | | | 45 | 1 | 2 | | | 2 | | | | | | | | | 50 |
| 75 | | | 41 | 2 | | | | 6 | | | | | | | | 1 | 50 |

Table V: Pollen observed in samples from FRE-756

through March) precipitation. The average annual value--approximately 20"--is significantly less than that received by the higher elevation sites (25"). It would appear that this lower average annual winter precipitation value is reflected by the Quercus pollen value in these sites, and higher average values are reflected by pine pollen in the higher elevation sites. Site 608 has much the same sort of dominant vegetation as is observed at site 741, but site 682 is quite distinctive in that regard. However, sites 741 and 682 are similar to each other but distinct from site 608 in regard to the quanitity and variety of forbes in the local vegetation. A number of these plants are members of the Tubuliflorae tribe of the Compositae family. They are adapted to the longer growing season of the lower elevation locales. It would appear that the occurrence of high Tubuliflorae pollen frequency values in the sites located at 2800' and 2000' elevation, and the greater quantity of pine pollen in the 4480' elevation locale is a response to length of growing season.

At the lowest elevation site sampled (FRE-622; 640' elevation), the vegetation is of the open oak woodland zone. The area has been cultivated, however, so the present chapparal-like pattern may be the result of disturbance. If this is true, one would expect oak pollen to be over-represented. But the frequency values of pine, oak and Tubuliflorae pollen occurring in this sample are consistant with the patterns observed at higher elevation locales. That is, they similarly indicate a locale with a low average winter precipitation value (low pine value and low oak value) and a long growing season (high Tubuliflorae value). The frequency values of Anthemidae (cf. sage) pollen and pollen of spring annuals (Geraniaceae and Plumbaginaceae) are on the order of those observed in the desert scrub zone east of the Sierras (Mehringer 1967:140). These pollen values thus appear to reflect the significantly higher average annual temperature values observed at low elevations today.

RESULTS OF ANALYSIS: THE FOSSIL SAMPLES

Tables III, IV and V illustrate the fossil pollen records of sites 661, 534 and 756 respectively. The surface pollen sample records of all three sites are comparable. All of the fossil pollen records of the three sites are also comparable. Site 534 has yielded radiocarbon evidence of greater antiquity than is indicated for the other sites. Presumably, the deepest pollen samples (90-100 cm at profile XIX-386 and 80-90 cm at profile XIX-81B) are approximately 5000 years old. But no changes occur in either of the pollen sequences from this site, nor is there evidence of palynological variation over time from either of the other sites. The most parsimonious interpretation of these data is that all of the fossil pollen samples reflect the same ecological conditions which are uniformly reflected by the surface samples of these sites. Presumably, this indicates that the significantly high average winter rainfall values now common to those locations have not changed substantially over the last 5000 years.

At site 608, which dates no earlier than 1000 A.D. but which was occupied until the histroic period, there is less oak in the fossil than in the surface samples (Table VI). This could be a reflection of a preservation problem. The oak pollen observed is small, and often battered. Two subsurface samples yielded only 50 grain counts because the preservation is so poor, and two samples produced less than 50 grains per drop of extract. However, similar relationships of modern to fossil pollen values also occur at other sites.

Site 741 is characterized by a series of re-occupations in prehistoric and historic times. The historic occupation is presumably represented in the upper 30 cm of the sampled deposits. The oldest occupation level sampled could be older than A.D. 500. The sequence of pollen values (Table VII) is quite variable but seems to break down into a series of pollen zones. The youngest zone is represented by a single sample (15 cm level) which is ostensibly of historic age. It is characterized by an

| | Abies | Picea | Pinus | Cupressaceae | Quercus | Juglans | Ericaceae | Chenopodiineae | Anthemidae | Ambrosieae | Tubuliflorae | Liguliflorae | Gramineae | Onagraceae | Leguminosae | Unknowns | Total Pollen |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface | 1 | 6 | 314 | 40 | 86 | | 1 | | 3 | 4 | 30 | | 8 | 1 | 1 | 4 | 500 |
| 15 cm | | | 34 | 1 | 3 | | | | | | 7 | | | 3 | | 2 | 50 |
| 30 | | | 12 | | | | | 3 | | | | | | | | | 15 |
| 45 | | | 33 | 1 | 1 | | | 8 | | | 6 | | | 1 | | | 50 |

