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The Journal of California Anthropology

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Journal

The Journal of California Anthropology, 5(2)

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Publication Date

1978-12-01

Peer reviewed

Archaeology and California's Climate

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SCHOLARS have long been concerned with relationships between environmental and cultural change (cf. Butzer 1964), but most such studies have endeavored to account for the latter by reference to the former. One may reverse the equation, however, using archaeology to test and amplify the paleoenvironmental record. While natural sciences can reconstruct former environments, archaeology can indicate what the past conditions meant to human societies and thus show more precisely the magnitude and nature of the changes.

Moreover, archaeological deposits record human adaptation to specific localities, including places where the direct evidence of past environmental shifts may be incomplete or lacking. Archaeological data, therefore, may be used to translate general paleoenvironmental records into terms meaningful for specific places. It is in such terms that predictions about future conditions can best be made to serve as bases for land-use, resource, and population planning.

In this paper, we summarize some information about California's Holocene environments, and present archaeological evidence for some dramatic cultural adjustments to natural changes. Our goals are to show how archaeology may be used: (1) to help validate models of environmental change developed in other sciences; (2) to independently discover environmental trends and conditions; (3) to add

the dimension of human adaptation to studies of environmental change; and (4) to show how natural changes affected particular localities. Our findings not only suggest how archaeology may contribute to better paleoenvironmental reconstructions, but they also raise questions about the long-term viability of current land-use patterns in the Far West.

At the outset, it is useful to distinguish between "climatic change, which is after all a condition of the earth's atmosphere, and environmental change, which relates to the set of conditions on the ground actually occupied by human societies" (Aikens 1977:212).

HOLOCENE ENVIRONMENTS: AN OVERVIEW

The Holocene epoch (*ca.* 10,000 B.P.—present) is marked by the retreat of continental glaciers and extinction of many Rancholabrean species. Holocene climates, although generally warmer than those of the late Pleistocene, have changed through time in complex yet broadly synchronous ways. Changes in temperature, humidity, and precipitation significantly affected the distribution of water, floras, faunas, and the human populations dependent on these resources.

In broad perspective, California's Holocene climates were subhumid or semi-arid with cool/moist and warm/dry seasons like those of today. Pollen analysis and other studies indicate that summer drought conditions prevailed

both inland and along the coast from Tioga (late Pleistocene) times until the present; that is, California experienced Mediterranean climates throughout the Holocene epoch (Johnson 1977). Nonetheless, when viewed region by region, California's climates changed significantly during the last 10,000 years.

Pollen analyses, glaciology, timberline and tree-ring studies show major fluctuations in California's Holocene climates. At least six relatively cool/moist episodes and five warm/dry periods are indicated (Fig. 1). These intervals correlate with certain archaeological changes. Favorable (cool/moist) eras coincide in specified localities with population growth, settlement expansion, increased trade, and greater sociocultural complexity, while adverse (warm/dry) intervals correspond with diminished population, abandonment of many settlements, disruption of trade, increased warfare, and other signs of cultural retrenchment. The most salient cultural adjustments seem to coincide with the most striking climatic shifts, particularly in regions of the Central Valley, Sierra Nevada, and Great Basin. These findings, which support and amplify existing models of Holocene climates in California, are described more fully below.

The Paleoclimatic Record

In pioneering work, Antevs (1948, 1953, 1955) interpreted geological and palynological data to mean that the arid West had experienced three Holocene climatic ages: the moderately cool/moist Anathermal (*ca.* 10,000-7500 B.P.); the warm/dry Altithermal (*ca.* 7500-4000 B.P.); and the Medithermal (*ca.* 4000 B.P.-present), with moisture and temperature conditions like those of today. Further studies have refined this sequence and its dating.

The most precise, climatically sensitive records available are two Bristlecone Pine (*Pinus longaeva* Bailey) growth ring chronologies from the White Mountains in eastern

California. Tree-ring series are ideal climatic proxies in that they are continuous, are datable to the calendar year, can be calibrated with modern weather records, and are amenable to detailed time series analysis. The longevity of Bristlecone Pine and its well-preserved deadwood provide good time depth. A 5400-year ring width record from the upper tree-line mainly reflects the positive influence of high summer temperatures, while a complementary 6000-year series from the lower forest border records the positive effects of high precipitation and low evapotranspiration. Dated remains of Bristlecone Pine up to 150 m. above the present tree-line indicate relatively high summer temperatures from before 5400 B.P. until about 4000-3500 B.P., when summers evidently began to cool. Drier conditions then forced an extensive tree-line retreat between *ca.* 900 and 500 B.P. (Fig. 1) (LaMarche 1973, 1974; LaMarche and Mooney 1967; LaMarche *et al.* 1974).

The tree-ring sequences, expressed in 100-year means, nicely match the chronologies of such climate-related phenomena as mountain glaciation (Fig. 1). A glacial chronology for the Sierra Nevada was first compiled by Birman (1964) and later expanded by Curry (1969, 1971), who also estimated the ages of glacial deposits using lichenometry. Although Birkenland *et al.* (1976) question the proposed ages of some deposits, the basic glacial sequence is generally accepted. This includes four advances following the Tioga glaciation of *ca.* 20,000-11,500 B.P.: (1) Hilgard, an early Holocene advance of perhaps 10,500-9000 B.P., and (2-4) three "Neoglacial" episodes—Recess Peak (2600-2000 B.P.), an unnamed glaciation (*ca.* 1100-900 B.P.), and Matthes (*ca.* 600-100 B.P.) (Curry 1971; Sharp 1972). These glaciations coincide in time with periods of cool/moist climate as determined by other methods (discussed below).

