Commentary on "Archaeology and California's Climate"

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During the past few decades our knowledge of late-Quaternary climatic change has been greatly increased. Climatic change research has become increasingly respectable and well-funded research projects have generated enormous quantities of paleoclimatic data. Long-term changes in climate are still not completely understood but there are some areas of general agreement. It is now generally accepted, for example, that during the Holocene global climates changed in a regionally coherent fashion in response to changes in the general circulation of the atmosphere (Lamb 1977; Denton and Karlen 1973). Less certain, however, is the extent to which Holocene climatic change affected human populations.

According to Moratto, King, and Woolfenden (1978), Holocene climatic change in California did have an important effect on prehistoric settlement and subsistence, at least in climatically sensitive areas such as the Sierra Nevada foothills. Their provocative thesis is based on a comparative analysis of archaeological and paleoclimatological data and I personally am inclined to accept it, at least in general terms. Furthermore, I would like to add the following comments in the hope that they will lead to further discussion and research.

In the first place, it would seem unwise and unnecessary to use archaeology to "test and amplify the paleoenvironmental record" (Moratto *et al.* 1978:147). Human populations are less than ideal climatic indicators for several basic reasons. As the authors themselves admit, non-climatic variables are often important determinants of human behavior. Furthermore, the effects of climatic change are often buffered by cultural adaptations and evidence of these may not always be visible in the archaeological record. In a broader sense, *Homo sapiens* has proven to be a remarkably adaptable species with a correspondingly cosmopolitan distribution. It is hard, therefore, to envisage a situation in which archaeological data could be used to reconstruct environmental change in a conclusive and precise way.

The danger also exists here that one may fall into the trap of circular argument. It is tempting, for example, to assume that changes in settlement and subsistence were caused by a change in climate and then to argue further that the archaeological record provides evidence of climatic change. A much safer strategy here is to look for independent non-archaeological evidence of climatic change and then, if such evidence happens to correlate suggestively with the archaeological record, to postulate a possible causal relationship. In some cases, a convincing argument can be made, but correlation in itself can never provide definitive proof.

My second point relates to the nature of Holocene climatic change in California. Having reviewed the paleoclimatic record, Moratto *et al.* conclude that the Holocene in California was characterized by an alternating sequence of warm/dry and cool/moist episodes. This dichotomous view of climate is based largely upon the authors' interpretation of the Bristlecone Pine tree-ring record and in some respects it is misleading.

According to La Marche (1974a), ring width at the upper tree line in the White Mountains is primarily a function of summer temperature, whereas ring width at the lower forest border is largely dependent upon moisture. It follows, therefore, that if the proposed warm/dry-cool/wet scenario is valid for the Holocene there should be a strong negative correlation between ring thickness at the upper and lower treelines. In actual fact, this is not

the case. La Marche's own comparison of upper and lower treeline data for the period A.D. 800-1960 shows no evidence of a strong negative correlation. According to his graph, cool/wet and warm/dry conditions are indicated for less than 50 percent of the total time period (La Marche 1974a:1047). Detailed statistical analyses of the same tree-ring series also fail to show any evidence of an inverse relationship (La Marche 1974b). The implication is that Holocene climate in California was not simply cool/wet or warm/dry and that warm/wet and cool/dry conditions were also evident. In other words, Holocene climate was more variable than Moratto *et al.* suggest.

My third point relates to the magnitude of climatic change during the Holocene. According to Moratto *et al.* (1978:151), Holocene climatic shifts were of "major scope and intensity." The Altithermal, for example, was a period of "abnormally warm/dry climate," and from 1500 to 600 B.P. there was an "intense warm/dry episode."

In absolute terms, however, the change in climate seems to have been small. La Marche's tree line data, for example, indicate a maximum upslope displacement of only 150 meters during the Altithermal, which is equivalent to a warm-season temperature change of 3.5° F relative to the past few hundred years. In the same context, it should be emphasized that the Altithermal was not a period of continuous drought. The frequency of dry years undoubtedly increased during the mid-Holocene, but above average rainfall years must also have occurred. Tree ring curves based on 100 year mean values can only show longer-term changes in climate although higher frequency variation may have been quantitatively more important.

Moratto *et al.* correctly emphasize the difference between climatically complacent areas (such as the Coast) and climatically sensitive areas (such as the Sierra Foothills), but at the same time they overestimate the magnitude of climatic change needed to bring about changes in human subsistence and settlement. In marginal areas, such as the Sierra Foothills, even small changes in climate could have had far reaching effects.

My fourth point concerns the climatic conditions that characterized certain periods of archaeological interest. According to Moratto *et al.*, archaeological evidence from the southern Sierra Foothills (Buchanan Dam area) and from the Lake Tahoe region indicates that important changes in prehistoric settlement and subsistence occurred during the period 4000 B.P. to the present. They further suggest that these changes can best be understood as cultural responses to changes in climate. In the Buchanan Dam area, for example, during the cool/wet period after 1700 B.P. the population was "fairly sedentary and highly organized; settlements were large, and extensive trade was carried out with both coastal and trans-Sierran peoples," whereas after 1400 B.P. "there was a period of social disruption coexisting with the rapid warming and drying of climate; nucleated villages broke up, the population became dispersed, political organization deteriorated, and violence increased." According to Moratto *et al.* "the coincidence of environmental and cultural change in the Buchanan locality is striking." However, close inspection of the White Mountain Bristlecone Pine 100-year mean curves does not support this conclusion. The graphs indicate that the period 1800 B.P. to 1000 B.P. was cool and wet and that only after 1000 B.P. did the climate become warm and dry (Moratto *et al.* 1978: Fig. 1). This discrepancy does not necessarily mean that climatic change was not responsible for the changes in settlement in the Buchanan Dam area, but it does underline the irrelevance of the warm/dry-cool/wet classification.

Perhaps more meaningful in this context would be a climatic classification based on trends rather than deviations from the mean.

It is interesting to note here that the lower tree line curve suggests that rainfall increased during the period 1900 B.P. through 1500 B.P. and, having reached a maximum unequaled during the period of record, declined rapidly from 1500 B.P. to 900 B.P.

My fifth and final point concerns the problem of climatic prediction. Moratto *et al.* conclude by suggesting that the cool/moist interval which began *ca.* 600 B.P. may be ending and that California's climate may be reverting to conditions similar to those which existed during the warm/dry period of *ca.* 1400 to 600 B.P. As I indicated earlier, the reality of the 1400-600 B.P. warm/dry period is open to question and our chances of returning to it would therefore seem to be remote. Furthermore, according to La Marche (1974a) the cool/moist episode that began *ca.* 600 B.P. ended *ca.* 300 B.P. and the period since has been characterized by a sequence of cool/dry, warm/moist, and warm/dry climates.

The problem here is that the paleoclimatic data presented do not provide a firm basis for predicting future climate. Proxy records such as the Bristlecone Pine tree ring series do provide a valuable perspective on past climate but they cannot be used to project trends into the future.

A more defensible approach would be to take the tree ring record and use it to develop probability estimates of future conditions. For example, it is interesting to note that according to the Bristlecone Pine data presented (Moratto *et al.* 1978:Fig. 1) the recent warm/dry episode (A.D. 1850-1940?) was a period of rather unusual climate. Apart from the analogous warm/dry episode that lasted from 1000 B.P. to 600 B.P. there has been nothing like it for at least 3000 years!

In conclusion, I would like to endorse Moratto *et al.*'s proposal that climatic change studies be closely coordinated with archaeological research wherever possible. In California the prospects for such cooperation are good and certainly there is no shortage of interesting problems.

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