

CONTRIBUTIONS  
OF THE  
UNIVERSITY OF CALIFORNIA  
ARCHAEOLOGICAL RESEARCH FACILITY

Number 38

May 1978

LATE PREHISTORIC HUMAN ECOLOGY AT LAKE CAHUILLA  
COACHELLA VALLEY, CALIFORNIA

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## PREFACE

This monograph is a revised version of an earlier paper submitted to the Graduate Division of the University of California, Riverside, as a doctoral dissertation in anthropology in December, 1976. Its inclusion in this series has been made possible through the good offices of Professors Robert Heizer and John Graham of the University of California, Berkeley.

Berkeley, California  
March, 1978

## ACKNOWLEDGEMENTS

I acknowledge my debt of gratitude to those persons and agencies who contributed their time and resources to bring this work to completion. The credit for any new understanding acquired through this work goes in large part to the many persons listed below. I reserve for myself credit for all misinterpretations and inadequacies.

Richard D. Ambro, my dissertation committee chairman, largely oversaw the work and guided me through numerous problems. His critical reading of drafts of the manuscript and his helpful suggestions for improvement have been most appreciated. R. E. Taylor and Sylvia M. Broadbent also served on the committee and advised me throughout the work.

Present and past members of the faculty and staff of the University of California, Riverside, who aided me are as follows: James F. O'Connell, currently at the Australian National University, Canberra, followed the project from its inception and also served an active advisory role. Harry W. Lawton, College of Natural and Agricultural Sciences, read various drafts of the manuscript and provided valuable assistance and advice. Homer Aschmann, Department of Earth Sciences, read the manuscript and shared many hours of meaningful dialogue on the environment, ethnography, and prehistory of southeastern California. Oscar Clarke, Biology Department, worked closely with me on identification of plant remains and generously offered his seasoned knowledge of the vegetation and flora of the Salton Basin. Wilbur Mayhew of the same department gave valuable advice on fauna. William Ewart, Department of Entomology, identified insects and told me of their habits. Hyrum Johnson, currently with the United States Department of the Interior, Bureau of Land Management, was a valuable source of botanical information and accompanied me on a most instructive field trip for several days in the Colorado Desert. R. E. Taylor and Peter Slota, Radiocarbon Dating Laboratory, analyzed radiocarbon samples and advised me on their interpretation. Michael Woodburne, Department of Earth Sciences, identified certain reptile remains and provided me with literature on the geology of the region. Jack Mount of the same department granted access to maps in his care and Harry P. Bailey shared with me his views on paleoclimatology. Robert A. Hicks, also of the Department of Earth Sciences, prepared the excellent photographs of the dietary remains and assisted me with photographic matters too numerous to mention. His great contribution of time and effort is sincerely appreciated.

Michael Murphy, Department of Earth Sciences, allowed access to photographic equipment in his care. Cindi Shannon, formerly of the library staff of the University of California, Riverside, and Clifford Wurfel, Special Collections Librarian, helped locate old documents and references. The staff of the Department of Anthropology, especially Doris Churry, Sandi Stout, and Joye Sage, as well as Kay White of the Archaeological Research Unit, provided courtesies too numerous to itemize. Stephen Hammond, now with the California Department of Transportation, analyzed terrestrial faunal samples. Bill Jennings, Philip L.

Boyd Deep Canyon Desert Research Center, shared with me his extensive knowledge of ethnography and natural history, and accompanied me on a field trip to the Coachella Valley. My fellow students, Louis A. Payen, Robert L. Bettinger, Jeanne Binning, and Paul Langenwalter, shared my enthusiasm and offered hours of stimulating discussion. Thomas J. King, Jr., now with the United States Army Corps of Engineers, analyzed ceramic artifacts.

Outside the University, George M. Stanley of Fresno shared with me his nearly two decades of research on the geology of Lake Cahuilla and worked with me in the Salton Basin for many weeks on surveying and mapping prehistoric fish weirs. He also provided me with relevant literature and patient advice. Mrs. Stanley provided me with meals and hospitality for 14 weeks. Carl L. Hubbs, Scripps Institution of Oceanography, shared with me his views on the paleoecology of Lake Cahuilla and provided me with extensive literature on the region. W. I. Follett, California Academy of Sciences, identified fish remains and exchanged many informative communications on the fishes of Lake Cahuilla. Thomas W. Whitaker, United States Department of Agriculture, identified cucurbit remains from the Salton Basin and offered his thoughts on their significance. Kojiro Hioki, University of Cologne, Germany, advised me on Cahuilla words.

Peter J. Mehringer, Jr., and Eugene Hattori, Washington State University, conducted pollen analysis of the Myoma Dunes coprolites. Rainer Berger, Isotope Laboratory, University of California, Los Angeles, offered advice on the interpretation of radiocarbon data. J. Richard Bowersox, San Diego State University, granted access to his unpublished manuscript on the molluscan paleontology and paleoecology of Lake Cahuilla and identified certain species of molluscs. Charmion McKusick, Globe, Arizona, analyzed avifaunal remains from Lake Cahuilla and advised me on their significance. Norah van Kleeck, State Seed Laboratory, California Department of Food and Agriculture, undertook the task of identifying and correcting tentative identifications of plant remains. Chester King, San Jose, analyzed shell artifacts and advised me of their chronological significance.

Mary DeDecker, Independence, California, shared with me her data on aboriginal use of *Dicoria*. P. C. Van de Kamp, formerly with Shell Development Company and now with Geo-Logic, Inc., provided information on radiocarbon dates he obtained in the Salton Basin and a report of his research there. Ken Newbury and James Shirley, Indio, provided flying service for aerial photography. Ole Nordland, Coachella Valley County Water District, granted access to aerial photographs and equipment, and offered his generous hospitality to my field party. Douglas N. Fain and his wife, Muriel, of Indio, provided me with equipment and comforts that, in a final sense, made this work possible. Mr. Fain also shared many excursions with me and offered his extensive knowledge of local archaeology. H. J. Hall, formerly of the University of Chicago, and now with the University of Queensland, provided much advice on coprolite analysis. Barbara Gorrell, Berkeley, located and passed on to me important accounts and documents to which I did not have access.

Lucinda Long worked endlessly on the task of sorting coprolite constituents, and the 27 members of Richard Ambro's class in dietary

reconstruction analyzed an equal number of samples. Claudia Nissley, Gerrit Fenenga, Pamela Thomas, Janice Nordland, John Craib, Clark Wilke, and James P. Barker served as volunteer members of field parties. Katherine Saubel, Jane Penn, Anthony Andreas, and David and Ruby Modesto all provided information on their native Cahuilla culture, and Mr. and Mrs. Modesto shared hospitality and conveniences at every turn.

Financial support for this study was provided by the Coachella Valley Historical Society, and by the Department of Anthropology, Archaeological Research Unit, and Radiocarbon Dating Laboratory, University of California, Riverside. For a time while this work was in progress my tenure at the university was funded by the National Science Foundation. The final manuscript was typed by Joye Sage and Kay White, to whom I am especially indebted.

Finally, I thank my wife, Lolly, for bearing with me in my years of graduate study.

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Shoreline of Lake Cahuilla marked by tufa deposits on the rock formation called Coral Reef, as seen by W. P. Blake on November 17, 1853. On that date Blake made the first written record of the Cahuilla Indian oral tradition of the lake and of occupation of its shores. The view is toward the southeast with Travertine Point faintly visible on the far left. From Volume V of the *Pacific Railroad Reports* (1856).

## Chapter I

### INTRODUCTION: ORAL TRADITION AND PREHISTORY IN COACHELLA VALLEY

Prehistoric human lifeway in the desert regions of southeastern California (Fig. 1) has long been a neglected area of study. Those who have speculated upon it have generally concluded that with the drying of pluvial lakes and the onset of arid conditions in the early Holocene the desert assumed its characteristic low biomass, and the human populations that frequented the ancient water courses and lakeshores dispersed. Until historic time, most of the region appears to have remained sparsely occupied by small, loosely organized bands of hunters and gatherers who foraged in an endless cycle of seasonal nomadism.

Early historic subsistence and settlement adaptations of some Southern Paiute and Shoshoni groups that occupied the Mojave Desert of eastern California and adjacent portions of Nevada have been studied, providing partial ethnographic coverage of that region (Fig. 2).<sup>1</sup> It is tempting, in the almost complete absence of archaeological information, to use these ethnographic and ethnohistoric descriptions as models of human adaptation for at least the last several millenia of Mojave Desert prehistory. Such an approach is probably reasonable in a general sense inasmuch as the distribution and abundance of water and natural food resources on the Mojave are believed not to have fluctuated greatly over the last several thousand years (Mehringer 1977), and aboriginal lifeway may likewise have undergone few significant changes (Chang 1967).<sup>2</sup>

Ethnographic records are also available on the historic inhabitants of the Colorado Desert, essentially that region encompassing the Salton Basin, to the south of the Mojave Desert.<sup>3</sup> The Yuman-speaking tribes of the Lower Colorado are also well known.<sup>4</sup> Unlike that of the Mojave, the natural environment of much of the Colorado Desert has undergone marked change throughout the Holocene. This has resulted not from climatic changes, but rather as a consequence of the successive stands of Lake Cahuilla, a freshwater body over a hundred miles long. Lake Cahuilla (also known as Lake Coahuila, Lake LeConte, and the Blake Sea)<sup>5</sup> stood many times in the Salton Basin for periods of unknown duration as a result of prolonged inflow of the Colorado River, the most recent stand terminating perhaps 400-500 years ago. Because of this marked change in the character of the natural environment, historic patterns of Cahuilla and Kamia Indian adaptation on the bed of Lake Cahuilla are of limited value as analogs for a reconstruction of prehistoric cultural adaptations in the Colorado Desert during periods when the lake existed. It is, however, apparent that lakeside adaptation is as much a part of Colorado Desert prehistory as any historically documented pattern, although few scholars seem to have considered it in any detail. Archaeological investigations bearing on the aboriginal occupation of Lake Cahuilla have been for the most part brief, sporadic projects which are often inadequately reported and remain unsynthesized.<sup>6</sup>

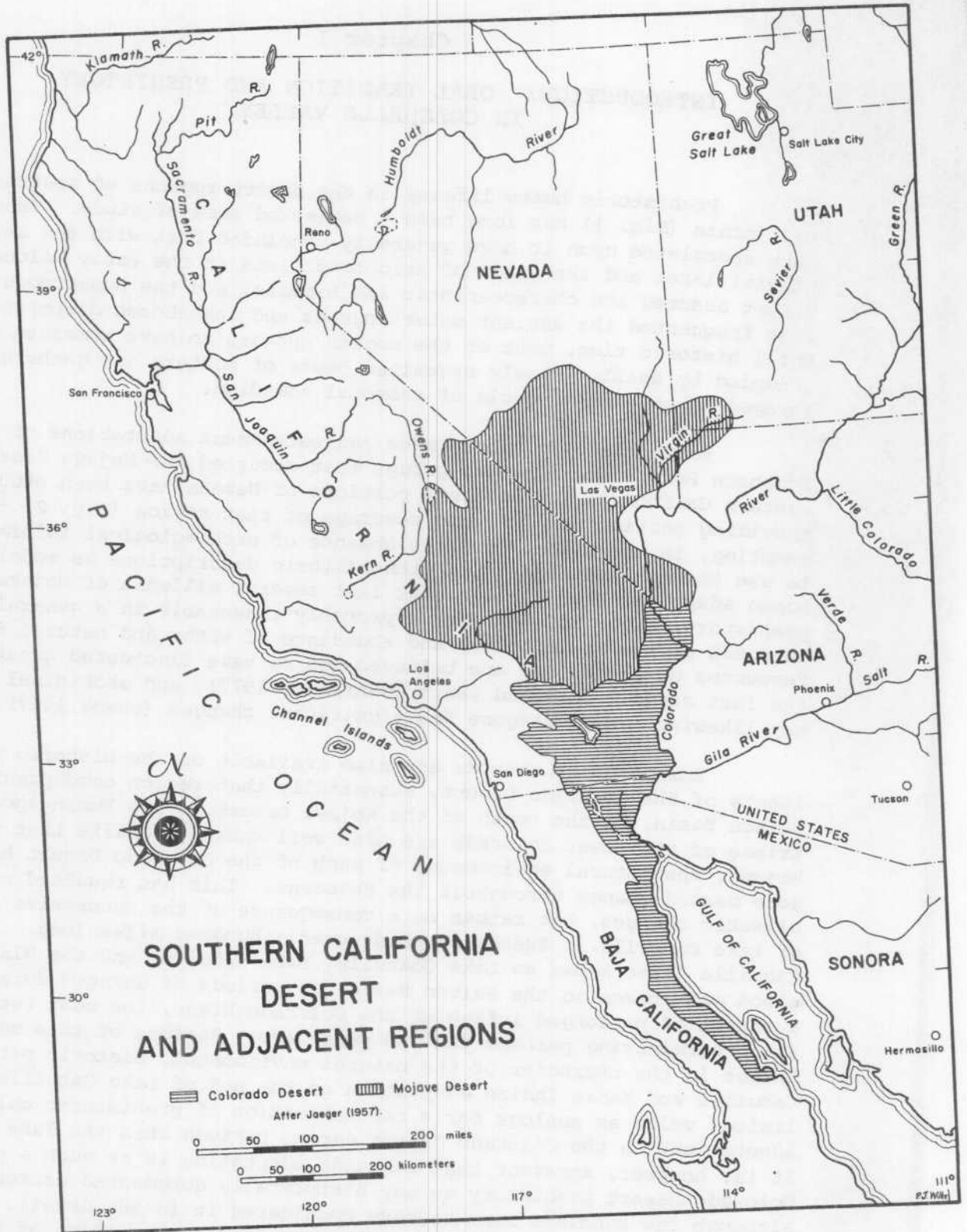


Fig. 1. The deserts of southern California.

The body of this paper is directed to an examination of the final phase of lakeside adaptation in Coachella Valley, the northern portion of the Salton Basin. In addition, consideration is given to the cultural adjustments which accompanied the drying of Lake Cahuilla, and which culminated in the historic occupation of the desert. While it is true that little insight into the nature of prehistoric lakeside adaptation in the Salton Basin can be found in ethnographic descriptions of native groups of the region, brief glimpses of it are recorded in Cahuilla Indian oral history. These fragmentary narratives have been recorded over the years by explorers, surveyors, and others, and form the basis for the investigations reported here.

#### EARLY HISTORIC OBSERVATIONS

For the Spaniards, Mexicans, and Americans that chanced to travel there, the Colorado Desert was an inhospitable region, stark, austere, and foreboding. From the first crossing of the desert by Anza in the spring of 1774 (Bolton 1930) to the fall of 1853, almost all travel in the region was restricted to crossings of the southern part, what is now called Imperial Valley. These travelers, including several thousand Forty-niners who passed over the Southern Trail to California, saw the region as inhospitable in the extreme (Edwards 1961). Westward from the Colorado River, the desert crossing was an eight-day journey of over 140 miles, for the first 90 of which there was no assurance of finding potable water. Consequently, the desert was often crossed at night, and most of the surviving records of these crossings contain only brief, sketchy accounts of aboriginal life or fail to mention the Indians at all (Lawton 1976). However, significant observations of Kamia occupation along New River, an intermittent slough draining the north slope of the Colorado River Delta, are to be found in the writings of Heintzelman (1857), LeConte (1855), and Veatch (1858). These accounts portray the Kamia as rather opportunistic cultivators of the floodplain of the New River in times when this slough contained water for crops. *cultivation*

In early historic time, Coachella Valley remained almost unknown. The only parties that crossed it appear to have been those accompanying the Romero expeditions in 1823-24 and 1825 (Bean and Mason 1962), and perhaps that of the Mexican general José María Flores on his retreat from California to Sonora in 1847. It was the search for a railroad route to the Pacific that, in 1853, finally resulted in a detailed documentation of the native lifeway of Coachella Valley.

In the fall of 1853, the Pacific Railroad Survey expedition under the command of Lt. R. S. Williamson, Topographical Engineers, pushed through the San Geronio Pass and entered the Coachella Valley. It was the first train of wagons to enter the Salton Basin from the north, and records made by W. P. Blake (1854, 1856), geologist for the expedition, remain the most valuable source of ethnohistoric information on the Cahuilla Indians of Coachella Valley. Most of the places he described can be identified, and his report contains astute observations on Cahuilla settlements at Agua Caliente (now Palm Springs), Indian Wells, Toro, probably *puichekiva* near Martinez, and Agua Dulce, the southernmost Cahuilla *ranchería* in Coachella Valley in 1853. From Blake's record and

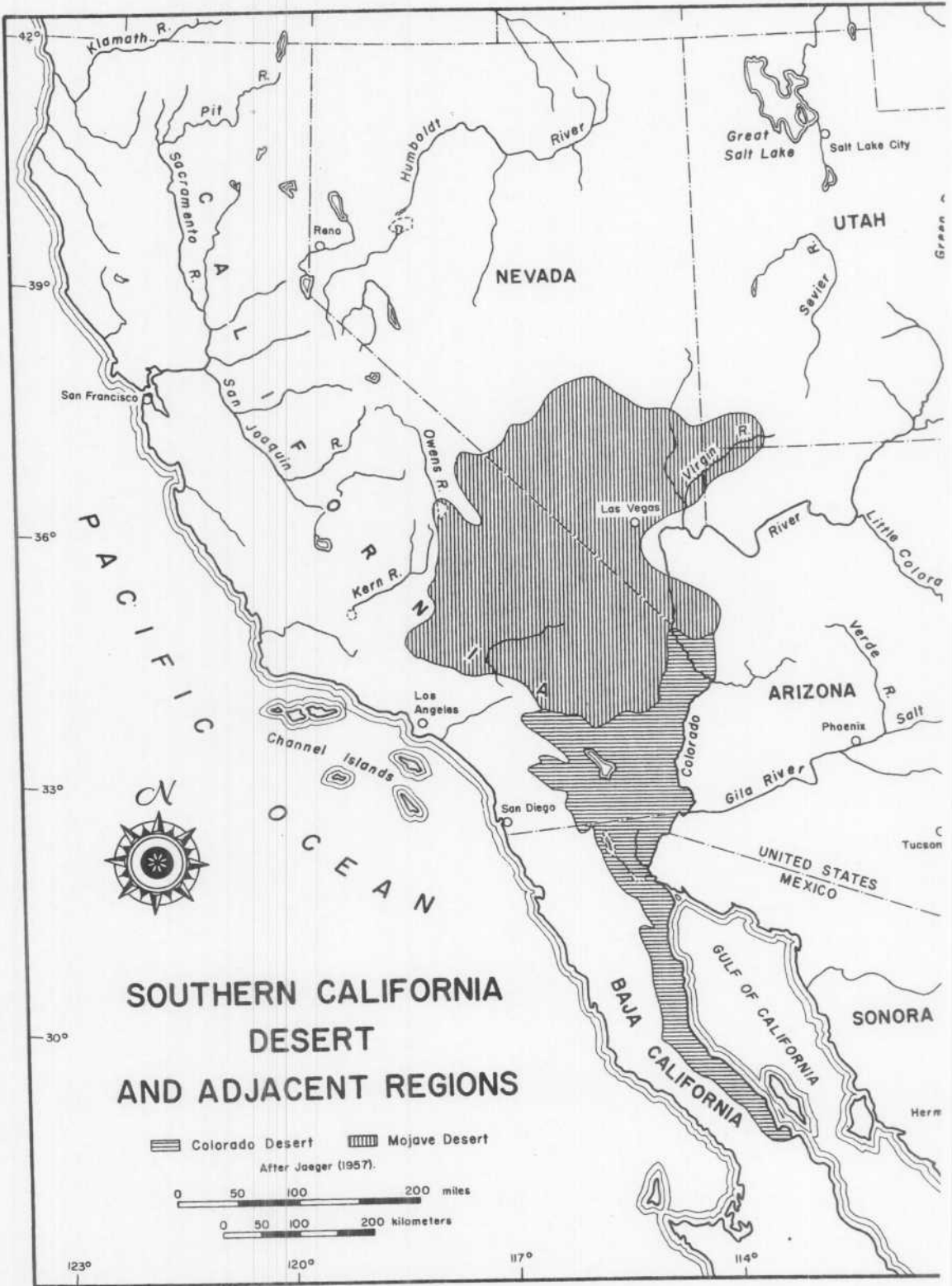


Fig. 1. The deserts of southern California.



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and scavenging animals came down from the mountains to feast themselves on the carrion. W. C. Mendenhall (1909a:20) learned from the Cahuillas that the lake had disappeared "as far back as the lives of four or five very old men, say four or five centuries, at most." Elsewhere, Mendenhall (1909b:685) equated four or five long lifespans with three or four centuries, which seems more reasonable. Stephen Bowers (1888, 1891) was informed that when the lake receded the coyote (mythic Coyote) came down from the mountains and planted mesquite beans on the lakebed.

More subtle fragments of the tradition are to be found in Cahuilla ceremonial songs. William Duncan Strong (1929:71) called attention to the frequent mention of aquatic birds, such as the comorant, grebe, and great blue heron, in some of the songs.<sup>8</sup> In addition, his text of the migration legend of the *sewahilem* clan (1929:86-87) discusses the formation of the lake, settlement near the lake at *kavinic* (*pal kavinic* 'water hole', present Indian Wells, about two miles from the lakeshore, just west of Indio), and fishing along the lakeshore as the waters receded. Taken individually, each of these fragments of oral literature is tantalizing. When considered together, however, they comprise a significant body of unwritten history. It has been considered in some detail elsewhere (Wilke and Lawton 1975).

#### HISTORICAL SIGNIFICANCE OF CAHUILLA ORAL TRADITION

##### Factors which Maintain Historical Validity in Oral Traditions

Several investigators, notably Lord (1960) and Vansina (1965), working in Europe and Africa, respectively, have contributed significantly toward an understanding of the factors which maintain historical validity in oral traditions of non-literate peoples. Among these factors are two which seem to have been especially important in perpetuating the tradition of the last stand of Lake Cahuilla and its complex of natural food resources.

Fixed poetic structure. First, oral testimonies with a fixed poetic structure are memorized and can thus be repeated word-for-word over a number of generations, even if some of the words in them assume new connotations, became archaic, or even lose their meaning entirely. That such archaism occurred in Cahuilla myth and ritual is indicated by Strong (1929:129), who discussed the esoteric dialects which were understood and spoken only by the ceremonial leader, or *net*, and were used in ritual contexts. When such testimonies function in a ritual context, they can be re-told for generations, particularly by specialized or esoteric singers, as among the Cahuilla; and it seems probable that herein lies the explanation of terms for aquatic birds in some of the ceremonial songs. It has been suggested elsewhere (Wilke and Lawton 1975) that the songs date from the last stand of Lake Cahuilla, and thus provide some documentation of the environmental situation that obtained at that time.

Mnemonic mechanisms. The second factor, which has probably been more important in promoting continuity of the tradition of Lake Cahuilla, is the repeated or cyclical occurrence of natural phenomena which serve as mnemonic mechanisms. The flow of the Colorado River varies greatly in

Songs  
in aquatic  
birds

volume from year to year (Hely 1969:49), largely as a result of variation in the magnitude of the snowpack on the Rocky Mountains. Much of the spring melt drains ultimately into the Colorado, and, before it was dammed and its waters diverted early in the twentieth century, the river usually crested in its delta in June and July. In some years the flood failed to occur at all; in others it inundated large portions of the delta. It was normal during very great flows for some of this floodwater to collect in sloughs on the northern slope of the delta and drain into the Salton Basin, which is part of the distributary system of the Colorado River. This delta overflow proceeded northward down one or two principal sloughs into the sink, where it formed transient lakes. These lakes were comparatively small, probably seldom exceeding 10 or 15 miles in length and a few feet in depth, were always confined to the unoccupied lowermost portion of the basin, and dried by evaporation within several years at most. Records of the flow of the river during the early historic period are incomplete, but available information indicates that significant flows formed ephemeral lakes in the Salton Basin in 1828, 1840, 1849, 1852, 1862, 1867, and 1891 (MacDougal 1914a:173).<sup>9</sup> Given the structure of the delta and its ever-changing system of distributary channels (Kniffen 1932; Sykes 1937), this pattern of periodic overflow and drainage into the Salton Sink must have prevailed for the last several hundred years. Therefore, every few years the Cahuilla might have seen lakes form in the Salton Sink. This is precisely the kind of recurring phenomenon necessary to prompt the retelling of the tradition of the former great lake and hunting and fishing along its shores.

In this desert environment where evaporation from standing bodies of water approaches six feet per year (Young 1947:29), shallow transient lakes that formed on a desolate playa could never have been significant or permanent habitats for waterfowl. Thus, they cannot account for the mention of aquatic birds in historic ceremonial songs. These must ultimately derive from the last stand of Lake Cahuilla. However, given the tradition of Lake Cahuilla and the repeated formation of lesser ephemeral lakes in the Salton Sink, one can readily understand why the Cahuilla laborers left the salt works and related the tradition when floodwaters from the Colorado reached Salton in 1891. And there can be little doubt that Blake observed correctly when he stated (1856:98) that the Cahuillas believed the waters would again some day fill the basin.

#### IMPLICATIONS FOR PREHISTORIC STUDIES

While ethnographic and ethnohistoric summaries offer almost no bases from which to attempt a reconstruction of the cultural ecology of lakeside adaptation in the Salton Basin, and almost no archaeological data are available, the native oral tradition of Lake Cahuilla and occupation of its shores provides a significant starting point. Admittedly, the tradition is incomplete, fragmentary, and contains inconsistencies. One testimony (Strong 1929:86-87) suggests that the ancestral Cahuilla were sedentary occupants of the lakeshore:

Then the water from the south began to rise and all the people moved ahead of the water toward Palm Springs. They settled near kavinic, which the water did not reach. Here they lived for some time; then

the water began to go back, gradually at first and sometimes rising again. All the people separated along the edge of the water to catch fish.

Another version of the tradition (Blake 1856:98) implies seasonal hunting and fishing at Lake Cahuilla by groups living in the nearby mountains:

When questioned about the shore-line and water marks of the ancient lake, the chief gave an account of a tradition they have of a *great water* (*agua grande*) which covered the whole valley and was filled with fine fish. There was also plenty of geese and ducks. Their fathers lived in the mountains and used to come down to the lake to fish and hunt. The water gradually subsided 'poco,' 'poco,' (little by little), and their villages were moved down from the mountains, and into the valley it had left. They also said that the waters once returned very suddenly and overwhelmed many of their people and drove the rest back to the mountains.

Are these conflicting testimonies, or do they imply both sedentary occupation of the lakeshore and seasonal hunting and fishing there by groups living in the nearby mountains? Irregularities such as these are common in oral tradition, and are to be expected as logical consequences of memory loss, elaboration by a narrator, error in translation or recording, or other factors (Vansina 1965). They only serve to point out that while tradition cannot necessarily be accepted as fact, it can at times offer valuable insights into prehistory. In this case, it would seem advisable to consider the possibility that both types of settlement patterns existed.

Certain aspects of Cahuilla oral tradition are particularly informative in that they can be evaluated with reference to data from the natural sciences and known historical events. The testimony recorded at Salton in 1891 stated that when Lake Cahuilla underwent its last recession millions of fish died and were stranded on the beach, and wild animals came from the mountains to feast on the carrion. This implies that the fish populations in the lake succumbed within a relatively short period of time.

The Pattie Basin lies due south of the Salton Basin, the two being separated by the Cocopah Mountains. The ephemeral lake which formed periodically in the Pattie Basin as a result of flooding in the Colorado Delta is called the Laguna Salada or Laguna Maquata. When Colorado River water entered this basin, it introduced fish populations into the lake that formed there. In 1884, when the delta was in full flood and water flowed westward to the Cocopahs, it collected in the Hardy River, which carried it southward. Part of this floodwater rounded the Cocopah Mountains and entered the Pattie Basin, recharging the Laguna Salada. By February, 1890, all that remained of the *laguna* was a series of small pools of brackish or salt water. Remains of the fish, identified as mullet (*Mugil cephalus*), were everywhere on the former shoreline. Coyotes had extensively scavenged the remains (Orcutt 1890:914). The extinction of fish populations in the Laguna Salada as it receded was observed as early

as 1774 by Garcés (Coues 1900, I:194). MacDougal (1907:720-721) also reported seeing a windrow of dead carp (*Cyprinus carpio*, an introduced species) extending for at least 15 miles along the former shoreline in February, 1907, as a subsequent ephemeral lake receded in the basin. Since the dead fish were beached in a single strand, MacDougal concluded that they had died almost at once, with no significant change in water level. He suggested that various factors, such as increasing water temperature and concentration of dissolved and suspended solids, had killed the fish. These records of the extinction of fish populations in the receding Laguna Salada conform almost exactly to the Cahuilla tradition of a similar event of much greater magnitude which accompanied the final drying of the great lake from the Salton Basin (San Francisco Chronicle 1891:2).

The drying of Lake Cahuilla would have been a particularly dramatic event for aboriginal populations that relied heavily on its food resources if it occurred as a single progressive decline, rather than as a series of diminishing fluctuations. Examination of the recessional beaches of the lake near Travertine Point (before they were obliterated by recent off-road vehicle activity) led Free (1914:29) to conclude that its decline was progressive and one-directional: "Lake Cahuilla was simply a falling lake." This series of beaches examined by Free is apparently the same series observed some years ago by Carl Hubbs, who informed the writer (Carl Hubbs, personal correspondence, July 23, 1971) that "They were approximately five feet apart, indicating the rapid rate of recession of [Lake Cahuilla] after the Colorado River waters failed to enter the basin" (see also Hubbs 1960:109).

The notion of a progressive recession of Lake Cahuilla is suggested in part by a study of the elevations of large numbers of what are apparently stone fish weirs or traps. These structures have been studied on a series of 15 recessional shorelines, the elevations of which were determined by careful levelling to be a little over five feet apart (G. M. Stanley and P. J. Wilke, reports in preparation). These shorelines appear to document a period of 15 consecutive years of recession of Lake Cahuilla by evaporation after inflow of water from the Colorado ceased. The rate of evaporation thus indicated for the last stand of Lake Cahuilla is slightly less than that computed for the Salton Sea (discussed in Chapter II). An annual loss by evaporation of approximately five and one-half feet of surface elevation would have dried Lake Cahuilla within 55-60 years, assuming no renewed inflow occurred from the Colorado River. At present there is no evidence which would suggest that renewed inflow ever occurred. In all probability, 30 years of progressive recession (lowering the surface of the lake by about 160 feet) would have sufficiently altered the chemical and ecological balance of the lake to all but eliminate its economically important plant and animal resources. fish weirs

A recent study by Bowersox (1973) indicates that the freshwater mussel *Anodonta dejecta*<sup>10</sup> which abounded in the shallow waters of Lake Cahuilla essentially disappeared within the first 10 years of recession. Its demise is linked to the increasing salinity of the water as the volume of the lake diminished, and probably also to the destruction of habitat as the shallow waters retreated. This would soon have been followed by the decline of fish populations for the same reasons. A point mussel

would have been reached at which the aboriginal occupants of the lake-shore had to relocate and/or rely on other sources of food than those obtained from the waters of Lake Cahuilla.

It would thus seem reasonable to suggest that a major settlement change occurred throughout the Salton Basin and adjacent regions within 30-40 years after the recession of Lake Cahuilla began. A continuous series of 30 or 40 recessional beaches below the main shore of the most recent lake stand has yet to be documented, since neither Free nor Hubbs made accurate measurements of the elevations of those they observed near Travertine Point, and the series documented by the fish weirs is not that long. However, it would appear that no evidence currently available contradicts the notion of the rapid drying of the lake, and continued study of the elevations of fish weirs or traps at other localities may well extend the known series of recessional shorelines.

Although oral tradition implies that the "stone fish traps" were actually facilities for taking fish from Lake Cahuilla, their function is still to some extent problematical. Similar structures have not been reported from other tideless bodies of standing water in western United States (Rostlund 1952). The structures are semi-circular, U-, or V-shaped rock constructions of dry-laid masonry, one to several courses high and about five to fifteen feet long, extending from the former shoreline. The apex, which pointed toward open water, is an opening one and one-half to two feet wide. Available data, including their elevational distribution and their similarity in form to fish "traps" of brush used by the Mohave, Yuma, Maricopa, and Yaqui (Drucker 1941:100; Forde 1931: 119-120; Wallace 1955:90), suggest that the structures were built for obtaining fish from the lake. Perhaps they were used in conjunction with dip nets dropped at the apex to capture fish disturbed while spawning or feeding as they attempted to escape to deep water. This method is clearly indicated for the Maricopa, Mohave, and Yaqui by Drucker (1941:100). A discussion along these lines will be presented elsewhere, and contrasts with the view of Treganza (1945), who considered the structures he studied near Valerie in Coachella Valley to be the remains of houses or hunting blinds. It was noted above that the migration legend of the *sewahilem* clan recorded by Strong states that as the lake receded the people living near present-day Indian Wells spread out along the shore to catch fish. The legend goes on to say that a quarrel ensued among three brothers when two of them refused to give fish to a third, but gave him instead only the net to hold (Strong 1929:87).

Waterfowl play an important role in Cahuilla oral tradition. This no doubt reflects the significance of Lake Cahuilla as a former region of intense activity along the Pacific migratory flyway. Even today the Salton Sea, formed during the period of 1905-07, and subsequently maintained by inflow of waste water from agriculture and urban centers, is an important point on the flyway, as both a wintering and nesting locus for large numbers of waterfowl (Lincoln 1950:52; U. S. Department of the Interior 1970).

Hunting and fishing are indicated in the tradition as aspects of the subsistence pattern at prehistoric Lake Cahuilla, but there is no mention of the use of plant foods. Studies of contemporary hunters and

gatherers, exclusive of those in polar regions, indicate that such peoples generally derive the major part of their subsistence from plant, rather than animal, sources (Lee and DeVore 1968; Bicchieri 1972). Likewise, detailed analyses of prehistoric human fecal material from dry cave deposits attests to the overriding significance of plant foods in aboriginal western North America (Wilke and Hall 1975). Analysis of fecal material, or coprolites, from dry caves which formerly overlooked vast marshes in the Humboldt and Carson sinks of west-central Nevada reveals the importance of such aquatic plants as bulrush (*Scirpus* spp.), cattail (*Typha* spp.), etc., as food items, the use of which persisted with increasing intensity over the last 5000 years (Napton 1969, 1970; Heizer and Napton 1969, 1970). The topographic and biotic similarity of this region to Coachella Valley during the last stand of Lake Cahuilla is striking, and at first glance one would imagine the existence of similar aboriginal subsistence practices. We should perhaps also expect aquatic plants to be important food resources along with fish and waterfowl at prehistoric Lake Cahuilla, and to be mentioned in the oral tradition. But plants are not mentioned at all.

There are several possible explanations for this apparent anomaly. Fish, waterfowl, and other food items, the abundance and availability of which are not especially predictable, or that require special equipment and/or skill to obtain, may figure more prominently in oral traditions. Or, perhaps more likely, the explanation may lie in sex role differences in subsistence behavior. Among hunters and gatherers, fishing and especially hunting are typically men's activities, while collecting of seeds, roots, and other plant foods is usually done by the women. This pattern also obtained in historic time across arid western North America (Barrows 1900:51; Steward 1938:44; see also Murdock 1949:213). Among the Cahuilla, the formal transmission of oral tradition (including such activities as singing the creation story at the annual *nukil* ceremony), was also done by a ritual singer (*haunik*) who was always a male (Bean 1972:106). It seems probable that when alluding to subsistence activities men would discuss the tasks typically associated with men. For this reason, male-oriented subsistence tasks such as hunting and fishing seem to be emphasized in the tradition at the expense of the female-related chores of plant collecting and processing. And the lack of emphasis--indeed, even the mention--of plant collecting need not lead to the notion that plants were unimportant in the prehistoric diet. On the contrary, plants may well have surpassed animals in importance as food items on a day-to-day basis.

#### PROBLEMS OF INTERPRETATION

Some aspects of the tradition of Lake Cahuilla are more difficult to reconcile with available geological and biological information. One of these, recorded by Blake (1856:98), is the statement that the lake receded, but then returned very suddenly and overwhelmed many people and drove the rest of them back to the mountains. While such an event may have occurred, there is currently no evidence to suggest that it did. This may be simply a tale of primeval horror evolved from humble and obscure origins by successive retelling, not altogether unlike the Homeric account of the fall of Troy. Whatever its origin, this aspect of the tradition was well developed, as exemplified when the Cahuilla laborers

abandoned the flooding salt works in 1891. H. N. Rust, Indian Agent, reported (1891:103) that some of the Indians continued to work on the flooding salt pan as a gesture of defiance when insulted by the proprietor of the industry, G. W. Durbrow. It seems that as they were leaving, Durbrow mockingly urged them to get out since they were more frightened of the flood they thought was coming than their women were. Reluctantly, some of them stayed but kept a close watch on the southern horizon as if they expected at any moment to see a wall of water descending upon them.

Blake thought that a sudden reappearance of Lake Cahuilla might have occurred as a result of an enormous tidal bore in the estuary of the Colorado, combined with a great flood in the delta. Perhaps these conditions did occur and cause a lake to suddenly form in the Salton Sink. It should be noted, however, that in order for a seismic wave to enter the basin it would have to breach the delta at about 40 feet above sea level and nearly 50 miles inland from the gulf. If a lake did form in this manner, it would almost certainly not have resulted in a body of water of the proportions of Lake Cahuilla, 315 feet deep and more than 100 miles long. It would probably have been more on the order of magnitude of the ephemeral lakes which formed in the sink during the nineteenth century as a result of overflow from the delta.<sup>11</sup> Delta overflow and the sudden formation of comparatively minor lakes may well account for this aspect of the tradition. Such lakes might conceivably have displaced groups living or gathering food at very low elevations on the floor of the basin. One of the nineteenth century Kamia villages, Hieronimo's *ranchería*, was located near the terminus of New River Slough, not far from the Obsidian Buttes and the mud volcanoes, perhaps 240 feet below sea level (Heintzelman 1857:40; Veatch 1858:3). In addition, pickleweed (*Allenrolfea occidentalis*), an important food resource among aborigines of the arid West, grew abundantly at low elevations prior to inundation in 1905 when the Salton Sea was formed. The formation of even a minor ephemeral lake could have displaced persons gathering the seed of this plant.<sup>12</sup>

On the basis of the limited archaeological investigations reported from the Salton Basin (see note 6), it is evident that the most recent stand of Lake Cahuilla was characterized by a rich resource complex that was exploited by aboriginal groups. Radiocarbon determinations have been made on shoreline middens yielding evidence of exploitation of fish and freshwater clams, and there is a nearly continuous scatter of ceramic sherds along the habitable shoreline, as noted by Aschmann (1959:44) and subsequently verified by personal observation. Although published reports indicate that a lakeside occupation occurred, they reveal almost no details of the form that particular adaptation took--whether it was seasonal or year round, what the diet consisted of, what patterns of seasonal harvesting and collecting of food resources occurred, etc. It is a fact that the oral history of the Cahuilla Indians of Coachella Valley provides a better insight into the nature of that adaptation than can be found in published archaeological reports.

Current interpretations of available linguistic data suggest that the Cahuilla have occupied generally their present territory for a minimum of 1000 years (Lamb 1958; see also Goss 1977 and references therein). It therefore seems evident that the Cahuilla tradition of the former great lake, of its abundant biota, of fishing and hunting along its shore, and



of the dramatic disappearance of the lake and its resources, identifies these fishers and hunters as ancestral Cahuilla.

#### TOWARD AN UNDERSTANDING OF THE LATE PREHISTORY

In order to more readily consider changing human ecology in the Salton Basin during the last thousand years, it is necessary to organize what we know and can infer into a tentative culture-chronological framework. We must at once consider changes in time, changes in environment (including available food resources), known and inferrable patterns of aboriginal subsistence behavior, and available archaeological data. The dearth of archaeological data pertinent to the last thousand years is recognized, and it is realized that proposing a model of culture history without first obtaining the necessary archaeological evidence to support it may be criticized by some as premature. However, without some kind of framework, it is difficult to raise or in any way consider questions of changing human ecology in the basin. To whatever extent possible, such questions should be formulated at the outset, or field and laboratory investigations will simply answer questions that were never asked. Assuredly, more questions are raised than can be answered in this paper, but perhaps those that cannot be answered here can form the basis for future research.

The late prehistory of Coachella Valley is reckoned to consist of two distinct time periods: (1) a period of lakeside, or lacustrine, adaptation at Lake Cahuilla; and (2) a period in which there was a return to desert conditions. The latter period actually involved two separate stages. First, there was a time of accelerated environmental changes and coincident cultural adjustments. This then culminated in a second stage, which saw the occupation of the bed of Lake Cahuilla by the Cahuilla and the Kamia tribes, as observed in historic time. Until more archaeological data are available, it seems best not to separate these stages, but to consider them both as aspects of the cultural adjustments to renewed arid conditions. Chron

Following an analysis of the nature of cultural adaptations during these periods, it should be possible to re-cast them as cultural phases in the prehistory of southeastern California.

#### Lacustrine Adaptation

It is proposed that certain aspects of Cahuilla Indian oral tradition document the history of ancestral Cahuilla occupation of the Coachella Valley during the last stand of Lake Cahuilla. Given the considerations outlined in the preceding pages, this tradition is offered as a very tentative model of lakeside adaptation with reliance to a greater or lesser extent on aquatic food resources. We may suppose that occupation at the lake was either seasonal or year round, that fishing was an important subsistence activity, and that waterfowl were hunted. We can also infer use of aquatic plant foods. Currently available information suggests that this period extended from about A.D. 900 to perhaps A.D. 1500.

AD 900-1500

Lakeside adaptation is discussed in Chapter IV, and is known primarily from analysis of the contents of human coprolites (desiccated feces) from shoreline campsites at the Myoma Dunes in Coachella Valley, at the northwest end of former Lake Cahuilla. The following questions are considered: (1) What is the nature of the prehistoric dietary patterns at Lake Cahuilla? (2) Was the shore of Lake Cahuilla occupied primarily on a seasonal or year round basis? (3) If sedentary, year round occupation is indicated, was subsistence oriented primarily to aquatic resources, or did it also involve significant food collecting in the adjacent low desert and nearby montane plant communities? (4) Did the aboriginal subsistence pattern at Lake Cahuilla also involve plant cultivation, as practiced in historic time? (5) How does the reconstruction of lacustrine adaptation at Lake Cahuilla compare with that known to have occurred in similar settings, such as in the Central Valley of California and in west-central Nevada? (6) Does the reconstruction of late prehistoric subsistence ecology at Lake Cahuilla conform to the model of lakeside adaptation as drawn from native oral tradition?

From this study, it should be possible to more critically assess the value of using oral tradition as a basis for prehistoric reconstruction.

#### The Return to Desert Conditions

The return to arid conditions is alluded to briefly in Cahuilla oral history. According to the tradition, the lake receded little by little, the fish died, and finally villages were moved down onto the lakebed. The transition probably ensued completely within no more than a century, and it was probably during the fifteenth and sixteenth centuries A.D.