It is worth emphasizing that the ongoing retreat of montane glaciers parallels a century-

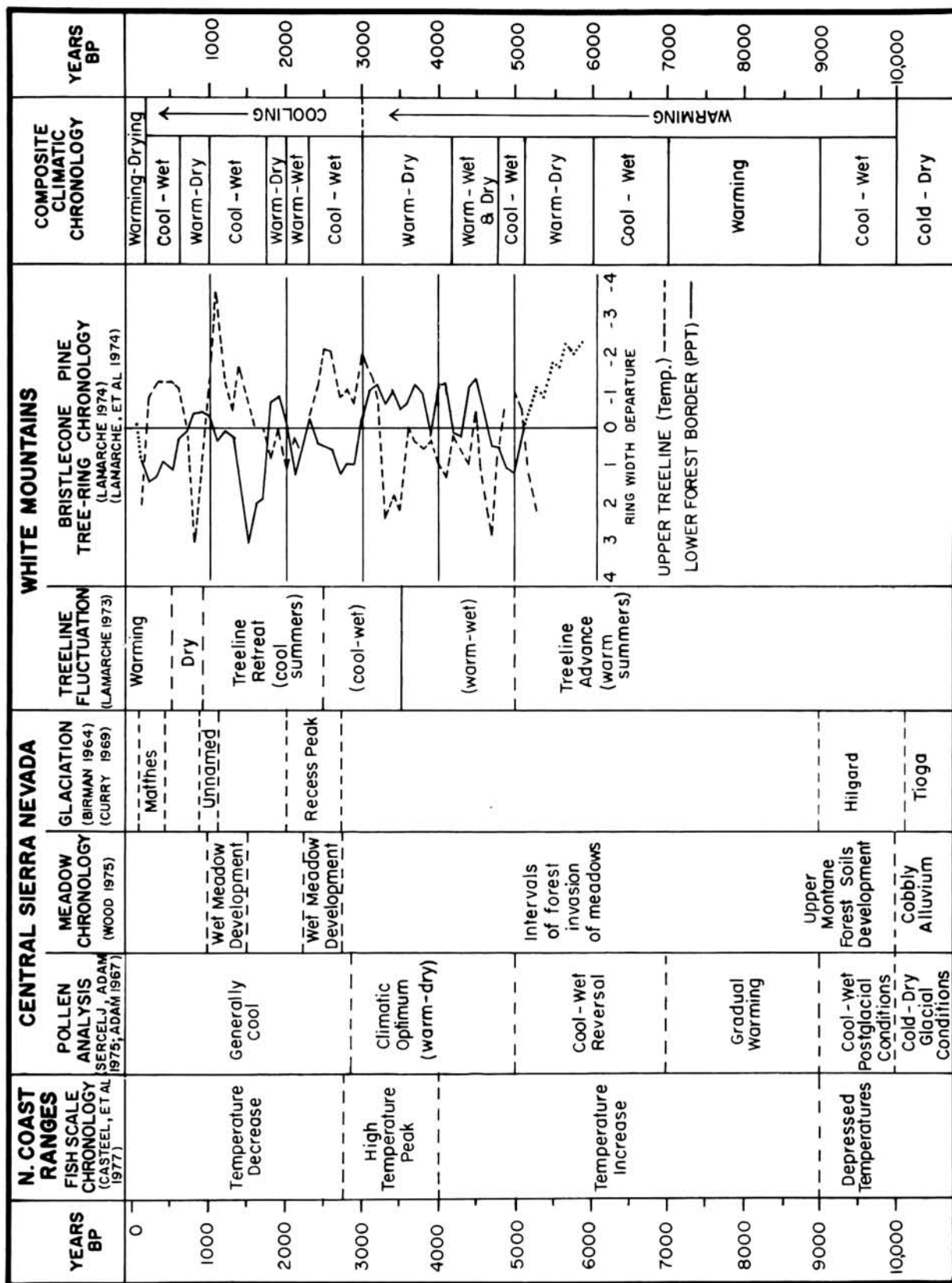


Fig. 1. Reconstruction of California's Holocene climates.

long drying trend recorded in the outer portion of the tree-ring sequences as well as a recent incipient tree-line advance, reflecting a temperature increase since *ca.* A.D. 1850 or 1860 (Fig. 1) (LaMarche 1973; LaMarche and Mooney 1967).

Five pollen diagrams from the Lake Tahoe and Yosemite localities, viewed mainly as temperature and water depth indicators, also provide a comparable climatic record. The pollen spectra reflect a vegetation shift during the transition from cold/dry climate to cool/moist post-Pleistocene conditions about 10,000 years ago. After *ca.* 9000 B.P., a general temperature increase is evident until *ca.* 2900 B.P., except for a cool/moist reversal between *ca.* 7000 and 5000 B.P. The past 2900 years witnessed several warm, moist, and dry intervals within a prevailing cool/moist period (Fig. 1) (Adam 1967; Šercelj and Adam 1975).