Table VI: Pollen observed at FRE-608

| | Abies | Picea | Pinus | Cupressaceae | Quercus | Juglans | cf. Salix | Ericaceae | Chenopodineae | Anthemidae | Ambrosieae | Tubuliflorae | Liguliflorae | Gramineae | Onagraceae | Geraniac./Plumbaginac. | cf. Cleome | Leguminosae | Unknown | Total Pollen |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface | 2 | | 121 | 5 | 61 | 2 | 6 | | | 2 | 3 | 157 | | 7 | 2 | 1 | 1 | | | 370 |
| 15 cm | | | 5 | | | | | | | | 1 | 38 | | | 1 | | | | 1 | 50 |
| 30 | | | 59 | | 2 | | | | 7 | | | 100 | | | 3 | | | 2 | 3 | 200 |
| 45 | | | 10 | | 2 | | | 7 | 2 | | | 100 | | | | | | 1 | 6 | 150 |
| 75 | | | 2 | | | | | | | | | 17 | | | 2 | | | | 4 | 30 |
| 105 | | | 16 | | 3 | | | | | | 2 | 7 | | | 2 | | | | | 30 |
| 120 | | | 25 | | | | | | | | 1 | 3 | | | | | | 1 | | 30 |

Table VII: Pollen observed in the samples from FRE-741

| | Abies | Picea | Pinus | Cupressaceae | Quercus | Juglans | Chenopodiineae | Anthemidae | Ambrosieae | Tubuliflorae | Gramineae | Liguliflorae | Onagraceae | Unknowns | Geraniac./Plumbaginac. | Fern spores? | Leguminoseae | Total Pollen |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface | | | 31 | 1 | 21 | 1 | 2 | 2 | | 35 | | 1 | 1 | 1 | 1 | 3 | | 100 |
| 15 cm | | | 18 | | 5 | | 2 | | | 21 | | | 2 | 4 | | | 1 | 50 |
| 45 | | | 11 | | 1 | | 12 | | | 23 | 1 | | 2 | 1 | | | | 50 |
| 75 | | | 7 | | 2 | | 3 | | | 24 | | | 2 | 2 | | | | 40 |

Table VIII: Pollen observed from FRE-682, Unit B

| | Abies | Picea | Pinus | Cupressaceae | Quercus | Juglans | Chenopodiineae | Anthemidae | Ambrosieae | Tubuliflorae | Gramineae | Geraniac./Plumbaginac. | Unknowns | Total Pollen |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface | | | 34 | 6 | 7 | | 3 | 16 | | 26 | 1 | 7 | | 100 |
| 40 cm | | | 1 | | 3 | | 1 | | | 93 | | 2 | 1 | 100 |
| 60 | | | 1 | 2 | 1 | | 2 | | 2 | 91 | | 2 | | 100 |

Table IX. Pollen observed from FRE-622

extremely high Tubuliflorae pollen value and significantly lower values for pine and oak pollen than occur in the surface pollen record. The second zone is represented in the 30 cm. level. This pollen record is comparable to the surface pollen spectrum, and ostensibly represents the occurrence of essentially modern ecology at the site just about the protohistoric/historic horizon boundary.

The third pollen zone is represented in the samples from 45 and 75 cm depth. Oak pollen values are comparable to those of the surface, but pine pollen values are significantly lower and Tubuliflorae values somewhat higher than occur today. Relative to the situation today, these samples seem to reflect the occurrence of a paleoenvironment which was generally distinctive in regard to the forhe vegetation but has about the same level of winter precipitation. The fourth pollen zone is represented by the two oldest samples, which contain significantly more pine pollen and less oak and Tubuliflorae pollen. They would seem to indicate the ancient occurrence of significantly increased winter precipitation at this elevation.

In these fossil records, pollen preservation is generally poor, and the 75, 105 and 120 cm levels are represented by only thirty grain counts. It was noted that the Tubuliflorae pollen often occurs in contiguous masses which may indicate whole plants being brought into the site. No surface pollen record at any elevation exhibits such a low frequency of pine pollen as do the 45 and 75 cm levels at site 741, or such a high Tubuliflorae level. This change from the norm could be the result of some adaptive strategy which involved bringing large amounts of forbes to be processed in the bedrock mortars at the camp.

The pollen sequence of site 682, at the 2000' contour, shows steady change through time (Table VIII). The pine pollen frequency increases and Tubuliflorae decreases gradually through time. Counts are very low and preservation poor for subsurface samples. Even the surface sample was not normally polliniferous. Because change is consistent through time, it is more likely to be a reflection of natural than human factors, but differential preservation may play some role. It is notable that the oldest samples from this site, which may date before A.D. 1450, were not productive. These fossil pollen records, then, are temporally comparable to that of the second pollen zone at site 741. They are statistically comparable to that sample also.