The decline of the freshwater lake over a hundred miles long with its complex of natural food resources would have sharply reduced the carrying capacity of the Salton Basin, especially until thickets of mesquite and other forms of desert vegetation were established on the lakebed. We can postulate that human populations in Coachella Valley were subjected to a greater or lesser degree of stress, depending on how heavily they had relied on the lacustrine resource complex. The expected cultural responses to a sharp decline in carrying capacity would include (1) more extensive use of available resources by acquiring new gathering territories or expanding those already held; (2) movement of populations to more productive regions, such as the Peninsular Range, Little San Bernardino Mountains, etc.; (3) expansion of existing exchange networks to include especially populations living in contrasting environments, thereby ensuring that some of the interacting groups would always have essential goods for exchange; (4) increased emphasis on population control measures, including delayed mating, spacing of births by prolonged breast-feeding, abortion, infanticide, senilicide, etc.; (5) increased use of storage facilities for conservation of seasonally available plant foods, water, etc.; (6) more intensive use of available resources by such means as multiple harvesting (collection of blossoms, as well as the stalk and crown of agave; collection of blossoms, green pods, and dry pods of mesquite, etc.); (7) food production through plant cultivation (assuming

that this was not already part of the subsistence pattern at Lake Cahuilla); (8) water production by means of hand-dug wells; and (9) ultimate re-occupation of the floor of Coachella Valley when the desert biota became well established.

Whatever the form it took, the return to desert conditions is seen as a time of accelerated cultural change in response to pronounced reduction of carrying capacity as Lake Cahuilla receded from the Salton Basin. As far as understanding the prehistory of southeastern California is concerned, the drying of Lake Cahuilla may well hold the solution to questions concerning the inception of agriculture, warfare on the Lower Colorado River, historically observed military and exchange alliances, etc. agric  
warfare

The cultural responses of hunter-gatherer populations to gross environmental degradation, or reduced carrying capacity, are poorly understood and to a large degree remain conjectural. Yet, most prehistorians would agree that these kinds of adjustments have been of major importance in shaping human destiny over time. Similar responses, albeit responses that developed very slowly, must have been widespread as climate became drier and the carrying capacity of many environments was reduced at the terminal Pleistocene. It is perhaps in such situations that the impetus for initial food production either by invention or by diffusion from elsewhere will ultimately be found, along with the development of complex exchange systems, more elaborate forms of social and political organization, and other cultural complexities.

It is not known at present how long the historic desert lifeway of the Cahuilla persisted in Coachella Valley, or what major changes occurred in that adaptation over time. The observations made in the nineteenth century, discussed briefly at the outset, may essentially describe cultural patterns which began as much as 300-400 years ago; but it should at once be emphasized that this is assumption, since archaeological studies in the Colorado Desert are almost non-existent. Nevertheless, with some reservation we may postulate that the general patterns of historic adaptation in Coachella Valley, as recorded in the middle of the nineteenth century, reflect the situation over the previous 300-400 years. The historic patterns of Cahuilla Indian occupation in Coachella Valley are fairly well known (see note 3), and will be reviewed only briefly in Chapter V.

In order to further consider late prehistoric human ecology in Coachella Valley, it is necessary to examine the kinds of environments that obtained there during the last millenium.

#### NOTES

1. Ethnographic sources on the Mojave Desert tribes include Coville (1892), Dutcher (1893), Euler (1966), Kelly (1934), Laird (1976), Manners (1974), Steward (1938), and Zigmond (1941).
2. Analysis of rock art in the Coso and Argus ranges leads Grant, Baird, and Pringle (1968) to conclude that in that region the bighorn

sheep (*Ovis canadensis*) populations suffered drastic reduction around 2000 years ago. This decline is linked to the introduction of the bow and arrow, a superior weapon to the atlatl, which had been used previously. It is possible, if not probable, that overkill of bighorn sheep was widespread in the California desert and the rest of the Great Basin, and that it could have had a widespread, although probably not major, effect on prehistoric subsistence patterns. However, this reduction of an important resource appears to have been brought about by a change in hunting technology rather than by changes in the natural environment.

3. Ethnographic and ethnohistoric accounts of the Cahuilla include Barrows (1900), Bean (1972), Bean and Saubel (1972), Curtis (1926), Drucker (1937), Heizer (1974), Hooper (1920), Kroeber (1908), Lawton (1974), Lawton and Bean (1968), Strong (1929), Wilke (1976), Wilke, King, and Hammond (1975), and Wilke and Lawton (1975). The Kamia (Kumeyaay) of Imperial Valley are treated in words by Gifford (1931), Hedges (1975), Heintzelman (1857), and Lawton (1976).

4. Literature on the Yuman tribes of the Lower Colorado River is summarized and cited by Forbes (1965). Important works include those of Alvarez de Williams (1975), Castetter and Bell (1951), Devereux (1961), Drucker (1941), Forde (1931), Gifford (1933), Kelly (1977), Kniffen (1931), Kroeber (1925), and Trippel (1889).

5. For discussions of the merits of the various names that have been proposed for Lake Cahuilla, see Free (1914), Hubbs and Miller (1948: 103), and Wilke and Lawton (1975:10).

6. Reports treating the aboriginal occupation of Lake Cahuilla include those of Gates (1909), Hubbs (1960), Hubbs and Bien (1967:282-283), Hubbs, Bien, and Suess (1960:200-203, 215-217; 1963:260-261, 265, 269-270; 1965:89), Hubbs and Miller (1948:106-108), MacDougal (1917: 459-462), McCown (1954, 1955a, 1956, 1957), Rogers (1945:192-194), Treganza (1945), and M. Weide (1976).

7. An excellent photograph of a Cahuilla walk-in well with steps leading down to the water was made by C. C. Pierce. It has been reproduced in various publications, including Bean and Mason (1962).

8. Strong (1929:71) gave the following words for aquatic birds: *suwalwal* 'great blue heron', *tamaswut* 'grebe', *kwowit* 'shore bird, probably curlew', *pumuis* 'cormorant'. Katherine Saubel (personal correspondence, June 11, 1975) suggested that the first of these should be written *súwalwal*, but could not agree that *pumuis* is the correct term for cormorant. Kojiro Hioki (personal correspondence, November 11, 1975) gave *súwalwal* as the correct term for great blue heron, and *k<sup>w</sup>áwit* as the correct form for *kwowit*. He offered no glosses for *tamaswut* and *pumuis*, but listed the following additional words: *káal* 'crane (white or black)', Desert Cahuilla; *pàl vúkivaš* 'lit. that which hits the water, cranelike bird', Mountain Cahuilla; *la<sup>?</sup>la<sup>?</sup>* 'goose (grayish, with a long white beak)'. Hooper (1920: 376), discussing the origin of the birds, stated that on the death of Mukat (the Creator) the people wandered around and finally came to the edge of the water, where they saw *sovalivil* 'pelican'. Other references to aquatic birds, aquatic animals, and the body of water that formerly

filled the Salton Basin are to be found in Patencio (1943). The point made here is that the desert-dwelling Cahuilla have aquatic birds playing very important roles in their cosmology.

9. Elsewhere, Wilke and Lawton (1975:12) compiled a list of years in which floodwaters probably collected in either or both the Salton and Pattie Basins, using earlier information given by MacDougal (1906:8) and Orcutt (1893:77). That series varied slightly from the dates given in this text, and is as follows: 1840, 1842, 1849, 1852, 1859, 1862, 1867, 1884, and 1891. The purpose here is not to establish positively every year in the historic period when an ephemeral lake formed in the Salton Basin (which is probably not possible to do), but rather to show that such lakes formed every few years, and could thus have served a mnemonic, or reminder, function. For the present discussion, it is thought advisable to consider only the years in which the Salton Basin received floodwater.

10. The species name for this clam is sometimes given in literature on the Salton Basin as *Anodonta californiensis*.

11. The occurrence of shells of marine molluscs at very low elevations on the floor of the Salton Basin is sometimes taken as evidence of a marine stand of Lake Cahuilla in comparatively recent times. It has been shown by Van de Kamp (1973) that these marine molluscs are confined to the lower elevations in the basin, and he suggests that they represent saline conditions that ensued in advanced stages of the recession of freshwater lakes. This interpretation is accepted here.

12. It appears that this plant, *Allenrolfea occidentalis*, pickleweed, iodine bush, Cahuilla *hu?at*, may have been confused by some writers with another member of the same family, *Salicornia subterminalis*, glasswort, pickleweed, Cahuilla *hoat*. The two plants superficially resemble one another to the untrained eye, and have the same common name. The former, *Allenrolfea occidentalis*, is most commonly found in the alkaline portions of Coachella Valley. It seems probable that there are two recorded transcriptions of the same term, and that the plant is actually *Allenrolfea*, as pointed out to me by my informants, David and Ruby Modesto.

## Chapter II

### ABORIGINAL ENVIRONMENTS OF COACHELLA VALLEY

Coachella Valley includes a broad range of biotic zones and habitats ranging from coniferous forests high on the Peninsular Range to arid plains with drought- and salt-tolerant plants on the desert floor. In addition, the various stands of Lake Cahuilla offered a variety of aquatic plant and animal resources. The present biotic diversity of the valley is a result of complex climatic and edaphic factors, which in turn have been shaped by the geological history and structure of the Salton Basin. The following pages describe briefly the environmental setting of Coachella Valley and the way in which it changed over the last millennium. Since a very important part of the past environment of the valley has been the various stands of Lake Cahuilla, which covered the floor of the whole Salton Basin, it is necessary to review the recent history of the lake with reference to the entire basin and the Colorado Delta.

#### GEOLOGIC HISTORY

Sometimes called the Cahuilla Basin or the Salton Trough, the Salton Basin is a northwestern landward continuation of the Gulf of California rift. This structural trough was formed by gradual subsidence coincident with the uplift of the surrounding mountains during the Miocene, Pliocene, and Pleistocene (Dibblee 1954; Hamilton 1961). There is evidence in the form of raised Pleistocene and Holocene shorelines (Stanley 1962, 1965, personal correspondence) and active fault zones which indicates that the crustal movements which formed the trough are still going on (see Elders *et al.* 1972). During mid-Pleistocene time, sediments eroded from the Colorado Plateau were deposited in the Colorado River Delta in sufficient volume to form a great natural dam across the trough (Downs and Woodward 1961). The delta thus forms a low divide between the basin and the Gulf of California, with the minimum elevation of the delta variously reported to be about 40-47 feet above sea level (Arnal 1961:445; Van de Kamp 1973).

Lake Cahuilla stood many times in the Salton Basin during the last several tens of thousands of years (Hubbs, Bien, and Suess 1965:89-90). Most or all of these lake stands since at least the late Pleistocene were of fresh water, formed by inflow of the Colorado River for extended periods of time. However, the number of lake stands and their duration during the Holocene alone has not been determined. Between lake stands the basin was dry, or visited but briefly by ephemeral lakes. Shells of marine molluscs only several thousand years old occur in the basin, but these are found at very low elevations and probably indicate highly saline conditions during advanced stages of recession of freshwater lakes, rather than actual marine conditions (Van de Kamp 1973:841-844). The most recent stand of Lake Cahuilla is generally considered to have begun not more than 1000 years ago and to have ended 400-500 years ago (Rogers 1939:4).

## GEOGRAPHIC FEATURES

From the Colorado Delta the floor of the Salton Basin dips to at least 273 feet below mean sea level in the Salton Sink, then gradually narrows and rises along the axis of Coachella Valley to 2580 feet at the summit of San Gorgonio Pass 150 miles to the northwest (Fig. 3). The drainage is about 75 miles in maximum width, although the floor of the depression averages only about 20 miles wide. Coachella and Imperial valleys comprise the northern and southern portions of the basin, respectively. These valleys are today separated by the Salton Sea, which occupies the Salton Sink, the lowest part of the basin. This body of water was formed in the interval 1905-07, when the Colorado River was accidentally diverted into the basin. It survives today as a sump into which waste water from irrigation is constantly channelled.

The Coachella Valley is bordered on the west by the San Jacinto and Santa Rosa mountains, which form the prominent ridge of the northern Peninsular Range. These mountains reach elevations of from 6000 to more than 10,000 feet and cause a pronounced rainshadow effect in the valley. To the north and east, the most prominent topographic features are the Little San Bernardino, Cottonwood, Eagle, Orocopia, and Chocolate mountains. The first of these are merely continuations of the Transverse Range of southern California, and are high enough to support an open Pinyon-Juniper Woodland plant community, while the latter two are exceedingly arid and desolate, with only the sparsest cover of scrub vegetation. The Indio and Mecca hills, badlands of uplifted Miocene (?) and Pliocene sediments (Buwalda and Stanton 1930), rise along the San Andreas fault zone on the immediate northeast flank of Coachella Valley.

Precipitation is sparse enough in the Salton Basin that in aboriginal times no active streams habitually flowed all the way to the playa in the Salton Sink. Even today, waters that reach the foot of the mountains quickly sink in the porous detrital outwash at the mouths of desert canyons. It is probable that runoff from the surrounding mountains collected in the sink only rarely, in times of very severe thunderstorms.

The Whitewater River drains the eastern slope of the San Bernardino Mountains. It is the largest perennial stream that entered the Salton Basin in aboriginal times. The waters of this stream sink at the eastern entrance to San Gorgonio Pass, rarely flowing more than a mile or two after entering the upper Coachella Valley. A few small creeks also rise high on the desert slope of the Peninsular Range. Most notable of these are Snow, Chino, Tahquitz, and Andreas creeks, all of which rise high in the San Jacinto Mountains. These streams descend into the eastern entrance to San Gorgonio Pass and the upper end of Coachella Valley. In historic time, Cahuilla Indian settlements were located at the various canyon mouths where water was available, and also at springs and shallow wells dug to the water table in the lower valley.

A number of large washes enters the Coachella Valley from the north and east. The larger of these include Salt Creek, and Berdoo, Fargo, and Box canyons. These washes are visited but occasionally by ephemeral streams whose sometimes violent flow is measurable only in minutes or hours, and are thus of no consequence as dependable water sources. But the washes served the important function of providing access to and from the adjacent uplands.

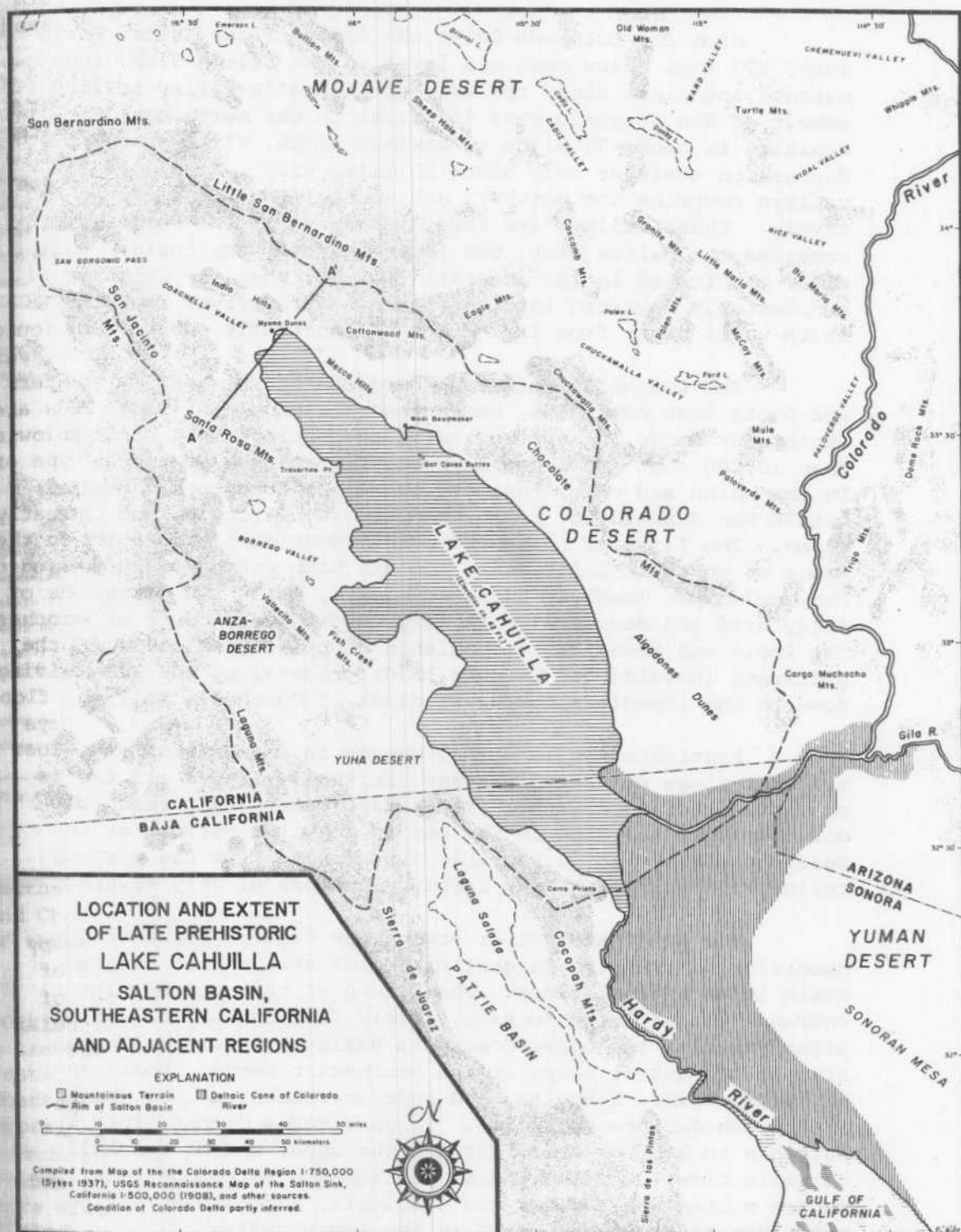


Fig. 3. The Salton Basin of southeastern California, and location and extent of late prehistoric Lake Cahuilla. Section A-A' marks location of vegetation transect shown in Fig. 13.



An alignment of springs rises along the San Andreas fault zone at the southwest base of the Indio Hills, giving rise to native fan palm (*Washingtonia filifera*) oases, but with the exception of that in Thousand Palms Canyon, all of these springs are small and of limited flow.

Very fine Colorado River alluvium covers the floor of the lower Coachella Valley. In a strict sense, the area covered by these deposits (the bed of Lake Cahuilla) is part of the Colorado Delta (Sykes 1937). As used here, however, the term "delta" refers to the alluvial semi-cone south and west of the junction of the Colorado and Gila rivers.

#### CLIMATE

The climate of the Salton Basin is among the most arid to be found in the western deserts. It is characterized by low relative humidity, very low rainfall, high summer temperatures of up to 125° F., and mild winters with frost usually occurring only in December and January. High winds are common, especially in the spring, and are frequently accompanied by blowing sand and dust. Coastal southern California enjoys a Mediterranean type of climate, with warm, dry summers, and mild, wetter winters (Bailey 1966; Felton 1965). These conditions exist also on the desert, but in a greatly modified form, since most of the winter precipitation tends to fall on the mountains and very little rain occurs on the floor of the basin. At Indio, only about 3.20 inches of rain are recorded annually, about two-thirds of which falls in the winter. Elsewhere, the average is closer to 2.5 inches. In late summer, tropical cyclonic storms sometimes move northward up the Gulf of California, striking the mainland at the Colorado Delta and giving rise to thunderstorms on the desert. These sometimes result in flash flooding, but within a few hours the arroyos are again dry, and in a few days the relative humidity is again low. Snow almost never falls on the floor of Coachella Valley. The extreme aridity of the floor of the valley is shown by climatic data from weather stations at Palm Springs and Indio (see Table 1).

#### BIOTIC ENVIRONMENT

Even as the climate of the Salton Basin is determined largely by topographic features, particularly the position of the basin leeward of the Peninsular Range, climate in turn largely dictates the character of the biotic environment. As one proceeds from the crest of the Peninsular Range eastward into the basin, the climate becomes increasingly arid. This results in a marked zonal distribution of the vegetation. The eastern scarp of the San Jacinto and Santa Rosa mountains is so abrupt that a complete transition of vegetation types from Montane Coniferous Forest to Desert Scrub is seen in less than a half-dozen miles. The former type occurs at elevations of from 6500 to more than 8000 feet and receives 25 inches or more precipitation annually with abundant snow. The latter is typical Sonoran Desert vegetation (Shreve 1951) on a landscape plunging to below sea level and receiving three inches or less average annual precipitation with no snow. To the northeast, as one crosses Coachella Valley and ascends the Little San Bernardino Mountains, the succession of vegetation types is partly reversed, but the mountains are lower, receive less precipitation, and crest in Desert Woodland.

Table 1  
CLIMATIC SUMMARY OF THE COACHELLA VALLEY

PALM SPRINGS, Elevation 420 Feet

Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Highest	98.-	105.-	105.-	110.-	118.-	121.-	122.-	121.-	121.-	109.-	98.-	93.-	122.-
Average Max.	68.8	72.4	78.5	86.0	93.9	102.0	107.7	106.0	101.3	90.3	79.2	69.9	88.0
Average Min.	40.3	44.0	47.2	52.6	58.0	63.7	72.9	71.4	65.7	57.2	48.2	42.1	55.3
Record Mean	54.8	57.8	63.5	70.3	76.5	84.9	92.0	89.9	84.0	74.4	63.9	55.3	72.3
Lowest	18.-	25.-	32.-	35.-	38.-	48.-	54.-	54.-	46.-	37.-	29.-	26.-	18.-

Precipitation

Record Mean	0.95	1.28	0.59	0.21	0.06	0.01	0.15	0.25	0.21	0.34	0.32	1.25	5.62	
Average number of days with .01 or more precipitation:	15.												Average growing season:	323 days.

INDIO, U. S. DATE GARDEN, Elevation 20 Feet

Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Highest	92.-	97.-	104.-	110.-	121.-	121.-	125.-	121.-	122.-	113.-	101.-	94.-	125.-
Average Max.	69.8	74.1	79.9	86.8	93.4	101.7	106.8	105.5	101.0	90.9	80.4	71.3	88.5
Average Min.	38.1	43.5	49.4	56.9	63.9	71.2	77.3	76.0	69.3	57.9	45.7	38.9	57.3
Record Mean	53.7	58.8	64.8	72.2	79.1	87.3	93.0	91.6	85.6	74.9	62.9	55.5	73.3
Lowest	13.-	20.-	27.-	33.-	33.-	55.-	59.-	48.-	46.-	36.-	23.-	17.-	13.-

Precipitation

Record Mean	0.66	0.47	0.29	0.10	0.04	0.01	0.07	0.27	0.30	0.21	0.20	0.58	3.20	
Average number of days with .01 or more precipitation:	14.												Average growing season:	300 days.

After Felton (1965). Temperatures are given in degrees Fahrenheit; precipitation in inches.

Farther to the south and east, the somewhat lower Orocopia, Chuckawalla, and Chocolate mountains receive little more rain than falls on the floor of the basin, and have a cover of Desert Scrub vegetation.

A schematic and somewhat idealized cross-section of the northern portion of the Salton Basin is shown in Fig. 4. This figure represents a transect of the basin from the vicinity of Toro Peak (8716 feet) in the Santa Rosa Mountains to Indio (-14 feet) in Coachella Valley to Ryan Mountain (5461 feet) in the Little San Bernardino Mountains. The vegetation types represented in the transect of the valley are divided into plant communities after Munz and Keck (1949, 1950). These are described briefly below, together with notes on their respective faunal associations. A more elaborate system of classifying southern California plant communities, including those of the Salton Basin, is suggested by Thorne (1976). The newer system is not used here because it involves more divisions than are necessary for a basic understanding of the biotic environment of the region. Figure 4 represents a cross-section of the plant communities of Coachella Valley as they existed in early historic time. The natural environment of the lower valley floor was disrupted in the twentieth century by agricultural developments, and little of it remains undisturbed today.

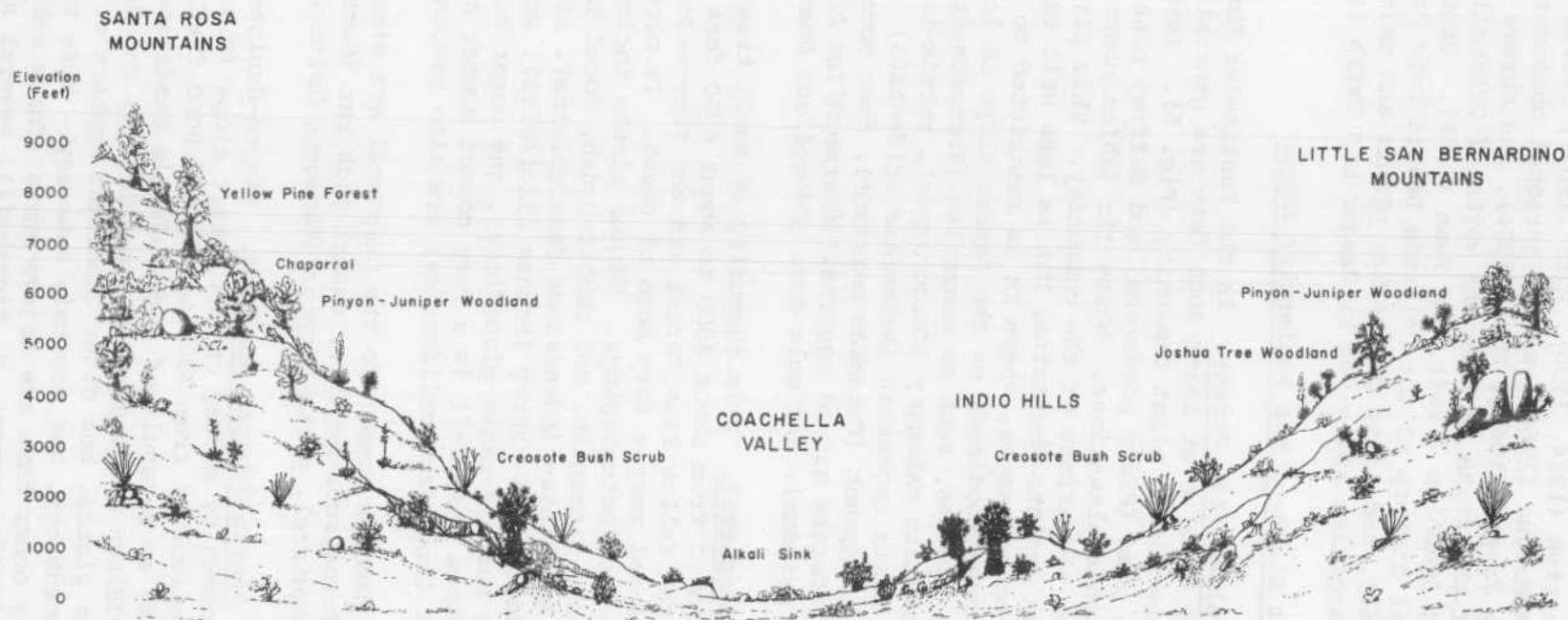


Fig. 4. Schematic and somewhat idealized cross-section of the northern portion of the Salton Basin showing the characteristic plant communities. Horizontal distance greatly reduced.

The description of the natural vegetation of the Coachella Valley which follows is based on the works of Hall (1902), MacDougal (1908), MacDougal and Collaborators (1914), McHargue (1973), Miller and Stebbins (1964), Parrish (1914, 1930), Ryan (1968), Shreve (1925, 1942, 1951), and Vogl and McHargue (1966), and on personal observation. The flora is treated by Jaeger (1941), Munz (1974), and Shreve and Wiggins (1964). Studies of the fauna include the works of Grinnell and Swarth (1913), Miller and Stebbins (1964), and Ryan (1968). Useful introductions to the natural history of the Colorado Desert have been compiled by Jaeger (1957, 1965), and lists of the key plants and animals of the various plant communities are given by Jaeger and Smith (1966).

### The Desert Slope of the Peninsular Range

Yellow Pine Forest. In the Peninsular Range, elevations ranging from about 6500 to at least 9000 feet are generally characterized by a Yellow Pine Forest plant community (Fig. 5). Important species here are ponderosa pine (*Pinus ponderosa*) and Jeffrey pine (*P. jeffreyi*), the latter at higher elevations. White fir (*Abies concolor*) is also common at the higher elevations of the community. This plant community occurs high on the San Jacinto Mountains, but is less well represented on the Santa Rosa and other ranges, where it is restricted to the higher elevations. Often an open woodland, on the desert slope it includes an understory of chaparral species, such as manzanita (*Arctostaphylos*), buck brush (*Ceanothus*), mountain mahogany (*Cercocarpus*), rabbit-brush (*Chrysothamnus*), and even basin sagebrush (*Artemisia tridentata*). Common mammals include Merriam's chipmunk (*Eutamias merriami*), deer mouse (*Peromyscus maniculatus*), California ground squirrel (*Spermophilus beecheyi*), gray squirrel (*Sciurus griseus*), and mule deer (*Odocoileus hemionus*).

Chaparral. This community of small trees and shrubs occurs at elevations of from about 4500 to about 6500 feet on the desert slope, between the Yellow Pine Forest and the Pinyon-Juniper Woodland (Fig. 6). The Chaparral merges into both of these. It occurs on heavy soils with numerous rock outcroppings. Common plants include mountain mahogany, buck brush, manzanita, and rabbit-brush, found in the pine forests above, as well as chamise (*Adenostoma fasciculatum*), ribbonwood (*A. sparsifolium*), holly-leaf cherry (*Prunus ilicifolia*), scrub oak (*Quercus dumosa*), antelope bush (*Purshia glandulosa*), and sugar bush (*Rhus ovata*). Whipple yucca (*Yucca whipplei*) is a very common member of this community, and junipers (*Juniperus californica*) are also present.

Mammals common to the Chaparral are mice, especially the brush mouse (*Peromyscus boylii*), desert pack rat (*Neotoma lepida*), California ground squirrel, pocket gopher (*Thomomys bottae*), and mule deer.

Pinyon-Juniper Woodland. Pinyon-Juniper Woodland is a prominent plant community midway on the desert slope (Fig. 7). It typically occurs at elevations of from 3500 to 4500 or 5000 feet, and shows great floristic diversity as a result of local edaphic conditions. One- and four-needled pinyon (*Pinus monophylla*, *P. quadrifolia*) and California juniper are the dominant plants, but other important members of the community are antelope bush, scrub oak, and mountain mahogany. More typically desert plants that commonly occur here are Mojave yucca (*Yucca schidigera*), Whipple yucca, nolina (*Nolina parryi*, *N. bigelovii*), several species of cholla (*Opuntia*),



Fig. 5. Yellow Pine Forest and Chaparral, San Jacinto Mountains.

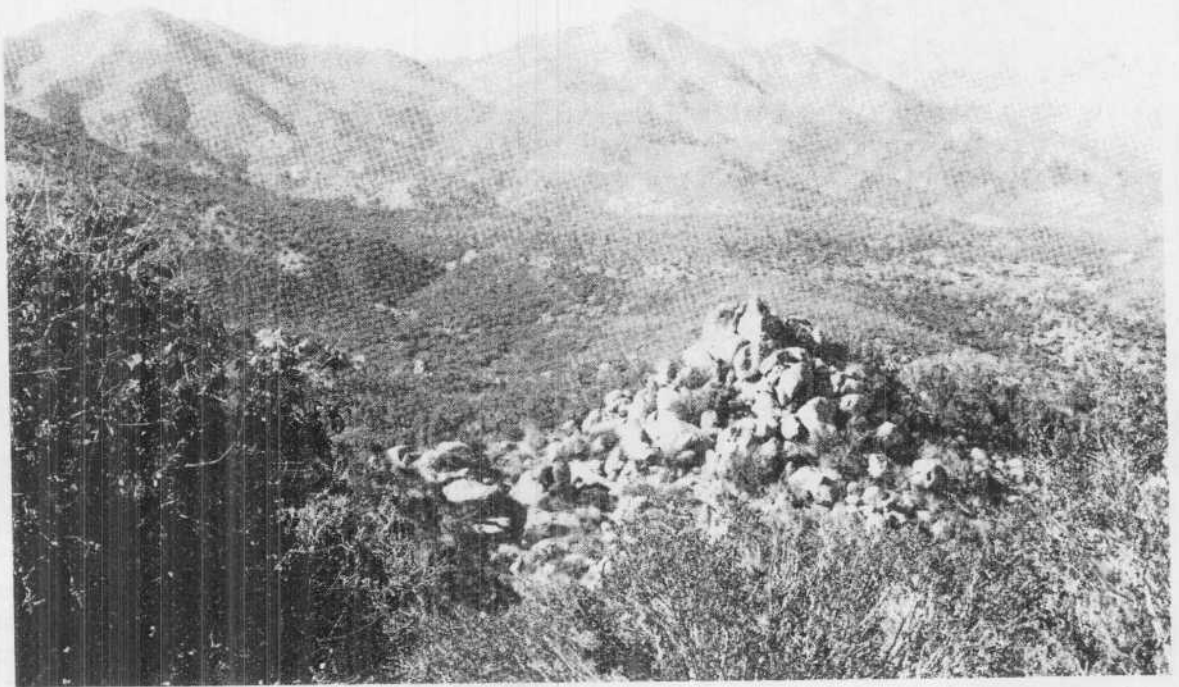


Fig. 6. Chaparral, here dominated by ribbonwood (*Adenostoma sparsifolium*), Santa Rosa Mountains.

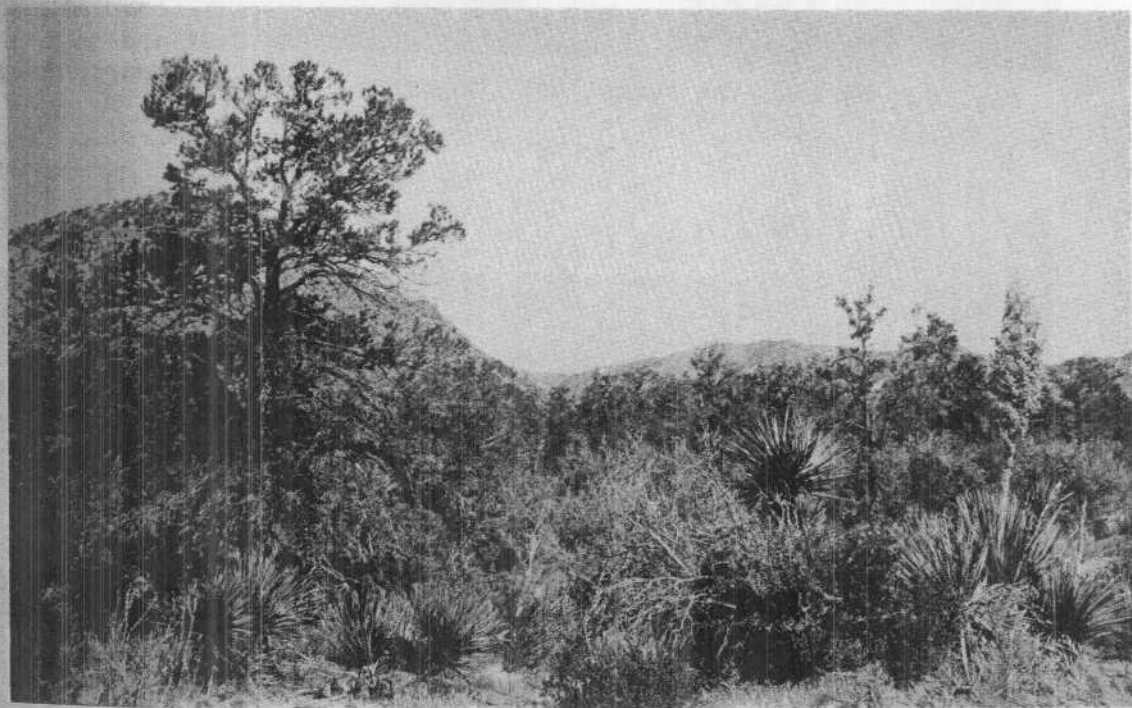
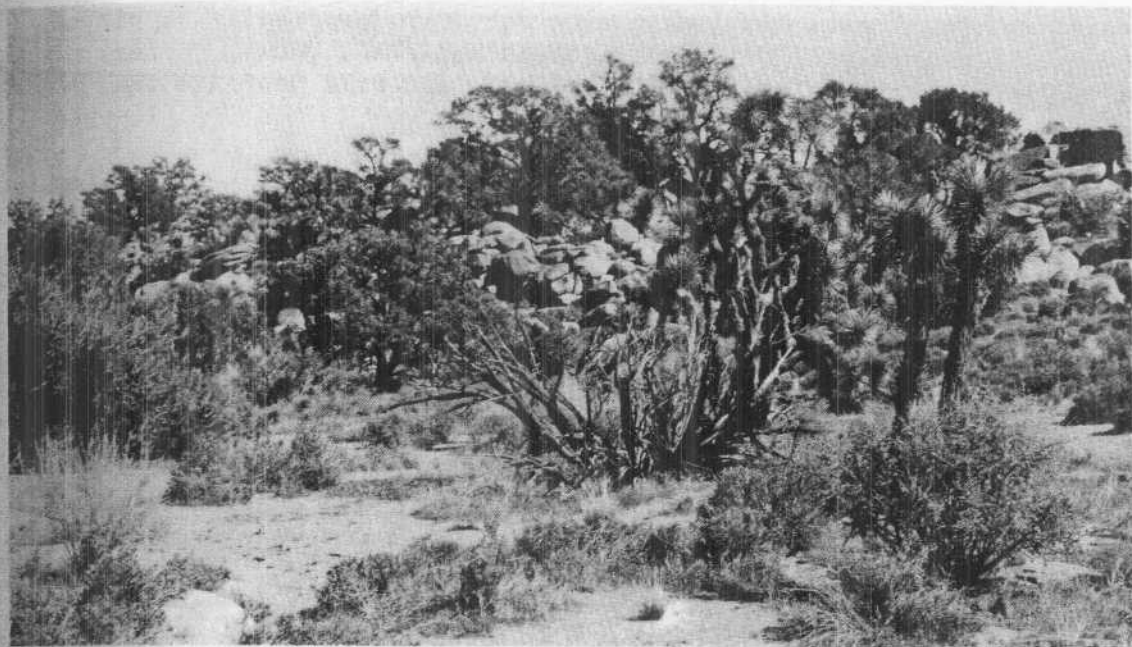


Fig. 7. Pinyon-Juniper Woodland. Upper: open woodland with blackbrush (*Coleogyne ramosissima*), antelope bush (*Purshia glandulosa*), and Joshua tree (*Yucca brevifolia*), Little San Bernardino Mountains. Lower: woodland with chaparral species, Mojave yucca (*Yucca schidigera*), and nolina (*Nolina* sp.), Santa Rosa Mountains.

and prickly-pear (*Opuntia*). On the ecotone between this and the Creosote Bush Scrub community, desert agave (*Agave deserti*) occurs in such abundance as to almost warrant a special designation.

Desert pack rat, nimble kangaroo rat (*Dipodomys agilis*), pinyon mouse (*Peromyscus truei*), California ground squirrel, pocket gopher, black-tailed jackrabbit (*Lepus californicus*), and mule deer are the common mammals of this plant community.

Creosote Bush Scrub. This is the plant community which dominates the Mojave and Colorado deserts (Figs. 8,9). In Coachella Valley it extends from about 3500 feet to below sea level, encompassing a larger area than any other community. It includes the lower mountain slopes, *bajadas*, and broad plains. Over most of its range, creosote bush (*Larrea tridentata*) and bur-sage (*Ambrosia dumosa*) are the co-dominant species, the plants being evenly spaced, sometimes to the exclusion of all other perennials. The monotony of these two species is broken by washes and canyons which crosscut the community and whose ephemeral streams give rise to many other species.

The Creosote Bush Scrub plant community is characterized by small, spiny trees, shrubs, and cacti. Trees include palo verde (*Cercidium floridum*), smoke tree (*Dalea spinosa*), box-thorn (*Lycium cooperi*, *L. andersonii*), desert willow (*Chilopsis linearis*), cat's-claw (*Acacia greggii*), mesquite (*Prosopis glandulosa* var. *torreyana*), screwbean (*P. pubescens*), desert apricot (*Prunus fremontii*), and desert ironwood (*Olneya tesota*). The latter is especially common to the east of the Salton Sink and on toward the Colorado River. Shrubs include desert almond (*Prunus fasciculata*), indigo bush (*Dalea schottii*), dye bush (*D. emoryi*), brittle bush (*Encelia farinosa*), chuparosa (*Beloperone californica*), cheese bush (*Hymenoclea salsola*), *Haplopappus* spp., ocotillo (*Fouquieria splendens*), and bladderpod (*Isomeris arborea*). Cacti are abundant on the rocky slopes and *bajadas*, and include barrel cactus (*Ferocactus acanthodes*), beavertail (*Opuntia basilaris*), several species of prickly-pear (*Opuntia*), silver cholla (*Opuntia echinocarpa*), and jumping (or Bigelow) cholla (*O. bigelovii*), to name a few. The desert agave is a very conspicuous plant in the upper part of this zone, where it occurs with Mojave yucca and ocotillo. Numerous annuals appear after winter rains, especially on the lower *bajadas* and on the floor of the valley. In the lower canyons off Coachella Valley and especially along the San Andreas fault zone springs and seeps support California fan palm (*Washingtonia filifera*) oases. The largest of these are located in Palm and Thousand Palms canyons.