The pollen record agrees with Wood's (1975) study of meadow stratigraphy on the west slope of the southern Sierra Nevada. Wood's review of meadow strata, ^{14}C dates, and tephrochronology indicates that: (1) the upper montane belt was forested between 10,200 and 8700 B.P.; (2) one or more intervals of good soil drainage and dry valley bottom conditions occurred between 8700 and 1200 B.P.; and (3) forest soils changed abruptly to wet meadow deposits around 2500 B.P. at some sites and 1200 B.P. at others, suggesting that the sierran meadows originated coevally with neoglaciation (Fig. 1).

The sierran record is compatible with paleoenvironmental data from the southern deserts. Plant species represented in 29 ^{14}C -dated pack rat middens show that by *ca.* 8000 B.P. woodlands had been replaced by grasslands and desert scrub communities in the Sonoran and Mojave deserts (Van Devender 1977). This further documents the post-glacial warming/drying trend of *ca.* 9000-7000 B.P.

Excellent data on later Holocene climates have also been obtained from Little Lake—a

spring-fed lake basin in the channel of the pluvial Owens River:

Dated sediments and fossil pollen, seeds and molluscs from an 11.3 m. core provide evidence for the water budget of Little Lake . . . for the past 5000 radiocarbon years From 5000 to 3000 B.P. the sediments and fossils primarily represent salt grass meadow and marsh deposition. After 3000 B.P., the basin was occupied by a shallow lake [Mehring and Sheppard 1978:153].

A brief but significant lowering of the water table is suggested by a return to marsh conditions at a depth of about 4 m., about 1.9 m. above a peat sample ^{14}C -dated at 3020 ± 120 B.P. The Little Lake sequence complements the montane climatic record very well; even the late reversal to marshland may correspond to the warm/dry episode of *ca.* 1500-600 B.P. indicated by Bristlecone Pine studies.

Holocene climatic variations documented in eastern California also influenced coastal regions. For example, a pollen record from the north coast apparently begins with the Alti-thermal, indicated by a prevalence of grasses and composites, followed by a dominance of alder as humidity rose and temperatures fell around 2500 B.P. (Heusser 1960). A post-glacial climatic optimum is further recorded by disjunct, relatively xeric plant communities now isolated in coastal areas of cooler, moister climate (Axelrod 1967).

Ichthyology provides further evidence of past climates in western California. Analysis of Tule Perch (*Hysterocarpus traski*) scales from a lower Clear Lake sediment core revealed systematic changes in the growth rates of these fish over time, interpreted by Casteel *et al.* (1977) as a response to variable ambient temperature. The growth trends seem to indicate lower temperatures from *ca.* 10,000 to 9000 B.P., followed by a steady warming that peaked between *ca.* 4000 and 2800 B.P.; the temperature has since been decreasing (Fig. 1).

Paleoclimatic Summary

In brief, although the many geological, botanical, and other studies of past environments vary in precision, all are remarkably consistent with respect to the nature and timing of late Quaternary events in California (as well as in other regions of the arid West, cf. Mehringer 1977). The overall synchronicity of climatic events presumably reflects the dominance of a macroclimatic system throughout the Holocene epoch (cf. Johnson 1977). Of all evidences, the dendroclimatic data are especially valuable, not only as a record of temperature and moisture variation, but also as a proxy history of glaciation from *ca.* 6000 to 2700 B.P., prior to the oldest recognized mid-Holocene moraines (LaMarche 1974).

The Holocene epoch apparently witnessed six relatively cool/moist periods of 400-1500 years duration separated by five warm/dry intervals. Prominent among the latter was the Altithermal, a time of abnormally warm/dry climate ending *ca.* 2900 B.P. Between 2900 and 1500 B.P., cool/moist conditions returned, but were cut short by an intense warm/dry episode from 1500 to 600 B.P. Thereafter, until *ca.* 100 B.P., California's climates were essentially like those of the early historic period. Available data, especially the Bristlecone Pine record, suggest that the most recent cool/moist trend—which began *ca.* 600 B.P. and reached its maximum *ca.* 200 B.P.—ended or at least reverted to generally warmer/dryer conditions beginning *ca.* A.D. 1860.

PREHISTORIC ENVIRONMENTS AND CULTURE CHANGE

Linking climatic shifts with archaeological change is a difficult task. Cultures seldom respond in direct, clearly predictable ways to environmental alterations, and the natural changes themselves are quite complex. Baumhoff and Heizer (1965) showed that prehistoric Great Basin cultures appeared more sensitive to changes in effective moisture than

to ambient temperatures, presumably because moisture more strongly determines biotic conditions. In much of California prehistory, however, moisture and temperature trends were largely parallel. Still, one cannot assume that environmental and cultural variations co-occur as neat cause-effect vectors. There are simply too many intervening variables. The rate and intensity of environmental change are at least as important as its nature or direction; a sudden shift may produce more dramatic effects than a slow one. Also, impacts of environmental change may be seen earlier and more intensively near ecotones or biotic "edge" communities than deep within a life zone. Lastly, cultures may react to natural changes in many ways. Faced with worsening surroundings—e.g., less rainfall and fewer traditionally-exploited plants and animals—a society might adapt by population reduction, importing food via trade, exploiting new food resources, expanding its land base, or moving to a more favorable place. Clearly, the environment shift does not cause a direct or simple cultural response.