The pollen sequence of site 622 (Table IX) does not exhibit change within the fossil record, but it is very different from the surface record. The surface exhibits 34% pine, 7% oak and 42% Tubuliflorae. The fossil samples yield records overwhelmingly dominated by Tubuliflorae pollen. These fossil pollen records are comparable to those of the youngest pollen zone at site 741, which is though to be of historic age. Evidence of historic occupancy also occurs at site 622, and it is notable that the older deposits (deeper than 60 cm) were unproductive of pollen.

## DISCUSSION

The modern surface pollen records of sites located above 5000' elevation on the western slopes above the San Joaquin valley are all comparable to each other. Fossil pollen records from these sites, though ostensibly of differing antiquity, are similarly comparable and are statistically identical to the surface samples. These data are most conservatively explained as the result of a consistant pattern of enviroment which occurs today and has occurred at these elevations for at least the last 5000 years. The probable common ecological factor is the occurrence in the past--as today--of an average annual winter precipitation value of at least 25 inches.

The surface pollen records of sites ranging from 640' to 4500' elevation vary principally in regard to pine, oak and Tubuliflorae pollen frequencies. Pine pollen values decline and Tubuliflorae values increase as the overall annual precipitation-temperature ratio changes with elevation. Oak pollen values apparently reflect the winter precipitation values uniquely at these elevations, however, as they are

substantially reduced at locations at which winter precipitation falls below ca. 20 inches.

Many of the fossil pollen records of the lower elevation sites are statistically similar to the surface pollen records, despite the fact that preservation is decidedly poorer. But the fossil pollen records of sites which have similar surface sample records may only be similar to each other in part. Alternatively, the fossil pollen records of some lower elevation sites undergo variation through time to the degree that pollen zone sequences may be identified. When the antiquity of the pollen records--as evidenced by archaeological associations and absolute depth--is taken into consideration, it can be seen that the low elevation fossil pollen records tend to be comparable if they reference the same horizon of time. This is somewhat surprising because the surface pollen records from these sites all reference the same horizon of time (i.e. today's environment), but are not comparable.

The youngest pollen horizon represented in the fossil record is observable at FRE-682 and at FRE-662. It seems to relate to conditions occurring after A.D. 1500, possibly ca. A.D. 1700-1850. The pollen spectrum of this horizon is characterized by very high frequencies of Tubuliflorae pollen--far higher than are probable indices of any natural patterns of climate or vegetation. The simplest explanation is that these pollen values are essentially artifacts of such human strategies as land clearance and agriculture. The next oldest pollen records are recovered from sites 682, 741, and 608. They apparently reflect conditions occurring about A.D. 1450, and perhaps are as old as A.D. 1000. These samples are characterized by pine and Tubuliflorae pollen values statistically equivalent to those obtaining at the sites today, but a lower oak pollen frequency value. The simplest interpretation is of an overall climatic pattern much like that occurring today, but somewhat lower winter precipitation values in the oak forest and chapparal vegetation zones.

An older set of pollen records, presumably dating to the A.D. 500-1450 horizon, has been recovered from site 741 at 45 and 75 cm. These contain significantly more Tubuliflorae and less pine pollen than the surface samples from the site, but have similar oak pollen frequency values. Judging by the surface samples, these may be interpreted to indicate a horizon of time during which the modern oak forest zone enjoyed a considerably warmer and longer growing season--more like the oak woodland does today--but received as much winter precipitation as it does at present. Under such conditions, the chapparal zone would have been considerably more limited in extent than it is today and both the oak forest and oak woodland zones of greater extent. Considering the low quality of pollen preservation in these samples, and the fact that the recovery of monotypic masses of pollen is an index of local over-representation, an alternate interpretation is fully justified. These pollen records could reflect a site-specific behavior pattern rather than a regional climatic situation.

The oldest pollen records from site 741, which presumably date earlier than A.D. 500, contain more pine pollen and less oak and Tubuliflorae pollen than any surface samples from low elevation sites. One of the two is statistically comparable to the high elevation surface samples, and the other approximates that pattern. Taken at face value, these fossil pollen records may be interpreted as indicating a major environmental change which brought a substantial increase in winter precipitation to the present oak forest and reduced the average annual temperature and length of growing season.