Ryan's (1968) study of the mammalian fauna of Deep Canyon reveals that it is abundant and varied in the diverse habitats represented in this plant community. At least 20 species of small mammals occur here, including three kangaroo rats (*Dipodomys*), nine mice (*Peromyscus*, *Perognathus*), desert cottontail (*Sylvilagus audubonii*), black-tailed jackrabbit, three ground squirrels (*Spermophilus*, *Ammospermophilus*), pocket gopher, gray shrew (*Notiosorex crawfordi*), desert pack rat, and several bats. Carnivores include coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), ringtail (*Bassariscus astutus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), bobcat (*Lynx rufus*), and desert kit fox (*Vulpes macrotis*). Many of these species are nocturnal. The desert

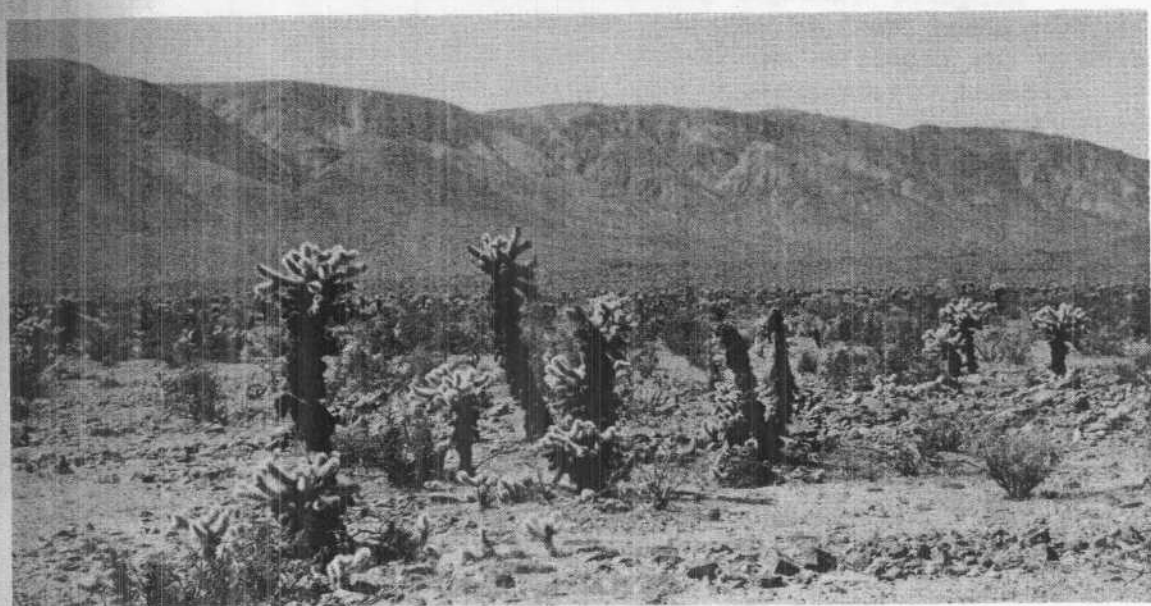
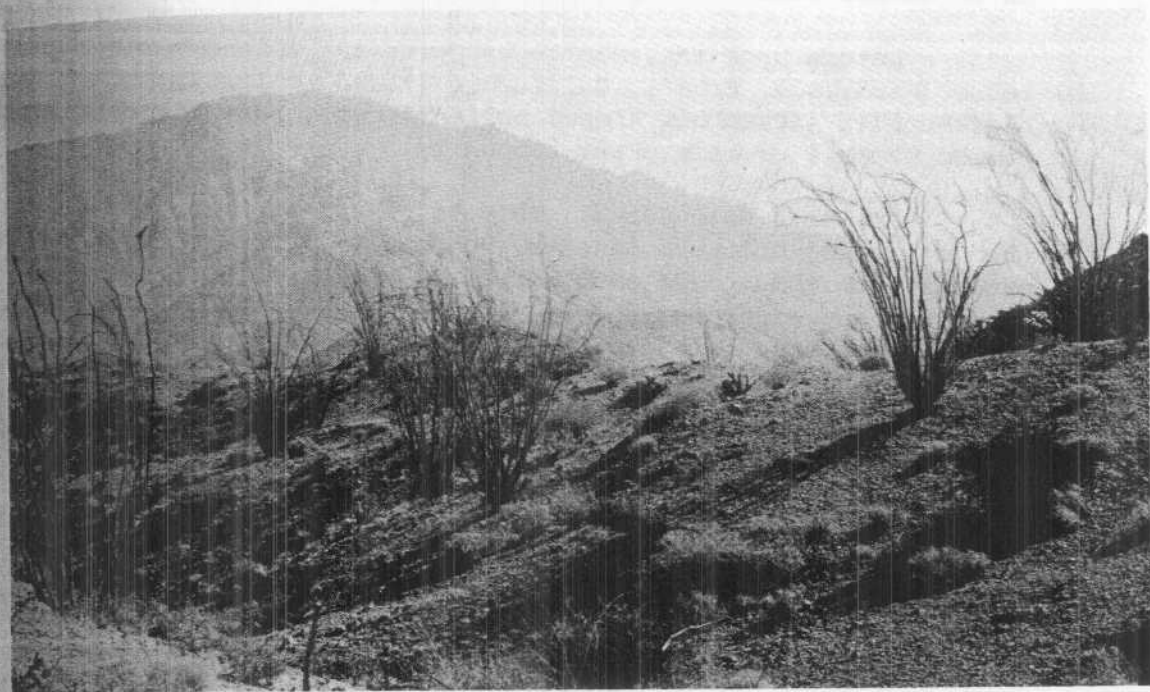


Fig. 8. Creosote Bush Scrub. Upper: view eastward into Deep Canyon, Santa Rosa Mountains, with ocotillo (*Fouquieria splendens*), bur-sage (*Ambrosia dumosa*), brittle bush (*Encelia farinosa*), and chollas (*Opuntia* spp.). Lower: scene in Cottonwood Mountains dominated by Bigelow cholla (*Opuntia bigelovii*).



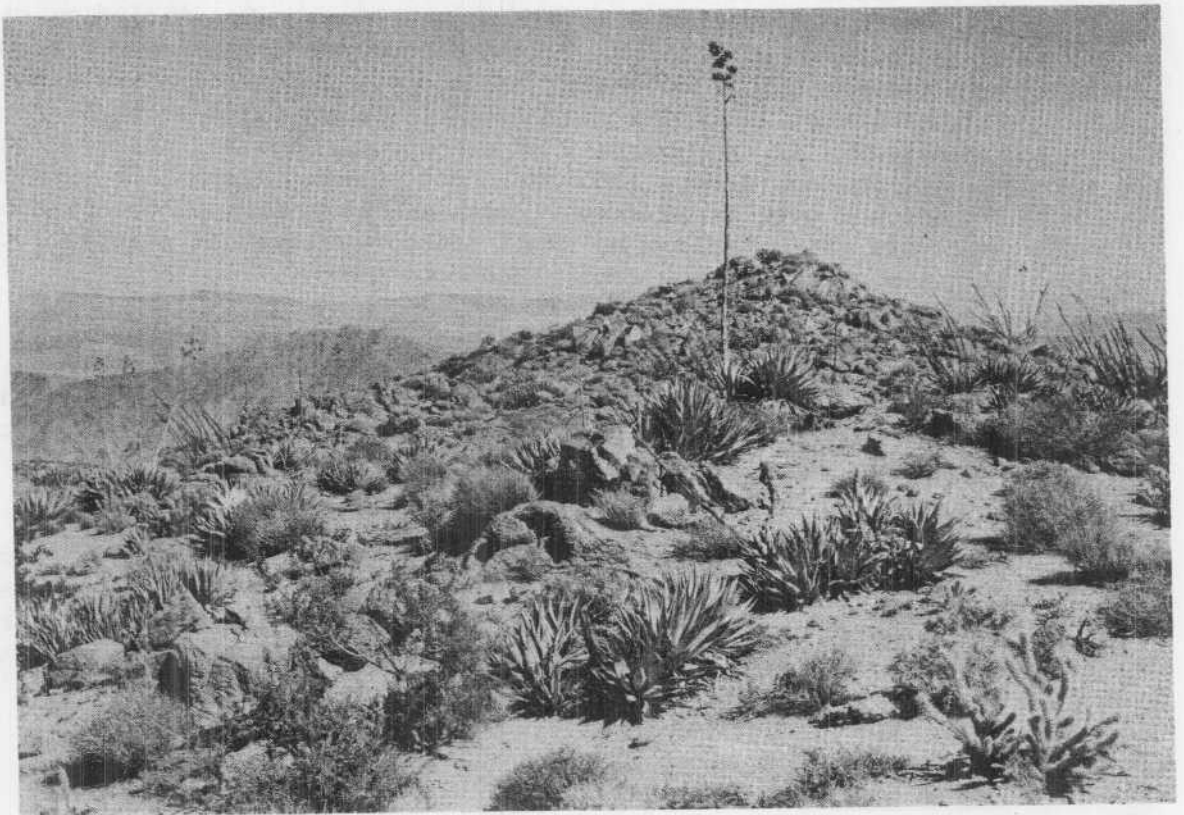
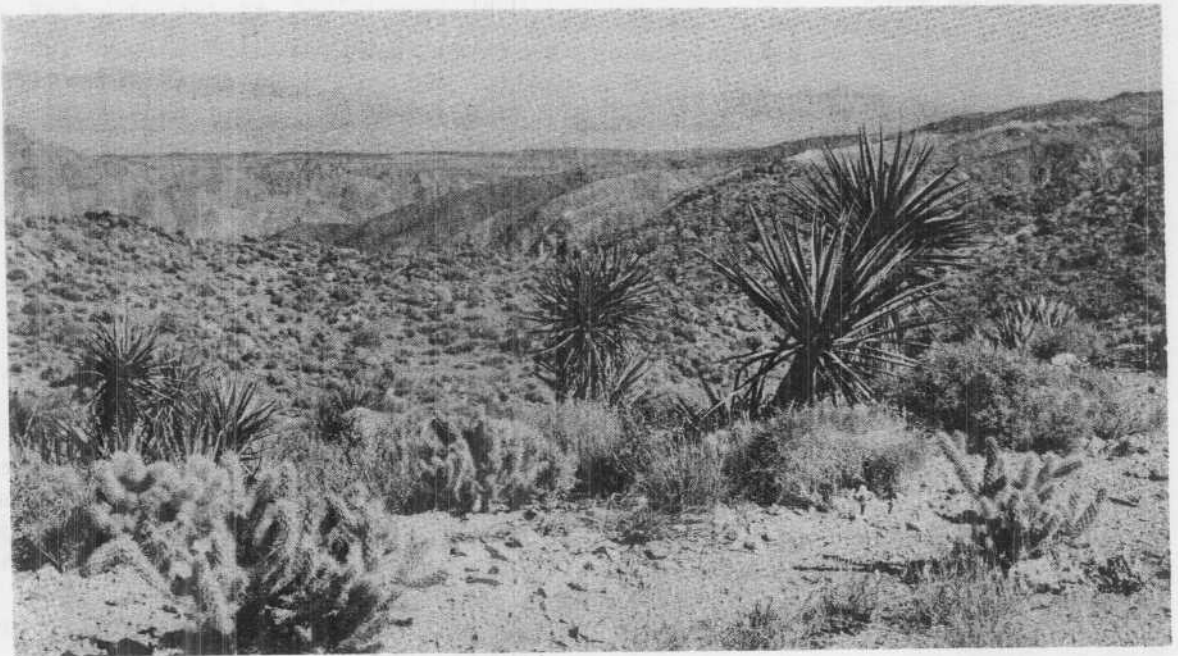


Fig. 9. Creosote Bush Scrub. Views eastward across Deep Canyon and Coachella Valley, with creosote bush (*Larrea tridentata*), Mojave yucca (*Yucca schidigera*), desert agave (*Agave deserti*), cholla (*Opuntia* sp.), bur-sage (*Ambrosia dumosa*), etc.

agave-ocotillo association on the upper limits of the Creosote Bush Scrub zone is the habitat of the desert bighorn (*Ovis canadensis*), a large population of which still thrives on the desert slope of the Santa Rosa Mountains (Jones, Flittner, and Gard 1957, Ryan 1968). The Gambel's quail (*Lophortyx gambeli*), white-winged dove (*Melopelia leucoptera*), and mourning dove (*Zenaidura macroura*) are among the many birds at home in this plant community, and there is a desert tortoise (*Gopherus agassizi*) and a number of lizards. The Creosote Bush Scrub supports the most diverse fauna of any plant community of the Salton Basin.

### Alkali Sink

The floors of most closed basins of the California Desert are characterized by an Alkali Sink plant community. In the Salton Basin it formerly occurred over most of the area below sea level, and included the lowest portions of the sink. The plants of this community are those capable of tolerating alkaline and saline conditions, as well as upper extremes of temperature and aridity. In aboriginal times, in parts of the basin deep-rooted plants such as mesquite were able to tap the shallow water table and assumed truly rank growth habits. Most of the floor of the Salton Basin has been turned over to agriculture or inundated by the Salton Sea, but some tracts are still occupied by Alkali Sink vegetation. Characteristic plants are the shrubs, including pickleweed (*Allenrolfea occidentalis*), lowland purslane (*Sesuvium verrucosum*), seep-weed (*Suaeda* spp.), glasswort (*Salicornia subterminalis*), quail bush or giant saltbush (*Atriplex lentiformis*), four-winged saltbush (*A. canescens*), and allscale (*A. polycarpa*). Trees include the mesquite, screwbean, palo verde, and desert ironwood. Salt grass (*Distichlis spicata*) forms a dense sod over broad areas. Even as the washes of the Creosote Bush Scrub are characterized by small trees, the typical plants of the Alkali Sink are shrubs of the family Chenopodiaceae.

Where the soil is moist, arrowweed grows in profusion, and springs and seeps give rise to bulrush (*Scirpus olneyi*), cattail (*Typha*), and reed (*Phragmites australis*), in addition to saltgrass and pickleweed (Fig. 10, upper). Prior to inundation by the Salton Sea, the lowest portions of the Salton Basin hosted only sparse occurrences of pickleweed, lowland purslane, seep-weed, and other halophytes.

The fauna of the Alkali Sink plant community includes species found in the adjoining Creosote Bush Scrub, but they are generally few in number of individuals. Included here are desert antelope ground squirrel (*Ammospermophilus leucurus*), Merriam's kangaroo rat (*Dipodomys merriami*), black-tailed jackrabbit, and desert kit fox.

### The Southwestern Slope of the Little San Bernardino Mountains

From the Salton Sink to the summit of the Little San Bernardino Mountains, the order of appearance of plant communities is as follows: Creosote Bush Scrub, Joshua Tree Woodland, Pinyon-Juniper Woodland.

Creosote Bush Scrub. The Creosote Bush Scrub plant community is dominant to about 3000 feet on the slopes of the Little San Bernardino

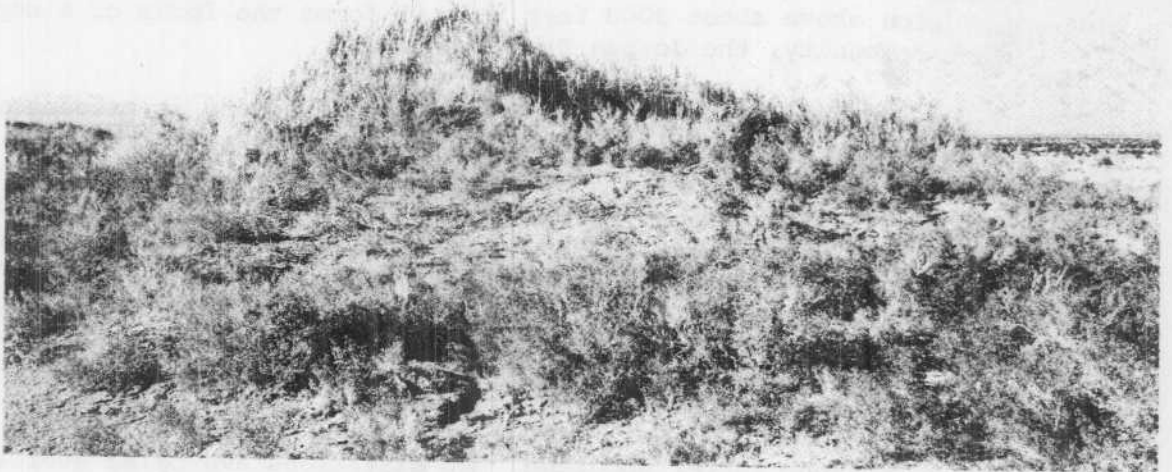


Fig. 10. Vegetation of the floor of the Salton Basin. Upper: spring mound with cattail (*Typha domingensis*) and pickleweed (*Allerrolfea occidentalis*) in Alkali Sink northeast of Bat Caves Buttes. View northward toward the Orocochia Mountains. Lower: Indio Hills with California fan palm (*Washingtonia filifera*) oases marking location of San Andreas Fault zone. Creosote bush (*Larrea tridentata*) and saltbush (*Atriplex* spp.) in foreground. View toward the north.

Mountains. It occurs over the sparsely vegetated Indio and Mecca Hills with their linear arrangement of fan palm oases (Fig. 10, lower). On this side of the valley the community is characterized by a greater abundance of desert ironwood than is seen on the western side. There is, however, a virtual absence of desert agave. Castetter, Bell, and Grove (1938) reported the existence of only six plants in Berdoo Canyon.<sup>1</sup> Mojave yucca is common, and in the western part of the Little San Bernardino Mountains the Joshua tree (*Yucca brevifolia*) occurs in such profusion above about 3000 feet that it forms the focus of a separate plant community, the Joshua Tree Woodland.

Joshua Tree Woodland. Joshua Tree Woodland is present in the Salton Basin at elevations of from 3000 to about 4500 feet (Fig. 11). This woodland occurs only along the northern rim; it is lacking on all other ranges that surround the basin. The most conspicuous plant is everywhere the majestic Joshua tree, but Mojave yucca, Whipple yucca, nolina, California juniper, Mormon tea (*Ephedra*), blackbrush (*Coleogyne ramosissima*), prickly-pear, cholla, buckwheat (*Eriogonum fasciculatum*), and galleta grass (*Hilaria rigida*) are also common. The fauna of this plant community closely resembles that of the upper reaches of the Creosote Bush Scrub in the Santa Rosa Mountains.

Pinyon-Juniper Woodland. At elevations averaging over 4500 feet, Joshua tree fades out and pinyon (largely *P. monophylla*) and juniper become conspicuous (Fig. 7, upper). Many of the plants in the Joshua Tree Woodland continue at higher elevations and form part of this community also. In addition, there is mountain mahogany, manzanita, antelope bush, scrub oak, etc. The fauna resembles that of the same community on the opposite side of the valley.

#### THE RECENT STANDS OF LAKE CAHUILLA

##### Origin of Lake Cahuilla

At some unknown date, probably about A.D. 900, there began a prolonged diversion of the Colorado River into the Salton Basin resulting in the most recent stand or stands of Lake Cahuilla. The basin filled to an elevation of about +42 feet and then overflowed across the delta at the site of Volcano Lake, near Cerro Prieto. Overflow entered the Gulf of California through an outlet channel presently occupied at its southern end by the Hardy River. The shore of the most recent stands of Lake Cahuilla is nearly continuous as beach and tufa deposits except for a few miles at the southeast end, where it is obscured by delta sediments. Lake Cahuilla extended from about 20 miles south of the international border to just northwest of the town of Indio, a total distance of about 115 miles. The maximum width of the lake was about 34 miles, and the depth was about 315 feet. It inundated the entire lower portion of the Coachella Valley.

In aboriginal times, when the Colorado annually flooded large portions of the delta, a higher concentration of silt was borne in its waters than in those of any other major river in the world (Kniffen 1932: 156). Much of the detrital load was dropped among the rank growths of

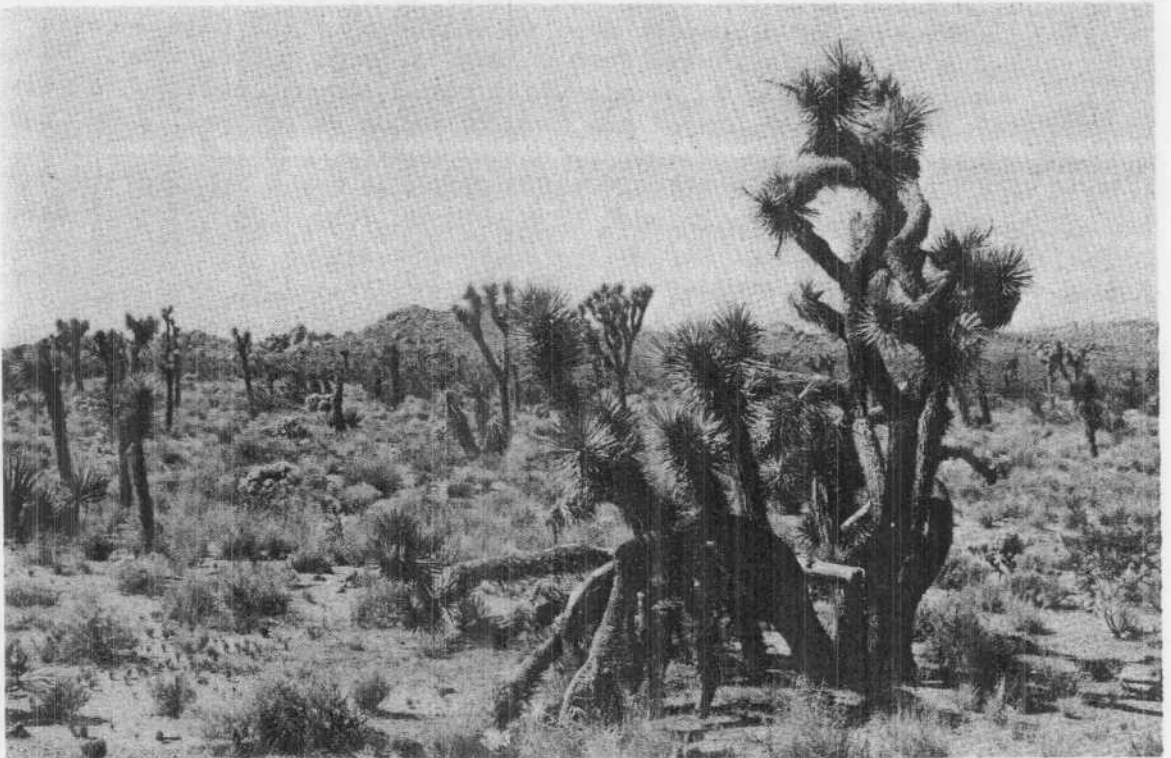
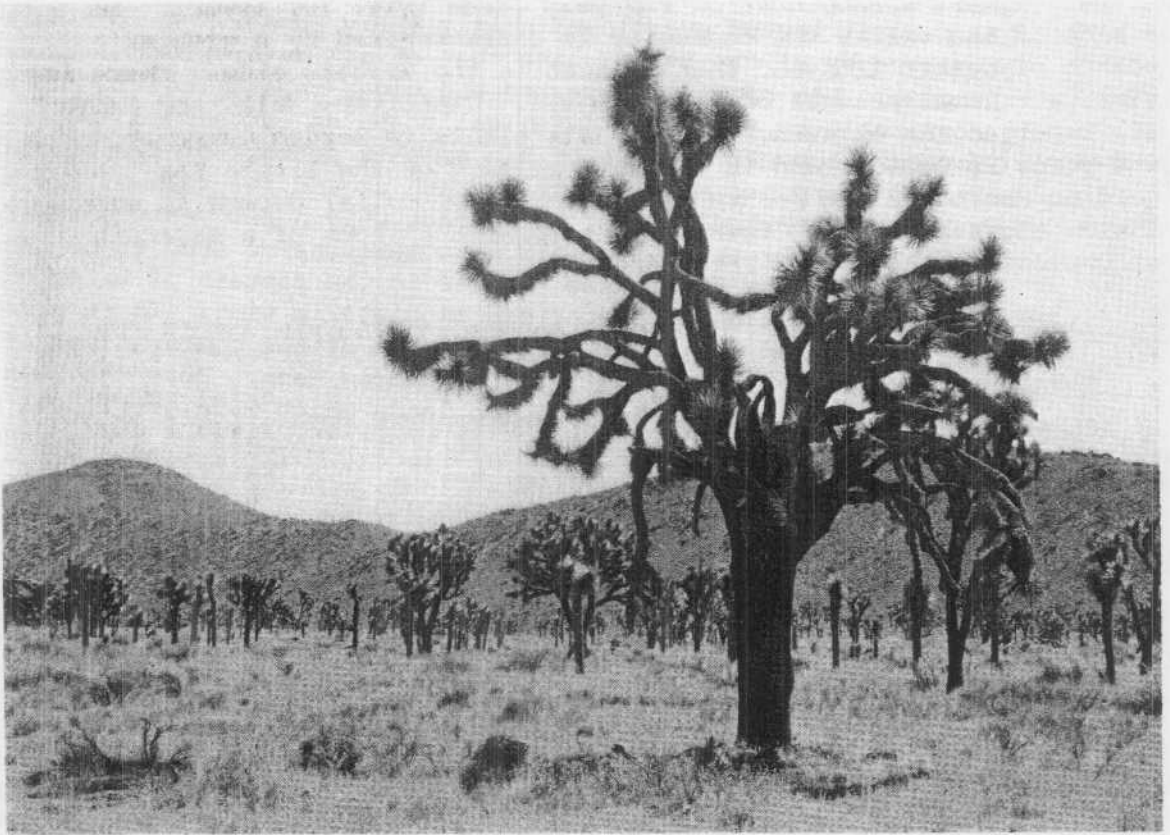


Fig. 11. Joshua Tree Woodland, Little San Bernardino Mountains.

black willow (*Salix nigra*), reed (*Phragmites australis*), arrowweed (*Pluchea sericea*), and MacDougal's cottonwood (*Populus macdougalii*) when the natural levees overflowed nearly every summer. As a result, the physiography of the delta, like that of all major river deltas, was ever changing. New channels appeared and older ones silted in but remained recognizable by their bordering galleries of cottonwood and sycamore (*Platanus racemosa*). Maps of the complex network of distributary channels and abandoned main channels drawn around the turn of the last century often differ markedly from others made only a few years earlier or later. Kniffen's (1932) and Sykes' (1937) comprehensive studies of the delta describe in great detail the changes in the pattern of water distribution and silt deposition that occurred in historic time. In recorded time, the river flowed in the braided channels of the comparatively flat southern slope of the delta against the Sonoran Mesa. Here the Yuma, Cocopah, Kohuana, and Halyikwamai farmed on lands which were overflowed nearly every summer. The flat gradient of these channels on the southern slope of the delta (less than two feet to the mile [Kniffen 1932:152]) precluded any significant downcutting, but was conducive to sheet flooding, rapid silt deposition, and natural levee formation.

Sometimes channels on the very crest of the delta overflowed their natural levees toward the north. When this occurred, some of the floodwater proceeded down the much steeper northern slope of the delta into the Salton Sink. This process gave rise to ephemeral lakes in the lowest portion of the basin during the nineteenth century. The steeper gradient of the northern slope created the potential for deep channel cutting and capture of the full flow of the Colorado River. As early as 1853 Blake recognized this potential and noted (1856) that a prolonged diversion of the river into the basin via one of these distributaries could cause the excavation of a deep channel to the head of the delta, entrap the full flow of the river, and form a lake of large proportions. Blake was of course referring to events which could account for the former presence in the Salton Basin of the body of water we now call Lake Cahuilla. The full realization of this potential nearly occurred in 1905-07 when the river was accidentally diverted into the basin forming the Salton Sea. At that time, the channel of New River, the major distributary on the northern slope of the delta, immediately went into an episode of spectacular headward erosion. A cataract 500-1000 feet wide moved upstream at the rate of one-half mile a day, carving out a *barranca* 50-80 feet deep (Davis 1907; Newell 1908). Similar downcutting occurred in the channel of the Alamo River. A refilling of Lake Cahuilla was averted only at great effort by damming the point of departure from the main channel near Yuma, and returning the river to its former bed, before the headward erosion reached that point. The events of 1905-07, exclusive of the misguided human element which set them in motion, closely resemble those that are thought to have given rise to the various stands of Lake Cahuilla.

Once deep channel cutting reached the head of the delta, the pattern of drainage was set for some time. Lake Cahuilla filled, rapidly at first, then more slowly as the surface area increased and more water was lost by evaporation. It then overflowed the deltaic barrier just east of Cerro Prieto and discharged into the Gulf of California.

Prolonged full-scale diversion of the Colorado River into the basin undoubtedly occurred many times (see Hubbs, Bien, and Suess 1965: 89-90). Each time it created a lake that was in reality a great settling basin for the millions of tons of silt suspended in its waters. The most immediate effect of this deposition was to flatten the stream bottom gradient at the point of inflow. Ultimately, the channel silted in until a point was reached at which the gradient was steeper to the south along the old distributary channels. When this occurred, the Colorado River again flowed over the southern slope of the delta to the Gulf, and Lake Cahuilla dried by evaporation. Thus, it appears that the Salton Basin has had alternating periods of lacustrine and desert conditions of as yet unknown number and duration.

### Stability of Lake Cahuilla

Lake Cahuilla would have offered an especially productive environment for aboriginal human populations if input from the Colorado River was sufficient to maintain a maximum lake level to the point of overflow. Overflow into the Gulf of California would have prevented the concentration of dissolved minerals in the water from rising to high levels, as occurs in closed lake basins, and would have permitted the growth of freshwater fish and shellfish populations. A relatively stable lake level would also have permitted the formation of marshes in shallow water, thus giving rise to a productive ecosystem. However, overflow could occur only if more water entered the lake than was lost by evaporation. Insufficient input would result in fluctuating or declining lake levels. Seasonal or annual fluctuations on the order of 5-10 feet would strand shoreline and emergent vegetation at irregular intervals, inhibit the growth of shellfish populations, and result in an environment which on the whole would be less attractive to waterfowl and human populations.

In order to assess the stability of the lacustrine environment in the Salton Basin, it is necessary to examine the hydrologic regimen of Lake Cahuilla with reference to the volume of water which entered the lake as precipitation and stream flow, and that lost by evaporation and overflow. David Weide (1976a) addressed this problem in another context, and his analysis is followed in simplified form here. Basically, the volume of water entering the lake through stream channels, plus the volume of precipitation to the lake surface, minus the volume lost by evaporation from the surface, should yield the volume overflowing into the Gulf of California. Substantial and regular overflow would indicate a stable lake.

Since it is necessary to apply current data to a prehistoric situation, one must assume that presently available estimates for precipitation, evaporation, and stream flow reflect past conditions, in effect, that the climate has not changed significantly over the last several hundred years. Significant climatic change would not only alter the evaporation and precipitation rates for the Salton Basin, it would also alter the rate of precipitation in the upper Colorado River basin, and thus affect the volume of water entering the lake. However, interpretation of the climate of the fifteenth and sixteenth centuries is a difficult task. It is apparent that this was a period of pronounced climatic oscillations (Denton and Porter 1970; Ladurie 1971). For that

reason, recent measurements of the volume of Colorado River flow, and of precipitation and evaporation rates in the Salton Basin, probably do not accurately reflect the situation at Lake Cahuilla four or five hundred years ago during the so-called Little Ice Age, the last major cycle of Neoglaciation. However, if present measurements for these variables suggest stable conditions for Lake Cahuilla, Neoglacial conditions characterized by reduced temperatures and decreased evapotranspiration (and possibly also increased precipitation) would result in an even more stable lake, provided that inflow of the river was not interrupted.

In several papers Carl Hubbs (e.g., 1960) has argued that significant climatic change characterized by warming temperatures and decreased rainfall occurred in southern California, both along the coast and in the Salton Basin, during the last 1000 years. He cites as evidence of such a change the occurrence of bones of immature fish representing the species humpback sucker (*Xyrauchen texanus*) and Colorado River bonytail chub (*Gila elegans*) in archaeological middens in the angle of the headwater forks of Fish Creek, on the eastern slope of the Peninsular Range about 15 miles from the shoreline of Lake Cahuilla. Adult fish of these species are presumed to have run up from Lake Cahuilla through the defile in Split Mountain to the headwaters of Fish Creek to spawn. Hubbs notes that prior to 1916, when a flashflood filled the creek channel with sediment, isolated pools still contained some small fish (species not stated). He suggests that deteriorating climate reduced Fish Creek from a running stream during the last stand of Lake Cahuilla to a series of pools that existed until 1916. He further suggests that the change is one of decreased rainfall in the Fish Creek watershed from something on the order of 10 inches per year to less than half that figure, with coincident increased evapotranspiration of the same order of magnitude. Without going into all the reasons why this seems to be a significant overstatement of the situation, it is known that the net evaporation from standing waters in the Salton Basin is slightly less than six feet annually (see below), rather than about ten feet, as suggested by Hubbs. It is also possible that the fish were caught at Lake Cahuilla and carried into the mountains, or that Fish Creek ran for a short time during a period of a very few wet years permitting fish to run up it to spawn. The data may therefore represent the exception, rather than the rule, as far as prehistoric climatic conditions are concerned. Since no archaeological report of the site at the headwater forks of Fish Creek has even been published, the incomplete data known from the site are difficult to interpret. While it is almost certain that the climate of the Salton Basin 400-500 years ago was somewhat less arid than it is at present, due to worldwide cooling at that time (Denton and Porter 1970), there appears to be insufficient data to support climatic changes of the magnitude suggested by Hubbs.

It therefore seems reasonable to attempt a rough calculation of the stability of the last stand of the lake using twentieth century data, since these are available and are considered reliable.

It was noted earlier that in historic time no active streams habitually flowed all the way into the Salton Sink. The volume of such runoff as occurred from the surrounding mountains as a result of occa-



sional heavy rains would be very difficult to estimate and probably seldom contributed significant quantities of water to Lake Cahuilla. For the present purpose, it is assumed to have been nil, and it is further assumed that the Colorado River provided all input into Lake Cahuilla through stream channels.

The Colorado River rises in the Rocky Mountains of Colorado, Utah, and Wyoming, and drains an area of more than 243,000 square miles. Most of its flow originates as snow melt on the western slope of the Rockies. Hely (1969) summarized estimates of the annual virgin flow of the river at Lees Ferry, Arizona, for the period 1896-1966. The maximum yearly flow during this interval was 24.04 million acre-feet, which occurred in 1917. The minimum was 5.64 million acre-feet, which occurred in 1934, one of the driest years ever recorded in the United States, in which very little snow fell on the Rocky Mountains. For the 71-year period, the average virgin flow of the Colorado River at Lees Ferry was 14.9 million acre-feet per year. It should be pointed out, however, that Lees Ferry is located far up the Colorado River near the Glen Canyon Dam site, and estimates for the virgin flow of the river at that point do not include the volume of water contributed by the Little Colorado River, Bridal Veil Creek, the Virgin River, Bill Williams Fork, the Gila River, and a host of lesser ephemeral tributaries below that point. The combined virgin flow of these tributaries below Lees Ferry probably averaged on the order of 1.4 million acre-feet annually (see Hely 1969). Therefore, the Colorado River and its tributaries can be considered to have annually supplied an average of 16.3 million acre-feet of water to Lake Cahuilla.

Inasmuch as groundwater seepage in the Salton Basin in historic time was nil, we can assume that it contributed no measurable volume of water.

Weide (1976a) computed the surface area of Lake Cahuilla to have been 1,256,550 acres, assuming the shoreline to have been at 40 feet above sea level. Using a figure of 0.22 feet for the annual precipitation to the surface of the lake, he set the volume of precipitation to the surface at 276,441 (0.28 million) acre-feet annually.

Thus, the combined annual input from stream channels and precipitation to the surface of the lake averaged about 16.6 million acre-feet.

The net annual evaporation from the surface of Lake Cahuilla is best estimated with reference to the evaporation rate determined for the Salton Sea. Hely, Hughes, and Irelan (1966:18) found that 5.78 feet of water evaporated from the Salton Sea annually. The figure is very close to the 5.73 feet computed by Young (1947). Since it is known that bodies of saline water evaporate at a rate of about two percent less than those of fresh water (Harbeck 1955), the figure given by Hely, Hughes, and Irelan (1966) for the annual evaporation (in feet of water) from the Salton Sea can be corrected to 5.9 feet. Using this value, and the figure determined by Weide for the surface area, the computed annual loss of volume by evaporation from prehistoric Lake Cahuilla was about 7.4 million acre-feet.

Table 2

## HYDROLOGIC REGIMEN OF LAKE CAHUILLA

Flow of water entering lake	16.3 million acre-feet per year			
Precipitation to surface of lake	0.3	"	"	"
	<u>16.6</u>	"	"	"
Evaporation from surface	7.4	"	"	"
Overflow into Gulf of California	9.2	"	"	"

(Compiled from data furnished by Hely [1969], Hely, Hughes, and Ireland [1966], and D. Weide [1976a])

From these figures (summarized in Table 2, above), it is evident that net loss of volume by evaporation from the surface of Lake Cahuilla totalled less than half the volume which entered it in an average year. In only one year for which data are available would the flow of the Colorado River at Lees Ferry not have been adequate to offset evaporation and maintain a stable lake. On the basis of present-day values for stream flow, precipitation, and evaporation, the volume of discharge from Lake Cahuilla into the Gulf of California was on the average greater than the volume lost by evaporation from the surface. We can therefore conclude that Lake Cahuilla was a stable freshwater lake that overflowed and maintained within very narrow limits a constant water level. Such fluctuations as occurred in the surface level of the lake were probably not greater than two or three feet, either seasonally or annually. We can also conclude that if Lake Cahuilla would be stable under the present climatic regime, it would be so also under the conditions that are thought to have prevailed 500 or 1000 years ago.

#### Biological Resources of Lake Cahuilla

Vegetation. The waters of Lake Cahuilla supported a varied flora and fauna. We can infer that the shallows at the northwest end of the lake in Coachella Valley, with their fine-grained substrate, gave rise to an extensive freshwater marsh extending from the vicinity of La Quinta to well north and east of Indio. The bottom gradient in this region is quite flat, sloping at the rate of 5 to 20 feet per mile. The along-shore dunes here both provide an irregular, undulating shoreline, and include many shallow basins among the dunes which were undoubtedly also filled with water. Such conditions are conducive to the development of a Freshwater Marsh plant community (Mason 1957). Plants in such a setting would include both those which grow along the shore on moist ground and also emergent species of the littoral zone rooted in water up to about eight feet deep. This marsh zone was probably quite irregular and a mile or so wide. We can infer the former presence of vast stands of cattail (*Typha*), tule or bulrush (*Scirpus*), and reed (*Phragmites australis*), as well as other economically important plants. This zone paralleled and

graded into the mesquite-covered shoreline dunes which still form a prominent aspect of the landscape of the Coachella Valley. Except for the more pronounced fluctuations which those bodies of water experienced annually and seasonally, this portion of the Lake Cahuilla shoreline was probably comparable in many respects to the marshes which formerly existed at Tulare and Buena Vista lakes in the San Joaquin Valley of California. A slight seasonal fluctuation, probably not exceeding two or three feet, which undoubtedly occurred as a result of increased flow of the Colorado River early each summer, would have been conducive to the growth of marsh vegetation (Green, MacNamara, and Uhler 1964). Elsewhere in the basin the shoreline is often marked by coarse sand and gravel beaches and steep near-shore bottom gradients which would have inhibited the growth of marsh plants. Extensive marshes much larger than those at the northwest end of the lake probably also existed in the region of the Colorado Delta, where the inflow and outlet channels assured adequate water movement, and the bottom was of good gradient and of fine silt.

Shellfish. In a special study of the molluscan paleontology and paleoecology of Holocene Lake Cahuilla, Bowersox (1973) reported that "The fauna is characteristic of a sandy mud substrate with aquatic vegetation and a slight, wave-induced current." The economically important species was the freshwater mussel, or clam (*Anodonta dejecta*), often identified in literature as *Anodonta californiensis*. The northwest end of the lake provided a particularly favorable environment for this species, to judge from the shell heaps which occur there, as well as the natural beds of still-paired valves where the mussels were stranded on the retreat of the waters of Lake Cahuilla. The valves are commonly about three inches long, and middens of them are sometimes seen exposed in the deflating dunes. Where exposures of these shells have been noted, they are up to a foot in depth, intermixed with charcoal, ceramic sherds, and other debris. These kitchen middens document use of the species for food (Fig. 12). *Anodontas* will achieve populations of about five individuals per square foot of substrate, and are abundant in waters three or four feet deep (Coker et al. 1922:79-82; Cvanacara 1972:154). Since freshwater mussels are not subject to the effects of the red tide, which renders marine species poisonous at certain seasons, they could have been gathered and eaten at any time of the year.

Fishes. The fish fauna of Lake Cahuilla included probably only five species, all common to the lower Colorado River. The following discussion is drawn from the works of Hubbs and Miller (1948), Kimsey and Fisk (1964), Casteel (1970), and Dill (1944). Species included:

Humpback sucker (*Xyrauchen texanus*), a large sucker restricted to the Colorado River drainage, up to three feet long and weighing up to 16 pounds, but generally only half that size; feeds on silt, bottom detritus, including algae, immature insects, etc.

Colorado River bonytail chub, or simply bonytail (*Gila elegans*), a minnow of considerable size, bony, but said to be good eating.

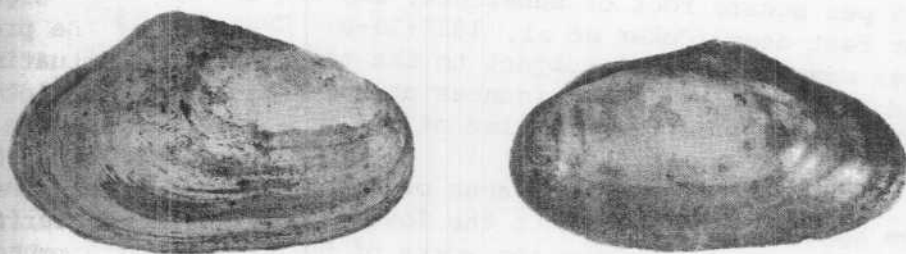
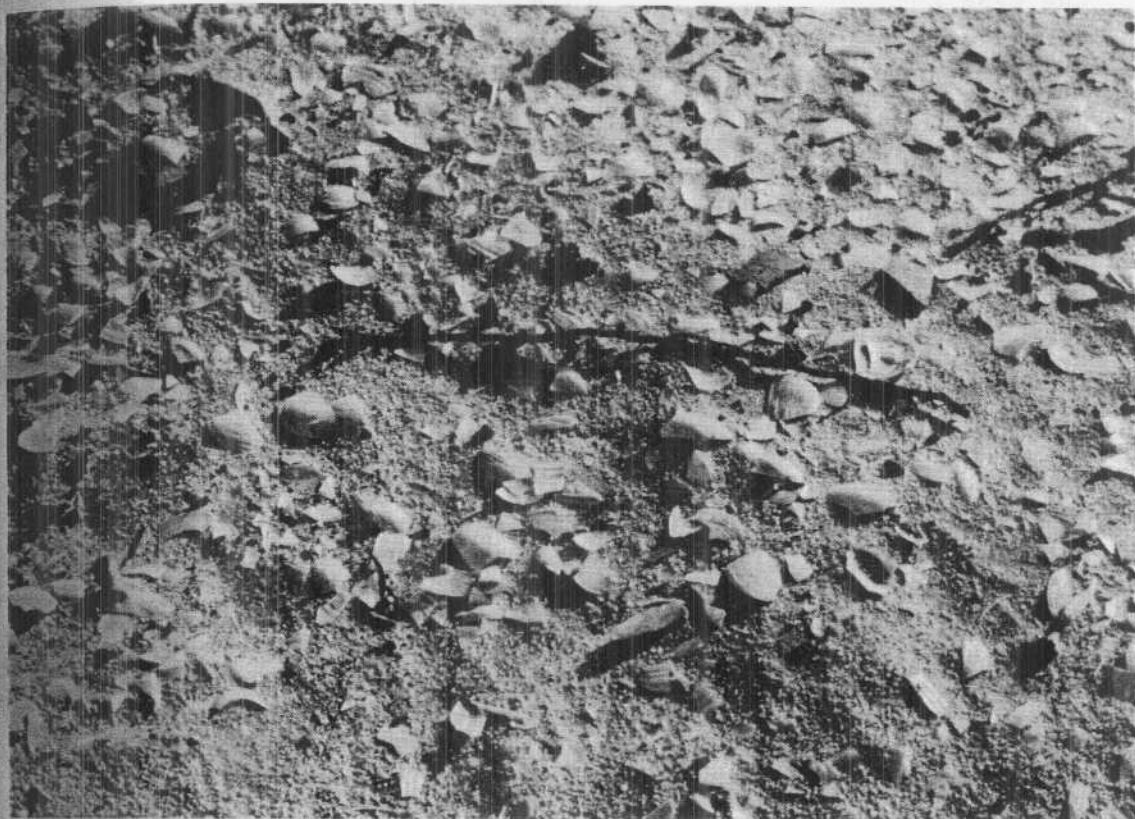


Fig. 12. Freshwater clam (*Anodonta dejecta*). Upper: midden with abundant *Anodonta* shells, ceramic sherds, charcoal. Exposed by deflation in shoreline dunes west of Indio. Lower: shells, or valves, actual size.