Nonetheless, some general cultural adjustments are likely to follow environmental trends. For example, increasing warmth and aridity may lead to: (1) diminished water supplies; (2) partial or total drying of some streams, lakes, and marshes with a concomitant loss of flora and fauna; (3) conversion of some deep lakes to shallow lakes or marshes with an attendant increase in exploitable biomass; (4) glacial retreat and lengthening of the growing season at high altitudes; and (5) a general advance of life zones to higher elevations and more northerly latitudes. The diminished water supply and biota would constrain dry-season habitation and reduce the carrying capacity of many areas, thus creating stress for human populations. The upward drift of life zones might also force the relocation of many settlements, particularly those at ecotones. Some new occupation of higher

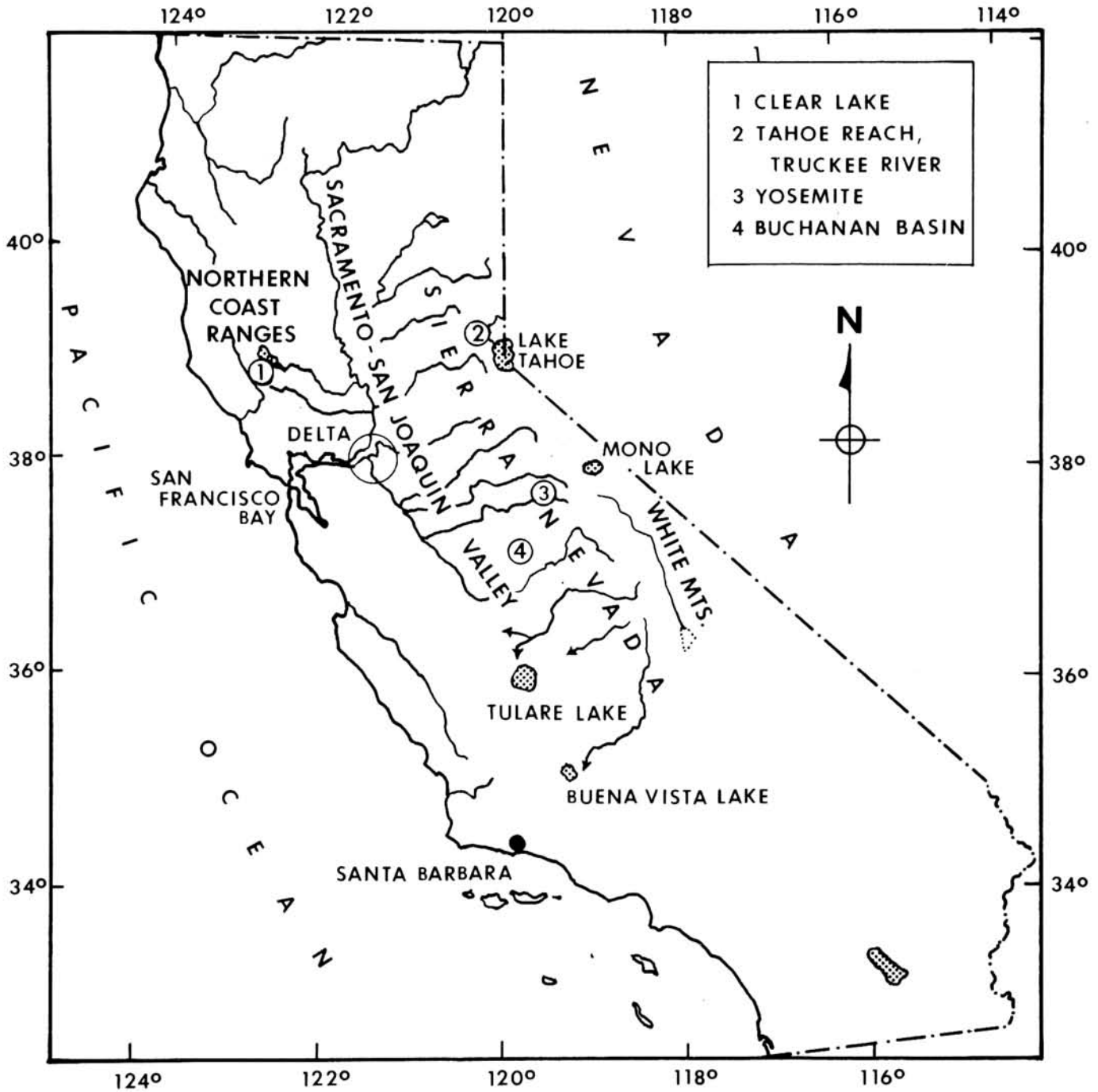


Fig. 2. California regions and localities discussed in the text.

zones would be possible, and in some locations the emergence of marshes in former lakebeds would probably sustain larger populations; but such local advantages would by no means offset the widespread losses caused by desiccation. Warming/drying trends, therefore, might render certain regions uninhabitable seasonally or perennially, force settlements to relocate,

and reduce the carrying capacity of large areas.