Because the two oldest palynological horizons are evidence only at one site, and because each horizon is represented by pollen counts which are low enough to be statistically suspect, their identification is not secure from these data. The prospect that future palynological research may yield valuable and significant clues to the Holocene paleoenvironmental history of the central California valleys, however, is evidenced by these pollen records.

CONCLUSIONS

Study of variation in the modern pollen rain trapped in terrestrial deposits at different elevations on the eastern slopes of the San Juaquin Valley demonstrates:

A. Modern pollen rain records allow the identification of a series of elevationally bounded zones through statistically significant distinctions in the relative frequencies of Pinus, Quercus, and Tubuliflorae pollen.

B. There is some indication these zones may be subdivisible into more ecologically sensitive units on the basis of variations in the frequency values of Cupressaceae, Geraniaceae-Plumbaginaceae and Anthemidae pollen, but the size of thepresent suite of samples is inadequate to confirm or deny this inference.

C. The pollen zones thus identified are not directly comparable to vegetation zones or vegetation patterns, though these are the obvious sources of the pollen observed. The frequency variations which distinguish the pollen zones appear to be controlled by such abiotic factors as the length of growing season and the quantity of winter precipitation.

Study of the pollen of sediment samples of archaeological context recovered from eight sites at different elevations demonstrates:

A. The quantity of pollen per unit volume of deposit tends to decline markedly with depth, as does the quality of pollen preservation. Deeper samples, then, require a larger investment for the recovery of pollen records adequately large for statistical evaluation and interpretation. There is no present evidence, however, that differential preservation of certain pollen types occurs.

B. Though a statistically adequate pollen count could be obtained from one drop of extract from each sample at four sites, all the samples from one site (S-391)failed to yield sufficient pollen for analysis and half the samples from three other sites were not polliniferous. Fossil pollen sampling and analysis programs to be undertaken in future should presume pollen recovery only 50% of the time, and compensate for this as much as possible by the collection of large numbers of sediment samples from each site and the submission of replicate series of samples from each site and horizon for analysis.

C. The pollen types observed in the fossil pollen records are normally those also observed in the modern pollen rain spectra, and the frequency values of the former tend to fall within the ranges of the latter which define pollen zones related to abiotic ecological parameters. A major exception to this generalization occurs in fossil pollen records which can be relagated to the historic horizon at two sites (682 and 662). The exception is most easily explained as an effect of a major modification in cultural patterns of land use.

D. The fossil pollen records fall into two major categories: those statistically comparable to the modern pollen rain spectra from the same locations, and those statistically comparable to modern pollen rain spectra from other locations. All fossil pollen spectra from sites in the 5000' to 8500' elevational range fall into the former category, irrespective of the probable antiquity of the fossil pollen record involved. Fossil pollen spectra from sites located below 5000' which fall in the former category uniformly date to the A.D. 1000-1450 horizon. All other fossil pollen records from the lower elevation sites fall in the second category and are older, judging by stratigraphic position and archaeological associations.

E. The sequence of fossil pollen records from site 741 apparently documents the occurrence of 4 temporally organized palynologically definable horizons. Comparison with surface pollen spectra, and application of the principle of uniformitarianism, supports an argument that each of these horizons represents a period of time when the site 741 area pollen rain was responding to the existence of distinctive climatic or behavioral conditions. Since the two most ancient horizons are evidenced only at this site, and are represented in pollen records which are of statistically minimal adequacy, they yet remain somewhat problematical. The two younger horizons, however, are represented at other sites as well and thus appear to be of regional significance.

F. The available evidence strongly indicates the probability that a regional pollen chronology may be developed for the San Juaquin Valley on the basis of pollen records of archaeological site deposits. Once available, this chronology should be of particular relevance in the study of Californian prehistory and may serve as a pivotal model for the development of other regional pollen chronologies in the state. The comparability of modern and fossil pollen records further indicates the strongprobability that the pollen chronology is interpretable in climatic terms.

The two original objectives of this research were those of exploring the potential of pollen analysis to resolve Helms Project problems in chronology, and exploring the potential of palynological data in offering insights into the cultural ecological relationships of populations of the study area in prehistoric times. Though the pollen research revealed the capability of palynological research to assist in the resolution of problems of chronology, it actually resolved none of them. The chronological problems towards which this research was directed involved the relative dating of high elevation sites. The pollen data seem--at least at present--to be more amenable to resolution of problems of relative chronology at low elevation sites.