Colorado River squawfish (*Ptychocheilus lucius*), one of the largest true minnows, achieving a length of five feet and a weight of nearly 100 pounds; probably predaceous on other fishes; reported to be good eating.

Striped mullet (*Mugil cephalus*), a schooling fish tolerant of saline conditions, occurring in the lower Colorado River and in the open sea; feeds on microscopic algae, to two and one-half feet long, good eating; probably entered Lake Cahuilla regularly through the outlet to the Gulf of California; supported a commercial fishery on the Salton Sea in the early years after it formed.

Desert pupfish (*Cyprinodon macularius californiensis*), a small, omnivorous cyprinodont fish first reported from Fish Springs and Dos Palmas Spring on the ancient lakebed in the lower Coachella Valley; averaging somewhat less than two inches in length; very tolerant of highly saline and tepid waters.

Of these, the first two were commonly eaten by the Indians, to judge from fish remains found on the surface of shoreline middens. The squawfish was taken in more restricted localities, notably on the rocky shore around Travertine Point (W. I. Follett, personal correspondence).

Waterfowl. Included under this heading are both the migratory ducks, geese, swans, etc., of open water, and also the shorebirds and waders which frequent southern California waters, and the communal island nesting species like pelicans, cormorants, and herons. Some idea of the former significance of aquatic birds at Lake Cahuilla is indicated by the vast numbers of waterfowl that today congregate on the Salton Sea (U. S. Department of the Interior 1970). The sea is today a major center of activity on the Pacific flyway (Lincoln 1950:52). Some migratory species winter there, but many which would have been of economic significance to the Indians occur there the year round. Inasmuch as the present Salton Sea is a highly polluted and saline body subject to fluctuating water levels and other disturbances by man, it is reasonable to picture Lake Cahuilla as a much more significant point on the flyway teeming with aquatic bird life. Grinnell (1908) studied the birds of the Salton Sea only three years after it formed and found that the white pelican (*Pelecanus erythrorhynchos*), double-crested cormorant (*Phalacrocorax auritus*), and great blue heron (*Ardea herodias*) had already established communal nesting sites on its islands. Evidence obtained at the Bat Caves Buttes, a former island about four and one-half miles from the northeast shore of Lake Cahuilla, indicates that it also was used for this purpose by great blue herons, black-crowned night herons (*Nycticorax nycticorax*), and Farallone cormorants. That these nesting grounds were a source of eggs and/or young birds for the Indians inhabiting the lakeshore is indicated by the campsite refuse there, described in Chapter IV. The marshes at the northwest end of the lake must also have provided food and shelter for large numbers of shore birds, ducks, and mudhens (*Fulica americana*).

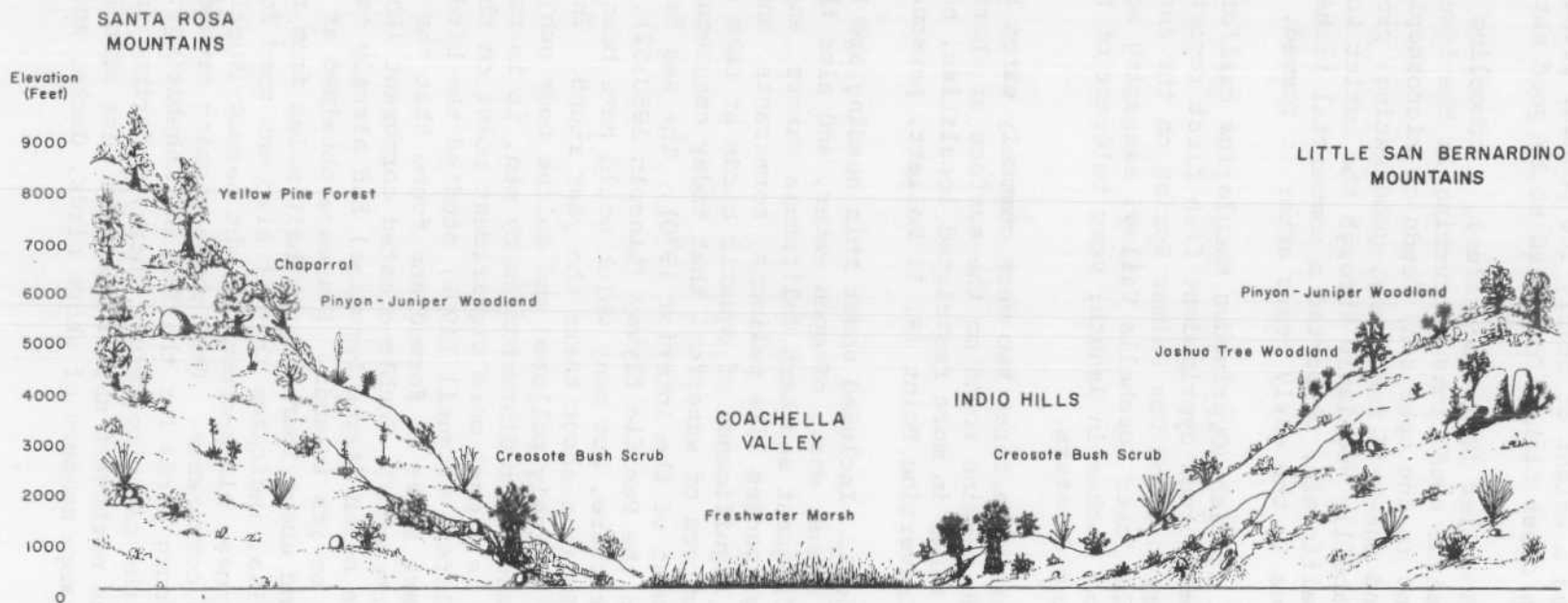


Fig. 13. Schematic and somewhat idealized cross-section of the northern portion of the Salton Basin as it existed during the last stand of Lake Cahuilla. All terrain below +42 feet elevation was inundated. Location of the transect is shown in Fig. 3.

## ENVIRONMENTAL CHANGES

From the foregoing discussion, it can be seen that the incursions of the Colorado River into the Salton Basin brought about profound changes in the natural environment. Lake Cahuilla inundated the lower portions of the basin to an elevation of about 42 feet above sea level. This largely eliminated the Alkali Sink plant community and a portion of the Creosote Bush Scrub. In their place appeared broad stretches of open water and a Freshwater Marsh plant community with economically important wetlands plants, shellfish, fish, and aquatic birds. The presence of the lake probably had little or no effect on the desert vegetation located more than several hundred yards from the shore, except that the raised water table gave rise to the mesquite dunes which still exist along the former shoreline in Coachella Valley. Figure 13 shows the character of the environment along the transect from Toro Peak across Coachella Valley to the uplands of the Little San Bernardino Mountains as reconstructed here during the last stand of Lake Cahuilla.

The disappearance of Lake Cahuilla saw a re-establishment of low desert conditions on the floor of the Salton Basin. But, unlike the rapidity with which marsh vegetation can become established within as little as a year or two after an area becomes flooded (M. Weide 1968: 93; Mason 1957:10), the appearance of productive and economically important desert perennials, such as mesquite and screwbean, on the bed of Lake Cahuilla may have required at least several decades.

## NOTE

1. It is interesting to speculate if the near absence of agave on the northeast side of Coachella Valley may be due to cultural factors, specifically whether it was exploited to its near extinction in this region at some time in the past. Ground survey for agave roasting pits at elevations where agave might have grown could shed some light on this question.

## Chapter III

### CHRONOLOGICAL FRAMEWORK

Dating the late prehistoric adaptation to lacustrine conditions in Coachella Valley hinges on the dating of the last stand of Lake Cahuilla. Several approaches can be used to estimate the dating of the last stand of the lake, including radiocarbon, historical accounts, and cross-dating of artifacts found on the lakeshore. However, none of these provides a fully satisfactory means of dating.

#### DATING THE RECENT STAND OF LAKE CAHUILLA

##### Radiocarbon

A large body of radiocarbon data pertinent to the various stands of Lake Cahuilla is available, but the data are difficult to interpret. Table 3 lists analyzed radiocarbon samples that document or suggest lake stands in the Salton Basin during the last 2000 years.<sup>1</sup> The apparent age ranges of these samples in radiocarbon years before the present are plotted in Table 4. Table 4 also shows the equivalent calendar date range for each sample based on data derived from the measurement of the radiocarbon content of dendrochronologically dated bristlecone pine (*Pinus longaeva*) samples (Ferguson 1970; Suess 1970). While each dated sample must be evaluated on its own grounds with reference to association and the basic parameters of radiocarbon dating (Ralph 1971), the available age determinations cluster into three groups. It is evident, however, that while a cluster of radiocarbon measurements suggests a single lake stand, it may in reality indicate two or more closely successive fillings of the basin. The term "lacustral interval" is used here to describe a period in which there was a single lake stand of prolonged duration, or several shorter, closely successive, lake stands. It describes a period of generally aquatic, rather than generally arid, conditions in the basin.<sup>2</sup> Radiocarbon measurements are not precise enough to determine the number of lakes that formed within a given lacustral interval, however Table 4 is interpreted to portray three such intervals separated by periods in which desert conditions presumably prevailed. The whole Salton Basin is a desert, but the floor of the basin was either covered with water or it was also arid. References to periods of arid conditions, or desert conditions, which follow, should be considered to refer to arid conditions on the floor of the Salton Basin.

Available data suggest that the earliest episode of lake fillings in the last 2000 years began sometime around the beginning of the Christian era, perhaps shortly before, and lasted until perhaps A.D. 600. It is of little concern to the present study, and no substantive archaeological data are presently known that clearly date to this interval.]



Table 3

SUMMARY OF RADIOCARBON DATA ON LAKE CAHUILLA  
DURING THE LAST 2000 YEARS

Lab code	Age, <sup>14</sup> C years B.P.	Source	Material	Associations	Comment
UCR-125	<100	[3]	Human coprolite	Coprolite Bed B, Myoma Dunes	Exposed by deflation
UCR-350	<100	[8]	Charcoal	Midden at fishing station designated Wadi Beadmaker, northeast shore near Orocopia Wash, depth 2-5 cm.	Last filling inferred
UCR-349	<100	[8]	Charcoal	Same as above, but sample from hearth at depth 10-20 cm.	
UCR-348	<150	[8]	Charcoal	Same as above, but sample from base of midden	
UCR-163	<150	[3]	Charcoal	Beam from house adjacent to Coprolite Bed A, Myoma Dunes	
UCR-319	<150	[8]	Charcoal	Hearth at heron rookery, Bat Caves Buttes; burned heron bones	Site on island 4.5 miles from northeast shore
M-598	120 <sup>+200</sup> <sub>-120</sub>	[1]	Charcoal	Fire pits about house rings on west shore; fish bones, pottery, late projectile points	Last filling?
M-597	130 <sup>+200</sup> <sub>-130</sub>	[1]	Charcoal	Lower level of Split Mountain dune site; "Playa" projectile points, trace of pottery, freshwater fish bones	Re-run as LJ-GAP-59
LJ-102	220 <sup>+100</sup>	[2]	Charred tule	East shoreline	Extensive tule fire
UCR-153	235 <sup>+150</sup>	[3]	Bulrush seed	Residue of decomposing coprolites, Bed A, Myoma Dunes	Date on aquatic fraction
UCR-152	240 <sup>+150</sup>	[3]	Mesquite seeds	Same as above	Date on terrestrial fraction
UCLA-192	270 <sup>+60</sup>	[4]	Charcoal	From hearths with freshwater fish bones, elevation -160 feet	
LJ-15	300 <sup>+100</sup>	[2]	Charcoal	Archaeological site, SW shore, 2 miles south of international border	Last filling inferred
UCR-124	365 <sup>+140</sup>	[3]	Human coprolite	Myoma Dunes Bed D; squash ( <i>Cucurbita</i> sp.) seeds recovered in association	Same gas re-counted as cross-check: 420 <sup>+80</sup> B.P. (UCLA-1889)
UCR-380	415 <sup>+140</sup>	[8]	Burned fish bone	Midden at fishing station of Wadi Beadmaker	Composite sample from entire depth of midden. To check results obtained on charcoal (UCR-348, UCR-349, UCR-350)
LJ-GAP-58	420 <sup>+100</sup>	[7]	Charcoal	Surface of Split Mountain archaeological site, west shore	Last filling inferred
PCV-2**	450 <sup>+130</sup>	[9]	Shells	Beach deposit at mouth of Martinez Canyon	
M-596	450 <sup>+200</sup>	[1]	Charcoal	Archaeological zone in clay deposit behind longshore bar; freshwater fish bones	Last filling?
LJ-GAP-59	470 <sup>+100</sup>	[7]	Charcoal	Archaeological stratum in Split Mountain dune site 60 cm. below surface; ceramics	Association with "Playa" points questionable
LJ-GAP-70	720 <sup>+100</sup>	[7]	Charcoal	Archaeological stratum in Split Mountain dune site 1.5 m. below surface; "crude" points	Associations unclear from published data in date list
LJ-99	760 <sup>+100</sup>	[2]	Charcoal	Charcoal in silt stratum which was formed during second of three cycles of inundation documented in the section	Next-to-last filling?
LJ-965	830 <sup>+140</sup>	[6]	<i>Anodonta</i> sp. valves	From hearth in archaeological site at headwater forks of Fish Creek in mountains west of Lake Cahuilla	Cross-check of LJ-7
LJ-106	960 <sup>+100</sup>	[2]	Charcoal	Archaeological stratum in arroyo cut on east shore of lake near Siphon 15 on Coachella Canal; ceramics, fish bone	1.7 m. deep in silt behind bar
LJ-7	1000 <sup>+200</sup>	[2]	Charcoal	From hearth in archaeological site at headwater forks of Fish Creek in mountains west of Lake Cahuilla; fish bones of species common to Lake Cahuilla	

(Continued)

Table 3 (continued)

LJ-960	1010+220	[6]	Anodonta sp. valves	Valves from west shoreline	
PCV-3**	1250+120	[9]	Unio shell	Lake sediments at New River Gorge, 1 mile south of Seeley, Imperial Valley (P. C. Van de Kamp, personal correspondence)	
LJ-105	1440+100	[2]	Charcoal	From archaeological stratum exposed in wall of arroyo, in silt behind bar at depth of 2.0 m., near Siphon 15, Coachella Canal, east shore; fish bones	
LJ-530	1510+180	[5]	Tufa	Tufa coating cobbles on west shoreline	
LJ-101	1580+200	[2]	Charcoal	From depth of 45 cm. in silt flat behind sand bar, SW of Valerie, west shore	
LJ-513	1800+200	[5]	Tufa	From outer 5 cm. of tufa coating on boulders of Travertine Rock, islet just off west shore	Sample is cross-check of LJ-458
LJ-458	1890+500	[5]	Tufa	Same as above	

\*\*Not official laboratory numbers. The dates were run by Shell Development Company and never submitted for publication in *Radiocarbon* (see Van de Kamp 1973). The laboratory is no longer operating.

Adapted from D. Weide (1976b) and expanded.

Sources:	[1] Crane and Griffin (1958)	[6] Hubbs, Bien, and Suess (1965)
	[2] Hubbs, Bien, and Suess (1960)	[7] Hubbs and Bien (1967)
	[3] Taylor (1975)	[8] R. E. Taylor (in preparation)
	[4] Fergusson and Libby (1963)	[9] Van de Kamp (1973)
	[5] Hubbs, Bien, and Suess (1963)	

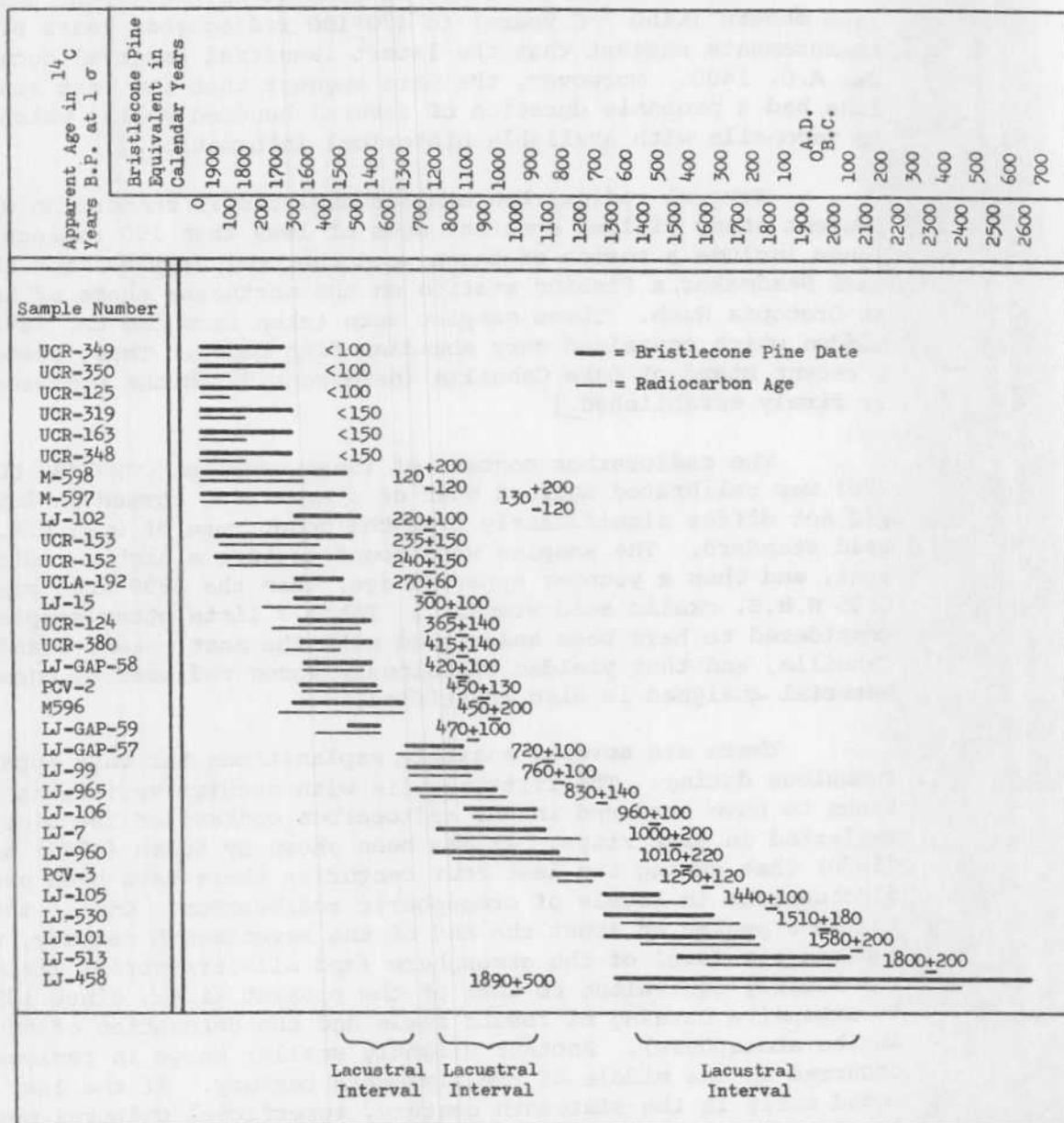
Two lacustral intervals are suggested for the period after A.D. 900. Sample LJ-99 (760+100 radiocarbon years B.P.) is of particular importance to the interpretation of these. It was collected by G. M. Stanley from a bed of silt on the west shore of the lake near Travertine Point. The silt "formed during the second of three cycles of inundation (due, presumably, to fluctuating lake level)" indicated in the exposed section (Hubbs, Bien, and Suess 1960:215). The apparent age of the sample is clearly within the cluster of measurements shown in Table 4 that suggests the second period of lake fillings within the last 2000 years. The stratigraphic interpretation did not indicate the magnitude of the fluctuation involved, whether it was minor, or whether it represents a complete drying of the lake. If a minor fluctuation is indicated, there may have been only one lake stand during the last millenium. This stand would therefore have lasted for well over 500 years. If a complete recession of the lake is indicated, which is suggested by the data in Tables 3 and 4, there were two periods of lake fillings within the last 1000 years or so.

Evidence from Perris Reservoir, near Riverside, about 100 miles to the northwest, tends to support the latter interpretation. Excavations at the Peppertree site (CA-Riv-463) (Wilke 1974) at Perris Reservoir yielded obsidian flakes and artifacts. Source analysis revealed that some of this obsidian originated in deposits at Obsidian Buttes, low rhyolite extrusions on the bed of Lake Cahuilla near the south end of the Salton Sea.<sup>3</sup> These buttes are of very low elevation, not rising above about 130 feet below sea level, and were thus under about 175 feet of water whenever Lake Cahuilla was filled to overflow. Access to the obsidian deposits was possible only in periods when the lake was dry or nearly so. At the Peppertree site, the obsidian from this source occurred

obsidian source

Table 4

RADIOCARBON CHRONOLOGY OF LAKE CAHUILLA  
DURING THE LAST 2000 YEARS  
WITH BRISTLECONE PINE CORRELATIONS



from level *g*, dated at 870<sup>+80</sup> radiocarbon years B.P. (UCLA-1815), through level *d*, dated at 215<sup>+60</sup> radiocarbon years B.P. (UCLA 1816). When these measurements are converted to calendar years after Suess (1970), they yield the following results: 870<sup>+80</sup> radiocarbon years B.P. = A.D. 1050-1200; 215<sup>+60</sup> radiocarbon years B.P. = A.D. 1470-1750.<sup>4</sup> These figures indicate that sometime during the last 1000 or 1100 years obsidian from the Obsidian Buttes locality was being quarried and taken out of the basin (see Fig. 14). In other words, there must have been one or more periods of complete desiccation between stands of Lake Cahuilla

after A.D. 900. However, information now available does not permit precise delimitation of the number of stands of the lake, or the duration of each, within the last 1000 years.

[Table 4 shows a cluster of samples with apparent ages ranging from modern (<150  $^{14}\text{C}$  years) to 470±100 radiocarbon years B.P. These measurements suggest that the latest lacustral interval occurred after ca. A.D. 1400. Moreover, the data suggest that the last stand of the lake had a probable duration of several hundred years, which is difficult to reconcile with available historical information.]

Several radiocarbon samples analyzed in connection with the present study yielded apparent ages of less than 150 radiocarbon years. These include a series of three wood charcoal samples from the site of Wadi Beadmaker, a fishing station on the northeast shore of Lake Cahuilla at Orocopia Wash. These samples were taken from the ca. 30-cm.-deep midden which contained very abundant fish bones. Thus, association with a recent stand of Lake Cahuilla (here considered the most recent stand) is firmly established.]

The radiocarbon content of these samples (UCR-348, UCR-349, UCR-350) was calibrated against that of a tree ring formed in 1890 which did not differ significantly from the count rate of 0.95 N.B.S. oxalic acid standard. The samples were found to have a higher radiocarbon content, and thus a younger apparent age, than the 1890 tree ring and the 0.95 N.B.S. oxalic acid standard. Table 3 lists other samples which are considered to have been associated with the most recent stand of Lake Cahuilla, and that yielded anomalously young radiocarbon ages. The material analyzed is also identified.

There are several possible explanations for this apparently anomalous dating. The first may lie with secular variations that are known to have occurred in the radiocarbon content of the biosphere, as reflected in tree rings. It has been shown by Suess (1970) and Ferguson (1970) that during the last four centuries there have been pronounced fluctuations in levels of atmospheric radiocarbon. One of these fluctuations peaked at about the end of the seventeenth century, when the radiocarbon level of the atmosphere (and all terrestrial living material) was roughly equivalent to that of the present (i.e., since 1890, prior to extensive burning of fossil fuels and the detonation of nuclear devices in the atmosphere). Another slightly smaller surge in radiocarbon levels occurred in the middle of the sixteenth century. If the last lake stand ended early in the sixteenth century, superficial cultural material on the lakeshore, dating to the closing phases of this stand, could yield essentially modern radiocarbon age determinations, given the accuracy of presently available counting methods. Perhaps this explains some of the apparently anomalous dates obtained on material associated with the last lake stand.<sup>5</sup>

Another possible explanation of the apparent modern ages (<150  $^{14}\text{C}$  years) of some of the radiocarbon samples from the shore of Lake Cahuilla may lie in as yet not understood phenomena peculiar to the Salton Basin. It is thought by most geophysicists that radiocarbon atoms produced by the detonation of nuclear and thermonuclear devices cannot

fish  
bones

tree  
ring

exchange with carbon atoms in the organic residues of superficial archaeological deposits. If, however, such replacement or exchange did occur, it would enrich the radiocarbon content of the samples, causing them to have apparent ages more modern than expected. Given the present understanding of radiocarbon dating, it does not seem advisable to suggest contamination of samples by exchange with bomb  $^{14}\text{C}$ , since the problem has not been observed elsewhere, and there is no particular reason to believe that it should occur in the Salton Basin. Future research may, however, show that such exchange can occur.

Isotopic fractionation, or selection for a heavier or lighter carbon isotope, in the metabolic processes that produced the sample material would affect the radiocarbon content slightly. However, when this occurs, it is usually in the direction of the lighter isotope, with the result that the apparent age is too old, rather than too young, and mass spectrometric checks of the  $^{13}\text{C}/^{12}\text{C}$  ratios indicated that fractionation had not occurred.

It is theoretically possible that fractionation might also have occurred during combustion in an ancient campfire (Peter Slota, personal communication, 1976). In this case, the lighter isotope,  $^{12}\text{C}$ , would be more active in oxidation, and a disproportionately large amount of it might be oxidized to  $\text{CO}_2$ . This would leave the partially burned organic sample enriched slightly with the heavier isotope,  $^{14}\text{C}$ , which, upon analysis, would yield an apparent age more recent than expected. Such fractionation might account for the modernity of the three charcoal samples analyzed from Wadi Beadmaker (UCR-348, UCR-349, UCR-350). If such fractionation occurred in the aboriginal burning of wood, but not the burning of bone, it could account for the apparent age of  $415 \pm 140$  radiocarbon years (UCR-380) obtained on burned fish bone from the same deposits (see Table 3). The fish bone might have been in part composed of carbonate ions of great radiometric age drawn from the waters of Lake Cahuilla, so the question remains open. It would seem useful, therefore, to give additional attention to the problem of fractionation during combustion in ancient fires, and to determine if it might be a source of error in radiocarbon determinations, although the matter is usually considered a nonproblem.

Although not suggested by historical records, it is possible that the last stand of Lake Cahuilla was more recent than heretofore realized or expected. Such an event would be in harmony with the recent radiocarbon age determinations. To evaluate this possibility, it is necessary to examine briefly the historical record of the flow of the Colorado River and to see if there are periods in historic time (post-A.D. 1540) when the river could have flowed into the Salton Sink causing Lake Cahuilla to fill.

#### Historical Records

Explorations in the Colorado River delta region provide general information on the drainage pattern of the river after A.D. 1540. Not only did explorers of the region follow the river downstream to tide-water, and thereby establish that it was not flowing into Lake Cahuilla, they also sailed up the river from its mouth or ascended it by land. The

history of the region is treated in works by Alvarez de Williams (1975), Bolton (1925), Forbes (1965), Sykes (1937), Venegas (1759), and Wagner (1929), among others. Since 1540, no period of more than 95 years has elapsed in which it is not possible to rule out an inflow of the Colorado to the Salton Basin from evidence contained in historical records, assuming that these are interpreted correctly. The historical record is summarized as follows:

- 1539--Francisco de Ulloa sailed from Acapulco to the head of the Gulf of California. The shoals and reddish water he described indicate that he reached the Colorado Delta, but he did not go ashore (Wagner 1929:11-50, 293-312).
- 1540--Hernando de Alarcón sailed from Colima to the head of the Gulf of California as part of the expedition of Francisco de Coronado. He ascended the Colorado River in ship's boats probably to just below the junction with the Gila (Hammond and Rey 1940:124-155), possibly as far as present Parker, Arizona, and found the river flowing directly into the gulf.
- 1540--Melchior Díaz led an overland expedition from Corazones, Sonora, to the Colorado, also in connection with the Coronado expedition. He found messages left for him on the Colorado by Alarcón, ascended the river an unknown distance (possibly as far as present Blythe), crossed it, and descended it on the west (California) side. He almost certainly reached the mud volcanoes near Cerro Prieto (the site of the outlet channel of Lake Cahuilla, which was not seen), and was fatally wounded in an accident in the western part of the delta (Hammond and Rey 1940:231-232).
- 1604-05--Don Juan de Oñate led an overland expedition from New Mexico to the Colorado, which he reached by descending the Bill Williams River. He followed the Colorado down to tidewater along its approximate present course (Hammond and Rey 1953).
- 1615--Juan de Iturbi, pearl fisher, sailed up the gulf to near the Colorado Delta (Venegas 1759, I:180-181; Forbes 1965: 111). He was not in a position to observe the drainage pattern of the upper delta.
- 1700--Father Eusebio Kino led a missionary expedition from Mission Dolores, Sonora, to the junction of the Gila and the Colorado by way of the Gila. He ascended a high mountain in the vicinity, and with the aid of a powerful telescope he saw the Colorado flowing southwest 10 leagues and then southward 20 leagues more to the Gulf of California. To the northwest, in California, he reported seeing only the Peninsular Range (Venegas 1759, I:300-302). He thus determined that California was not an island. This was a widespread misconception at the time (Leighly 1972).

- 1701--Father Kino returned to the Gila junction and descended the Colorado River to Quiquima (Halyikwamai) territory (Venegas 1759, I:308-309).
- 1702--Father Kino again led a missionary expedition to the Colorado by way of the Gila and descended the Colorado to its mouth (Venegas 1759, I:310; Bolton 1948).
- 1706--Father Kino returned to the Colorado with Father Manuel de Ojuela. He found conditions there as before (Venegas 1759, I:311).
- 1721--Father Juan de Ugarte sailed from Loreto on the east coast of Baja California to the head of the Gulf of California. He attempted to ascend the Colorado River, but was discouraged by the summer floods, tidal disturbances, and storms (Venegas 1759, II:46-62; Clavigero 1937:246-254). He could not have seen anything about the river that would indicate whether it was flowing out from the Salton Basin, or whether it was flowing directly into the Gulf of California.
- 1744--Father Jacobo Sedelmayr journeyed from Tubutama, Sonora, to the Colorado by way of the Gila. Little is known of his observations or the extent of his movements there (Venegas 1759, II:183; Ives 1939).
- 1746--Father Ferdinand (Fernando) Consag (Konschak, Konšćak, etc.) journeyed northward by sea along the east coast of Baja California to the Colorado Delta (Venegas 1759, II:308-353). He explored the delta for a short distance upstream, but his observations were so limited in scope that nothing can be said for the possible existence of Lake Cahuilla.
- 1748--Father Sedelmayr journeyed from Tubutama, Sonora, to the Colorado River by way of the Gila. He descended the Colorado to Yuma (Quechan) territory (Venegas 1759, II:209). The evidence is inconclusive, but he probably would have seen Lake Cahuilla had it then been in existence.
- 1771--Father Francisco Garcés descended the Gila to the Colorado, followed the latter to its mouth, crossed it, and explored the western edge of the delta as far north as Signal Mountain, near the present international border (Bolton 1930, I:31-32). Had Lake Cahuilla been in existence, he would have seen it.
- 1772--Pedro de Fages pursued deserters from San Diego to Imperial Valley and was forced to return to the Peninsular Range for lack of water (Bolton 1931:219).
- 1773--Sebastián Taravál, a Cochimí Indian originally of Santa Gertrudis Mission in Baja California, fled from San Gabriel Mission to the Colorado River. His route took him to the San Sebastián Marsh, across Imperial Valley, and through the Algodones Dunes, where his wife died of thirst (Bolton 1930, III:65).

1774--The first Anza expedition reached the Colorado River, traversed the delta, crossed the Cocopah Mountains, proceeded to the north end of the Pattie Basin, and entered the Imperial Valley at Signal Mountain (Bolton 1930, I:67-101). The Salton Basin was dry.

After the first Anza expedition, explorations in the Lower Colorado River region and in the Salton Basin were so frequent that it is clear the Colorado generally followed its recent pattern of flow into the gulf. From the historical record spanning the period 1540-1774, it would appear that there was no interval in which the Colorado could have flowed into the Salton Basin long enough to fill it to overflow, maintain it long enough for its shores to develop a substantial archaeological residue, and return to its pattern of draining into the gulf without such a diversion being observed and noted. The longest gap in the historical record is 95 years, from 1605, when Oñate descended the Colorado, to 1700, when Kino reached the Colorado and saw it flowing into the Gulf of California. It is possible that shortly after Oñate's expedition the river was again diverted into the basin forming another stand of Lake Cahuilla, and returned to its old channel by the beginning of the eighteenth century. If this did occur, Lake Cahuilla could have been undergoing its final recession even as Kino visited the delta. But if this actually did happen, we should have to wonder why Kino did not see the lake or learn of it from the Indians. In view of the net annual evaporation suggested for Lake Cahuilla (nearly six feet per year, as deduced from present climatic conditions), it would have required nearly 60 years to dry completely if all inflow from the river ceased abruptly. And there remains the question of whether a lake stand of only one or two generations could have resulted in the abundance of archaeological remains which apparently dates to the most recent stand. This does not seem at all probable.

If the historical records are interpreted correctly, it would appear that there has been no stand of Lake Cahuilla since A.D. 1540.

#### Unresolved Historical Problems

There remain several perplexing problems in the history of the Colorado Delta region and the possible late existence of Lake Cahuilla that were not mentioned above. Godfrey Sykes (1914:15) called attention to the remarkable map of John Rocque (ca. 1762) in the cartographic archives of the British Museum. The map clearly shows the combined streams of the Gila and the Colorado flowing into a lake of sizeable proportions, located to the north of the Colorado Delta, and having no outlet to the sea. The source of the information on which this part of Rocque's map is based remains a mystery.

Several early explorers on the Lower Colorado were told by the Indians of a mythical lake. Alarcón first learned of it in 1540 (Hammond and Rey 1940:144-145), and Oñate was told of it when he reached the confluence of Bill Williams Fork and the Colorado River on his expedition from New Mexico in 1604-05. According to Zárate Salmerón's account of the Oñate expedition,



Here was heard the first news of the Lake of Copalla . . . . They described this lake and land and all its banks as densely populated. An Indian said Copalla very plainly . . . . And those Indians also said that those of that language wore bracelets of gold . . . and that from there they were fourteen days' journey, of those which they travelled. They pointed to this language [of Copalla] between west and northwest [quoted from Bolton 1925:271-272].

The fact that the lakeshore inhabitants are described as having gold suggests that the Spaniards elicited the answers they sought to the loaded questions they must have asked. But perhaps the tale of this lake told by the Indians of the Colorado had a kernel of truth, recalling the former existence of Lake Cahuilla in the then recent past.

Some authors have noted that early maps and records of exploration sometimes indicate the head of the Gulf of California at about 34° North latitude, where it is actually less than 32° North. George Carter (1964) suggested that if Spanish vessels of shallow draft entered the outlet channel of Lake Cahuilla, they might have sailed to the north end of it and reached 34° North latitude (actually only 33½° North). Carter's discussion relates specifically to the voyage of Francisco de Ulloa to the head of the gulf in 1539. Study of Ulloa's narrative (Wagner 1929:11-50, 293-312) does not seem to support Carter's contention, and the error of two degrees is possibly attributable to the limited accuracy of the astrolabes then in use. But even with sixteenth century astrolabes, the navigational measurements should have been more accurate. In any event, the fatal march of Melchior Díaz a year later seems to rule out any possibility that Lake Cahuilla ever existed in Ulloa's time.

It would, however, seem possible (in theory, at least) that Spanish vessels could have sailed up the outlet channel of Lake Cahuilla and entered the lake, had it been in existence, since some of these ships were of very small dimensions by today's standards. Two of Ulloa's three ships reached the head of the gulf and one of these, the *Trinidad*, displaced only 35 tons. An even smaller vessel, the *Santo Tomás*, displacing only 20 tons, was damaged in a storm and blown far to the south (Wagner 1929:12). Vessels of this size presumably could have navigated the shallow waters of the delta and entered the outlet of Lake Cahuilla. Such a voyage could account for the origin of a myth to this effect recorded in the last century:

The Cahuillas . . . also have a tradition that long ago white birds bearing little men came sailing over the waters [of Lake Cahuilla] seeking provisions of the Indians, after which they sailed away and they heard of them no more. This indicates ships and sailors, but who could they have been, and from what nation did they come? In view of the probable long time that must have elapsed since there was water in this desert sufficient to float ships, the answer would be mere conjecture [Bowers 1891:230].

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And so the myth remains, even today (O'Dell 1957:147-151). Homer Aschmann has suggested to me that this tale might have originated among the Cocopah or other groups of the Colorado Delta, and only later been transferred to the Cahuilla. This would seem a reasonable explanation.

Carter (1964) also suggested that the presence of Lake Cahuilla might have contributed to the notion that California was an island separated from the mainland by the Strait of Anian, as portrayed by seventeenth century map makers the world over (Leighly 1972). While there remain certain intriguing aspects of the history of the Colorado Delta region, it seems most reasonable to conclude that the Colorado River had already ceased flowing into Lake Cahuilla when the Spanish frontier reached the head of the Sea of Cortez in 1539.

### Cross-Dating

An attempt was made to cross-date the most recent stand of Lake Cahuilla with shell beads and other ornaments. Twenty-six lots of shell artifacts from Coachella Valley originated in archaeological contexts which suggested association with recent stands of the lake. For the most part, these were surface collections made from archaeological sites on or adjacent to the shoreline. The samples were selected because of proximity to the shoreline. Many were in clear association with aquatic remains, such as fish bone, burned *Anodonta* valves, etc. Some historic items were expected to occur in the sample because ethnographic Cahuilla villages were located at Indian Wells and in the vicinity of Indio, where the collections were made. Some of the shell items were grave offerings associated with cremations exposed over the years by deflation of the sandy shoreline deposits.<sup>6</sup> One lot came from the excavated site of Wadi Beadmaker, but the lack of contextual association of some of the surface collections is recognized.]

Shell  
beads

Many of the shell artifacts were manufactured by the ancestral Chumash Indians of the Santa Barbara Channel region of the Pacific coast of southern California. These beads had both decorative and monetary value in the aboriginal cultures through which they were exchanged, and their styles changed markedly over time.] Studies of the beads and other ornaments from coastal sites have resulted in a working chronology of styles. Earlier shell artifacts are placed in time by radiocarbon. Later shell and glass beads are dated by both radiocarbon associations and historical records, including mission registers. Seriation of individual lots has helped to refine the chronology.

Not all of the shell artifacts examined originated on the Pacific coast. Some of them were made from the valves of molluscs whose distributions are restricted to the Gulf of California, but the chronology of the artifacts made from gulf species is less well known. In the Southwest, where cultural chronology has been worked out to a high degree of precision by means of tree-ring correlations and ceramic stratigraphy, artifacts of gulf shell are widely distributed. The problem with extending this refined chronology to shell artifacts and cross-dating into the southern California deserts stems from the fact that shell artifacts are generally not well described in literature. This makes it difficult to correlate types.<sup>7</sup> Probably some day it will be possible to date inland southern

California sites by cross-dating into the southwestern chronology by means of Gulf of California shell artifacts; however, for the present, one must rely largely on comparisons with the Santa Barbara Channel region. One rather common form of shell ornament in archaeological deposits at Lake Cahuilla is made by grinding both ends from the valve of the Gulf of California gastropod *Olivella dama*. The result is a barrel-shaped to cylindrical or even ring-shaped bead. Haury (1976:309) reports similar ornaments from Santa Cruz and Sacaton Phase (A.D. 700-1100) deposits at the Hohokam site of Snaketown, in Arizona.

The shell artifacts were examined by Chester D. King, and will be reported elsewhere. For the present, it can be noted that no firm dating of the last stand of Lake Cahuilla is possible due to the lack of definite temporal association of certain of the bead lots with the lakeshore, and the long time span in which many of the ornaments were manufactured. Most of the lots, however, were judged to be equivalent with Phase 1 of the Late Period of the Santa Barbara Channel region, or roughly within the interval A.D. 800 $\pm$ 100 to 1500 $\pm$ 100. The Pacific coast specimens in the small assemblage from the excavated site of Wadi Beadmaker dated to this period. The few items which could be cross-dated into the southwestern sequence were in use during, or limited to, this period of time also. Thus, there is general agreement between this method of dating and the dating of the last two lacustral intervals of the Salton Basin as established by radiocarbon dating.

A few lots comprised or included shell items of later periods, including the Historic Period of the Santa Barbara coast, which for practical purposes begins about A.D. 1785, or roughly when the Spanish missions were established in that region. For reasons already stated, this was as expected. Most of the analyzed lots are probably contemporaneous with one or more recent lake stands, and date to some portion of the interval A.D. 800 $\pm$ 100 to 1500 $\pm$ 100, based on correlations with the Santa Barbara Channel region. More precise determinations based on cross-dating of shell artifacts are not at present possible.

Two other categories of artifacts from lakeshore contexts provide limited information for dating the recent stand of Lake Cahuilla. These are projectile points and ceramics, neither of which is as precisely datable as certain shell artifacts.

Examination of projectile point collections from the shore of Lake Cahuilla reveals that nearly all of these fall into the Desert Side-notched series, originally defined as a type with four variants by Baumhoff and Byrne (1959), and the Cottonwood series, originally defined by Lanning (1963). Both of these styles originated about A.D. 1000, as indicated by published radiocarbon dates associated with them (Hester 1973:35-37), and continued in use into historic times. In their discussion of the time periods in inland southern California prehistory, Bettinger and Taylor (1974) placed the origin of these point styles at A.D. 1300. This is undoubtedly conservative, in view of the fact that similar projectile points occurred in large numbers in Sedentary Period Hohokam contexts (A.D. 900-1100) in Painted Rocks Reservoir on the Gila River near Gila Bend, Arizona (Wesley and Johnson 1965:30). The projectile points recovered from the site of Wadi Beadmaker were exclusively of

these two styles, and serve therefore to date the site to some time after A.D. 900.

To date, only one ceramic assemblage from a shoreline site at Lake Cahuilla has been studied in detail, namely that from Wadi Bead-maker (King 1975). Of more than 900 sherds studied, nearly all of them were classified as Tumco Buff and Tumco Stucco after Schroeder (1952), with the former predominating. These styles are thought to have originated prior to A.D. 900, and Tumco Buff is thought to have been manufactured until perhaps at least A.D. 1450.

While these additional artifact categories are useful in providing a general chronological framework for shoreline sites associated with the last stand of Lake Cahuilla, they are not as time-sensitive as the shell artifacts, and can only be considered to augment and support dates derived from other means.