In contrast, cooler and wetter climates would: (1) stimulate ice buildup and shorten the growing season in high country; (2) depress the snowline, thus lowering the elevation of possible winter occupation; (3) cause downslope and southerly movements of life zones; (4) increase stream discharge and the amount

of water in lakes and marshes; and (5) create "new" marshes and shallow lakes in former playas and meadows, often increasing the available biomass as well. Cooler conditions in the high country and lower snowlines would limit summer occupation and preclude winter residence in mountainous zones. These limitations would be compensated for by improvements—more water, relatively abundant flora and fauna, etc.—at lower elevations. A transition to cool/moist conditions, like any climatic change, would probably require population movements along the shifting ecotones; but the net result would be greater carrying capacity.

Prehistory in the Southern Sierra Nevada

Early studies of California archaeology emphasized the Pacific coast, San Francisco Bay, and the Sacramento-San Joaquin Delta. These areas are seen as climatically "complacent," that is, they probably felt minimum impact from fluctuations in effective moisture and thus may not be good places to investigate cultural responses to environmental changes. During the 1960's and 1970's, however, to satisfy historic preservation laws, archaeological work was done increasingly in the Sierra Nevada foothills and other climatically "sensitive" areas away from the coast and Delta.

One of the larger such studies was undertaken between 1967 and 1972 by two of us (T.F.K., M.J.M.) in the Buchanan Dam vicinity on the Chowchilla River in the southern Sierra Nevada foothills (Fig. 2). The Buchanan basin, ranging from 130 to 300 m. in elevation, transects the ecotone between the Lower Sonoran grasslands of the Central Valley and the Upper Sonoran life zone, characterized by Digger Pine (*Pinus sabiniana*)—Blue Oak (*Quercus douglasii*) woodland. Most of the basin is an open Lower Sonoran oak savanna or parkland.

Sixty-seven aboriginal sites were recorded at Buchanan during a 1967 field survey (Moratto 1968). Based upon excavations at 27 of these sites, Moratto (1972) defined a local

sequence of three archaeological phases designated, from oldest to youngest, Chowchilla, Raymond, and Madera. Also in 1972, King recovered a large sample of mortuary data from three sites (King 1976). Although the focus of King's (1976) work was on defining Chowchilla Phase political organization, it also produced refinements in Moratto's sequence. Lastly, in 1975, Peak tested three Buchanan sites and obtained data on Raymond Phase burials from a site peripheral to a major village excavated previously (Peak 1976).

Based on these studies, we can outline the prehistory of the Buchanan locality as follows:

The Chowchilla Phase began ca. 2800 B.P. and ended rather abruptly by 1200 B.P., with the most intensive occupation between ca. 1700 and 1400 B.P. (Moratto 1972; King 1976). Habitation was concentrated at three large sites on the banks of the Chowchilla River (Fig. 3), evidently with little or no settlement in the rest of the basin. Analysis of cemetery data suggests an heirarchical, nonegalitarian form of political organization (King 1976). The subsistence economy was based on hunting and gathering; no agriculture was practiced. There is considerable evidence of hunting with atlatl and dart, and of gathering and processing hard seeds—presumably those of grasses or sage. Trade was intensive and widespread; obsidian was derived chiefly from the Mono Lake vicinity on the east side of the Sierra (Fig. 2), and numerous ornaments and beads of marine shell were obtained from the Pacific coast (Moratto 1972). Bead and ornament types are like those used coevally along the coast near Santa Barbara (compare Moratto 1972:350-374 with C. King 1974:75-92).

The Raymond Phase, ca. 1400-500 B.P., contrasts markedly with the Chowchilla Phase. Settlements appear to have been widely dispersed; old Chowchilla Phase sites were occupied sporadically and/or by small groups, while new sites were settled for the first time,