Cultural ecological analyses involve assessment of interactive relationships of human behavior and/or cultural patterns and environmental conditions. Normally, the role of techniques of paleoenvironmental recnstruction in that assessment is limited to providing a description of the environmental context within which certain behavioral and/or cultural patterns occurred. Cultural ecological analysis then takes place when the archaeologist considers this in light of the evidence of behavioral/cultural phenomena reconstructed from the archaeological record. In the present study, however, two things have been discovered which allows the palynologist to play a more active role. First, it is fairly evident that land use practises initiated in the historic period were of sufficient magnitude to markedly modify the biological-climatic-edaphic relationships which are expressed as pollen rains. The fact of a modification in cultural ecology, then, is directly expressed in the pollen record of this study. Second, the pollen research provides evidence that the environment of the Helms Project area has undergone changes as a result of climatic modification a number of times during its prehistory. The directions and characteristics of those changes are not yet securely evidenced, nor their geographic extent well understood. The fact of their occurrence, however, offers a number of clues to the archaeologist wishing to explain certain changes in the archaeological record, and offers a body of data upon which cultural ecological analyses may be based.

## COMMENTS AND SPECULATIONS

The quantity and quality of palynological data made available through the Helms Project research program is far too small to justify more wide-ranging conclusions than those presented above. Some workers may feel even those conclusions are insufficiently evidenced, as they constitute a radical departure from common sense conceptions of (a) the character of vegetation/pollen rain relationships; (b) the probable effect

of historical land use practises on the regional pollen record of the San Juaquin Valley; (c) the probable effect of Holocene environmental changes on high elevation and low elevation mountain slope pollen rains; and (d) the probable degree to which pollen records of archaeological site context accurately reflect regional climatic phenomena. We make no apologies for those conclusions, since we have presented the empirical data to justify these statements and consider them scientifically evidenced. That they are not as well-evidenced as we would prefer is a problem only resolvable through more effort and investment. Those who would debate them are free to present contradictory empirical data justifying alternative conclusions more in concordance with common sense arguments.

If one grants the assumption that further research will replicate and amplify the data of this study, some rather interesting implications for both archaeological and paleoecological study are indicated. Archaeologists will perhaps be most interested in the implications of the inference that a major paleoenvironmental change may have occurred at about the same time as the technological change which marks the transition from the Middle to the Late Periods of Californian prehistory. On the basis of present evidence, this change is one which would have greatly affected fish, game and acorn gathering potentials on the slopes of the Interior Valleys Region. Before A.D. 500 the low elevation oak woodland zone may have been relatively small in extent, the chapparal zone much broader and located at a lower elevation, and the pine forest zone extensive at elevations which today support chapparal and live oak-digger pine plant associations. Heavier winter rainfall, extending over a greater period of years, would have dramatically affected the hydrologic patterns of the Interior Valleys and the freshwater resources of the aboriginal population. Later, until about A.D. 1000, the oak woodland and oak-pine vegetation zones appear to have expanded at the expense of both chapparal and pine forest vegetation and, as winter precipitation values declined to present levels, the modern hydrographic pattern became instituted. This change would have effectively maximized the economic potential of an adaptive strategy based on acorn and seed gathering in the Interior Valleys while minimizing the potential of an earlier strategy centered on fish and game procurement. Coincidentally, the change in hydrologic regime would have modified coastal estuarine habitats dramatically, and generally reduced shellfishing potential at the close of the Middle Period.

The implications of the conclusion that a pollen chronology reflecting variations in paleoclimate can be developed are of wider relevance. Climatic conditions at any point on the earth's surface are today recognized as local manifestations of a global atmospheric system which undergoes regular and predictable modification throughout the year and over time horizons measured in centuries and millenia. If the chronology and character of climatic variations in the San Juaquin Valley are understood, our knowledge of the operations of the global atmospheric system will allow us to retrodict contemporary weather patterns of other areas of California and those western states (e.g. Nevada, Utah and Arizona) in which weather patterns are strongly influenced in certain seasons by the climatic conditions prevalent in California. If the increased rainfall of the Middle Period were a function of an intensified winter storms pattern, for example, this pattern would also markedly affect the amount of snowpack developing in the central and southern portions of the Basin and Range Province, with consequent effect on the recharge and discharge of water tables at moderate and low elevations. Populations of organisms adapted to winter season conditions in the Mohave and Sonoran Deserts would experience major demographic changes and expansion of territory, and the effect on desert geomorphological processes would have been in dramatic contrast to the situation one observes today.

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