### Summary

Radiocarbon data suggest that there have been three lacustral intervals in the Salton Basin representing an unknown number of stands of Lake Cahuilla during approximately the last 2000 years. The earliest of these is dated by radiocarbon between 100 B.C. and A.D. 600. The second occurred from perhaps A.D. 900 to 1250. The final lake stand occurred between approximately A.D. 1300 and 1500, to judge from available information. That at least two lake stands separated by dry conditions occurred between A.D. 900 and 1500 is suggested by the occurrence of obsidian from Obsidian Buttes (submerged by the waters of Lake Cahuilla) in archaeological deposits dating to this period at Perris Reservoir a hundred miles to the northwest. A cluster of radiocarbon measurements and the contextual interpretation of sample LJ-99 collected near Travertine Point (discussed above) also suggest that there have been two periods of lake fillings since A.D. 900. Historical records and cross-dates on shell artifacts found in proximity to the lakeshore indicate that the last stand of Lake Cahuilla did not last much, if any, later than A.D. 1500. Thus, while available information does not give a concise historical framework for the recent stands of Lake Cahuilla, it is possible to summarize the data now available. This provisional hydrologic history of the Salton Basin over the last two millenia is shown in Fig. 14.

For the present purpose, and given the available dating information, it seems most reasonable to conclude that the latest period of lacustrine conditions in the Salton Basin occurred between A.D. 1300 and 1500. It came to a close shortly before the Spanish exploration reached the Lower Colorado in 1540.

### POST-LAKE CAHUILLA TIME

The recession of Lake Cahuilla is seen as a time of accelerated environmental changes. Present evidence would suggest that the lake dried essentially in the late fifteenth and early sixteenth centuries. Within perhaps 55-60 years the waters became saline, marshes disappeared,

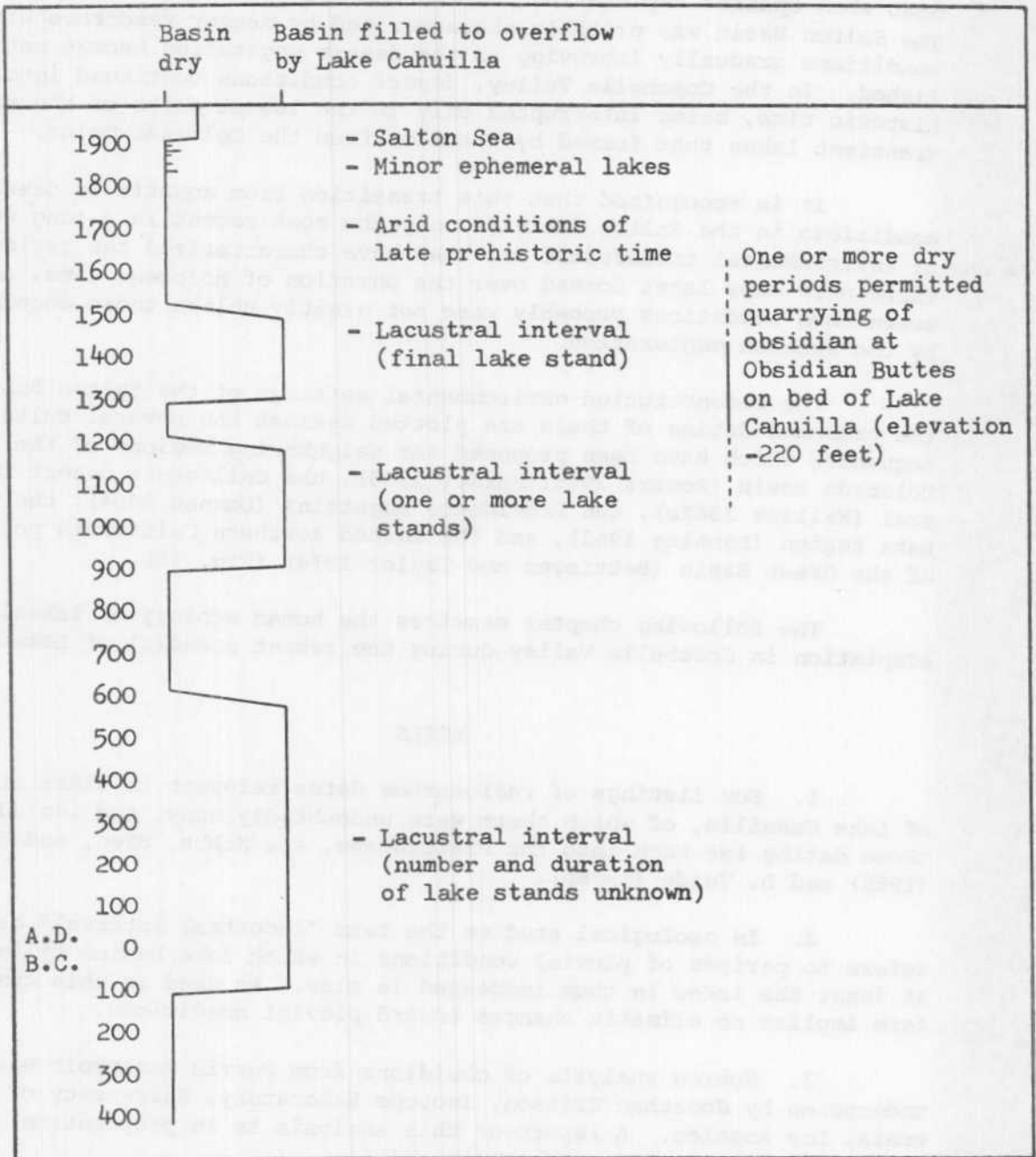


Fig. 14. Hydrologic history of the Salton Basin during the last 2000 years, as reconstructed in this text.

fish and shellfish died, aquatic birds sought better conditions elsewhere, the lake was reduced to a playa, and Colorado Desert vegetation invaded the lakebed. The transition from aquatic to typical Colorado Desert conditions probably required less than a century, assuming that the drying of Lake Cahuilla occurred in 55-60 years and a lag of several decades occurred as the desert vegetation became well established.

The return to desert conditions apparently had occurred by A.D. 1540 when Spanish exploration reached the southern end of Imperial Valley. The Salton Basin was probably characterized by meager resources with conditions gradually improving as the desert vegetation became established. In the Coachella Valley, desert conditions continued into historic time, being interrupted only in the lowest parts of the sink by transient lakes that formed by overflow from the Colorado Delta.

It is recognized that this transition from aquatic to desert conditions in the Salton Basin is only the most recent in a long series of environmental transformations that have characterized the region. There were many lakes formed over the duration of Holocene time, and between them conditions probably were not greatly unlike those encountered by the Spanish exploration.

The reconstructed environmental settings of the Salton Basin and the presumed dating of these are plotted against the several cultural sequences which have been proposed for neighboring regions of the Lower Colorado Basin (Rogers 1945; Harner 1958), the California Desert in general (Wallace 1962b), the Providence Mountains (Donnan 1964), the Owens Lake region (Lanning 1963), and the inland southern California portion of the Great Basin (Bettinger and Taylor 1974) (Fig. 15).

The following chapter examines the human ecology of lakeside adaptation in Coachella Valley during the recent stand(s) of Lake Cahuilla.

#### NOTES

1. For listings of radiocarbon dates relevant to older stands of Lake Cahuilla, of which there were undoubtedly many, and including those dating far back into the Pleistocene, see Hubbs, Bien, and Suess (1965) and D. Weide (1976b).
2. In geological studies the term "lacustral interval" generally refers to periods of pluvial conditions in which lake basins filled, or at least the lakes in them increased in size. As used in this text, the term implies no climatic changes toward pluvial conditions.
3. Source analysis of obsidians from Perris Reservoir was kindly undertaken by Jonathan Ericson, Isotope Laboratory, University of California, Los Angeles. A report of this analysis is in preparation.
4. Determining calendar date from radiocarbon age determinations is accomplished by working backward from data provided by Suess (1970). He originally determined the radiocarbon content (the unknown) of bristlecone pine tree rings of known age. From his long series of dated samples, it is possible to match the apparent radiocarbon age of any sample at hand with the approximate calendar years in which comparative amounts of radiocarbon were in the atmosphere, thus converting radiocarbon age into calendar date.
5. Not all investigators accept Suess' interpretations of the minor fluctuations or oscillations he believes he sees in the past radio-



Environmental Conditions in the Salton Basin  (this text)	California Desert Cultural Sequences					
	Lower Colorado Basin  (Rogers 1939)	Lower Colorado Basin  (Harner 1958)	California Deserts  (Wallace 1962b)	Providence Mountains  (Donnan 1964)	Owens Lake Region  (Lanning 1963)	Interior Southern California (Bettinger and Taylor 1974)
A.D. 1900	Desert (lake dry)	Yuman III	Historic	Historic	Late Cottonwood	Marana
1800				Shoshonean Horizon	Early Cottonwood	
1700	Lake Cahuilla (dry)	Yuman II	Period IV - Prehistoric Yuman and Shoshonean	Yuman Horizon	Late Rose Spring	Haiwee
1600						
1500	Lake Cahuilla (dry)	Yuman I	Period III Amargosa	Non-ceramic Yuman	Middle Rose Spring	Newberry
1400				Bouse 2		
1300	Lake Cahuilla (dry)	Yuman I	Period III Amargosa	Amargosa	Middle Rose Spring	Newberry
1200						
1100	Lake Cahuilla (dry)	Yuman I	Period III Amargosa	Amargosa	Middle Rose Spring	Newberry
1000						
900	Lake Cahuilla (dry)	Yuman I	Period III Amargosa	Amargosa	Middle Rose Spring	Newberry
800						
700	Lake Cahuilla (dry)	Yuman I	Period III Amargosa	Amargosa	Middle Rose Spring	Newberry
600						
500	Lake Cahuilla (dry)	Yuman I	Period III Amargosa	Amargosa	Middle Rose Spring	Newberry
400						
300	Lake Cahuilla (dry)	Yuman I	Period III Amargosa	Amargosa	Middle Rose Spring	Newberry
200						
100	Lake Cahuilla (dry)	Yuman I	Period III Amargosa	Amargosa	Middle Rose Spring	Newberry
0						

Fig. 15. Correlation of reconstructed environmental conditions in the Salton Basin with postulated California Desert cultural sequences.

carbon content of the atmosphere based on measurements of the radiocarbon activity of tree rings of known age (see, for example, Ralph 1971:27). In the absence of any better method of correlating radiocarbon age with true age, the Suess curve is employed here and will continue to be used until proven incorrect or otherwise unsatisfactory.

6. These cremations were subsequently reinterred in the Torres-Martinez cemetery.

7. Many of these are simply identified to the generic level, which in the case of olivellas is not sufficient to determine whether the shells originated on the Pacific coast or on the Gulf of California.

## Chapter IV

### LATE PREHISTORIC HUMAN ECOLOGY AT LAKE CAHUILLA

In this chapter we shall examine the ecology of lakeside adaptation in Coachella Valley at prehistoric Lake Cahuilla during its most recent high stand. The data to be considered are drawn from analysis of human coprolites and midden deposits obtained in shoreline campsites at the Myoma Dunes near present Indio; at Wadi Beadmaker, a fishing site in the Dos Palmas embayment on the northeast shore; at the Bat Caves Buttes, a former island off the northeast shore of Lake Cahuilla; and at Traver-tine Rock, a small islet near the west shore, just west of the present Salton Sea (Fig. 3).

coprolites

#### 1. THE MYOMA DUNES

At the northwest end of Lake Cahuilla, bordering the former shoreline and stretching from the vicinity of present La Quinta to well northwest of the town of Indio, a distance of nearly ten miles, is a region of accumulated sand derived from the Whitewater River drainage in the upper Coachella Valley. Mounded dunes lacking slip faces apparently were formed by deposition among mesquite (*Prosopis glandulosa*) thickets that grew in response to the high water table during the recent stands of Lake Cahuilla. The mesquite continued to crown out of the tops of the dunes as they gradually rose to heights of up to 35 or 40 feet. Many of the mesquite thickets that crown these dunes have ring-shaped growth patterns many yards across. They are probably clones, arisen from a single plant, and if so, are not less than 500 years old. There are also interdune basins with elevations of less than +42 feet, the level of the last stand of Lake Cahuilla. These evidently contained water during the recent lake stand. The +42 foot contour winds along the easterly side of the dune field and represents the actual former shoreline. The gradient of the floor of Coachella Valley in this region is quite gradual, and the undulating shoreline and adjacent shallows was the scene of a rather extensive Freshwater Marsh plant community (Figs. 3, 13, 16).

mesquite dunes

[Reconnaissance in the dunes revealed an almost continuous belt of archaeological sites, including shallow middens of *Anodonta* shells, vast scatters of ceramic sherds, burned rocks, and other artifacts, and bones of birds, fish, and other animals. These remains are normally buried within the dunes, but where the anchoring mesquite cover has died, or where the wind has cut into the deposits, the materials are exposed on the surface to be sandblasted into fragments with each new storm. The northwest faces of the dunes are most susceptible to such deflation because of the direction of the prevailing wind, and many of these deflating surfaces show abundant evidence of former occupation.] Sometimes when the wind blows strongly from another direction, as, for example, from the southeast, sites which normally are immense scatters of artifacts and

salt path

food remains are completely covered with sand and the opposite slopes of the dunes show the only evidence of former occupation. Thus, archaeological reconnaissance in this region is to some extent a hit-or-miss venture, depending on which way the winds have recently blown.

Since all the heavier materials exposed by deflation of the dunes settle to a common level, items of various ages occur together on the same deflated surface. Despite this fact, ceramics, shell artifacts, and occasional small projectile points of the Cottonwood and Desert Side-notched series date most of the exposed materials to about A.D. 900 or later. Occasionally items are seen which apparently date to earlier stands of Lake Cahuilla, but there is the growing conviction that the main sand deposits formed along and just back from the shore of the lake during the recent lacustral intervals. By locating cultural deposits in the process of deflation, materials relevant to a particular time plane can sometimes be obtained. Attention for this study focused on the Myoma Dunes, a locality just north of the former railway siding of Myoma. This is in turn just northeast of the present Bermuda Dunes Airport.

The Myoma Dunes locality was largely destroyed a few years ago in the course of highway construction. Some of the main dunes bearing cultural material were simply hauled away to be used for road fill. What remains today is but a remnant of a vast occupation zone. Several substantial shell middens and a bed of paired valves representing clam beds stranded by the receding lake were also destroyed. It was at the Myoma Dunes that a deposit of human coprolites was exposed where the mesquite had been removed. Further search disclosed several other such deposits.

The largest coprolite bed, a prehistoric latrine or refuse mound designated Bed A, was visited repeatedly for a period of several years and specimens collected following wind storms. Excavations with trowel and brush also produced large numbers of coprolites, but many of them were simply collected from the surface of the deposit as they were gently exposed by wind. In all, upwards of a thousand specimens were collected from an area about four yards across. The deposit had undergone some decomposition and the majority of the coprolites it contained were too friable to recover. Control stakes set in the deposit indicated that it deflated about two feet or more during the period in which coprolites were collected. At this writing, the deposit slowly continues to deflate, yielding additional specimens.

Coprolite beds B and D were discovered soon after they were exposed on the surface and were excavated in their entirety, yielding about 30 and 50 specimens, respectively. These letter designations are merely labels. They do not imply any stratigraphic position with respect to one another. An attempt was made to date the coprolite deposits by the radiocarbon method, with generally unsatisfactory results, as discussed in the previous chapter. The deposits are probably all of about the same age and are thought to date to some portion of the latest stand of Lake Cahuilla.

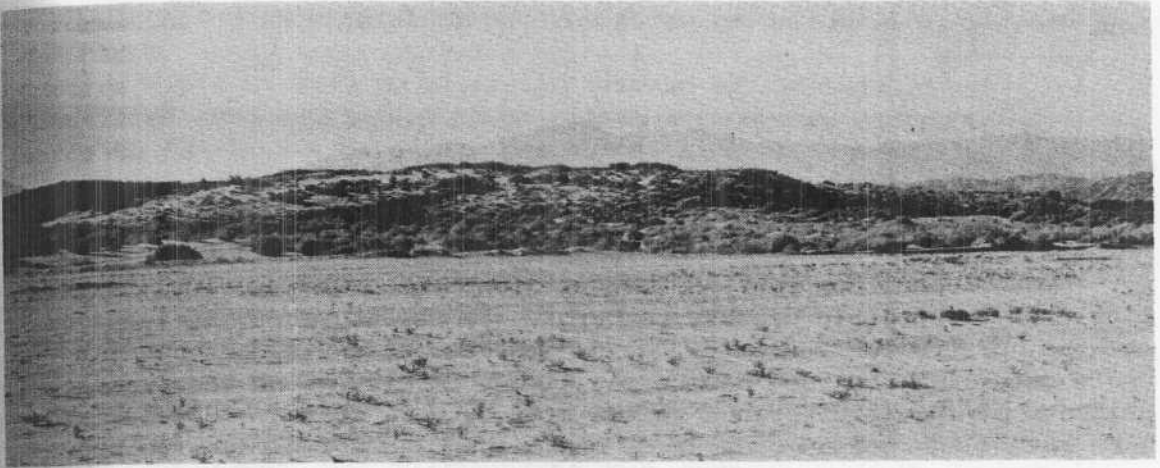


Fig. 16. Views of archaeological sites. Upper: view northwest from the bed of Lake Cahuilla showing the Myoma Dunes and location atop the dune of Coprolite Bed A. Lower: aerial view of Wadi Beadmaker. The site is located on the beach remnant between dissected mesa and Orocopia Wash in lower foreground. Coachella branch of the All American Canal at upper left.

Coprolites are perishable material and have seldom been recovered in open sites north of Peru. The fact that they are preserved at all in the Salton Basin makes the region an important one for research.

#### ANALYSIS OF COPROLITES FROM MYOMA DUNES BED A

##### Coprolites as a Source of Dietary and Paleoecological Information

Human coprolites contain the most complete archaeological record available on prehistoric dietary patterns. In recent years, analyses of coprolites, particularly from dry cave deposits, have yielded abundant evidence detailing the food habits and living conditions of the prehistoric inhabitants of specific regions in the arid western states. Specialized studies reveal the pollen content of coprolites and offer clues to the season of occupation represented at specific sites as well as information on prehistoric environments. It is even possible to recover evidence of endoparasites that afflicted human populations, and the history of such infestations has been worked out in detail for some regions, with the oldest evidence for the New World dating back as much as 10,000 years. The abundant literature on coprolite analysis has been summarized elsewhere (Wilke and Hall 1975).

In the Arid West, studies have been conducted on material from pueblo ruins in Colorado, Utah, and Arizona (e.g., Fry and Hall 1973, Rohn 1971; Callen and Martin 1969). (These analyses show the importance of both wild plant and animal foods and also cultivated plants in the diet. A series of samples spanning the greater part of the last 10,000 years has been analyzed from Danger, Juke Box, and Hogup caves on the margins of the inhospitable Bonneville Desert of western Utah (Fry 1970). These samples show the long-term reliance on such items as pickleweed (*Allenrolfea occidentalis*) seed, pronghorn antelope (*Antilocapra americana*), and other arid lands resources in this region, but the diet represented apparently reflects only the seasonal autumn occupation of the sites in question.) One of the most ambitious coprolite research projects ever undertaken focused on caves overlooking former shallow lakes and marshes in the Humboldt and Carson sinks of west-central Nevada (Napton 1969, 1970; Heizer and Napton 1970). Coprolites from Lovelock, Humboldt, and Hidden caves show that the aborigines of this region relied heavily on bulrush (*Scirpus*), cattail (*Typha*), and other aquatic plants, as well as fish of several species, aquatic birds, and other wetlands resources. There is also reason to believe that a year round diet is represented in the deposits of the caves and nearby open sites, and that the pattern of lake margin and marsh exploitation began in the western Great Basin as early as 2500 B.C. The pattern persisted with increasing intensity until it was destroyed by white intrusion in the nineteenth century.

Except for a few samples from historic deposits in Bamert Cave, Amador County (Nissen 1973), no coprolites have been analyzed from archaeological sites in California.

## Analysis

The coprolites from Lake Cahuilla were analyzed to recover information on aboriginal human ecological conditions, as outlined in Chapter I. Analysis followed essentially the method of Callen and Cameron (1960). The procedure employed is outlined in Appendix A. Identified components of each coprolite were coded on edge-punched cards to facilitate data interpretation. procedure

A total of 77 coprolites was analyzed from Bed A at the Myoma Dunes. Initially, 27 specimens were rehydrated and separated into dietary components in the context of a laboratory class on aboriginal diet reconstruction, conducted by Richard Ambro at the University of California, Riverside. An additional 50 samples were later analyzed. The coprolites were in most cases single, well-formed specimens (Fig. 17). A few consisted of several fragments considered at the time of collection to represent a single coprolite. This may have introduced a slight error in terms of the components represented in several samples (e.g., samples MDA-14, MDA-23), but it would not affect the overall diet represented in the archaeological deposit. Nine samples from Bed A were analyzed by Eugene Hattori (1975) for pollen content. Inasmuch as the coprolites were recovered from a definite latrine deposit only about four yards across, they are probably all of human origin. 77

### CONSTITUENTS OF COPROLITES FROM BED A

A variety of dietary elements, both plant and animal, was recovered from the coprolites analyzed from Bed A. These are described below, together with brief discussions of the nature of the material in each category, relative importance in the aboriginal diet as reflected in the number of samples in which a given item occurred, probable season of acquisition, and use by aboriginal groups in other regions. Floral remains are treated first, followed by faunal remains. A complete listing of all components identified from each sample appears in Appendix B.

#### Floral Remains

Bulrush (*Scirpus* spp.). Seeds identified as hardstem bulrush, also known as tule, or great bulrush (*Scirpus acutus*) (Fig. 18), occurred in 16 (21%) of the 77 samples. The seeds were both whole and fragmentary, but were not heavily milled, and may not have been milled at all. In most cases, they gave the appearance of having been parched, an observation also noted on the material from Lovelock Cave, Nevada (Napton 1970:306), where bulrush seeds of this species and of *S. robustus* were among the most important dietary elements. Apparently the seeds in the Myoma Dunes samples were parched in basketry or ceramic trays by shaking or swirling them around with live coals, a practice that occurred widely across western North America. Charcoal fragments occurred in all but two of the samples containing the seeds of hardstem bulrush. This bulrush is one of the conspicuous plants of freshwater marshes, sometimes forming immense stands of more than 15 feet in height. ✓

Seeds of the softstem bulrush (*Scirpus validus*) (Fig. 18) were also a common element in coprolites from Bed A. The seed was present

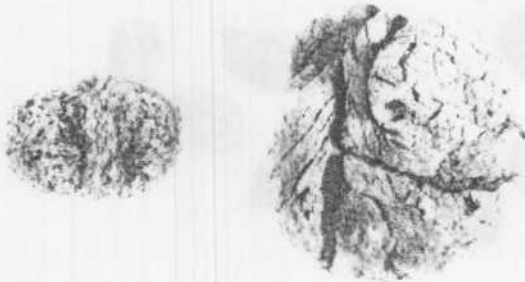


Fig. 17. Human coprolites from the Myoma Dunes, Bed A. Upper: coprolite with abundant hardstem bulrush (*Scirpus acutus*) seed, *in situ*. Lower: coprolites, X0.5; left specimen contains abundant seed of softstem bulrush (*S. validus*); right specimen shows burrowing by coprophagous insects.



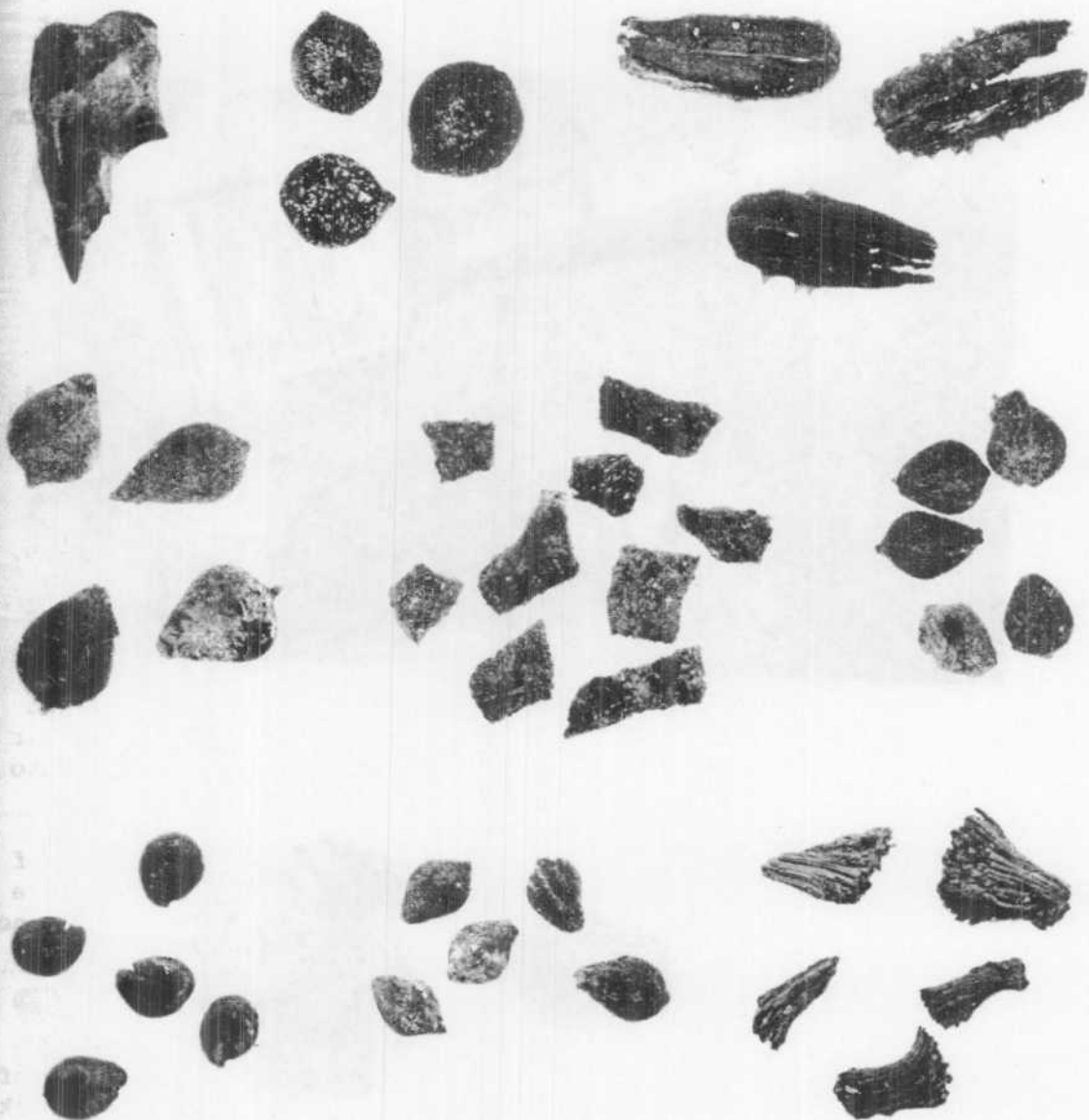


Fig. 18. Dietary remains from Myoma Dunes Bed A. Upper row: proximal ulna fragment of jackrabbit (*Lepus californicus*), X2, MDA-42; seeds of knotweed (*Polygonum* cf. *lepathifolium*), X10, recovered by flotation; seeds of *Dicoria canescens*, X7, MDA-103. Second row: seeds of hardstem bulrush (*Scirpus acutus*), X7.5, MDA-1; hull fragments of pinyon nut (*Pinus* cf. *monophylla*), X7, MDA-25; seeds of softstem bulrush (*Scirpus validus*), X7.5, MDA-40. Lower row: seeds of *Oligomeris linifolia*, X20, MDA-9; seeds of California bulrush (*Scirpus californicus*), X7.5, MDA-14; anthers of cattail (*Typha* sp.), X8, MDA-123.

in 23% of the samples, usually in small amounts. It was also frequently parched, and was often intact. The softstem bulrush has pliable culms that were fashioned into remarkably lifelike canvasback duck decoys at Lovelock Cave (Loud and Harrington 1929). It was also apparently this species, along with the hardstem bulrush, that was tied into bundles, which were then laced together to form tule balsas, a water craft common to much of the Great Basin and California. Such craft were probably used by the lakeshore inhabitants to reach the island rookery at the Bat Caves Buttes. There is confusion as to the occurrence of this species in California (Mason 1957:324; Munz 1974:903). In view of the abundance of seeds of this species in Myoma Dunes coprolites, it was apparently a common plant in the marshes of Lake Cahuilla.

California bulrush (*Scirpus californicus*) was represented by seed in two samples. This is another very large and widely distributed bulrush species common to many plant communities. It was apparently not a very important item in the diet at the Myoma Dunes, and probably was not a prominent plant in the aboriginal landscape.

Additional occurrences of bulrush seeds of undetermined species, but probably those already listed, were noted in five samples. These were, however, present only in very small quantities, which makes identification difficult.

The seeds of the various bulrushes represented in Lake Cahuilla coprolites come available for harvesting in late summer and fall. Their presence indicates occupation in those seasons and probably also on into the winter, when the stored seeds could be eaten. Bulrush seed was eaten by aboriginal groups across western North America, including the historic Cahuilla (Bean and Saubel 1972:139), and the Northern Paiute of the Great Basin (Stewart 1941). References in ethnobotanical literature frequently describe consumption of the rootstocks of bulrush. No evidence of this was found in the coprolites from Lake Cahuilla, but it may have gone unrecognized.

Cattail (*Typha* sp.). Cattail (*Typha* sp.) was represented abundantly in the coprolites. The minute seeds (Fig. 19) were found in 25% of the samples, usually frequent to abundant, and sometimes forming the bulk of the sample. In most cases, all that remained was the outer seed coat. No evidence of milling was noted, but sometimes the seeds appeared to have been parched or burned. This could result from collecting the heads, or inflorescences, shattering them on a clean surface, and then burning off the floss, or plumes, which ignite with a flash, leaving the seeds lightly toasted. This method of preparing the infinitesimally small seeds for consumption by the Indians of the Great Basin is vividly described in literature (Chamberlin 1911:341, 383; Harrington 1933). The species common in the Coachella Valley today are the narrow-leaved cattail (*Typha angustifolia*) and *T. domingensis*, the latter with characteristically buff-colored seed heads and commonly occurring in saline springs. The seed heads, or inflorescences, remain intact for a considerable time, and could presumably have been collected from summer through fall.

Pollen analysis of coprolites revealed that some of the Myoma Dunes specimens were composed almost entirely of cattail pollen and

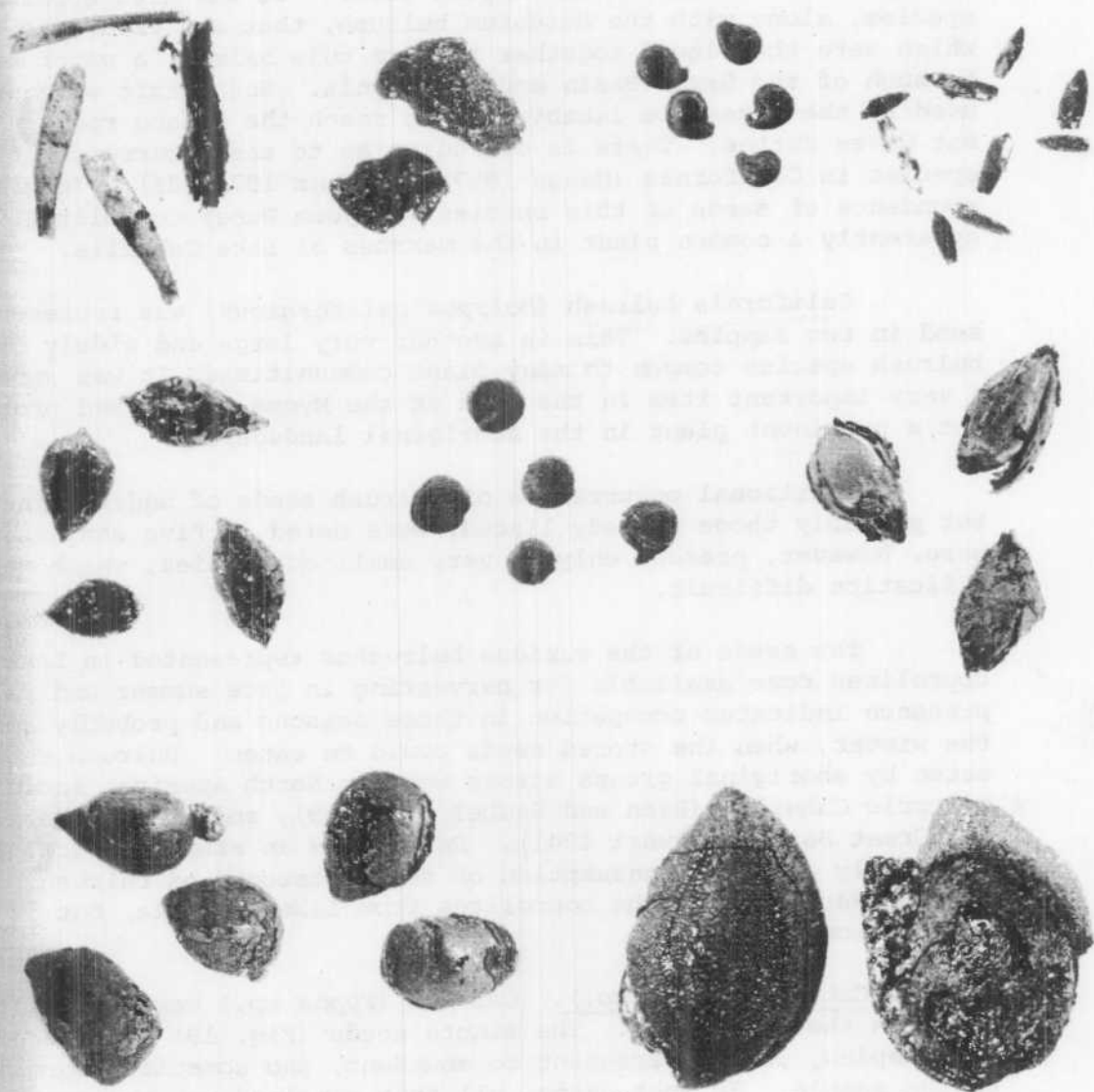


Fig. 19. Dietary remains from Myoma Dunes Bed A. Upper row: Pin feathers, apparently of mudhen (*Fulica americana*), X7.5, MDA-46; fragmentary seeds of barrel cactus (*Ferocactus acanthodes*), X7, MDA-23, MDA-46; seeds of lowland purslane *Sesuvium verrucosum*, X10, MDA-113; seeds of cattail (*Typha* sp.), X10, MDA-1. Second row: seeds of bulrush (*Scirpus robustus*), X7, recovered by flotation; seeds of goosefoot (*Chenopodium glaucum* var. *salinum*), X10, MDA-6; seeds of barnyard grass (*Echinochloa* cf. *crusgalli*), X7, MDA-48. Lower row: carbonized seeds of screwbean (*Prosopis pubescens*), X7, recovered by flotation; carbonized seeds of mesquite (*Prosopis glandulosa* var. *torreyana*) X7, recovered by flotation.



Fig. 20. Dietary remains from Myoma Dunes Bed A. Upper Row: seeds of *Panicum urvilleanum*, X7, recovered by flotation; seeds of amaranth (*Amaranthus* sp.), X20, MDA-29. Lower row: seeds of goosefoot (*Chenopodium nevadense*), X10, MDA-23; bones of Colorado River bonytail chub (*Gila elegans*) fingerlings, X7, MDA-23.

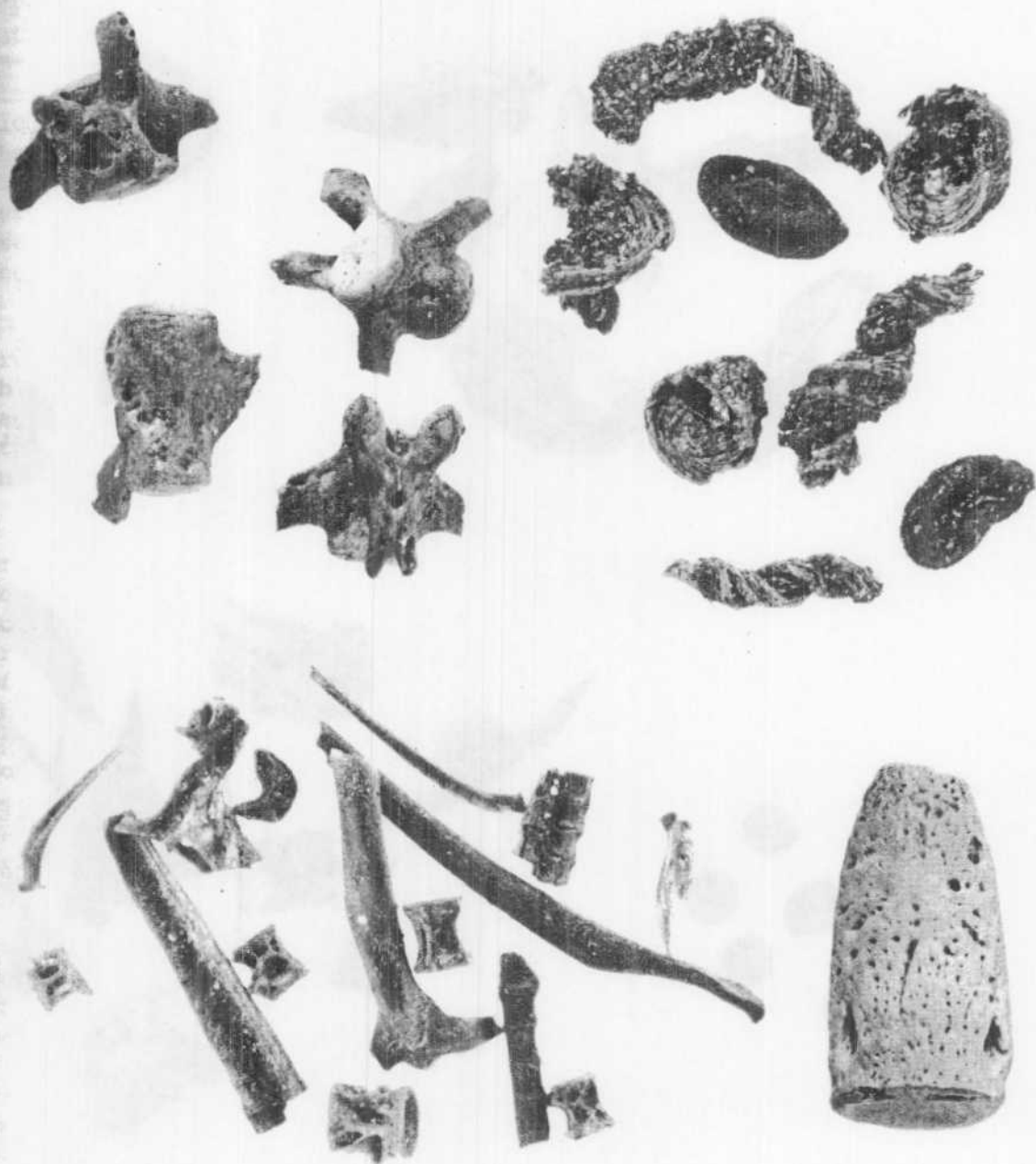


Fig. 21. Dietary remains from Myoma Dunes Bed A. Upper row: small mammal vertebrae, unidentified, X7, MDA-112; pod fragments and seeds of screwbean (*Prosopis pubescens*), X7.5, MDA-112. Lower row: bones of small fish, unidentified, X7, MDA-47; toe bone of tortoise, probably desert tortoise (*Gopherus agassizi*), X4.5, MDA-110

anthers (Hattori 1975). Similar findings were reported for the specimens from Lovelock Cave (Napton and Kelso 1969; Napton 1970:297). Cattail anthers (Fig. 18) were found in 9 coprolites from Bed A. The samples that contained abundant anthers and pollen indicate stripping of the anthers from the flowering heads before pollination occurred. This would place the occupants on the lakeshore in the late spring. Samples containing abundant cattail anthers contained few other dietary remains, suggesting that consumption of the anthers for the pollen they contained may alone have provided an adequate diet at that season. Ethnographic records indicate that the pollen of cattails was collected and baked, whereupon it became hard and sweet like candy (Loud 1929:158; Heizer, in Napton 1970:297). Baked pollen was found in coprolites from Lovelock Cave (Napton 1970:298). The nutritional value of cattail pollen may not have matched its palatability.

The rootstocks of cattails were eaten by many aboriginal peoples, but, as in the case with bulrush, no evidence of rootstocks was found in the coprolites.

It appears that cattails provide food, either as pollen, seeds, or rootstocks, to people the world over, and have done so for thousands of years. The abundant literature on the economic significance of cattails is summarized by Morton (1975).

X Screwbean (*Prosopis pubescens*). Fragments of screwbean pods are easily recognized (Fig. 21), and were noted in 32 (44%) of the samples. In 24 samples screwbean was frequent to abundant. Most of the samples containing screwbean pod fragments also contained the seeds of this species (Fig. 19). [From the nature of the material, it would appear that the pods were only partially ground or consumed fresh without grinding.] The shrivelled seeds would suggest consumption of pods before they reached maturity. Barrows (1900:56) states that the pods "may be eaten with relish as plucked from the tree," being very high in saccharine matter.

Screwbean was a staple among the Cahuilla of Coachella Valley (Bean and Saubel 1972:118-119), among the Kamia of Imperial Valley (Gifford 1931:23), and in the entire region of the Lower Colorado (Castetter and Bell 1951:179-186). Various methods of preparing screwbean for consumption, including pit-curing for a month or more, are described by Bell and Castetter (1937) and Castetter and Bell (1951:184-185). The season for gathering screwbean is about mid-summer. It was clearly a staple food item at the Myoma Dunes.

Screwbean grows best where there is a very high water table, requiring this even more than its relative, the honey mesquite (*P. glandulosa* var. *torreyana*). It apparently grew in vast stands where the water table was raised to the northwest of the Myoma Dunes.

f Mesquite (*Prosopis glandulosa* var. *torreyana*). Wherever it occurred, the honey mesquite was a favorite food among the Indians of the western deserts, and one not usually susceptible to crop failure. It was probably important at the Myoma Dunes also, although little evidence of it was found in macroscopic analysis of the coprolites. The seeds, or fragments of them, were found in only three samples. In view of the

method of preparing mesquite beans for consumption, the seed would be expected to occur in low frequency even if it were a staple food. Mature mesquite beans were pounded in a wooden mortar by the Cahuilla (Bean and Saubel 1972:110), a process which reduced the bean or pod to flour, but the highly resistant seeds were usually not cracked. The flour from the bean was actually the desired commodity, and the seeds themselves were either steeped in water to make a drink, further ground with milling stones, or discarded. The seeds found in the coprolites were possibly accidental ingestions, but even so, they would indicate use of mesquite for food at the Myoma Dunes. It is today, and has long been, a dominant part of the landscape in the immediate area.

*Prosopis* sp. pollen was observed in two samples from Bed A. Crushed grains indicate consumption of pollen before pollination occurred. This suggests the eating of mesquite blossoms, as described by Bean and Saubel (1972:108). Blossoms were the first of three harvestable food items produced by mesquite plants (blossoms in April and May; green pods in early summer; mature pods in mid-summer).