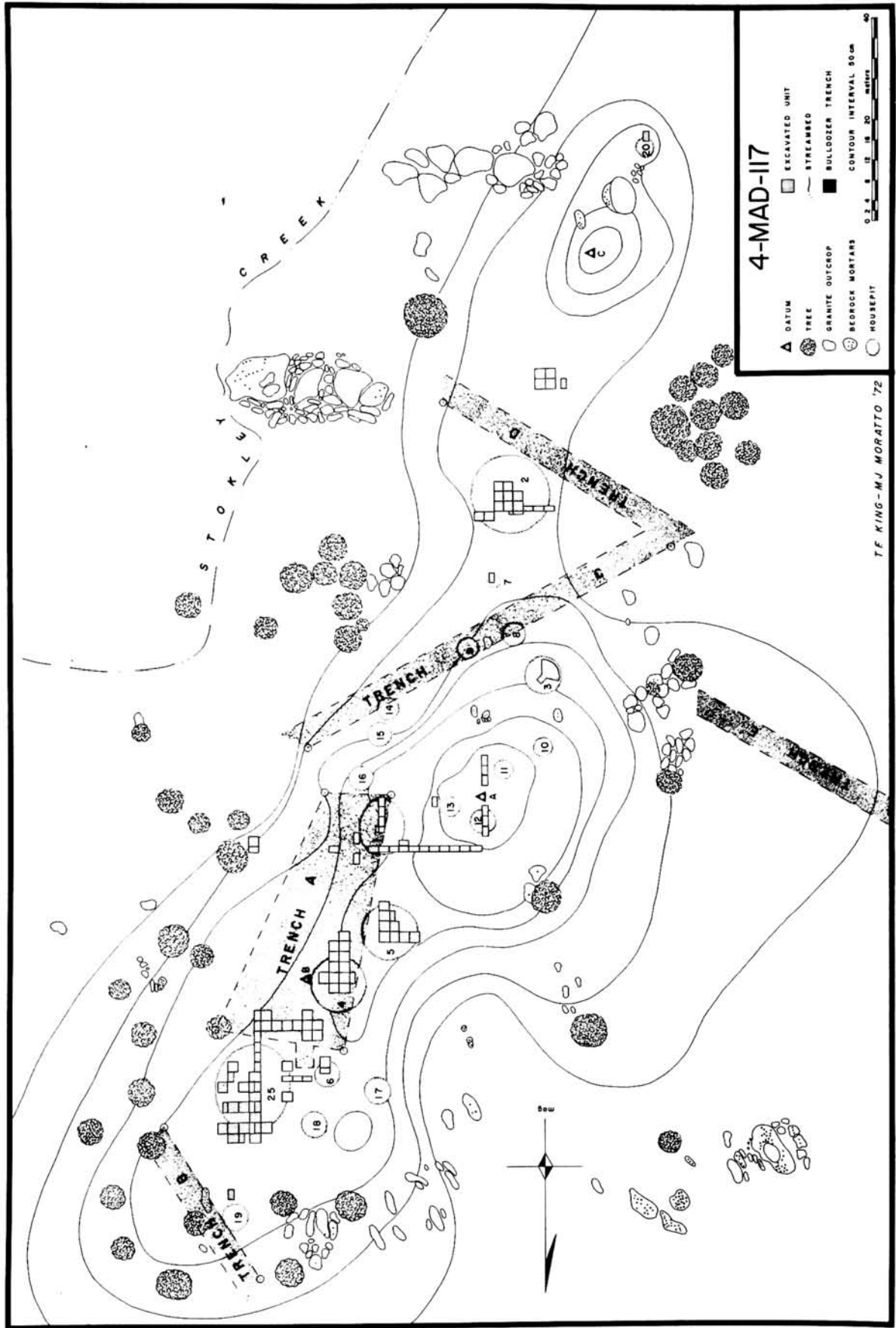


Fig. 3. The Schwabacher site, 4-Mad-117. This site, excavated by King and Moratto between 1967 and 1972, was evidently occupied from ca. 2800 until 100 B.P.

also by small groups. Chowchilla political organization seems to have broken down by early Raymond times; burials are scattered without organized cemeteries, and indicators of social ranking are absent. Bedrock mortars and cobble pestles presumably indicate that acorns were being processed for food, and small projectile points affirm that the bow and arrow were used. Trade relations shifted and became more restrictive; although obsidian still came from trans-sierran sources, shell beads and ornaments from the coast were lacking. The rare beads which did occur were typical of the Delta region rather than the south-central coast. Hostility (warfare?) is demonstrated by substantial evidence of violent death. More than 50% of the adult males appear to have been killed (King 1976; Moratto 1972).

The Madera Phase represents the final occupation of the Buchanan locality, from ca. 500 to 100 B.P. Older village sites were reoccupied and became large population centers, serving as nuclei for many satellite hamlets. Populations evidently increased dramatically. Central villages included large ceremonial buildings (see Fig. 3) and cremations of apparently high-status persons; political organization was evidently similar to that reported historically in the area, where village and tribelet chiefs and functionaries controlled redistribution and other economic activities through operation of a ritual exchange network. Subsistence activities continued to focus on hunting and acorn processing, and obsidian was still obtained from east of the Sierra. Shell beads were again abundant, with types representative of both the Delta and south-central coast (King 1976; Moratto 1972).

Concordance with Environmental Changes

The coincidence of environmental and cultural changes in the Buchanan locality is striking:

(1) Settlement began only after the ameli-

oration of very warm/dry conditions around 2900 B.P., and was sporadic until very cool/moist climate prevailed around 1700 B.P. Between ca. 2800 and 1700 B.P., the area was sparsely inhabited by small, presumably mobile groups.

(2) During the cool/wet period after 1700 B.P., the population became fairly sedentary and highly organized; settlements were large, and extensive trade was carried out with both coastal and trans-sierran peoples.

(3) After 1400 B.P., there was a period of social disruption coeval with the rapid warming and drying of the climate; nucleated villages broke up, the population became dispersed, political organization deteriorated, and violence increased. During this arid interval, persisting until ca. 600 B.P., the southern Sierra foothills were occupied by relatively small groups with little hint of complex political organization or status differentiation. If population centers existed, they apparently were at higher altitudes where environmental conditions previously typical of the lower foothills were replicated; the discovery of a Raymond Phase village in the Upper Sonoran zone upstream from the Buchanan Basin tends to support this inference (Moratto 1972). The bow and arrow were introduced, and acorn processing apparently increased. Contact was maintained across the Sierra, but trade with the coast virtually ceased.

(4) With the return of a cool/moist climate around 600 B.P., the population increased substantially, social organization became more complex, and settlements proliferated. Status differentiation was marked, and trade across the San Joaquin Valley resumed (Fig. 4).

Archaeological data from the Chowchilla River sites support the climatic reconstruction given above and indicate that climate-based environmental changes substantially affected human populations. Likewise, the cultural sequences identified at Hidden Reservoir

| YEARS BP | CLIMATIC CHRONOLOGY | CULTURAL CHANGES | | | | |
|----------|---------------------|----------------------------------|-------------------------|--|--|---|
| | | SOUTHERN SIERRA PREHISTORY | LAKE TAHOE PREHISTORY | SOCIETY | DEMOGRAPHY | ECONOMY |
| 0 | Warming | MIWOK | WASHO | Well-developed status differentiation; complex political organization; chieftainship | Dense populations; extensive settlements; large nucleated villages | Extensive trade with the coast and Great Basin; craft specialization for trade |
| 500 | Cool - Wet | MADERA PHASE | LATE KINGS BEACH PHASE | Poorly developed status differentiation; simple political organization; bands | Depopulation of some localities; small, dispersed populations settled in temporary camps; violence is common | Disruption of trade across the Sacramento-San Joaquin Valley; delta people no longer obtain obsidian from Eastern Sierran sources |
| 1000 | Warm - Dry | RAYMOND PHASE | EARLY KINGS BEACH PHASE | | | |
| 1500 | Cool - Wet | | | | | |
| 2000 | Warm - Dry | CHOWCHILLA PHASE | LATE MARTIS PHASE | Well developed status differentiation; complex political organization | Large populations concentrated in villages; high population density | Extensive trade with the coast and Great Basin; craft specialization for trade |
| 2500 | Warm - Wet | EARLY PART OF PHASE POORLY KNOWN | | Increasing social complexity | Increasing population | Elaboration of trade networks |
| 3000 | Cool - Wet | ← OLDEST 14C DATE | MIDDLE MARTIS PHASE | Very little data, except from Tahoe, where cultural activities were diminished | | |
| 3500 | Warm - Dry | | EARLY MARTIS PHASE | Cultural elaboration at high elevations; no data from the foothills or valley | | |
| 4000 | | | | | | |

Fig. 4. Concordance of late Holocene climatic and archaeological sequences from the Sierra Nevada.

(Fenenga 1973; Kelly 1974), 16 km. southwest of Buchanan, and at Yosemite National Park (Bennyhoff 1956; Fitzwater 1962, 1964, 1968), 80 km. to the northeast, as well as all other southern sierran archaeological data known to us are compatible with our findings.

Lake Tahoe Prehistory

Elston and others (1977) have reported a long sequence of complementary environmental and cultural changes in the "Tahoe Reach" along the Truckee River on the northeastern side of Lake Tahoe, elev. 1897 m. (Fig. 2). Excavations at four sites in 1975 and 1976 produced evidence of seven cultural phases spanning most of the Holocene epoch. The earliest phase—Tahoe Reach—represents a poorly-known Anathermal occupation dated *ca.* 8130 ¹⁴C years B.P. Traces of Altithermal habitation during the subsequent Spooner Phase (*ca.* 7000-4000 B.P.) are present but sparse, and there is evidence that Lake Tahoe did not discharge into the Truckee River during much of this period (Elston *et al.* 1977).

The most intensive occupation took place during the Early, Middle and Late Martis phases (*ca.* 4000-1500 B.P.), coinciding with Neoglacial climates and the regular overflow of Lake Tahoe. The Martis phases were characterized by high population densities, a "subsistence and land use strategy which may have involved territoriality and elaborate social organization," and craft specialization in stone tool manufacture—evidently for trade purposes (Elston *et al.* 1977:166). The Martis phases of the central high Sierra thus parallel the Chowchilla Phase of the southern foothills (Fig. 4).

During the Early Kings Beach Phase (*ca.* 1500-700 B.P.), "the intensity and regularity of occupation" were much less than during Martis times, apparently due to a drier climate—Lake Tahoe often failed to drain into the Truckee River—and decrease in carrying capacity. The less dependable resources of the

period after 1500 B.P. required seasonal transhumance, dispersed populations, and sufficient mobility that groups could go wherever resources happened to be available at a given time. "Thus, base camp sites were not visited on a regular basis and even winter villages were probably not occupied every year" (Elston *et al.* 1977:167).

From all indications, the Late Kings Beach Phase (*ca.* 700-100 B.P.) represents the ancestral culture of the historic Washo Indians in the Lake Tahoe vicinity (Elston *et al.* 1977), just as the Madera Phase may be ascribed to the ancestral Southern Sierra Miwok. The overall correspondence between the Tahoe and Buchanan sequences is excellent, suggesting that comparable environmental changes occurred simultaneously at least throughout the Sierra Nevada, and that cultures hundreds of kilometers apart were similarly affected by these shifts.