Witchgrass (*Panicum capillare*). The small caryopses, or seeds, of this grass (*Panicum capillare* var. *occidentale*) (Fig. 22) occurred in more than 19% of the samples, usually recognizable only in trace amounts, but palea and lemma fragments assigned to the species occurred with greater frequency. The seeds were apparently milled. Judging from the habits of this species, it must have been quite common in moist places along the shore of Lake Cahuilla. The seeds compared favorably with herbarium specimens from the vicinity of Riverside, and the identification is considered firm. The grains occur in very large panicles and should have been easily collected with a seed-beater. In terms of seasonality, this species is variable, mature seed appearing from late spring through early fall.

*Panicum urvilleanum*. The large seeds of this hairy perennial grass (Fig. 20) occurred in two samples. Sample MDA-8 was composed almost entirely of seed of this species, and most of it was fragmentary. Bean and Saubel (1972:98-99) report that the grains were singed to remove the hairs and then prepared as a gruel. The grains from sample MDA-8 compare favorably with material recovered from an olla found a few years ago near Palm Springs.<sup>1</sup> The grains of both of these samples had clearly been exposed to heat, probably by parching. Observation of a stand of *Panicum urvilleanum* near Thousand Palms over a three-year period indicated that the seed fell around the first of May. Presumably this was the time of collection of the material recovered from Bed A. Additional examples were recovered by flotation of Bed A residues.

Barnyard Grass (*Echinochloa crusgalli*). Seeds of *Echinochloa* (Fig. 19) were found in low frequency in one sample only. Of the two principal species they might represent, it is probably *E. crusgalli* since most authorities (Hitchcock 1950:712; Munz 1974:964) indicate that *E. colonum* is introduced in America. The caryopses contain 11-15% protein (Earle and Jones 1962:224). Flowering is indicated from July to October (Munz 1974:964). Collection of seed would therefore have occurred from late summer to fall. The plant frequents wet places. The seeds were eaten by the Owens Valley Paiute (Steward 1933:243) and by the tribes of the Lower Colorado region (Castetter and Bell 1951:187, 190).

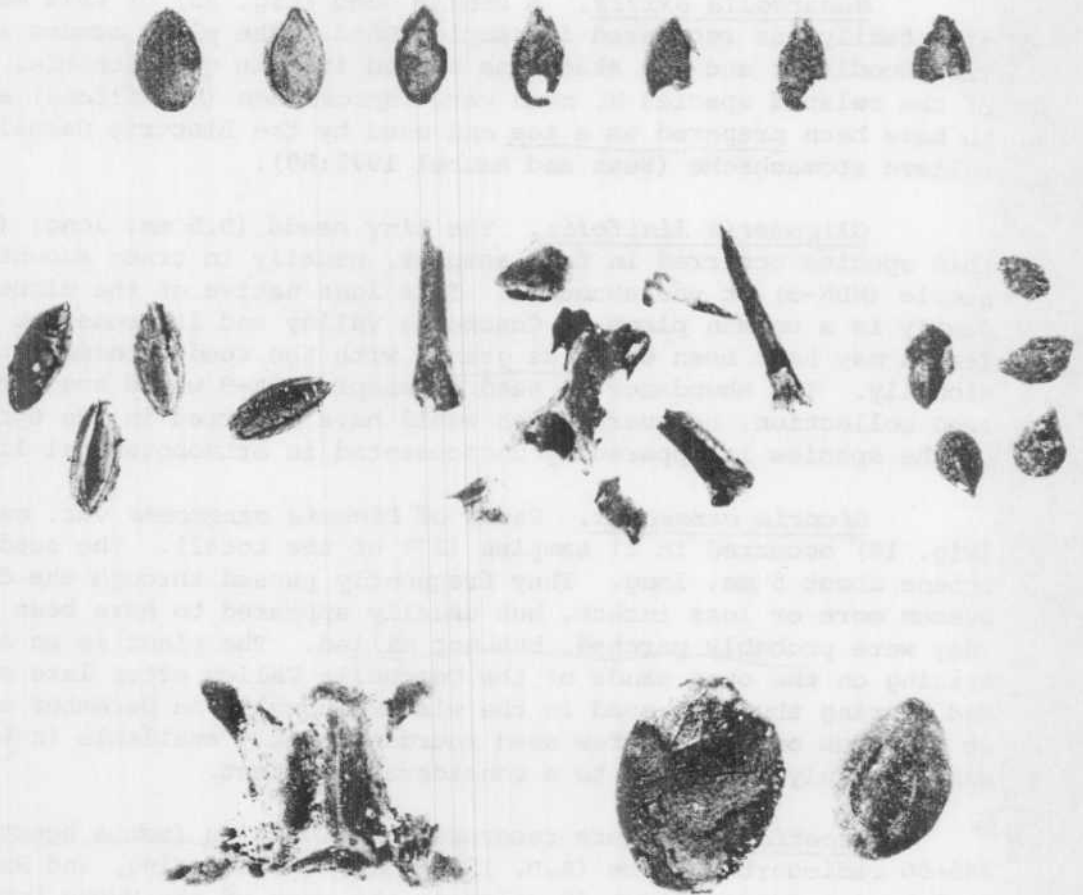


Fig. 22. Dietary remains from Mycna Dunes Bed D. Upper row: seeds of cultivated squash (*Cucurbita pepo*), X.85, recovered by screening. Second row: seeds of witchgrass (*Panicum capillare*), X10, MDD-6; bones of mudhen (*Fulica americana*), X2, MDD-10; seeds of dock (*Rumex cf. salicifolius*) X10, MDD-4. Lower row: vertebra of small reptile, unidentified, X7, MDD-12; carbonized seeds of senna (*Cassia cf. covesii*), X7, left specimen recovered by flotation from Bed A, right specimen recovered by screening from Bed D.



Saltgrass (*Distichlis spicata* var. *stricta*). A single seed of saltgrass was found in sample MDA-14. The plant was a source of salt for western Indians (Heizer and Rappaport 1962; Bean and Saubel 1972:66), and the seed may have been an accidental ingestion. Plants in the Salton Basin, where saltgrass forms a dense ground cover, frequently reproduce vegetatively, the mature seed appearing on occasion.

*Monardella exilis*. A single seed (Fig. 23) of this member of the mint family was recovered in sample MDA-2. The plant occurs in Joshua Tree Woodland, and its status as a food item is questionable. The leaves of the related species *M. nana* var. *leptosiphon* (*M. villosa*) are reported to have been prepared as a tea and used by the historic Cahuilla to relieve stomachache (Bean and Saubel 1972:89).

*Oligomeris linifolia*. The tiny seeds (0.5 mm. long) (Fig. 18) of this species occurred in four samples, usually in trace amounts. In one sample (MDA-9) it was abundant. This lone native of the mignonette family is a common plant in Coachella Valley and its somewhat fleshy leaves may have been eaten as greens with the seeds consumed unintentionally. The abundance of seed in sample MDA-9 would suggest deliberate seed collection, however, which would have occurred in the spring. Use of the species is apparently undocumented in ethnobotanical literature.

*Dicoria canescens*. Seeds of *Dicoria canescens* var. *canescens* (Fig. 18) occurred in 21 samples (27% of the total). The seed is an achene about 5 mm. long. They frequently passed through the digestive system more or less intact, but usually appeared to have been chewed. They were probably parched, but not milled. The plant is an annual, arising on the open sands of the Coachella Valley after late summer rains and bearing abundant seed in the winter, usually in December and January. It was thus one of the few seed sources readily available in winter, and was obviously collected to a considerable extent.

Tahquitz  
*Dicoria* seeds were recovered by flotation from a hearth dated at 245±50 radiocarbon years (A.D. 1510-1640) (Wilke, King, and Hammond 1975) at Tahquitz Canyon about 20 miles to the west of the Myoma Dunes. Mary DeDecker (personal correspondence) reports finding a basketry seed bottle containing seed of *Dicoria canescens* var. *clarkae* in the Last Chance Mountains, which border Eureka Valley, about 250 miles to the north. Hough (1898) reported use of the seeds of the related species *Dicoria brandegei* by the Hopi of Arizona. Use of the genus is only beginning to be documented in California. The seeds have a strong, somewhat pungent taste, which may have been improved by parching. On the lateral margins of the seed is a thin, papery wing which appears on many specimens from the coprolites to have been burned off, leaving a more resistant sawtooth edge. Because of its appearance, bugseed is sometimes given as a common name.

Las  
Barrel Cactus (*Ferocactus acanthodes*). Fragmentary seeds of barrel cactus (Fig. 19) were noted in two samples. These seeds are very diagnostic and there is no mistaking them for the seeds of any other local species. The buds of barrel cactus were picked just before blossoming in April and parboiled to remove bitterness by the historic Cahuilla (Bean and Saubel 1972:67-68). The mature fruit is a capsule containing nearly a tablespoonful of shining black seeds. These can be collected



Fig. 23. Additional components of Lake Cahuilla coprolites. Upper row: very large vertebrae and pharyngeal tooth of Colorado River bonytail chub (*Gila elegans*), X3.5, WB-9; fecal pellets of coprophagous insects, X7, MDA-26. Second row: seeds of goosefoot (*Chenopodium chenopodioides*), X10, MDA-9; seeds of *Monardella exilis*, X20, MDA-2; seed of sow-thistle (*Sonchus oleraceus*), X10, intrusive in MDA-109; red flour beetle (*Tribolium castaneum*), X6.5, probably intrusive, MDA-108; Lower: insect remains, unidentified, but possibly also of the red flour beetle, and probably intrusive, X10, MDA-7.

in May and June in the low desert, and this apparently accounts for the seeds recovered.<sup>2</sup> Earle and Jones (1962) found that the seeds of *Ferocactus* sp. contain about 18% protein and 17% oil, making them very nutritious indeed.

Opuntia sp. A single seed of *Opuntia* occurred in sample MDA-107. This would represent one of the chollas or prickly-pears, as both belong to the same genus. The mature fruits of various chollas were collected by historic Cahuilla and eaten in early summer (Bean and Saubel 1972:95-97). The mature fruits of certain prickly-pears were also eaten, both by the Cahuilla and also by the tribes of the Lower Colorado (Castetter and Bell 1951:206-207).

Pinyon Pine (*Pinus* cf. *monophylla*). Objects identified as fragments of pinyon pine nut hulls (Fig. 18) occurred in 17 samples (22% of the total). These are probably of *Pinus monophylla*, which grows abundantly on the desert slope of the Santa Rosa Mountains and is also present on the crest of the Little San Bernardino. The related species *P. quadrifolia* is less abundant. The hull fragments are probably accidental ingestions, but they document the importance of pinyon nuts in the diet of the lake dwellers. Pine nuts were obtained in quantity in early fall by historic Cahuilla (Bean and Saubel 1972:102-105), and were an important winter food across much of eastern California and the Great Basin. Hulled pine nuts contain about 60% fat according to Zigmund (1941:32). Production of pine nuts is irregular, ranging from super-abundant to none at all; thus, little reliance could be placed on them as a regular and reliable resource.

Lowland Purslane (*Sesuvium verrucosum*). The seed of lowland purslane (*Sesuvium verrucosum*) (Fig. 19) occurred in 25 samples (32% of the total), and was frequent to abundant in 12. It was one of the most common dietary items recovered. The seeds, about 1 mm. long, black, and shining, were frequently intact. The plant occurs on alkaline soils of low elevation. Seed production is variable in terms of seasonality, occurring from spring through fall. Presumably, the plant flourished in the flats to the northwest of the Myoma Dunes when the water table was high during the last stand of Lake Cahuilla. Its use does not seem to be documented in ethnobotanical literature. Seeds of this species were recovered by flotation from a hearth dated at 245±50 radiocarbon years (A.D. 1510-1640) at Tahquitz Canyon (Wilke, King, and Hammond 1975).

Goosefoot (*Chenopodium* spp.). *Chenopodium* seed was a common dietary element recovered from the Bed A coprolites. Several species were identified. *Chenopodium glaucum* var. *salinum* (Fig. 19) was identified in the residues of six (7%) of the samples, and was frequent to abundant in five. The plant occurs on low alkaline flats and was apparently obtained locally. It flowers from July to October (Munz 1974:363), and would therefore have been collected in late summer and autumn. *Chenopodium nevadense* (Fig. 20) was identified with confidence from three samples, one of which (MDA-105) contained little else. Today this species occurs occasionally in valleys in the region of the Inyo and White Mountains (Munz 1974:364). Its presence at the Myoma Dunes would imply a former range farther south. *Chenopodium chenopodioides* (Fig. 23) was identified in two samples. This species frequents moist alkaline places

usually above 5000 feet elevation and occurs on the edge of the deserts. It was possibly not obtained locally, but in the adjacent uplands. Additional occurrences of *Chenopodium* seed of undetermined species occurred in 10 samples. Seeds of this genus, especially after passage through the digestive tract, are at best difficult to identify with confidence. *Chenopodium* species have a protein content ranging from about 12-19% (Earle and Jones 1962). Several species of *Chenopodium* not found at the Myoma Dunes contain strong anthelmintic substances effective in purging parasitic worms from the digestive tract (Krochmal, Paur, and Duisberg 1954; Kliks 1975).

Species of *Chenopodium* not found at the Myoma Dunes were collected and ground for flour by the historic Cahuilla (Bean and Saubel 1972:52-53). Young shoots of *Chenopodium* species were eaten as greens by the tribes of the Lower Colorado (Castetter and Bell 1951:202). Seed of various species was an important resource across the entire Great Basin (Steward 1938:23).

Amaranth (*Amaranthus* sp.). Seeds tentatively identified as amaranth, or pigweed (Fig. 20), occurred in four samples (5% of the total). There are several species of this genus native to southeastern California, notably *A. californiensis*, *A. fimbriatus*, *A. palmeri*, and *A. watsonii*. The seeds of these species are generally borne in late summer and fall. Historic Cahuilla used *A. fimbriatus*, which they parched, ground for flour, and made into mush. The quelite of the Lower Colorado tribes, the greens and seeds of which were gathered extensively for food, is *A. palmeri* (Castetter and Bell 1951:189-190).

Mistletoe (?) (*Phoradendron*). Three apparent fruits of mistletoe were found in sample MDA-33. The common mistletoe that infests mesquite and palo verde in Coachella Valley is *Phoradendron californicum*. The confused ethnobotanical literature on this species is summarized by Bean and Saubel (1972:101). Inasmuch as the fruit of the mistletoe is said to be toxic (Hardin and Arena 1969:76), perhaps the species was used more for its medicinal qualities than for food. The occurrence in sample MDA-33 may be spurious, but some sources indicate use of *Phoradendron* for food.

### Faunal Remains

Mudhen (*Fulica americana*). Bones of the mudhen, or coot (Fig. 22), occurred in nine coprolites from Bed A (12% of the total). Both adults and immature individuals are represented. The identified elements include the foot bones of the young, suggesting consumption of the entire bird. The age of the young indicates they were taken about late August or early September. The adults cannot be seasonally dated. Mudhens dominated the avian remains in the coprolites. Feathers (Fig. 19) apparently representing mudhens were found in two samples containing the bones of this species. Mudhens frequent shallow freshwater lakes and are fond of bulrush seed and submerged vegetation (Martin, Zim, and Nelson 1951:74-75). Steward (1938:127) reported that communal mudhen drives were held among the Shoshoni of Spring Valley, Nevada, and Scott (1966:23-25) described such a drive among the Northern Paiute of the Humboldt Sink, west-central Nevada. Scott noted that after a successful mudhen drive in which many were taken in nets, large numbers of the birds were dried for winter use.

In the festivities that followed, the people "danced and chewed mudhen bones for three days." Driving would seem to have been an effective method of acquiring the still flightless young, and may have been employed at the Myoma Dunes. Adult mudhens lumber skyward after a long run on the surface of the water. This mode of takeoff makes them susceptible to capture in nets raised ahead of a startled flock. signature

Eared Grebe (*Podiceps caspicus*). Bones of an immature eared grebe in sample MDA-124 comprise the only other bird remains identified with certainty in the Bed A coprolites. Remains of an immature mudhen occurred in the same sample. Eared grebes are residents in the Salton Basin today and would have been residents at Lake Cahuilla also. They feed on fish, aquatic insects, shellfish and molluscs, and crustaceans in clear water. They nest on floating rafts of aquatic vegetation, sometimes in sizable colonies. [Young hatch from about June 29 to July 9 at the latitude of the Myoma Dunes. The young would therefore have been taken about late August or early September] (Charmion MuKusick, personal correspondence; U. S. Department of the Interior 1970; Martin, Zim, and Nelson 1951:48).

Unidentified pin feather shafts occurred in two samples. One of these contained bone fragments of an unidentified bird.

Desert Tortoise (*Gopherus agassizi*). A toe bone identified as that of a large tortoise (Fig. 21) was present in sample MDA-110. This would very likely be the desert tortoise (*Gopherus agassizi*). It is a common reptile of the Creosote Bush Scrub plant community, but seldom occurs as low as the floor of the Salton Basin. Carapace fragments of this species occurred in the midden at Wadi Beadmaker (described below). [Bean (1972) reports that the desert tortoise was eaten by the historic Cahuilla, and its shell used for household utensils and rattles.] An unpublished sketch book of Carl Eytel in the Coachella Valley Historical Society archives describes the abundance of tortoise shells lying about on the site of the Indian rancheria at Twenty-nine Palms about 1907 (Horace Parker, oral communication). X

Black-tailed Jackrabbit (*Lepus californicus*). Bones of black-tailed jackrabbit (Fig. 18) were recovered from six coprolites (nearly 8% of the total). In two samples the bones were of immature individuals. Jackrabbits are susceptible to being driven into nets (arranged into a large enclosure) and clubbed to death. [Jackrabbit drives were a characteristic aspect of culture in desert California and the Great Basin (Steward 1938:38-39). Egan (1917:235-237) described such a drive among the Gosiute of western Utah. Jackrabbits could also be shot with the bow and arrow, but their speed and agility made them difficult targets. The throwing stick was also an effective weapon sometimes used in hunting them (Bean 1972:59).

Audubon Cottontail (*Sylvilagus audubonii*). Bones of the Audubon, or desert, cottontail rabbit were identified with considerable confidence in three samples. In one sample they were of an immature individual. This rabbit is not generally susceptible to being driven in the manner that jackrabbits were hunted, and was [probably shot with the bow and arrow, trapped, or taken with a throwing stick.] It commonly occurs

On the floor of Coachella Valley in mesquite thickets, and was probably obtained in the immediate vicinity of the Myoma Dunes. The possibility that the bones represent the brush cottontail (*S. bachmani*) should not be overlooked. This small rabbit occurs from the upper limits of the Creosote Bush Scrub zone on up into the Chaparral, where it is primarily at home. It could thus have been obtained by hunters in the mountains and brought to the valley floor.

Unidentified Lagomorph. Bones of lagomorphs of undetermined species occurred in five samples. These presumably represent the black-tailed jackrabbit and/or the Audubon cottontail.

Kangaroo Rat (*Dipodomys* sp.). Bone fragments of immature kangaroo rats occurred in two samples. The species represented would likely be either the very small Merriam kangaroo rat (*Dipodomys merriami*) or the larger desert kangaroo rat (*D. deserti*). The latter is restricted to the eolian dunes (like those at Myoma) on the desert floor (Ryan 1968:94). These species would most readily have been taken in traps.

Unidentified Mammal Remains. Bones of undetermined species, but probably representing small rodents, occurred in five samples. In addition, four samples contained bone fragments tentatively classified as small mammals (Fig. 21). Occasional hairs or fibers of undetermined origin were found in six samples.

Fishes. Fish remains, generally bones, but occasionally eroded otoliths, pharyngeal teeth, or scale fragments, were recovered in 49 samples (64% of the total). In some cases, little other identifiable residue was present in a given coprolite, but usually fish bones occurred with a variety of plant food items. The size of the bones indicates a wide range of sizes of fishes. Some of them were mere fingerlings; others would have been quite large. Many of the bones were burned, especially the fin spines and rays. This would indicate exposure to fire, either in drying and smoking or roasting, and 88% of the samples containing fish remains also included charcoal fragments. The frequency of fish remains indicates that this resource was very important in the diet of the Indians living at the Myoma Dunes. Presumably fish were taken all year. Small fingerlings, as, for example, those of Colorado River bonytail chub (*Gila elegans*) were consumed whole, as indicated by the pharyngeals and vertebrae recovered from the coprolites (Fig. 20). The species identified, and possibly the only ones represented, are humpback suckers (*Xyrauchen texanus*), Colorado River bonytail chub (*Gila elegans*), and striped mullet (*Mugil cephalus*).

Bones representing the humpback sucker were recovered from seven samples. The species was consumed in historic times by the tribes of the Lower Colorado, where it was taken by various methods, including the bow and arrow, nets of several types, and possibly weirs (Chittenden 1901; Castetter and Bell 1951:218-223; Gifford 1933:268). Poisons were apparently not used.

Remains of bonytail were identified in 16 samples (21%) from Bed A. Its distinctive pharyngeals and pharyngeal teeth, as well as certain vertebrae (Fig. 20) are easy to recognize. The species was also taken on the Lower Colorado.

Mullet remains were identified with certainty in only one sample. But this and the Colorado River squawfish (*Ptychocheilus lucius*), which was not identified in the coprolites, were important items of subsistence on the Lower Colorado.

Fish of undetermined species were represented by bone fragments in 30 samples (39% of the total).

The identifications made on these fish remains are recognized as preliminary. Those reported here are considered reliable, but they are by no means complete, since complete skeletons of these species were not readily available for comparative study. Certainly a more thorough listing could be accomplished by a capable analyst with adequate comparative material. It seems probable, however, that the humpback sucker and the bonytail were the primary species consumed at the Myoma Dunes, with mullet occasionally taken. The squawfish was probably only rarely obtained at this locality, and no remains small enough to represent the desert pupfish (*Cyprinodon macularius californiensis*) were found.

#### Other Items Recovered

Additional items, probably none of them dietary remains in a strict sense, were identified in the coprolite residues. Some of these are intrusive, perhaps introduced into the samples by coprophagous insects (i.e., those that feed on dung or other decomposing residues) or other natural agencies.

Lovegrass (*Eragrostis* sp.). A single seed tentatively identified as lovegrass occurred in sample MDA-14. It resembles *E. cilianensis*, but this species is introduced. It is probably intrusive in the sample.

Sow-thistle (*Sonchus oleraceus*). A single seed (Fig. 23) of this introduced species occurred in each of two samples. The seeds are clearly intrusive and perhaps were introduced by coprophagous insects. Insect remains occurred in each sample that contained a seed of sow-thistle, and these remains are probably of coprophagous forms.

Insect Remains. Insect remains were common occurrences in the Bed A coprolites, the highly resistant, chitinous exoskeleton fragments (Fig. 23) being observable in 35 samples (45% of the total). It seems probably that for the most part these represent coprophagous insects. A single, very well preserved specimen (Fig. 23) was found in the residue of sample MDA-108. Its diagnostic antennae identify it as the red flour beetle (*Tribolium castaneum*), a serious pest of stored cereals and other organic substances. While this beetle may have infested stored food supplies in aboriginal times at the Myoma Dunes, it is more likely a recent intrusion. The specimen is so well preserved as to suggest that it never passed through the intestinal tract, and most authorities agree that it is introduced in America (Kurtz and Harris 1962).

It seems probable that a large proportion of the insect remains recovered may represent the red flour beetle, as they are of the same color, size range, and appearance, but the diagnostic elements, the antennae, were not found in the screenings.

Insect fecal pellets (Fig. 23) were recovered in five samples and represent invasion by coprophagous insects. These would, by their feeding habits, alter the content of coprolites. Sample MDA-26, from which the illustrated specimens were taken, had largely been reprocessed by insects since its deposition at the Myoma Dunes. The pellets are too large to have been left by the red flour beetle, and possibly the larvae of another insect is responsible. Insect burrows were seen in many coprolites.

Charcoal. Charcoal flecks and grains occurred in 60 samples. They are considered indicative of seed parching, fish roasting, or other culinary activities. Fragments up to a centimeter in diameter were observed.

#### Additional Items Recovered by Flotation

Residues of the decomposing coprolite bed were subjected to flotation, or water separation, analysis (Struever 1968) to recover quantities of terrestrial and aquatic seeds for radiocarbon dating, and to possibly obtain additional dietary evidence. Seeds of three species of plants not recovered directly from the coprolites were obtained.

Senna (*Cassia* cf. *covesii*). Two seeds identified as probably representing this species were recovered by flotation (Fig. 22), but none was found in the coprolites themselves. The sennas, or cassias, occurring in the Colorado Desert are of two species, *C. covesii* being the less frequent. It is a small, hairy bush usually not over a foot or two high, with yellow flowers. The plant is occasionally seen in dry washes of the Creosote Bush Scrub zone below 2000 feet elevation, and is more common to the east of the Salton Basin than to the west. The seeds may have been collected and ground in a similar manner as other members of the legume family (Fabaceae), such as mesquite (*Prosopis glandulosa* var. *torreyana*), screwbean (*P. pubescens*), cat's claw (*Acacia greggii*), desert ironwood (*Olneya tesota*), and palo verde (*Cercidium floridum*), the use of which is documented in ethnobotanical literature. Use of senna by historic groups is not documented.

Knotweed (*Polygonum* cf. *lepathifolium*). Seeds of knotweed, or smartweed (Fig. 18), were recovered from flotation samples of Bed A residues. The species in question is not firmly established, but is probably *P. lepathifolium*. The seeds compare favorably with herbarium material of this species from southeastern California. They are a bit smaller than one frequently observes in *P. lepathifolium*, but the range of seed size in this species varies considerably. The related indigenous species, *P. fusiforme*, is common on the Lower Colorado and would likely have been present at Lake Cahuilla as well, but no comparative specimens were available for study. Both species frequent low moist places. The seeds of both would have been available for collection in late summer and autumn. The Cocopah are said to have parched and ground the seeds of *P. argyrocoleon*, which is naturalized on this continent from Asia (Castetter and Bell 1951:187, 196).

Bulrush (*Scripus robustus*). Seeds of bulrush species were common in the Bed A coprolites. Flotation added *Scirpus robustus* (Fig. 19) to



the inventory. The seeds are slightly smaller than those of most *S. robustus*; otherwise, they compare favorably. This species was abundant in Lovelock Cave coprolites (Napton 1970:303-307).

Anodonta (Anodonta dejecta). Fragments of andonta shell were a common item in flotation samples taken from Bed A residues. Several substantial shell middens of this species occurred within 1000 yards of the dune on which Bed A occurs, and a large bed of paired valves of clams stranded when the lake receded also is located a short distance away, in former shallow waters. It seems probable that shellfish were more extensively used in the winter than at other seasons. At this time, inflow into the lake would be reduced and the depth of the water over the shellfish beds also reduced, making it easier to collect them. shell

Summary of Dietary Evidence from Myoma Dunes Bed A

The dietary remains from Bed A represent a variety of foods derived from plant, and fewer from animal, sources. Clearly, the most consistently abundant plant foods recovered from the coprolites are screwbean pods (*Prosopis pubescens*), seeds of the various bulrushes (*Scirpus*), *Dicoria canescens*, lowland purslane (*Sesuvium verrucosum*), cattail (*Typha*), goosefoot (*Chenopodium*), and witchgrass (*Panicum capillare*), as well as pinyon nuts (*Pinus monophylla*) which are represented by hull fragments. Cattail anthers, and therefore pollen, were also commonly eaten. Many other plant foods occurred occasionally in the coprolites, or in the decomposing residues of the deposit.

When we examine the seasonal availability of these food items (Table 5), it is apparent that, with the exception of *Dicoria*, all of them are available for collection between mid-spring and mid-autumn, say between the first of April and the end of October. With the possible exception of cattail pollen, which was almost certainly eaten as it became available in about April and May, all of them can be stored for consumption in the less productive season from November through March. *Dicoria* is the only plant food recovered that can and must be harvested in the winter. It was almost certainly consumed during the winter, as there is little reason to believe it would have been stored for use in the more productive seasons of the year. seasonality

If, for the sake of discussion, we accept this reasoning, and consider *Dicoria* to have been collected and eaten during the winter, the items occurring with it in coprolites should also have been consumed during that season.

Before examining the co-occurrence of *Dicoria* seed and other items, we should exclude from further consideration two samples (MDA-14, MDA-23) comprised of fragments that may in fact represent two or more coprolites deposited at different seasons. Thus, in the remaining 19 coprolites that contained *Dicoria* seed,<sup>3</sup> the following items were also represented:

screwbean pods	occurred in	17
bulrush seed	" "	8
witchgrass seed	" "	10
goosefoot seed	" "	8
lowland purslane seed	" "	11
pinyon nut hulls	" "	7
fish remains	" "	10
various small mammal remains	" "	9

With slight reservation, we can consider these items representative of the winter diet at the Myoma Dunes, as revealed by analysis of coprolite Bed A. All of the above-listed plant foods would of necessity have been stored for winter use. Presumably, the small mammals and fish were obtained during the winter as well as at other seasons.

Cattail anthers, the occurrence of which would indicate a seasonal dating of roughly April and May, were not observed in any of the coprolite samples containing *Dicoria* seed. Small amounts of cattail pollen did occur in samples MDA-41, MDA-42, and MDA-45 (Hattori 1975). These grains may have occurred in stored foods or they may have been ingested in drinking water. Only one sample (MDA-27) containing *Dicoria* seed also yielded cattail seed, and it was present in trace amounts only. Mesquite pollen (*Prosopis*), either of the honey mesquite or of the screwbean, produced from about late April through early June, occurred in sample MDA-42, which contained *Dicoria* seed. These grains may have been present in supplies

Table 5

AVAILABILITY OF SEASONALLY RESTRICTIVE DIETARY ELEMENTS  
FROM MYOMA DUNES BED A

<u>Dietary Element</u>	<u>Availability</u>											
	(spring)						(winter)					
	M	A	M	J	J	A	S	O	N	D	J	F
Cattail ( <i>Typha</i> sp.) pollen	-----											
Witchgrass ( <i>Panicum capillare</i> ) seed	-----											
<i>Panicum urvilleanum</i> seed	----											
<i>Oligomeris linifolia</i> seed	-----											
Mesquite ( <i>Prosopis glandulosa</i> ) blossoms	-----											
Cholla cactus (?) ( <i>Opuntia</i> sp.) fruit*	-----											
Lowland purslane ( <i>Sesuvium verrucosum</i> )	-----											
Barrel cactus ( <i>Ferocactus acanthodes</i> ) seed	-----											
Mesquite ( <i>Prosopis glandulosa</i> ) pods	-----											
Cattail ( <i>Typha</i> sp.) seed	-----											
Screwbean ( <i>Prosopis pubescens</i> ) pods	-----											
Senna ( <i>Cassia covesii</i> ) seed	-----											
Mudhen ( <i>Fulica americana</i> ), immature												
Eared grebe ( <i>Podiceps caspicus</i> ), immature												
Bulrush ( <i>Scirpus</i> spp.) seed	-----											
Barnyard grass ( <i>Echinochloa crusgalli</i> ) seed	-----											
Knotweed ( <i>Polygonum</i> cf. <i>lepathifolium</i> ) seed	-----											
Goosefoot ( <i>Chenopodium</i> spp.) seed	-----											
Amaranth ( <i>Amaranthus</i> sp.) seed	-----											
Pinyon ( <i>Pinus monophylla</i> ) nut**									----			
<i>Dicoria canescens</i> seed												-----

\* Represented by seed

\*\* Represented by hull fragments

of stored screwbean pods, or in ground mesquite, which almost surely was an important winter food, but which was only detected occasionally in macroscopic analysis of the coprolites.

[Thus, most of the plant foods represented in coprolites from the Myoma Dunes Bed A are obtainable from spring through autumn (Table 5). But stored screwbean pods, pinyon nuts, and seeds of various kinds, as well as fish and small mammals, supplemented the seed of *Dicoria canescens* in the winter diet.]

If there was a truly slack season of the year for the prehistoric inhabitants of the Myoma Dunes, it was not the winter, but rather the spring, when stored foods collected during the previous year were exhausted. This was a critical period for many groups of California and Great Basin Indians, usually requiring mobilization and search for the first plant foods of the season, often greens, roots, tubers, etc. At the Myoma Dunes, it was apparently cattail pollen that became important as soon as it made its appearance in the spring. (*Anodonta* clams may also have been very important at this season, but are not likely to be represented in the coprolites.)

Cattail anthers were observed in the macroscopic examination of nine coprolite samples (12% of the total). None of these yielded much of a variety of other plant foods. In the nine samples that contained cattail anthers,<sup>4</sup> the following items were also represented:

witchgrass seed	occurred in	1
unspecified bulrush seed	" "	1
hardstem bulrush seed	" "	1
softstem bulrush seed	" "	3
cattail seed	" "	1
fish remains	" "	8

Three samples contained no other identifiable plant food items. None of them contained the remains of small mammals. There is a suggestion in these data that bulrush seed was deliberately stored for use in the spring to supplement a diet of fish and cattail pollen. The possibility that cattail anthers and pollen were consumed almost to the exclusion of other plant foods because it was a preferred food should also be entertained. Accounts (e.g., Loud 1929:158) describe roasted cattail pollen as tasting sweet, like candy, and it may have been eaten more for this reason than for the nutrition it provided.

Taken together, [the data from Bed A indicate that the Myoma Dunes locality was inhabited the year round, at least during the period of time represented by the deposit. The presence of some items, such as pinyon nut hulls, indicates that the inhabitants of this part of the Lake Cahuilla shore made use of plant communities in the surrounding uplands as well as the low desert and lakeshore environment.]

Table 6 lists all identified constituents of the 77 coprolites from Bed A. Also shown are the number of samples in which each item was represented, and the number of samples in which each was represented in abundant, frequent, infrequent, and trace amounts.

Table 6

CONSTITUENTS OF 77 HUMAN COPROLITES  
FROM MYOMA DUNES BED A  
AND DISTRIBUTION WITHIN THE SAMPLE

	N <sub>O</sub>	A	F	I	T
<b>PLANT REMAINS</b>					
Hardstem bulrush ( <i>Scirpus acutus</i> ) seed	16	3	2	3	8
Softstem bulrush ( <i>Scirpus validus</i> ) seed	18	2	0	1	15
California bulrush ( <i>Scirpus californicus</i> ) seed	3	0	0	1	2
Unspecified bulrush ( <i>Scirpus</i> sp.) seed	5	0	0	2	3
Cattail ( <i>Typha</i> sp.) anthers	9	5	2	2	0
Cattail ( <i>Typha</i> sp.) seed	19	13	1	1	4
Screwbean ( <i>Prosopis pubescens</i> ) pod fragments	34	15	9	9	1
Mesquite ( <i>Prosopis glandulosa torreyana</i> ) seed	3	0	0	0	3
Witchgrass ( <i>Panicum capillare</i> var. <i>occidentale</i> ) seed	15	0	1	0	14
<i>Panicum urvilleanum</i> seed	2	1	0	0	1
<i>Dicoria canescens</i> var. <i>canescens</i> seed	21	5	3	3	10
Pinyon ( <i>Pinus monophylla</i> ) nut hull fragments	17	0	1	1	15
Goosefoot ( <i>Chenopodium glaucum</i> var. <i>salinum</i> ) seed	7	2	4	0	1
Goosefoot ( <i>Chenopodium nevadense</i> ) seed	3	1	0	0	2
Goosefoot ( <i>Chenopodium chenopodioides</i> ) seed	2	1	0	0	1
Unspecified goosefoot ( <i>Chenopodium</i> sp.) seed	10	0	1	3	6
Cholla? ( <i>Opuntia</i> sp.) seed	1	0	0	0	1
Unspecified amaranth ( <i>Amaranthus</i> sp.) seed	3	0	1	0	2
<i>Oligomeris linifolia</i> seed	4	1	0	0	3
<i>Monardella exilis</i> seed	1	0	0	0	1
Barrel cactus ( <i>Ferocactus acanthodes</i> ) seed	2	0	0	0	2
Barnyard grass ( <i>Echinochloa</i> cf. <i>crusgalli</i> ) seed	1	0	0	0	1
Saltgrass ( <i>Distichlis spicata</i> var. <i>stricta</i> ) seed	1	0	0	0	1
Lowland purslane ( <i>Sesuvium verrucosum</i> ) seed	25	11	1	0	13
Mistletoe ( <i>Phoradendron</i> ) fruit (?) (identification uncertain)	1	0	0	0	1
Lovegrass ( <i>Eragrostis</i> sp.) seed (?)	1	0	0	0	1
Sow thistle ( <i>Sonchus oleraceus</i> ) seed	2	0	0	0	2
Unidentified seed	8	0	0	0	8
Charcoal fragments	60	1	8	10	41
<b>ANIMAL REMAINS</b>					
Colorado River bonytail chub ( <i>Gila elegans</i> ) bones	16	10	5	1	0
Humpback sucker ( <i>Xyrauchen texanus</i> ) bones	7	5	2	0	0
Striped mullet ( <i>Mugil cephalus</i> ) bones	1	0	1	0	0
Unidentified fish bones	30	5	10	5	10
Eared grebe ( <i>Podiceps caspicus</i> ) bones	1	0	0	1	0
Mudhen ( <i>Fulica americana</i> ) bones	9	2	4	3	0
Unidentified bird bones	2	0	0	2	0
Unidentified feathers	4	0	0	0	4
Black-tailed jackrabbit ( <i>Lepus californicus</i> ) bones	6	4	2	0	0
Audubon cottontail ( <i>Sylvilagus audubonii</i> ) bones	3	1	1	0	1
Unidentified lagomorph bones	5	0	3	2	0
Kangaroo rat ( <i>Dipodomys</i> sp.) bones	2	1	1	0	0
Unidentified rodent bones	5	1	1	1	2
Desert tortoise ( <i>Gopherus agassizi</i> ) bone	1	0	0	0	1
Red flour beetle ( <i>Tribolium castaneum</i> )	1	0	0	0	1
Unidentified insect fragments (mostly <i>Tribolium</i> ?)	35	0	0	1	34
Insect feces	5	1	0	0	4
Hair or fiber	6	0	0	0	6

N<sub>O</sub> = Total number of samples in which the item occurred

A = Number of samples in which the item was abundantly represented

F = Number of samples in which the item was frequently represented

I = Number of samples in which the item was infrequently represented

T = Number of samples in which the item was represented by trace amounts only

Table 7

DIETARY ITEMS REPRESENTED IN HUMAN COPROLITES  
AND RESIDUES FROM MYOMA DUNES BED A  
AND ENVIRONMENTAL ZONE IN WHICH THEY OCCURRED

	Zone	OW	FM	CBS	PJW
<b>PLANT FOODS</b>					
Hardstem bulrush ( <i>Scirpus acutus</i> ) seed			+		
Softstem bulrush ( <i>Scirpus validus</i> ) seed			+		
California bulrush ( <i>Scirpus californicus</i> ) seed			+		
Bulrush ( <i>Scirpus robustus</i> ) seed			+		
Bulrush ( <i>Scirpus</i> sp.) seed			+		
Cattail ( <i>Typha</i> sp.) anthers, pollen			+		
Cattail ( <i>Typha</i> sp.) seed			+		
Screwbean ( <i>Prosopis pubescens</i> ) pod				+	
Mesquite ( <i>Prosopis</i> sp.) blossom*				+	
Mesquite ( <i>Prosopis glandulosa</i> var. <i>torreyana</i> ) pod				+	
Witchgrass ( <i>Panicum capillare</i> var. <i>occidentale</i> ) seed			+		
<i>Panicum urvilleanum</i> seed				+	
<i>Dicoria canescens</i> var. <i>canescens</i> seed				+	
Pinyon ( <i>Pinus monophylla</i> ) nut**					+
Goosefoot ( <i>Chenopodium glaucum</i> var. <i>salinum</i> )				+	
Goosefoot ( <i>Chenopodium nevadense</i> ) seed				+	
Goosefoot ( <i>Chenopodium chenopodioides</i> ) seed				+	
Goosefoot ( <i>Chenopodium</i> sp.) seed				?	
Cholla? ( <i>Opuntia</i> sp.) fruit***				+	
Amaranth ( <i>Amaranthus</i> sp.) seed			+	+	
Knotweed ( <i>Polygonum</i> cf. <i>lepathifolium</i> ) seed			+		
<i>Oligomeris linifolia</i> seed, greens				+	
<i>Monardella exilis</i> seed****					+
Barrel cactus ( <i>Ferocactus acanthodes</i> ) seed				+	
Barnyard grass ( <i>Echinochloa</i> cf. <i>crusgalli</i> ) seed			+		
Saltgrass ( <i>Distichlis spicata</i> var. <i>stricta</i> ) seed****			+		
Lowland purslane ( <i>Sesuvium verrucosum</i> ) seed				+	
Senna ( <i>Cassia</i> cf. <i>covesii</i> ) seed****				+	
Mistletoe ( <i>Phoradendron</i> cf. <i>californicum</i> ) (?) fruit****				+	
Unidentified seed			?	?	?
<b>ANIMAL FOODS</b>					
Anodonta clam ( <i>Anodonta dejecta</i> )		+	+		
Colorado River bonytail chub ( <i>Gila elegans</i> )		+	+		
Humpback sucker ( <i>Xyrauchen texanus</i> )		+	+		
Striped mullet ( <i>Mugil cephalus</i> )		+			
Unidentified fish		+	?		
Eared grebe ( <i>Podiceps caspicus</i> )		+	+		
Mudhen ( <i>Fulica americana</i> )		+	+		
Unidentified bird		?	?	?	?
Unspecified small mammal			?	?	?
Unspecified lagomorph				+	
Unspecified rodent				+	
Black-tailed jackrabbit ( <i>Lepus californicus</i> )				+	
Audubon cottontail ( <i>Sylvilagus audubonii</i> )				+	
Kangaroo rat ( <i>Dipodomys</i> sp.)				+	
Desert tortoise ( <i>Gopherus agassizi</i> )				+	

\* Represented by pollen

\*\* Represented by hull fragments

\*\*\* Represented by seed

\*\*\*\* Status as a food item not established

+ Environmental zone of probable origin

OW Open Water

FM Freshwater Marsh

CBS Creosote Bush Scrub

PJW Pinyon-Juniper Woodland

Table 7 lists items considered to be dietary remains recovered from both the Bed A coprolites and midden residues. Also shown are the environmental zones from which each dietary item was derived.

AVIAN REMAINS FROM THE VICINITY OF  
MYOMA DUNES BED A

A collection of bird bones was made from the surface of the deflating midden adjacent to coprolite Bed A. The purpose was to gain a more complete understanding of the nature and extent of the utilization of birds by the aboriginal inhabitants of the Myoma Dunes and to obtain data on season of occupation of that locality. It was reasoned that avian remains would be more seasonally sensitive than those of terrestrial species, inasmuch as certain migratory waterfowl are present only at particular seasons and the young of resident species are more amenable to seasonal interpretation than those of any of the local terrestrial species.

The collection was made over an area within about 25 yards of the Bed A coprolite deposit. [Since it was made on a deflating surface of varying elevation, there is no way of dating it except to say that ceramic sherds occurred everywhere and a few projectile points of the Cottonwood and Desert Side-notched series were also found. The bones can be assigned to all or part of the last two lacustral intervals (Fig. 14) with confidence, and in all probability were deposited at the site during the last stand of Lake Cahuilla.] They are here considered to be of generally the same age as the Bed A coprolites and to supplement data on diet and seasonality derived from analysis of those specimens. The data presented here, as well as their interpretation, are taken from an unpublished report of avifaunal analysis provided me by Charmion McKusick (1975). Identification of species, minimum faunal count (minimum number of individuals of each species), age (whether adult or immature), and sex (where possible to determine), are shown in Table 8. A number of the bones were burned, and there is a minimum count of 38 individual birds in the collection.