Fluctuating Trade Patterns

Further evidence of the cultural response to climatic shifts comes from the analyses of prehistoric trade networks. Economic exchange in California tended to involve reciprocity between adjacent groups, not long-range entrepreneurship. People in the San Joaquin Valley thus served as middlemen in the trade of obsidian from its sources in the volcanic country east of the Sierra to the Pacific coast, and in the movement of shell artifacts from the coast to the Sierra.

As noted above, the southern sierran beads and ornaments of Pacific shells, similar to those used on the south-central coast, occur during the Chowchilla and Madera Phases, but are virtually absent during the Raymond Phase. This may indicate substantial depopulation in the San Joaquin Valley between 1300 and 600 B.P.

Patterns of obsidian exchange in the Sierra remain essentially unchanged throughout the sequence. To the west, however, the situation is

different: (1) On the south-central coast, obsidian artifacts are found (though in small numbers) in sites older than *ca.* 1500 years; they decrease markedly thereafter (Greenwood 1972); (2) in the Sacramento-San Joaquin Delta, obsidian from trans-sierran sources and obsidian from Napa County in the North Coast Ranges were both used about equally until the end of the "Middle Horizon" in the Delta sequence, *i.e.*, until *ca.* 1500 B.P. After 1500 B.P., Napa is clearly *the* source of obsidian for the lower Sacramento and northern San Joaquin groups (Jackson 1974). It seems likely that a general depopulation of the Central Valley, brought about by climatic warming/drying after *ca.* 1400 B.P., would have effectively cut off the supply of eastern obsidian to the Delta and shifted the trade exclusively to the North Coast Ranges.

CONCLUSIONS AND IMPLICATIONS

Only two archaeological localities have been discussed in the space available, but the prehistoric records of the Central Valley and California's arid regions seem to parallel the Sierran data presented above. Although we have found no data to contradict our interpretations, we emphasize that our conclusions are tentative and that our findings may be interpreted in different ways. We do find cases where change is not apparent or not readily explicable as a response to environmental variation. However, (1) we are not claiming that all cultural change reflects environmental shifts—only that certain events and adaptations in California prehistory may have been triggered by environmental shifts; (2) many archaeological reports indicating little cultural change through time are from the coast or Delta, where the effects of diminished moisture would have been relatively minimal; and (3) some reports providing little evidence of cultural change are normative in orientation, demonstrating that certain time periods in given areas are represented by distinctive arti-

facts, but providing few data on the social dynamics that might have produced the assemblages.

The Sierran data are consistent with the idea that Holocene California experienced a series of warm/dry and cool/moist climates. The periodicity suggested by the archaeological record is consistent with that inferred from the many paleoclimatic studies. The archaeological data show that climatic fluctuations were of sufficient magnitude to affect human populations. Although the prehistoric hunter-gatherers of the Sierra Nevada lacked the water transport and storage systems that would ease the impact of climatic change on modern populations, their experience warns us that Holocene climatic shifts have been of major scope and intensity.

Several conclusions may be drawn from the information at hand:

(1) Climatic changes and cultural responses—long documented in arid parts of the Far West—also occurred in cismontane California.

(2) Marginal, ecotonal, or "edge" areas may be better places to study human adaptations to climatic change than "complacent" areas such as the Delta or coast.

(3) As noted above, a cool/moist interval, which began *ca.* 600 B.P., may be ending. California's historic climate may be in the process of replacement by conditions like those of *ca.* 1400-600 years ago. The archaeological data tell us something about what those conditions were, and they may be predicting a renewed, serious desiccation of the Central Valley and its upland rim. If the onset of a new warm/dry episode is in progress—as suggested by dendroclimatic studies—and if it is similar to the one that evidently occurred some 1400 years ago, then we may expect a higher frequency of drought years resulting in a continuing decline in average effective moisture.

(4) The prospect of sustained drought conditions more serious than any recorded histori-

cally should be considered as decisions are made about the development and use of California's assumed land and water resources. Archaeological data hold great potential for practical applications in such decision making.

(5) To understand the impacts of climatic change on the environments of particular localities, and to predict how such environments may develop under possible future climates, we need further, carefully controlled studies in many localities. Archaeological research can provide valuable data, particularly if it is conducted with appreciation of the complex relationships between natural and cultural systems. The cultural systems represented by the archaeological record in any given place must be well understood in order to define accurately the ways they have been influenced by environmental change. Studies of relict springs, marshes, timberlines and other natural features in relation to detailed climatic chronologies are also needed, and these studies should be coordinated with archaeological research wherever possible. This is especially true in areas like California where there is a need for accurate long-range climate forecasting and land-use planning.

It is ironic that the crucial sources of data about past environments are being destroyed rapidly by dams, agricultural expansion and other projects having at their foundations largely untested—and possibly false—assumptions about future conditions.

Idaho Panhandle National Forests
Coeur d'Alene, Idaho

Trust Territory of the Pacific Islands
Saipan, Mariana Islands

Stanislaus National Forest
Sonora, California

NOTE

1. We thank Martin Baumhoff, Polly Bickel, Michael Gawel, Helen King, Patricia Parker, Lynn Riley, Joseph Wallace, and Kenneth Whistler for

helpful comments on earlier drafts of this paper, and Dave Adam and Spencer Wood for sharing their data with us.

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