A preponderance of mudhens (*Fulica americana*) (26 of the 38 individual birds in the collection) reflects the occurrence of bird remains in the Bed A coprolites, which yielded a minimum of 10 mudhens and an eared grebe (*Podiceps caspicus*).] Adult mudhens fell prey as well as the young. They may have been caught feeding out of the water, in which case they would have been unable to get airborne and could have been run to earth with relative ease. Alternatively, they could have been driven and netted or shot on the water. The young mudhens in this collection, as well as those from the coprolites from Bed A, are at least two months old. Given the latitude and altitude of the site, the earliest recorded egg laying date of about April 11 is probably reasonable, and incubation requires 21 or 22 days (Bent 1963a:361, 362, 371). Two months allowed for growth gives a date of sometime in July when the young mudhens were taken.

A similar procedure indicates that the immature great blue heron (*Ardea herodias*) died about late May and the young adult black-crowned

Table 8

## AVIFAUNA FROM THE VICINITY OF MYOMA DUNES COPROLITE BED A

<u>Species</u>	<u>Number**</u>	<u>Age</u>	<u>Sex</u>
Western grebe ( <i>Aechmophorus occidentalis</i> )	1	Adult	-
Double-crested cormorant ( <i>Phalacrocorax auritus</i> )	1	Adult	-
Great blue heron ( <i>Ardea herodias</i> )	1	Immature	-
Black-crowned night heron ( <i>Nycticorax nycticorax</i> )	1	Young adult	-
Canada goose ( <i>Branta canadensis</i> )	1	Adult	F
Canvasback ( <i>Aythya valisineria</i> )	1	Adult	F
Redhead ( <i>Aythya americana</i> )	4	Adult	M
Lesser scaup ( <i>Aythya affinis</i> )	1	Immature	F
Mudhen ( <i>Fulica americana</i> )	11	Adult	M
"	3	Immature	M
"	8	Adult	F
"	4	Immature	F
Great horned owl ( <i>Bubo virginianus</i> )	1	Adult	F

\*\* Minimum faunal count

night heron (*Nycticorax nycticorax*) in July or later. The lesser scaup (*Aythya affinis*) dates to about October (Wyman and Burnell 1925:45).

Non-resident adult waterfowl, the canvasback (*Aythya valisineria*) and redhead (*Aythya americana*) are present in the area today from October through March, and could have been taken at any time during that interval. The western grebe (*Aechmophorus occidentalis*) is present from about September through April.

The locality would appear, on the basis of coprolite data, to have been occupied the year round. Additional support for such an interpretation is found in definite periods of site use in May, July, and October, based on analysis of bird remains from the midden.

The herons feed extensively on fish in shallow, clear waters and would have been at home in the marshes at the northwest end of Lake Cahuilla. They were probably taken locally. A heronry used by these species existed on the Bat Caves Buttes, the former island about 35 miles to the southeast (see below).

The great horned owl (*Bubo virginianus*) adapts to most environments from the northern limit of trees to the Strait of Magellan. It frequents a wide range of biotic zones including marshes and uses the nests of other large birds such as herons. It feeds on a variety of animals and birds, including ducks. Whether it was used for food by the Indians is open to question, but this seems unlikely.

The waterfowl especially the diving ducks, are deep water species, rather than those characteristic of shallow, marshy waters. They may have been shot from tule balsas out on the open water. If so, decoys of some

sort, such as those of tule found in Lovelock Cave, Nevada, may also have been employed.

Shorebirds are characteristically absent from the collection and did not appear in the coprolites. They apparently were not sought by the inhabitants of the Myoma Dunes.

#### ANALYSIS OF COPROLITES FROM MYOMA DUNES BED B

The second coprolite deposit investigated at the Myoma Dunes is designated Bed B. As in the case with Bed A, it was located atop a shoreline dune rising perhaps 35-40 feet above the lakeshore, about 300 yards northwest of Bed A. It was a small deposit occurring on a common level over an area about 12 feet across, and yielded, upon excavation, about 30 specimens. These were exposed when a large saltbush (*Atriplex canescens*) growing adjacent to the deposit died and that portion of the dune began to deflate. The coprolites occurred about four feet below the recent surface of the dune and all were thoroughly penetrated by roots of the saltbush. These roots probably contributed in part to the apparent modern age of the one coprolite dated by radiocarbon (see Table 3), although every effort was made to remove them. Ten coprolites from Bed B were rehydrated and analyzed. All dietary components identified in these samples except one have been previously described in the discussion of the contents of Bed A, and are therefore listed and described only briefly in Table 9. Also included in Table 9 are data on the frequency of occurrence of items recovered. The identified contents of Bed B coprolites are listed by specimen number in Appendix C.

Table 9

#### CONTENTS OF 10 HUMAN COPROLITES FROM MYOMA DUNES BED B

Component	Occurrence in Sample			
	Present in	9	Frequent to	Abundant in
Witchgrass ( <i>Panicum capillare</i> ) seed	"	5	"	4
Screwbean ( <i>Prosopis pubescens</i> ) pod fragments	"	1	"	1
Cattail ( <i>Typha</i> sp.) seed	"	1	"	0
Goosefoot ( <i>Chenopodium glaucum</i> var. <i>salinum</i> ) seed	"	2	"	0
Goosefoot ( <i>Chenopodium</i> sp.) seed	"	1	"	0
Amaranth ( <i>Amaranthus</i> sp.) seed	"	3	"	0
Hardstem bulrush ( <i>Scirpus acutus</i> ) seed	"	1	"	0
Softstem bulrush ( <i>Scirpus validus</i> ) seed	"	2	"	0
California bulrush ( <i>Scirpus californicus</i> ) seed	"	2	"	0
Lowland purslane ( <i>Sesuvium verrucosum</i> ) seed	"	1	"	0
Mesquite ( <i>Prosopis glandulosa</i> var. <i>torreyana</i> ) bean**	"	2	"	1
Calyptridium cf. <i>umbellatum</i> seed	"	1	"	0
Unidentified seed hull fragment	"	7	"	1
Unidentified fish bone	"	1	"	0
Unidentified bone	"	9	"	0
Charcoal fragments	"	8	"	0
Insect remains (probably non-dietary)	"		"	0

\*\* Represented by seed coat



Seeds identified as *Calyptridium umbellatum*, a member of the Portulacaceae, occurred in two samples. This plant, a small herb, commonly grows on sandy or gravelly soils at elevations of 4500 feet and higher, and is often found in Yellow Pine Forest. It generally flowers from May to August, setting seed from perhaps about late June to September (Munz 1974:711). It could have been obtained in the Santa Rosa or San Jacinto Mountains. A closely related species, *C. monandrum*, is common to the Colorado Desert and occurs locally in the Coachella Valley. Examination of seeds from herbarium specimens of the latter species reveals, however, that they are slightly smaller than those recovered from the coprolites. Apparently the species represented is *C. umbellatum*, and seeds are present in sufficient numbers to indicate that they were intentionally consumed as food, and are not accidental ingestions. The possibility that *C. monandrum* is represented should not be ruled out. Use of *Calyptridium* species seeds for food is not documented in ethnobotanical literature.

The vegetal remains from Bed B are all available for collection in the summer and early autumn. No evidence of cattail anthers, the source of pollen in late spring, was noted. Neither was there any evidence of *Dicoria* seed, which is usually available for collection in early December and continuing on through January. This was shown to have been an important winter resource in the samples from Bed A. Thus, the coprolites of Bed B indicate use of the immediate locality during some (probably brief) period from about mid-summer through mid-autumn. See also...

Witchgrass seed and screwbean pods were the most important vegetal items in the diet represented by Bed B. Unidentified fish remains occurred in most of the samples, but usually in very small numbers. Except for the *Calyptridium*, all of the remains are definitely those that could have been obtained in the immediate area of the Myoma Dunes.

#### ANALYSIS OF COPROLITES FROM MYOMA DUNES BED D

Bed D was a small, well-defined deposit of coprolites not over 10 feet across and a few inches deep, located near Bed B. Lake bottom clays occur within a few yards of the collection site at slightly lower elevation. The deposit was discovered as it started to deflate, and was excavated in its entirety, yielding about 50 coprolites, most of which were fragments of once-larger specimens. By far the vast bulk of the deposit had decomposed. In the course of collecting samples, seeds of various kinds were observed in the decomposing residues, including those of cultivated squash (*Cucurbita pepo*). Fifteen large bags of soil residues from the deposit were then collected for later screening, which yielded additional specimens.

Several analyses were performed on the Bed D coprolites. One specimen was submitted for radiocarbon dating and yielded an apparent age of 365±140 radiocarbon years (UCR-124; recounted as UCLA-1889, yielding a cross-check of 420±80 radiocarbon years; see Table 3). Palynological analysis was carried out on eight samples in an attempt to determine if pollen grains of cultivated plant species were present. Twelve samples were rehydrated to recover information on aboriginal diet.

With but two exceptions, the dietary remains recovered from the rehydrated coprolites were represented in the specimens from Bed A. Table 10 shows the range of food items and other materials identified from 12 Bed D coprolites, together with information on their occurrence and relative abundance in the samples. A complete listing of the contents of each analyzed specimen appears in Appendix D.

Table 10

## CONTENTS OF 12 HUMAN COPROLITES FROM MYOMA DUNES BED D

Component	Occurrence in Sample	
	Present in 7	Frequent to Abundant in 7
Cattail ( <i>Typha</i> sp.) anthers	" 8	" 3
Witchgrass ( <i>Panicum capillare</i> ) seed	" 8	" 1
Hardstem bulrush ( <i>Scirpus acutus</i> ) seed	" 1	" 0
Softstem bulrush ( <i>Scirpus validus</i> ) seed	" 1	" 0
Unspecified bulrush ( <i>Scirpus</i> sp.) seed	" 5	" 3
Screwbean ( <i>Prosopis pubescens</i> ) pod fragments	" 1	" 0
Mesquite ( <i>Prosopis glandulosa</i> var. <i>torreyana</i> ) bean**	" 3	" 2
<i>Dicoria canescens</i> seed	" 2	" 0
Pinyon ( <i>Pinus</i> cf. <i>monophylla</i> ) nut hull fragments	" 1	" 0
Goosefoot ( <i>Chenopodium</i> sp.) seed	" 1	" 0
Dock ( <i>Rumex</i> cf. <i>salicifolius</i> ) seed	" 1	" 0
Mudhen ( <i>Fulica americana</i> ) bones, immature	" 1	" 1
Mudhen ( <i>Fulica americana</i> ) bones, adult	" 1	" 1
Unidentified bird or mammal bone	" 2	" 0
Colorado River bonytail chub ( <i>Gila elegans</i> ) bone	" 3	" 3
Unidentified fish bone	" 9	" 4
Unidentified small reptile bone	" 1	" 0
Charcoal	" 9	" 0
Insect remains (probably non-dietary)	" 6	" 0

\*\* Represented by seed coat

Among the items recovered from the Bed D coprolites, but not observed in samples from Beds A and B, were small, acutely trigonous seeds identified as a species of dock (*Rumex*), perhaps willow dock (*Rumex salicifolius*) (Fig. 22). This species occurs in moist places throughout California from low valleys to high in the mountains (Mason 1957:439). It probably grew on the shore of Lake Cahuilla. Flowering occurs from May to September (Munz 1974:708); therefore seed could have been collected from early summer to fall. The seed occurred in sample MDD-4 in sufficient quantity to conclude that it was intentionally collected and consumed. Its use is not documented in ethnobotanical literature.

Also recovered from Bed D coprolites (sample MDD-12) was a single vertebra of a small reptile which remains unidentified (Fig. 22). It apparently is of either a snake or one of the various lizards common to the local area.

Soil samples from Bed D were screened through 1/8-inch mesh screen to recover additional seeds of cultivated squash (*Cucurbita pepo*). About a dozen seeds, mostly fragmentary, were recovered (Fig. 22). This domesticated species apparently originated in Mexico by 4000 B.C. and was cultivated in the American Southwest by 2000 years later. Its first

occurrence in the Southwest is at Bat Cave, New Mexico (Dick 1965), and available information on its origin and evolution is summarized by Cutler and Whitaker (1961). The species was not grown on the Lower Colorado River until comparatively recent times. The seeds pose a most interesting problem, since they are obviously of a cultivated species, and are the sole evidence of plant cultivation in an otherwise strictly hunting and gathering lakeshore economy. It was reasoned that if squash and other domesticates had been grown locally, evidence to that effect might be found in the pollen content of the Bed D coprolites. Analysis yielded no pollen of cultivated plants of any kind (Hattori 1975). It would thus appear that the squash grown for a long time in the Southwest was not cultivated in the immediate vicinity. Such cultivation on the moist ground of the lakeshore was once suggested by Lawton and Bean (1968) to have given rise to historic Cahuilla agriculture. The squash was probably obtained from sources to the east, perhaps northern Arizona (Thomas W. Whitaker, personal correspondence).<sup>5</sup> These squash remains are described in detail elsewhere (Wilke, Whitaker, and Hattori 1977).

\*  
Cult.  
water

An apparent carbonized pinyon nut (*Pinus monophylla*) and a seed tentatively identified as senna (*Cassia cf. covesii*) were recovered by screening of Bed D sediments (Fig. 22).

Pollen analysis showed that the samples yielding abundant cattail (*Typha*) anthers contained cattail pollen to the near exclusion of all other types. Two samples (MDD-2, MDD-4) contained abundant mesquite (*Prosopis*) pollen, which may document consumption of mesquite blossoms. Since mesquite blossoms were roasted in a pit lined with hot stones, according to Curtis (1926:24), and then pressed into balls and dried, they could be stored for some time to be cooked up in water as needed. Thus, any interpretation of seasonality of site use based on abundant mesquite pollen in coprolites should be approached with caution. Sample MDD-5 contained abundant low spine Compositae pollen. Macroscopic analysis revealed abundant achenes (seeds) of *Dicoria canescens*, a member of the Asteraceae (Compositae). This plant is resinous and sticky to the touch, and pollen would be expected to adhere to it in quantity. Low spine Compositae pollen in this sample may therefore be of *Dicoria*.

The dietary contents of Bed D reflect a similar seasonal aspect as that described for Bed A. Cattail anthers were frequent to abundant in seven samples, indicating late spring or very early summer occupation. A similar season can be cautiously suggested by the occurrence of copious amounts of mesquite pollen in two samples. *Dicoria* seed suggests the winter. Most of the other items are available during the summer and early autumn. Year round occupation is suggested. Food resources identified in the coprolites were derived from the waters of Lake Cahuilla, from the Freshwater Marsh, Creosote Bush Scrub, and Pinyon-Juniper Woodland plant communities, as well, apparently, as by exchange.

Seas

#### AVIAN REMAINS FROM MYOMA DUNES SOUTH

Myoma Dunes South is the designation given to a locality about 600 yards south and slightly east of the high dune on which coprolite

Bed A is located. The two localities were formerly part of the same shoreline dune complex, but the entire intervening eolian deposits were removed for highway construction. The adjacent lakebed is flat with an almost imperceptible grade toward the southeast, indicating very shallow water conditions. Myoma Dunes South was an exposure of cultural deposits on the northwest face of a prominent dune. As the wind cut into the deposits, it exposed lenses of charcoal and anodonta (*Anodonta dejecta*) shell, ceramics in abundance, projectile points of the Cottonwood and Desert Side-notched series, and other assorted artifacts. There were large quantities of fish, bird, and small mammal bone. The deposit was largely destroyed by wind within the last two years. It yielded only isolated coprolite fragments, which field inspection showed contained abundant fish bones. No excavations were conducted here, but surface collections of artifacts and faunal remains were made on several occasions. Only the avian remains are reported here. Analysis of these is still in progress at this writing. The preliminary results are given in Table 11.

Table 11

## AVIFAUNA FROM MYOMA DUNES SOUTH\*

Species	Number**	Age	Sex
Black-crowned night heron ( <i>Nycticorax nycticorax</i> )	-	-	-
Double-crested cormorant ( <i>Phalacrocorax auritus</i> )	-	-	-
Mudhen ( <i>Fulica americana</i> )	8	Adult	M
"	14	Adult	F
Band-tailed pigeon ( <i>Columba fasciata</i> )	2	Adult	M
Mourning dove ( <i>Zenaidura macroura</i> )	3	Adult	F
Eared grebe ( <i>Podiceps caspicus</i> )	2	Adult	-
"	1	Immature	-
Mallard ( <i>Aythya platyrhynchos</i> )	2	Adult	M
"	1	Adult	F
Pintail ( <i>Anas acuta</i> )	2	Adult	M
"	1	Adult	F
Redhead ( <i>Aythya americana</i> )	2	Adult	M
"	1	Adult	F
Barn owl ( <i>Tyto alba</i> )	1	-	-
cf. Cinnamon teal ( <i>Anas cyanoptera</i> )	2	-	-
Bufflehead ( <i>Bucephala albeola</i> )	1	Adult	M

\* Based on an interim oral report provided by Charmion McKusick

\*\* Minimum faunal count

The preponderance of mudhens (*Fulica americana*) seen in the remains from the vicinity of Bed A is in evidence also in this collection, with 22 individuals, all adults, present. A variety of waterfowl is represented, including both diving ducks and dabbling ducks. The divers of open water are the bufflehead (*Bucephala albeola*) and redhead (*Aythya americana*), both winter residents. Dabbling ducks in the collection are the mallard (*Aythya platyrhynchos*), pintail (*Anas acuta*), and two individuals that appear to be cinnamon teal (*Anas cyanoptera*).

The latter of these breeds locally. The mourning dove (*Zenaidura macroura*) is a common bird in the area today and is a year round resident, as is the barn owl (*Tyto alba*). The latter may not have been eaten.

Probably the most surprising occurrence in this lakeside collection is the band-tailed pigeon (*Columba fasciata*), represented by two adult males. This is emphatically a woodland species, occurring in the San Jacinto and Santa Rosa Mountains in Yellow Pine Forest and on the desert slope down to Pinyon-Juniper Woodland. One would not expect it to occur naturally at the Myoma Dunes even when Lake Cahuilla was present. The band-tailed pigeon is fond of acorns and pine nuts, and may have been taken by hunters as part of joint hunting-pinyon nut collecting expeditions in the mountains.]

The available data are inadequate to fix season of occupation at Myoma Dunes South. Restrictive dates of availability of the birds in the collection are as follows:

Eared grebe, immature	-	late August or early September
Redhead	-	October through March
Bufflehead	-	October through March
Mallard	-	October through February (occasionally in summer)
Pintail	-	October through April <sup>6</sup>

While theoretically the entire collection could have been acquired in September and October of a single year, there is no evidence to suggest that year round occupation did not occur.

The typical small shorebirds and waders that one might expect to have frequented the Myoma Dunes locality during the last stand of Lake Cahuilla are entirely lacking in the avifaunal collections. This must be due to selective hunting, with the Indians preferring the larger species, even if these were more difficult to obtain.

## 2. WADI BEADMAKER

The site of Wadi Beadmaker is located about 30 miles southeast of the Myoma Dunes on the northeast shore of Lake Cahuilla.<sup>7</sup> To the northeast of the Bat Caves Buttes (Fig. 3) is a lobe of the lake that I term the Dos Palmas embayment after the oasis of that name. Wadi Beadmaker is located on the northwest shore of this embayment on an immense beach of perhaps 47 feet elevation. The beach, one of the most prominent in the Salton Basin, traces westerly across comparatively flat terrain near the foot of the Orocopia Mountains and ends at a much dissected mesa that was once a small peninsula extending southward from the Mecca Hills a mile or two into Lake Cahuilla. What remains of the site is a small remnant of beach between this mesa and Orocopia Wash, which cuts through the beach at this point (Fig. 16). Vegetation in this locality is very sparse Creosote Bush Scrub with a scattering of desert ironwood (*Olneya tesota*) and palo verde (*Cercidium floridum*) marking ephemeral water courses.

Excavations were carried out at Wadi Beadmaker from August to October, 1973, largely working alone. A total of 29 excavation units was

completed and passed through 1/8-inch mesh screen. [The deposit consisted of mounded refuse averaging 20-40 centimeters in depth. The refuse contained abundant rocks, flakes and irregular chunks of quartz, charcoal, ceramics, and occasional projectile points of the Cottonwood and Desert Side-notched series, unfired clay figurines, shell beads, etc. Coprolites and faunal remains were also recovered.] A report on the excavation is in progress and emphasis here will focus on the faunal remains and the coprolites.

[From the beginning of the excavation it was apparent that the primary activity carried out at the site was fishing. There were literally bushels of fish bones, of which a large sample was saved. Except for a large hearth, features were conspicuously absent. The mounded debris, which contained an estimated 3-5% fish bone by bulk, gave the impression of deliberate attempts to cover over the discarded remains of fish with rocks and sand. Such action could have been undertaken to keep down the flies and the stench of rotting fish that must have pervaded the atmosphere for a considerable distance from the site.] A similar occurrence of refuse was found in all excavation units, and if remains of structures or other features were ever in evidence, they may have been destroyed by the cutting of the beach by Orocopia Wash since the site was abandoned.

[The age of the deposits is uncertain. The exposure of midden on the surface and three charcoal samples from surface, mid-depth, and basal levels, each with apparent modern radiocarbon ages (Table 3) suggest the last stand of Lake Cahuilla. Analysis of a composite sample of all burned fish bone from one excavation unit gave an apparent age of  $415 \pm 140$  radiocarbon years (UCR-380).] The deposits are assigned to the last lake stand, with the possibility that some of the basal material may date to the next-to-last stand.

### Coprolites

About 70 coprolites were recovered from the midden. These tended to occur scattered throughout the deposits and were nowhere concentrated into a single spot, as at the Myoma Dunes. There is thus the possibility that some of them are not of human origin. [Dogs around a camp such as Wadi Beadmaker could eat scraps that bore evidence of deliberate food preparation. Their fecal remains would then contain burned bones, perhaps charcoal, etc., and thus be difficult to distinguish from human samples, especially if the latter contained no seeds or other plant remains. For this reason less reliance is placed on the results of this analysis than on those from the Myoma Dunes, where coprolites were recovered in well-defined refuse heaps.] The coprolites from Wadi Beadmaker were exceedingly friable, and many of them could only be scraped into plastic bags as the particulated residue of what had been upon exposure well-formed specimens. Most of the specimens contained obvious fish bone, and a few of them consisted largely of grass seed. [Ten samples were rehydrated. Table 12 shows the range of items identified, as well as general information on their occurrence and relative abundance. The list of identifiable items is short, and with but one exception, they are also present in the sample from Myoma Dunes Bed A.

Table 12

## CONTENTS OF 10 HUMAN COPROLITES FROM WADI BEADMAKER

Component	Occurrence in Sample	
	Present in 2	Frequent to Abundant in 2
Colorado River bonytail chub ( <i>Gila elegans</i> ) bone	" 2	" 2
Humpback sucker ( <i>Xyrauchen texanus</i> ) bone	" 6	" 5
Unidentified fish bone	" 1	" 0
Anodonta ( <i>Anodonta dejecta</i> ) valve fragments	" 2	" 2
Witchgrass ( <i>Panicum capillare</i> ) seed	" 1	" 0
Hardstem bulrush ( <i>Scirpus acutus</i> )	" 1	" 0
Bulrush ( <i>Scirpus</i> sp.) seed	" 1	" 0
cf. Amaranth ( <i>Amaranthus</i> sp.) seed	" 1	" 0
Dodder ( <i>Cuscuta</i> sp.) seed	" 1	" 0
Charcoal fragments	" 10	" 1
Insect remains	" 1	" 0

Fish remains occurred in 9 of the 10 samples, but identifiable skeletal elements were infrequent. As a result, the bonytail (*Gila elegans*) and humpback sucker (*Xyrauchen texanus*) were each identified in only two samples. Some of the fish remains, such as the large vertebrae in sample WB-9 (Fig. 23), are so large and coarse as to suggest a non-human origin for that sample. Charcoal fragments were, however, present in the specimen.

Except for probably intrusive insect remains in one sample, a few fragments of anodonta (*Anodonta dejecta*) shell were the only other evidence of animal foods. The valves of this mussel are very thin and fragile, and the fragments recovered could easily have been ingested accidentally along with the meat.

Two samples consisted almost entirely of milled seeds of witchgrass (*Panicum capillare*). A single seed of dodder (*Cuscuta* sp.) occurred in sample WB-3. The species is possibly *C. denticulata*, a small parasitic seed-bearing plant lacking chlorophyll and occurring on creosote bush (*Larrea tridentata*) and other desert shrubs. The seed may have been accidentally ingested. Bulrush (*Scirpus*) seed occurred in small amounts in two samples, and probable amaranth (*Amaranthus*) in one.

If this sample of coprolites is adequate to reflect any significant dietary pattern, it indicates the importance of fish and witchgrass seed. These were important at the Myoma Dunes also, but the range of food items seen there is not present at Wadi Beadmaker. The emphasis on fish reflects the abundance of fish remains in the midden. Although all of the seasonally sensitive dietary remains in the coprolites are available in summer and autumn, the possibility of occupation in other seasons cannot be ruled out.

#### Terrestrial and Avian Faunal Remains

Analysis of the terrestrial and avian fauna from the bone refuse collected during excavation provides additional information on dietary patterns at Wadi Beadmaker. Both of these collections are small, however,

when compared with the remains of what must be thousands of fishes. Neither terrestrial nor avian creatures contributed much toward the diet represented at the site. The summary that follows is drawn from unpublished reports provided by Charmion McKusick (1975) and Stephen Hammond (1975).

Terrestrial fauna was analyzed using the comparative skeletal collections at the University of California, Riverside. Minimum numbers of each species were determined after the method described by White (1953), in which each identified left skeletal element is matched against each corresponding element on the right, with allowances for age differences, and the greater number taken as the minimum estimate of the number of individuals in the collection. The result is in some cases a low estimate, since there is no way of knowing that all left elements go with all right elements. Be that as it may, White's procedure indicates that there are at least 20 individual animals in the collection from the site as a whole. The terrestrial fauna are listed in Table 13.

Table 13

## TERRESTRIAL FAUNA FROM WADI BEADMAKER

<u>Species</u>	<u>Number**</u>	<u>Age</u>
Desert tortoise ( <i>Gopherus agassizi</i> )	5	Adult
Black-tailed jackrabbit ( <i>Lepus californicus</i> )	8	Adult
"	2	Immature
Audubon cottontail ( <i>Sylvilagus audubonii</i> )	1	Adult
?White-throated woodrat ( <i>Neotoma cf. albigula</i> )	1	Immature
Coyote or dog ( <i>Canis sp.</i> )	1	Young Adult
- Desert bighorn sheep ( <i>Ovis canadensis</i> )	1	Adult
"	1	Immature

\*\* Minimum faunal count

With the exception of the possible dog, the terrestrial species would have been present in the region all year. Seasonal dating of the site is therefore not possible on the basis of terrestrial fauna.

The collection includes the remains of at least two desert bighorn sheep (*Ovis canadensis*), one of which was immature. A sizeable population of bighorns still inhabit the eastern slope of the Santa Rosa Mountains, and they may still be present in the Orocochia and Chocolate Mountains on the east side of the basin. Certainly these uplands were part of the former range of this species.

Jackrabbits (*Lepus californicus*) dominate the assemblage with 10 individuals present (50% of the total minimum number of animals), including two of which were immature. The only other lagomorph present is an Audubon cottontail (*Sylvilagus audubonii*).

Desert tortoise (*Gopherus agassizi*) is represented by five individuals. This species can be found within a mile or two to the north of the site today.



Because they are so closely related, it is often not possible to distinguish between the coyote (*Canis latrans*) and the domesticated dog (*Canis familiaris*). The latter has been present in the New World since at least 8400 B.C. (Olsen 1971:23). In times of severe hardship it could have been eaten even as the coyote was. The young adult individual in question is represented by 35 skeletal parts, more than half (18) of which were charred. The long bones were splintered, apparently to obtain marrow. There seems little question that it was eaten. The bones occurred in nearly contiguous excavation units. A possibly intrusive woodrat (*Neotoma cf. albigula*) completes the assemblage.

[Eighty-one (25%) of the 330 bones and bone fragments show evidence of burning, suggesting that most, if not all, of the animals in the sample were roasted.]

Avifauna were analyzed using the comparative collections at Gila Pueblo, Globe, Arizona, and at the University of Arizona, Tucson. There are a minimum of six individuals of five species in the collection (Table 14).

Table 14

## AVIFAUNA FROM WADI BEADMAKER

<u>Species</u>	<u>Number**</u>	<u>Age</u>	<u>Sex</u>
Eared grebe ( <i>Podiceps caspicus</i> )	1	Adult	-
"	1	Young adult	M
Whistling swan ( <i>Olor columbianus</i> )	1	Adult	-
Pintail ( <i>Anas acuta</i> )	1	Young adult	F
Mudhen ( <i>Fulica americana</i> )	1	Adult	M
Common raven ( <i>Corvus corax</i> )	1	Adult	M

\*\* Minimum faunal count

Three birds suggest an autumn occupation at Wadi Beadmaker. The eared grebe (*Podiceps caspicus*) is a resident breeder. Considering an early egg laying date of April 22 for this latitude and elevation, adding three weeks for incubation, and allowing about 100 days for growth to the young adult stage (Bent 1963a:30, 35), yields an estimated date of late August when it was taken. Pintails (*Anas acuta*) are migratory, and the young adults of that species arrive in the Salton Basin in October (Wyman and Burnell 1925:43). Whistling swans (*Olor columbianus*) arrive in about October (Bent 1963b:288-289).

Thus, [the most conservative seasonal dating for the site on the basis of the avian remains, the minimum time when all could be obtained locally, would be October or a little later. This would in no way conflict with inferences of seasonality drawn from other sources, such as the coprolites; however, there remains the possibility that the site was occupied in other seasons as well.]

birds  
- seasonality

## 3. BAT CAVES BUTTES

The Bat Caves Buttes are a rocky outcrop atop Durmid Hill, which rises from the floor of the Salton Basin just east of the Salton Sea and south of Salt Creek at the Riverside-Imperial County line. They are tilted exposures of sedimentary beds assigned to the late Pliocene and early Pleistocene Shavers Well Formation, and mark the southernmost obvious surface exposure of the San Andreas Fault zone (Babcock 1974). This prominence formed the only island of significance in Lake Cahuilla (Fig. 3). It was about 5000 feet long, but quite narrow and irregular, and was located a little over four miles from the northeast shore. The high point of the bi-lobed island extended about 60 feet above the water. The buttes rise sharply above the recent waterline where there are a number of wave-cut caves that give the outcrop its name.

A substantial sand bar or spit extends northeasterly from the southern butte for nearly a mile. Near its western end this bar is flanked by Lake Cahuilla beaches with estimated elevations of +42 and +47 feet on the north and south, respectively. These converge about 200 yards east of the southern butte forming a sandy flat of about the same width. Conspicuous perennial vegetation here is limited to creosote bush (*Larrea tridentata*) and bur-sage (*Ambrosia dumosa*).

Archaeological and paleontological remains were found on the triangular sand spit extending out from the buttes. Initial field observations disclosed the presence of many fragments of eggshell and bones of immature large aquatic birds, as indicated by incomplete epiphysial closure in the long bones. Several concentrations of these were seen weathering out of the sandy deposits. These deposits of bones and eggshell fragments are the remains of an island communal nesting site similar to those that existed in the Salton Sea shortly after it formed about 70 years ago (Grinnell 1908). Closer examination revealed that some of the bone fragments were burned.

Excavations disclosed a shallow deposit about 10 centimeters deep containing a quantity of burned bones of aquatic birds in what had been a large cooking fire. Associate artifacts were ceramic sherds representing probably a single cooking vessel.

The bird remains were studied by Charmion McKusick, and the following comments are drawn from her (1975) unpublished report. A minimum of 14 individual birds was represented as follows:

- 11 immature great blue herons (*Ardea herodias*)
- 2 immature black-crowned night herons (*Nycticorax nycticorax*)
- 1 immature mudhen (*Fulica americana*)

These species are all resident in the area. Judging from the age of the herons indicated by the degree of maturity of the long bones, and projecting a date of egg laying for these species based on the latitude of the site, a seasonal dating of about the fourth week in May is indicated.

There were also a few burned fish bones of undetermined species. Whether these had been caught and consumed by the Indians, or whether they had been consumed by the herons and ended up in the fire when the entrails were discarded cannot be determined.

A radiocarbon date of less than 150 years (UCR-319) was obtained on charcoal from the hearth. This date is obviously too modern.

[The data from the locus are suggestive of a single day's activities of the aboriginal hunters, who carried out a raid on the island rookery just prior to the young birds' leaving the nesting site. The raiders had apparently made the voyage of over four miles from the north-east shore in water craft of some sort, probably tule balsas.] Thus, even this island communal nesting ground far from shore figured into the food quest of the aboriginal lake dwellers. Additional cultural deposits on this former island are under study and will be reported elsewhere.

sub  
part

#### 4. TRAVERTINE ROCK

Travertine Rock is an easterly outlier of Villager Peak, projecting out into the Salton Basin from the main body of the Santa Rosa Mountains (Fig. 3). It is the northerly of several rocky outcrops joined by an immense sand bar at the locality usually called Travertine Point, at the Riverside-Imperial County line just west of the present Salton Sea. The rocks formed tiny islets just off the west shore of Lake Cahuilla. Below the waterline are deposits of dendritic calcareous tufa up to 60 centimeters thick (Jones 1914; MacDougal and Sykes 1915). [Hubbs and Miller (1948:107) reported finding a kitchen midden of fish bones in the crevices atop Travertine Rock. The bones represented the species Colorado River bonytail chub (*Gila robusta*, now *G. elegans*), Colorado River squawfish (*Ptychocheilus lucius*), and members of the sucker family (Catostomidae), evidently the humpback sucker (*Xyrauchen texanus*), all found in Lake Cahuilla during its recent stands. Some of the bones still had dried organic matter adhering to them.]

Presumably the Indians had swum the short distance out to Travertine Rock and obtained the fish there during one of the recent stands (probably the last stand) of Lake Cahuilla. Or, they could have had easy access to Travertine Rock by means of the great sand bar within a few years after the lake began its recession.

#### SUMMARY AND COMPARISONS

The dietary and ecological information drawn from analysis of coprolites and floral and faunal remains from middens at several archaeological sites provides some understanding of prehistoric living conditions at Lake Cahuilla during its most recent stand. Evidence from the Myoma Dunes indicates that occupation at the marshy northwest end of Lake Cahuilla, near present Indio, either occurred repeatedly in all seasons of the year, or, more probably, occurred the year round. Fish and small mammals, as well as shellfish, were probably taken in all seasons. Specific seasons of acquisition can be determined for migratory waterfowl and immature individuals of resident species, and for a variety of plant foods. Such data indicate the season of occupation.

Subsistence at the Myoma Dunes was, on the whole, focused on resources available in the immediate vicinity. Shellfish, fish, and aquatic

birds were taken in and on the open waters of Lake Cahuilla; seeds of bulrush, cattail, witchgrass, and others, and cattail pollen, were obtained in the Freshwater Marsh; small mammals, seeds of lowland purslane, *Dicoria canescens*, *Panicum urvilleanum*, and goosefoot, screw-bean pods, and various other resources were derived from the Creosote Bush Scrub plant community. Some major resources, such as the pinyon nut, were obtained in plant communities in the adjacent uplands, most likely in the Santa Rosa Mountains.

*Dicoria* seed was an important winter resource, supplemented by stored seeds of many kinds and undoubtedly an increased emphasis on fish and waterfowl. Likewise, cattail pollen was consumed in quantity in the spring, along with bulrush seed that had presumably been stored over winter. The only cultivated plant remains recovered are seeds of squash, which were apparently acquired by exchange with groups to the east.

It is apparent that the coprolite analysis has tended to produce a slightly biased reconstruction of aboriginal dietary practices at the Myoma Dunes in that certain items that probably figured into the subsistence pattern are not represented. [Specific resources that might have been consumed, but that were not recovered in the analysis, include bighorn sheep and mule deer. These species would not likely be represented in the coprolites by identifiable bone fragments, and any hairs that may have been accidentally ingested could have decomposed. Thus, there might be no recognizable evidence that they had ever been used for food.] Given the existence of both mule deer and bighorn sheep in the nearby Santa Rosa Mountains today, it seems probable that the aboriginal inhabitants of the Myoma Dunes may have hunted them also. Evidence of consumption of bighorn sheep or deer would probably be found in bone refuse in shoreline middens such as those at the Myoma Dunes. Analysis of both coprolites and terrestrial faunal remains recovered from midden excavations would tend to produce a more complete picture of aboriginal diet than that derived from coprolite analysis alone, particularly in regard to the consumption of large mammals.

[Similarly, there is little reason to believe that desert agave, which was so important in historic time, and which would have been no more difficult to obtain than the pinyon nut, was ignored. This resource would have been available during the winter and early spring when few other plant foods could be collected.] However, it is questionable whether any evidence of agave use would be present archaeologically at the Myoma Dunes or in other shoreline occupation sites. Such evidence, if present originally, would probably have consisted solely of quids, the wads of fiber spat out after pieces of the agave leaves, stalk, or heart had been chewed; but these may have completely decomposed. It is more likely that archaeological evidence of agave processing would be found in the mountains where the agave still grows.

[This raises the question of the existence, nature, and location of archaeological sites at some distance from the lakeshore that may have figured into the settlement-subsistence system that operated at pre-historic Lake Cahuilla. In recent years, archaeologists have employed the concept of site catchments, territories that could have been effec-

See  
part

tively foraged over from a base camp (Vita-Finzi and Higgs 1970). Catchments are usually considered to include all territory within the range of a two-hour walk (about six miles on flat land; less on rougher terrain). This figure (and in fact the entire concept of site catchments) is based on observations of contemporary hunters and gatherers, specifically the !Kung Bushmen of the Kalahari Desert of northeast Botswana (Lee 1969). These people will range as much as two hours' walking distance from a base camp in search of food. Hunting or collecting at more than two hours' walking distance from a base camp is considered impractical. Distant resources are more efficiently obtained by establishing a seasonal camp where they occur.

It seems reasonable to assume that generally similar concepts of cost as a function of distance operated in the prehistoric Salton Basin. In the case of the Myoma Dunes, bighorn sheep and agave would not have occurred in abundance within two hours' walking distance. If these resources were used, and they almost certainly were, we should expect to find temporary camps, ambushing blinds, agave roasting pits, etc., in the agave-ocotillo association at the upper limit of the Creosote Bush Scrub zone. These would be linked with the hunting of bighorn sheep and the collecting and processing of agave. Similarly, temporary camps used by deer hunters would be expected to occur in Yellow Pine Forest, Chaparral, and Pinyon-Juniper Woodland plant communities, and to be linked to the shoreline occupation on the floor of Coachella Valley. It has already been shown that another resource, the pinyon nut, was extensively used at the Myoma Dunes. Pinyon trees do not occur within a two-hour walk of the Myoma locality, and unless the nuts were obtained by exchange it is probable that temporary camps must have been used by the lake dwellers during the autumn pine nut harvest in the Pinyon-Juniper Woodland. ]

catch  
sites

[Fishing was one of the most important economic activities, both at the Myoma Dunes and at Wadi Beadmaker.] At the latter site, refuse containing the remains of probably thousands of Colorado River bonytail chub and humpback sucker, and probably other species in lesser amounts, was excavated, along with coprolites, which also document the importance of fish in the diet of the Indians that formerly fished there. Waterfowl and terrestrial animals, including the desert tortoise, jackrabbit, and desert bighorn sheep were also taken. Plant foods consumed were the seeds of witchgrass, bulrush, and apparently amaranth. The site may have been used primarily in the fall, but the seasonal dating is unclear.

The island rookery at the Bat Caves Buttes was also visited by the lakeshore inhabitants, probably by means of tule balsas. Evidence obtained there indicates that this island communal nesting site more than four miles from shore was raided, and young great blue herons and black-crowned night herons taken just prior to their leaving the nesting grounds. Some of these were roasted and eaten on the spot, but there is every reason to believe that supplies of this readily available harvest of protein were also brought to shore.

The relationship between the several sites for which data are now available is uncertain. It is entirely possible that sites like Wadi Beadmaker, with its seemingly more specialized function, were seasonally used by groups living the year round in other localities offering a broader

array of available resources, such as the Myoma Dunes. And there is little reason to believe that even the remote island nesting grounds of the Bat Caves Buttes could not have figured into the seasonal food quest of groups at the extreme northwest end of the lake. But it should be emphasized that the focus of this research has been on the Myoma Dunes in Coachella Valley, and that the entire east shore of Lake Cahuilla, along and near to where these sites are located, as well as most of the southwest shore, in large part remains to be investigated. This fact only serves to point out that the pattern reconstructed for the Myoma Dunes may differ significantly in important details from that even in other parts of Coachella Valley, not to mention the central and southern portions of the Salton Basin. There is a marked change in topography and therefore differences in the prehistoric distribution of available food resources along different parts of the Lake Cahuilla shoreline. Items available in one locality, such as marsh sedges, were entirely lacking in others. Likewise, resources like pinyon were more readily available to groups that might have lived along the west side of Coachella Valley where the Santa Rosa Mountains lie close to the former shore.

The pattern of subsistence revealed in the deposits of these sites indicates a fairly stable economic base with food items available the year round. All of the plant foods recovered are also storable for extended periods of time. Popul- The great frequency of habitation sites like those of the Myoma Dunes, stretching for about ten miles along the northwest shore of Lake Cahuilla in a former marsh zone, as well as a nearly continuous midden along the entire habitable shoreline, indicates that the population of Indians involved was substantial indeed. The adaptation outlined in the preceding pages is believed to date to the interval from A.D. 900-1500, with one interruption, when the lake went dry for a brief period. Most of the data reviewed here probably date to the last two centuries of that interval.

The orientation toward aquatic resources with seasonal use of adjacent uplands at this, the largest lake in California in recent times, has strong parallels with the ethnographic and prehistoric situation in the Great Central Valley. Especially in its southern part, the latter is decidedly a desert of shallow basins, but as in the case with the Salton Basin, inflow of river water gave rise to some substantial lakes and marshes. Examination of published reports on the lake- and marsh-dwelling Yokuts such as the Tachi of Tulare Lake, or the Tulamni and their predecessors on Buena Vista Lake, for example (Beals and Hester 1958; Gayton 1948; Latta 1949; Wedel 1941), reveals that the basic ecological adaptation of the Indians of this region is quite similar to that reconstructed for the Coachella Valley during the last stand of Lake Cahuilla.

Parallels can also be drawn with archaeological situations in the Great Basin. An ecological adaptation with parallels to that reconstructed for the Myoma Dunes existed in the Humboldt and Carson sinks of west-central Nevada. Some of the same categories of food resources, such as bulrush seed, cattail pollen, fish, and aquatic birds, were important there, as at the Myoma Dunes. There are differences that set the two apart, such as the apparent greater use of pinyon in Coachella Valley.<sup>8</sup> In addition, it is probable that the caves of the Humboldt and Carson

sinks may have been resorted to primarily in the winter, whereas it appears that the Myoma Dunes saw a year round occupation. But even so, there are sites on the shore of Humboldt Lake that apparently represent a continuous occupation except in times of severely cold weather (Heizer and Napton 1970; Napton 1970).

Adaptation to lakeside resources, or to a combination of those of lakeside settings and nearby uplands, was an effective long-term subsistence orientation. It persisted for nearly 5000 years in west-central Nevada. Its eclipse in the Coachella Valley was due to the disappearance of Lake Cahuilla, and not to any basic changes in cultural adaptation.

#### NOTES

1. This olla was taken to the Bowers Museum in Santa Ana, California, where it is presumably now located (Bean and Saubel 1972:98-99).
2. The presence of barrel cactus seed in samples containing an abundance of the seed of *Dicoria canescens* suggests that the former was collected and stored for winter use.
3. Sample numbers MDA-4, 7, 11, 25, 27, 29, 33, 41, 42, 45, 46, 47, 50, 101, 103, 110, 112, 114, 124. For a listing of the macroscopic contents of these samples, see Appendix B.
4. Sample numbers MDA-10, 18, 26, 34, 40, 44, 106, 121, 125.
5. These squash remains are probably the oldest dated cultivated plant remains from archaeological contexts in California. Rogers (1929) reported finding undated corn (*Zea mays*) in the Mojave Sink near Crucero. Wilke and Fain (1974) described a bottle gourd (*Lagenaria siceraria*) they found in a rockshelter near the Lake Cahuilla shoreline in Coachella Valley which probably also dates to the last period of lacustrine conditions in the Salton Basin. Seeds of probable cultivated squash (*Cucurbita pepo*) (Thomas W. Whitaker, personal correspondence) were recently forwarded to me for study by Rose Tyson of the San Diego Museum of Man. These came from an olla found along the shore near Fish Creek, in the southwest portion of the Salton Basin, and apparently date to the last stand of Lake Cahuilla. Other than these instances, remains of cultivated plants from prehistoric archaeological contexts in southeastern California have not been reported. Elsewhere Wilke, Whitaker, and Hattori (1977) reported on the squash remains from the Myoma Dunes and from the Fish Creek Mountains.
6. Pyle (1961:18) indicates that pintails are abundant in inland southern California from late July through about the first of May.
7. This site is named for a nearby colony of women who occupied a small palm oasis which they had designated Wadi. They were, at the time of fieldwork, extracting a meager living by fashioning beads from the seeds of desert ironwood, California fan palm, and other desert plants.

8. The largest body of data on the lacustrine adaptation of aboriginal inhabitants of this region comes from Lovelock Cave overlooking the Humboldt Sink. The nearest pinyons to this locality are about 40 miles to the southeast in the Stillwater Mountains.

THE RELATION OF MAN AND BEAST TO THE LAKE

There is a general impression that the aboriginal inhabitants of the Great Basin were hunters and gatherers rather than farmers. This impression is based on the fact that the only agricultural products found in the archaeological remains of this region are the seeds of wild fruits and berries. The absence of any domesticated animal bones is also taken as evidence that the aboriginal inhabitants were hunters rather than hunters-gatherers. However, the discovery of bones of domesticated animals in the archaeological remains of the Great Basin has led some to conclude that the aboriginal inhabitants were hunters-gatherers. The bones of domesticated animals found in the archaeological remains of the Great Basin are the bones of sheep, goats, cattle, horses, and pigs. The bones of these animals are found in the same strata as the bones of wild fruits and berries. This fact is taken as evidence that the aboriginal inhabitants were hunters-gatherers. However, the discovery of bones of domesticated animals in the archaeological remains of the Great Basin has led some to conclude that the aboriginal inhabitants were hunters-gatherers.

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## Chapter V

### THE RETURN TO DESERT CONDITIONS

About the end of the fifteenth century a change occurred in the course of the Colorado River which allowed it to flow across the southern slope of the delta directly into the Gulf of California, as it did in historic time. This cut off the inflow of water to Lake Cahuilla. The waters of the lake evaporated, and within 60 years--perhaps less--what had once been an inland sea of fresh water some 115 miles long was reduced to a barren salt playa. While almost no archaeological data are available on the cultural adjustments which occurred in this period of accelerated environmental change, the sequence of natural and cultural events is reckoned as follows: (1) loss of aquatic resources; (2) coincident adjustments in both subsistence and settlement patterns by the Indians of the region; (3) establishment of desert vegetation on the lakebed; and (4) occupation of the lakebed (at least that portion of it in Coachella Valley) by the Cahuillas who lived there in historic time. This sequence of events may have ensued within about a century, centering on the beginning of the sixteenth century, A.D.

From the standpoint of its role in shaping the late prehistory of southeastern California, the drying of Lake Cahuilla was probably one of the most important factors, as suggested by Aschmann (1959:45). It forced substantial populations to undergo a transition from lakeside oriented existence to one that relied entirely on low desert and upland resources. Many groups no doubt found it necessary to physically remove themselves to new surroundings in the process. But the fact remains that of this period of transition ~~almost no archaeological documentation is available.~~ At this point we can only infer what must have occurred when Lake Cahuilla receded, summarize the meager data available from the regions bordering the Salton Basin, and devise ways of researching the cultural adjustments which transpired.

#### DECLINE OF AQUATIC RESOURCES

The first important change to occur in the biotic environment as the lake level began to drop was the loss of the Freshwater Marsh plant community in Coachella Valley.<sup>1</sup> As shown in the previous section by the analysis of coprolites from the Myoma Dunes, the Freshwater Marsh had had been of major importance as a source of plant products for the Indians living at the northwest end of Lake Cahuilla. Emergent marsh vegetation will tolerate moderate fluctuations in lake levels, and will even thrive if the fluctuations do not exceed four or five feet seasonally or annually (cf. M. Weide 1968:87-95). But emergent plants like bulrush (*Scirpus*) and cattail (*Typha*) will not tolerate a progressive decline which both lowers the water level and causes the shoreline to regress several thousand feet each year. These species expand into

shallow waters as much by vegetative reproduction as they do by seeding. If the retreat of the water is slow, and the chemistry of the water not greatly altered, such growth can accommodate the change and the marsh can maintain itself, provided that there is a favorable substrate. However, [if the water retreats 1000-3000 feet per year, as it would have in Coachella Valley, the effect on marsh vegetation is devastating. The loss of bulrush, cattail, and other economically important plants was therefore one of the first changes to occur in the inventory of natural food resources as Lake Cahuilla began its latest recession.] Within the vegetation went the assemblage of birds and animals common to the Freshwater Marsh plant community. The Myoma Dunes were probably abandoned, except for seasonal harvesting of mesquite and screwbean, and perhaps *Dicoria*, within a year or two after the lake started its decline.

[It was shown earlier that the shellfish *Anodonta dejecta* was of some importance as a food item in Coachella Valley where the Indians obtained it in water up to a yard or so deep. This clam all but disappeared within the first 12 years of the recession of Lake Cahuilla, as shown by Bowersox (1973), who found the shells of this species largely confined to the first 60 feet below the main shoreline. He attributed the disappearance of *Anodonta* to an increase in salinity as the volume of water in the lake diminished.] L. A. Payen (personal communication) suggests, however, that destruction of habitat may have been of greater importance than the change in salinity of the water. The sandy mud substrate in which the clam thrived would have been laid bare within a year or two as the lake level began to drop. It is doubtful whether this shellfish could have maintained viable breeding populations for more than a few years even if the salinity had remained unchanged. Probably both factors were important in its disappearance. Although it was not a major food item, the clam was eaten, as indicated by the beds of shells exposed in deflating sand dunes along the former lakeshore in Coachella Valley. Its disappearance therefore figured into the overall adjustments in food-getting that accompanied the drying at Lake Cahuilla.

[Fish fared better than shellfish and aquatic plants, at least for a time.] The mullet (*Mugil cephalus*) tolerates the salinity of the open sea, but also ascends rivers that enter the sea. Its spawning habits are not well understood, but based on reports by Fitch (1972) and Johnson and McClendon (1970), it would appear that the species can and does spawn in both fresh and salt water. It was probably able to spawn in the declining Lake Cahuilla, at least in the early years of its recession. If so, it and the desert pupfish (*Cyprinodon macularius californiensis*) may have been the last species of fish to survive in the lake. Bones of the humpback sucker (*Xyrauchen texanus*) and bonytail (*Gila elegans*) were found in abundance in the ruins of a house excavated at an elevation of about -95 feet in a field of several hundred fish weirs on the west side of Coachella Valley (Figs. 24, 25). The bones indicate that these species still survived about 25 years into the recession, which lowered the lake by about 140 feet. But this was probably about the end for both of these species, as the construction of weirs, which was evidently built for taking these species, ended at that locality within two years after the house was occupied. The lowest complete and definite weir occurred at about -99 feet, and no indication of others was found at lower elevations there or elsewhere. Recently a midden containing the bones of humpback



Fig. 24. Fish weirs built annually as Lake Cahuilla receded. Earliest of seven construction episodes shown is at top. Aerial view from 2750 feet. Horizontal distance across photo is 790 feet.

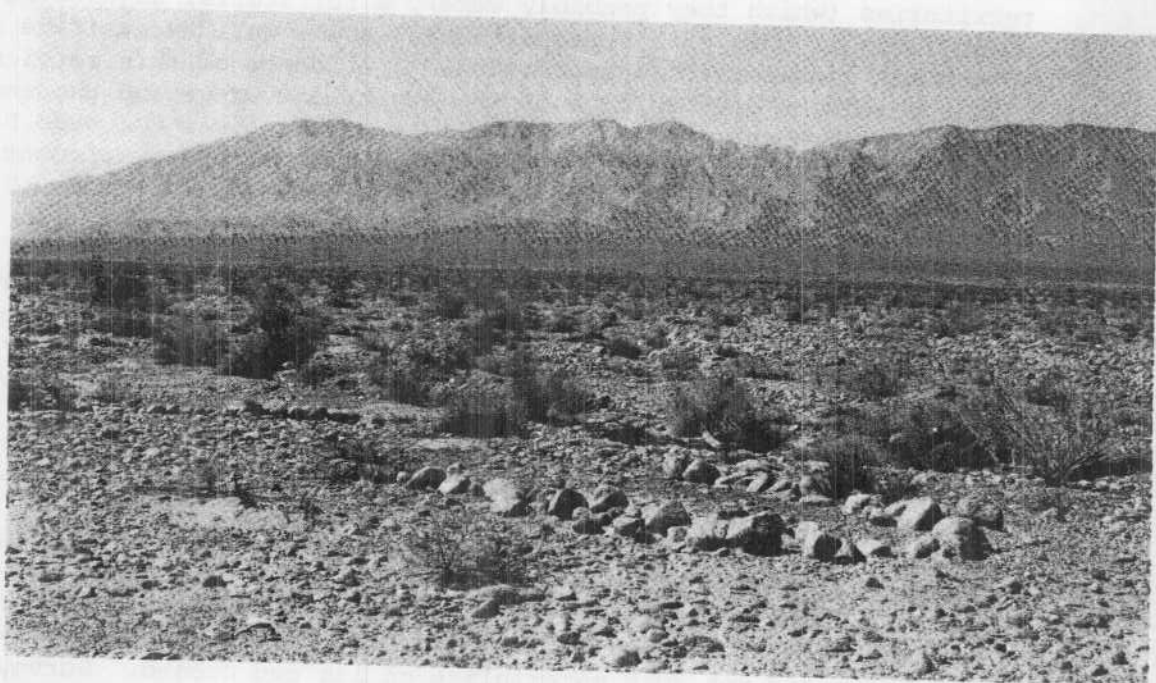
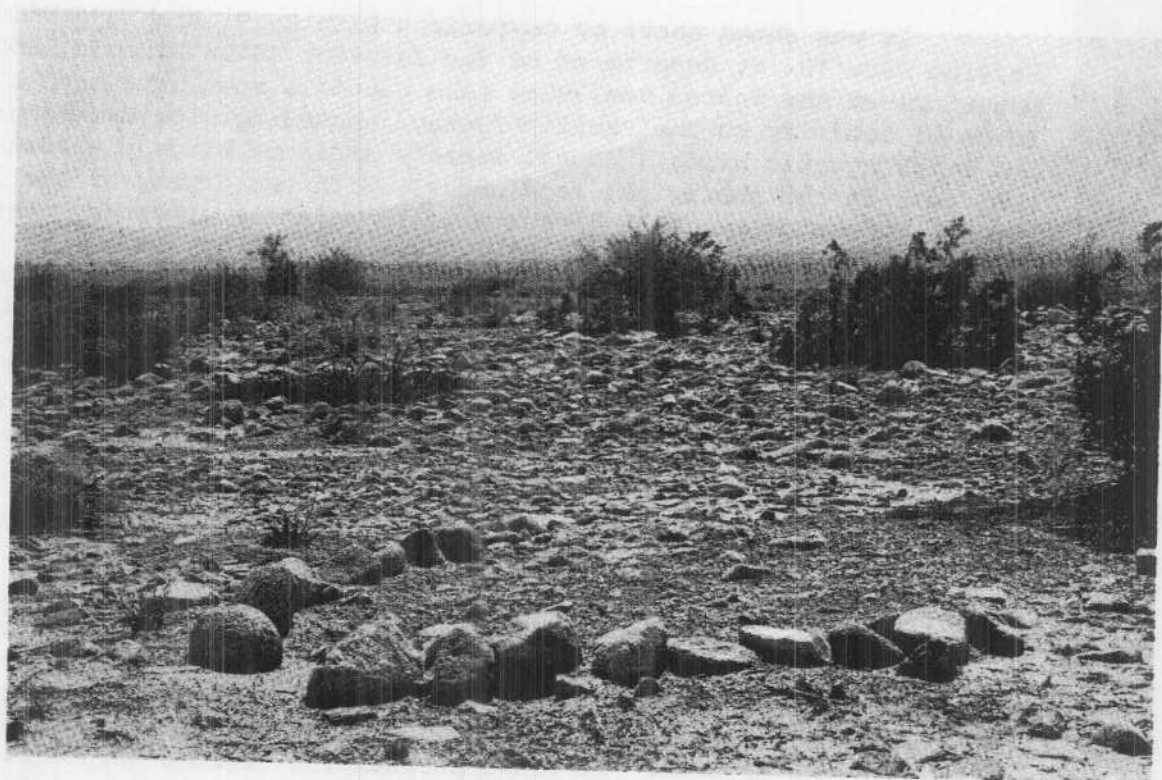


Fig. 25. Fish weirs, west side of Coachella Valley near Alamo Canyon. Upper: weir with rock wings about eight feet long. Lower: weir with wings about sixteen feet long. The vegetation is characteristic of the Creosote Bush Scrub plant community.

sucker and bonytail was found at the Thermal Airport at an elevation of -103 feet.

It was shown above by comparison with U. S. Fish and Wildlife Service data (U. S. Department of the Interior 1970; Lincoln 1950) on waterfowl at the Salton Sea, that Lake Cahuilla must have been a major focus of activity on the Pacific flyway, abounding with ducks, geese, and other aquatic birds. Faunal remains indicate birds played an important part in the aboriginal food quest. With the drying of the lake, species common to marshy habitats were immediately affected. These included the mudhen (*Fulica americana*), the remains of which were so common at the Myoma Dunes, as well as the various ducks and geese that feed on the seeds of bulrush, cattail, and other marsh plants (Martin, Zim, and Nelson 1951). The disrupted ecological balance of the ever-diminishing lake no doubt had a devastating effect on the food chains of many species. It seems logical to assume that the focus of activity on the Pacific flyway simply shifted to the nearby Colorado River Delta.

#### ADJUSTMENTS IN SETTLEMENT AND SUBSISTENCE PATTERNS

Increased seasonal intrusions into the mountains for plant and animal foods to replace those no longer available at Lake Cahuilla would soon have been followed by both intensive and extensive reliance on the resources of those regions. It is difficult to imagine the range of adjustments necessary in such a sudden and large-scale intrusion of people into the uplands. If these surrounding regions were already occupied, and the primary resource zones already claimed as gathering territories (which they probably were), a territorial adjustment one place, even if only on a seasonal basis, could well necessitate another adjustment elsewhere. Archaeologically, evidence of this settlement change should be seen throughout the Peninsular Range and the eastern part of the Transverse Range, as well as on the Lower Colorado River. This would amount to a major shift in subsistence and settlement patterns throughout the regions surrounding the Salton Basin (Aschmann 1959, 1966; Wilke 1971).

seas/  
sett patt  
territories?  
hypothesis

Several regional studies in inland southern California seem to bear out the notion that a change in settlement patterns occurred, and that it occurred at about the right time to be linked to the drying of Lake Cahuilla. However, it is realized that with presently available methods of archaeological dating, it is difficult to fix events in time with sufficient precision to suggest cause and effect relationships. About the best that can now be employed is cross-dating, with such items as ceramics and small triangular arrowpoints taken to indicate a date of "roughly post-A.D. 1000." In the absence of other data, sites yielding such items could as well date to A.D. 1750, or even later. One thing is certain: the known abundance of so-called Late Horizon or Late Period (i.e., post-A.D. 1000) sites that occurs in the regions bordering the Salton Basin did not just materialize on its own accord. Surveys have repeatedly documented large numbers of specialized milling and other processing sites, together with many small camp sites, in regions that yield evidence only of late occupations characterized by ceramics and small triangular projectile points. There is simply a profusion of such

late  
occupations

sites, and they date, according to conventional understanding of artifact chronologies in the area, to sometime between A.D. 1000 and 1750. It does not seem unreasonable to suggest that this profusion of sites in regions bordering the Salton Basin reflects a profound change in life style for some substantial human populations, and that the change was, at least in part, triggered by the drying of Lake Cahuilla. Some of the regional studies can be reviewed briefly.

#### Settlement Changes in the Peninsular Range

Investigations in the Peninsular Range include first of all the surveys and excavations conducted in the Anza-Borrego Desert on the arid eastern slope of the mountains to the west of the Salton Sink.

Borrego Sector, Anza-Borrego Desert State Park. Meighan (1959) reported on a reconnaissance of portions of the Borrego sector of the Anza-Borrego Desert State Park. Portions of San Felipe Valley, Culp Valley, Collins Valley, Coyote Canyon, Indian Canyon, and Clark Dry Lake basin were surveyed. One hundred seventy-three sites, including milling stations, mesquite pits, temporary camps, and village sites were recorded. All of these sites are believed to date to the period of ceramic use in inland southern California, or to sometime after A.D. 1000. Meighan estimates that the sample represents only 5-10% of the 2000-4000 archaeological sites actually present in the Borrego sector of the park. Such an abundance of late prehistoric sites suggests that there was a significant influx of people into the Anza-Borrego Desert in late prehistoric time. It also suggests that in earlier periods the region was only sparsely populated, if at all. This seems to be borne out, since no evidence of earlier occupations was found in the course of survey despite attempts to locate older sites. The limited excavations conducted in this region (site SDi-474 in Culp Valley and site SDi-453 in Grapevine Canyon) (Townsend 1960) also failed to uncover evidence of occupation dating prior to the late prehistoric period.

Anza Sector, Anza-Borrego Desert State Park. Archaeological reconnaissance and limited excavations were conducted in the southern (Anza) sector of the park under the direction of William Wallace. In the vicinity of Mountain Palm Springs, Wallace (1962a) recorded 14 sites, all but one of which yielded pottery from the surface. All of the sites recorded in this district are assigned to the ceramic period, or sometime after A.D. 1000, according to Wallace.

Wallace also reported (1962d) the findings of a site survey in the Indian Gorge-Indian Valley district of Anza-Borrego. Twenty-eight sites were recorded here, including many mesquite pits. These sites were assigned to some portion of the interval from A.D. 1000 to historic time, as all but one of them yielded ceramics from the surface, and projectile points were of late prehistoric styles (now classified as Cottonwood series and Desert Side-notched series). No evidence of earlier occupation was found in this district.

Additional surveys were conducted in the Bow Willow Canyon and Indian Hill districts (Wallace and Taylor 1958, 1960a). A total of 48 sites were found in these districts, and again, the occupation at all of them was judged to date to sometime after A.D. 1000.

One of the sites in the Indian Hill district, designated the Indian Hill Rockshelter (Wallace and Taylor 1960b; Wallace, Taylor, and Kritzman 1962), was trenched and found to contain about five feet of cultural deposits. The lower levels of the deposits dated to pre-ceramic times. Projectile points from these levels were large lanceolate, and notched forms (Elko series or equivalent), indicating use of the atlatl. Scraper planes were confined to these lower levels also. A gradual transition to small triangular arrowpoints occurred in the upper levels, which also yielded ceramics. The deposits appear to span the last 2-3000 years, with abundant evidence of use in late prehistoric times. Many hearths were reportedly discovered, but the chronology of the deposits was not refined by radiocarbon dating.

pre-  
ceramic

Test excavations at another site (survey site BW-9) in the Bow Willow Canyon district (Wallace 1962c) yielded evidence of use only in late prehistoric and/or historic time.

The overall impression that emerges from published reports on the archaeology of the Anza-Borrego Desert is that the region contains a great many sites, including campsites reflecting short-term occupation, milling sites, mescal (agave) roasting pits, quarries, and substantial village sites. But with the exception of the lower levels of the Indian Hill Rockshelter, the archaeological data that can be cross-dated with artifact forms of known age suggests intensive use only in late prehistoric and historic time. The range of site types indicates a pattern of seasonal hunting and plant collecting not unlike that of the Cahuilla of Coyote Canyon in historic time (Barrows 1900; Bean and Saubel 1972).

#### Perris Plain (San Jacinto Plain)

Some of the best evidence for a late prehistoric population intrusion into a locality that had previously seen little use comes from surveys and excavations conducted on the Perris Plain west of the San Jacinto Mountains (O'Connell et al. 1974). Surveys at Perris Reservoir revealed the presence of at least 61 archaeological sites, including temporary campsites with bedrock milling facilities and midden deposits, rock art sites, and many isolated milling sites with one to a dozen or more bedrock metate "slicks." A careful search failed to disclose anything approximating the large ethnographic village sites such as those excavated and described by McCown (1955b), True (1970) and True, Meighan and Crew (1974) on the Pacific slope of the Peninsular Range. This fact, together with functional interpretation of the various site types based on local ethnographic comparisons, and excavation data from five temporary campsites, indicates that the region was used for seasonal hunting and plant food collecting. Stratigraphic interpretation of the deposits revealed almost no evidence of occupation prior to the late prehistoric period; intensive use of the locality did not begin until about A.D. 1500 or 1600. Thereafter, the region saw intensive seasonal use, apparently from spring through fall, by small groups of people who used ceramics and engaged in the collection and processing of small seeds, holly-leaf cherry fruits (*Prunus ilicifolia*), and possibly some acorns (*Quercus dumosa*). Hunting was also an important activity, with a minimum faunal count of well over 1000 individual animals representing more than

X

30 taxa tabulated from the bone scraps collected in the course of excavation. These were mostly small mammals, but waterfowl and large animals like mule deer and bighorn sheep were also represented (Hammond 1974). The data clearly indicate an intensification of land use after ca. A.D. 1500. The artifact forms recovered in the excavations at Perris Reservoir are largely duplicated at the Christensen-Webb site in Menifee Valley about 30 miles to the south (Kowta et al. 1965).

### Upper Coachella Valley

*Tahquitz* ✱  
 Under agreement with the Agua Caliente Band of Cahuilla Indians, an archaeological survey was made of the mouth of Tahquitz Canyon. The survey (Wilke, King, and Hammond 1975) revealed abundant evidence of occupation on the alluvial fan where Tahquitz Creek, a perennial stream, sinks upon emerging from the San Jacinto Mountains. Ceramics were everywhere abundant. Limited excavations at one site locus (TC-27N) revealed faunal and floral remains reflecting the hunting and gathering aspects of historic Cahuilla lifeway in the Colorado Desert. The deposits were dated by radiocarbon at 245±50 radiocarbon years B.P., or A.D. 1510-1640 when corrected to calendar years.

### Little San Bernardino Mountains

Several studies across the Coachella Valley in the vicinity of Joshua Tree National Monument seem to reflect a late prehistoric population intrusion into the Little San Bernardino Mountains and adjacent ranges to the east and northeast. These studies are reviewed and summarized by T. F. King (1976). Campbell's (1931) report of early reconnaissance and excavation, largely in the territory around Twentynine Palms, provides a sampling of the artifacts of this region; but little information on specific sites or on artifact provenience and frequency is contained in the report. Consequently, it is difficult to draw conclusions on possible increased use of the region in post-Lake Cahuilla time. [Certain projectile points from the collections described are of types that date to at least 5000 years ago, according to current understanding (Hester 1973; Hester and Heizer 1973), but these may have been collected around the dry lakes to the north and east of Twentynine Palms. Among the most common points, however, appear to be those now included in the Cottonwood series and Desert Side-notched series. Ceramics are well represented in the collections, having been found in many small storage caves and shelters. It seems probable that much of the material is of recent origin, dating from the late prehistoric and historic periods. The pinyon- and yucca-clad uplands of the Little San Bernardino Mountains would have been one of the more attractive regions adjoining the Salton Basin for seasonal gathering and hunting after the decline of Lake Cahuilla. Certainly, the many cached vessels found in this region (primarily ceramic ollas, or storage jars) suggest that it was visited annually by groups of people who gathered plant foods as they became available, and then cached their implements until the following year. The region is characterized by very limited water sources. Permanent occupation by large groups of people would be impossible, given present climatic conditions. The available data, which are admittedly difficult to interpret, may, however, indicate intensive seasonal plant collecting by small groups since the recession of Lake Cahuilla in the adjacent Coachella Valley.]



Such small groups of people could have foraged from isolated springs, probably carrying their water supplies with them.

More recent studies seem to document a late prehistoric intensification of land use in this region. Wallace and Taylor (1960c) described the findings of a survey in the Deep Tank-Squaw Tank district of Joshua Tree National Monument. Twenty-three sites were found, all but two of which yielded pottery. Milling implements were common. The sites in this district reflect the seasonal collecting pattern of the historic period, a pattern that we can logically infer extended at least several hundred years back into prehistoric time.

One of the sites near Squaw Tank was excavated (Wallace and Desautels 1960). Pottery occurred throughout the deposit and small arrowpoints were common. The site was apparently occupied seasonally in the late prehistoric period, with occupation continuing into historic time as well.

Similar findings were reported for the Sheep Pass district (Wallace 1964), including portions of the adjacent Queen and Lost Horse valleys. Sixteen sites were found, all but two of which yielded ceramic artifacts from the surface. All of these sites are thought to date from the late prehistoric and historic periods, and seem to duplicate the pattern of land use seen at the nearby Deep Tank-Squaw Tank district.

#### Other Regions

Although detailed archaeological reports are available for several other regions of inland southern California, it is not possible to draw any firm conclusions about possible population movements into those regions in late prehistoric time. True (1970) described the Cuyamaca complex, a late prehistoric manifestation from the Laguna Mountains of southern San Diego County. A large number of sites in this region, many of them yielding ceramics and side-notched projectile points, reflect an adaptation of a large population to the forested uplands at least on a seasonal basis (probably summer and fall). It was suggested earlier (Wilke 1971) that the inception of the Cuyamaca complex sites might be traceable to the drying of Lake Cahuilla. It now seems apparent that the Cuyamaca complex is the culmination of long process of adaptation to upland resources and contains elements which are seemingly derived from the Hohokam of Arizona. These latter elements include the characteristic long, serrated projectile points and urn burial of cremations.

The related counterpart of the Cuyamaca complex, the San Luis Rey complex (Meighan 1954; see also Kowta et al. 1965), extends from northern San Diego County across western Riverside County, and is represented by an absolute profusion of archaeological sites. The complex is divided into preceramic (San Luis Rey I) (Meighan 1954) and ceramic (San Luis Rey II) (True, Meighan, and Crew 1974) phases. The dating of these phases is uncertain, but use of pottery probably began about A.D. 1600 or a little later, according to current estimates for this region. As one moves northward, pottery becomes less frequent. This is perhaps linked to a decreasing reliance on a few important resources like acorns and an emphasis instead on many plant and animal foods (and the greater

mobility required in the pursuit of these resources) as one proceeds to the north and especially the northwest. It appears that the San Luis Rey complex, as documented in the San Luis Rey River basin, also represents a long process of settling in to the resources of the inland hills and valleys. But near the north and northwest end of the range of the San Luis Rey complex, as observed at Perris Reservoir, there is clearly a late prehistoric movement, on a seasonal basis, into a region that had previously seen little use.

### Summary

Excluding from this discussion the probable movement of groups from the receding Lake Cahuilla to the Lower Colorado,<sup>3</sup> available data seem to document a movement into the habitable uplands surrounding the Salton Basin in the late prehistoric period. Such a settlement shift was suggested as one aspect of the cultural adjustments which accompanied the disappearance of Lake Cahuilla.

Lying immediately to the west of Imperial Valley, the Anza-Borrego Desert is a logical region to have received populations from the drying lake. It is a region which extends from nearly sea level to high elevations on timbered mountains. Its range of environmental zones is well suited to a diversified pattern of hunting and collecting like that of the historic Cahuilla. Perhaps some major aspects of Cahuilla Indian subsistence date to the drying of Lake Cahuilla and are reflected in the abundance and diversity of archaeological sites in the Anza-Borrego Desert.

A reasonable explanation for the abrupt settlement change seen at Perris Reservoir does not lie in local population growth. Rather, it would appear more likely that the locality was not considered an essential gathering territory until late prehistoric time when overcrowding (or less likely, a reduction of resources) in nearby regions necessitated use of the Perris Plain. Given the time that intensive use of the locality apparently began, it would seem reasonable that the drying of Lake Cahuilla may have initiated a restructuring of territories in the Peninsular Range, forcing some groups to make use of the plains and outlying mountain masses to the west in the summer months. The mountains were probably able to accommodate larger populations in the fall when acorns and pinyon nuts were available, but the summer months would be the time that small groups of people would have had to forage more widely for small seeds and game animals. [Use of the Perris Reservoir locality thus seems to represent such a situation of overcrowding and consequent territorial restructuring in the Peninsular Range, and the drying of Lake Cahuilla may well have initiated the process (O'Connell 1971; Wilke 1974b).]

Tahquitz Canyon is located about 20 miles from the northwest end of former Lake Cahuilla, and water sources like Tahquitz Creek would have become very important settlement locations after the lake dried. More excavations are needed to determine the relationship between historically occupied sites in the Palm Springs region and the disappearance of Lake Cahuilla. However, at present the oldest dated feature at Tahquitz Canyon (corrected to A.D. 1510-1640) certainly suggests that this region saw a population influx in about the sixteenth century.

Taken as a whole, it appears that the entire uplands of the Little San Bernardino Mountains-Cottonwood Mountains chain to the north-east of Coachella Valley contain a profusion of late prehistoric sites. The sites reflect intensive foraging on a seasonal basis, probably from spring to autumn, by pottery-using groups. This pattern continued also into historic time (cf. T. J. King 1976). It seems most reasonable to conclude that the region became an important gathering territory after the drying of Lake Cahuilla.

Thus, it would appear that the Anza-Borrego Desert, the Perris Plain, the region of the Little San Bernardino Mountains, and the upper Coachella Valley contain large numbers of ceramic period sites of a variety of types. These include many temporary camps, milling stations, mescal pits (in regions where agave is found; it is all but absent in the Little San Bernardino Mountains), etc., reflecting the extremely diversified food quest of the historic Cahuilla (Barrows 1900; Bean and Saubel 1972; Wilke 1976). It is suggested that this abundance of specialized late period sites, and a corresponding scarcity of sites from early periods in time in regions surrounding the Salton Basin, reflects the restructured settlement pattern that would have become necessary when Lake Cahuilla receded.<sup>4</sup>

#### REVEGETATION OF THE LAKEBED

Little information is available that might suggest the rapidity with which vegetation reoccupied the ground laid bare by the recession of Lake Cahuilla. There is reason to believe that plants of some sort would have been quick to appear on the newly exposed soil, but whether these would have included species of primary economic importance to the Indians is uncertain.

When the Salton Sea reached its maximum elevation (-197½ feet) in February, 1907, and began to recede, observations made by the Carnegie Institution's Desert Botanical Laboratory recorded the colonization of the exposed strands by plants (MacDougal 1914b). As might be expected, given the low elevations at which these strands occurred, the plants were largely those characteristic of the Alkali Sink plant community, including *Suaeda*, *Allenrolfea*, *Sesuvium*, *Atriplex*, *Pluchea*, etc. Seedlings apparently germinated from seeds stranded by the receding waters. It is impossible to identify the species which might have early vegetated the exposed bed of Lake Cahuilla, when it started its decline, but initially these would probably have been representative of the Creosote Bush Scrub plant community.

From an economic standpoint, the key plants would no doubt be the mesquite (*Prosopis glandulosa* var. *torreyana*) and screwbean (*P. pubescens*), both of which had been eaten previously by the lakeshore inhabitants and produce substantial quantities of nutritious food that is highly storable. They could therefore have been of considerable importance to the human populations undergoing the transition from aquatic to desert conditions. If these species early colonized the exposed strands, and if they reached a productive stage within a few years, the severity of the transition would no doubt have been reduced. If, however,

mesquite  
screwbean

two or three decades elapsed before they became established and productive, they may have appeared too late to benefit the lake dwellers who were witnessing their environment being transformed into a desert. There is simply not enough information presently available to discuss this point objectively.

#### OCCUPATION BY THE HISTORIC CAHUILLA

There seems little question that aboriginal settlement of Coachella Valley was seriously disrupted by the drying of Lake Cahuilla. Reoccupation of the lower valley, especially the dry lakebed, would also seem to have occurred when previously displaced groups moved down from the uplands. There are several reasons to believe that this was the case. For one thing, it was recalled by historic Cahuilla when W. P. Blake visited them nearly 125 years ago. He was told that when the lake dried (perhaps some time after it dried?) the Cahuillas moved their villages down from the (Santa Rosa?) mountains into the valley the lake had formerly occupied (Blake 1856:98).

More concrete evidence that historic groups in Coachella Valley came from the adjacent uplands was recorded by W. D. Strong (1929:37):

The migration legends and place names of the earliest family homes remembered, originate in the mountains, giving some reason for the belief that at an earlier time the people lived there--later moving out into the desert.

In recording notes on Cahuilla lineages on the desert in Coachella Valley, Strong was repeatedly told that a particular lineage was originally from the Santa Rosa Mountains (1929:41-42). From his data, one gets the impression that nearly all Cahuilla lineages on the desert originally came from these uplands.

Thus, by the Indians' own testimony they came down to the Coachella Valley from the mountains to the west. But, also by their testimony, they had earlier lived at Lake Cahuilla (as discussed in Chapter I). So the notion of the ancestral Cahuilla as lake dwellers, whose existence was disrupted by the drying of Lake Cahuilla, and who moved up into the mountains for a time before settling in the lower Coachella Valley is supported by oral history. It would be difficult to date the resettlement of the valley by the radiocarbon method or other means, but presumably it occurred in about the seventeenth century.

Within three years after Blake's original passage through Coachella Valley, surveyors for the U. S. Land Office recorded the locations of probably all Cahuilla villages in San Geronio Pass and in the valley proper (Fig. 26).<sup>5</sup> These notes comprise the best record available on the aboriginal settlement pattern of Coachella Valley. Availability of surface water was not the primary factor determining village locations in the lower valley, although many of them were located around springs and oases. Some of the villages had developed springs or excavated conical walk-in wells to obtain water. If one considers the population estimates usually given for the Cahuilla as a whole, roughly 2500-3500,<sup>6</sup> there must have been at least 2000 people residing in the 22 villages recorded by

the surveyors in the San Gorgonio Pass and Coachella Valley. This would have been on the order of 100 persons per village, which is probably a reasonable figure. Some of the villages are known to have been substantially larger.

Agricultural fields were also recorded at several locations in the valley in 1855-56 (Fig. 26), and crop growing had been noted also by Blake in 1853 and Estudillo in 1823 (Bean and Mason 1962). The crops are identified as corn, pumpkins, melons, and watermelons. Barley was added to the inventory in 1853. There was ample time and opportunity for these Cahuilla to have acquired the practice of agriculture from the Californios in the half-century prior to 1823, however careful examination of this problem reveals that Cahuilla agriculture was probably of some antiquity (Lawton and Bean 1968; Bean and Lawton 1973; Lawton 1974). Agriculture figures prominently in Cahuilla myth and ritual, there are Cahuilla terms for crop plants, the planting methods (including multiple cropping) are not those which might have been borrowed from Anglo settlements, and the crop plants themselves are probably derived from the Lower Colorado agricultural complex (Castetter and Bell 1951). There were also substantial irrigation works at Tahquitz Canyon at present Palm Springs (Wilke, King, and Hammond 1975) and down the valley at Agua Dulce (Wilke and Lawton 1975). The latter system involved a reservoir surrounded by an earthen embankment, a sort of flood-gate, and presumably ditches or canals to deliver the water to the fields one-half mile away. The Cahuilla of Coachella Valley were clearly involved to a considerable extent in agricultural pursuits in early historic time, and apparently were so in the late prehistoric period as well. We can as yet only speculate on the origin of food production among the Cahuilla. But inasmuch as agriculture does not appear to have been part of the subsistence pattern at Lake Cahuilla, but was well developed by early historic time, perhaps it originated as one facet of the cultural adjustments that followed the environmental changes that occurred in Coachella Valley 300 years earlier.

Agriculture is best viewed as but one aspect of Cahuilla Indian subsistence that had arisen by early historic time. The seasonal food quest of these people has been studied in considerable detail (Barrows 1900; Bean and Saubel 1972) and involved the pursuit of a host of plant and animal species. Ethnobotanical data on the Cahuilla are probably more complete than those on any other aboriginal group in the arid western United States. Although the number of plants collected at various seasons of the year was large, there were a few staple resources that were regularly sought. Some, such as mesquite (*Prosopis glandulosa* var. *torreyana*), screwbean (*P. pubescens*), and pickleweed (*Allenrolfea occidentalis*), etc., were obtained locally on the floor of Coachella Valley. Others, like agave (*Agave deserti*) and pinyon (*Pinus monophylla*) occurred high on the slopes of the mountains. Gathering territories characteristically cross-cut the several plant communities ensuring that each lineage village had access to a wide range of plant foods. And each plant community had its associated fauna which was avidly sought by the hunters.

The seasonal round of food gathering activities on the desert has been reviewed elsewhere (Wilke 1976) based on available information on

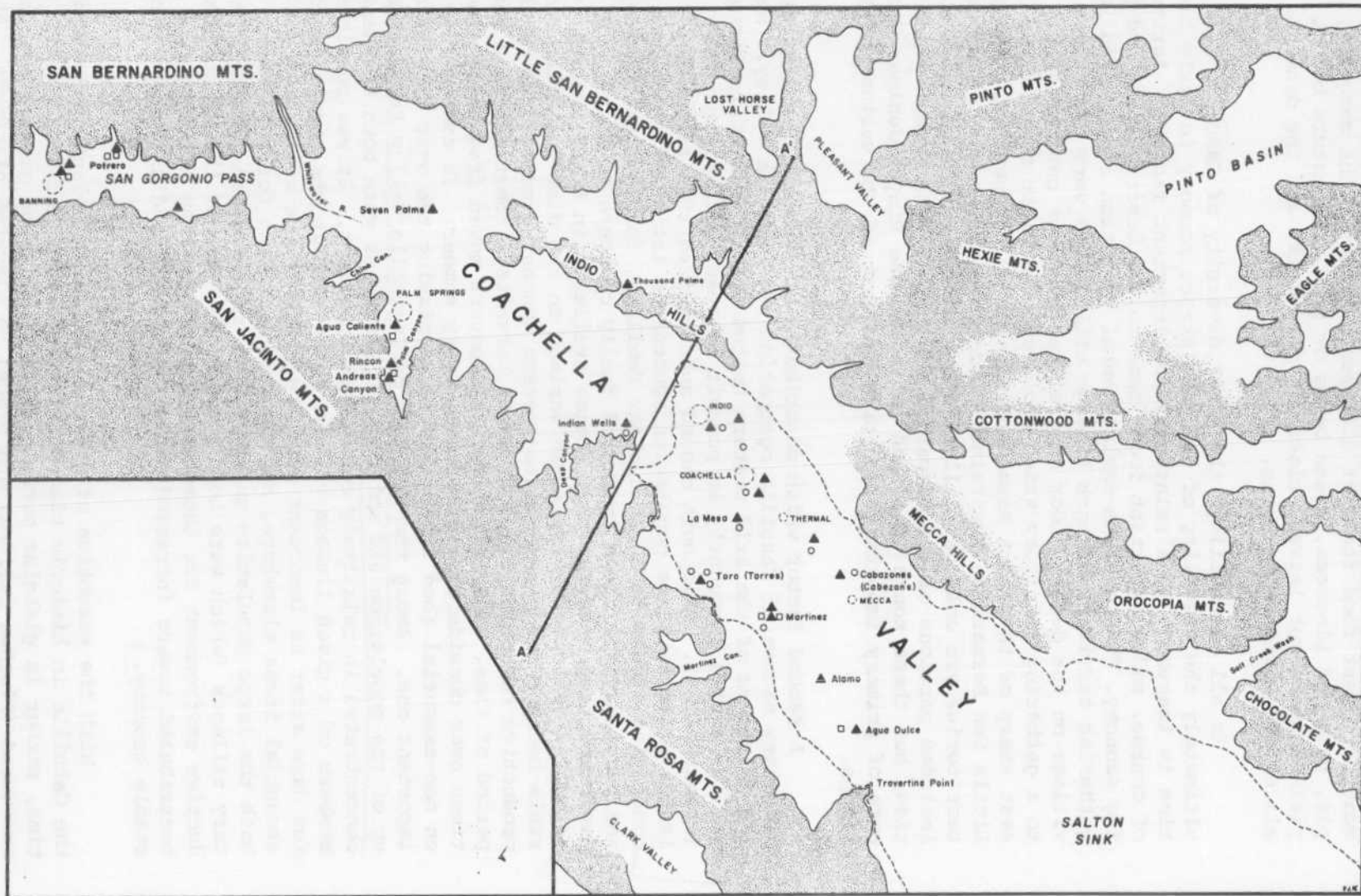


Fig. 26. Historic Cahuilla settlements, wells, and agricultural fields in Coachella Valley, as observed in 1856. Data from U. S. Government Land Office Survey. Section A-A' marks location of vegetation transect shown in Fig. 4.

species utilized and season of availability. It is significant that some of the more important plants used by the Cahuilla yielded two or more different food items at different seasons. The mesquite, for example, produced blossoms, green beans or pods, and mature beans. Agave yielded succulent leaves, blossoms, the stalk, and the crown or heart, all of which were also eaten.

In all probability, the great diversity of Cahuilla diet and ultimately the stability of the subsistence economy in early historic time is traceable to a relatively few important factors. Agriculture, of course, added important food items to the basic hunting and gathering economy. (The extreme environmental variation represented in the gathering territory of each lineage village was very important. Each village on the desert floor also either owned or controlled use rights to a gathering territory which cross-cut the plant communities on the east scarp of the Santa Rosa Mountains or on the southwest slope of the Little San Bernardino Mountains. Locations and boundaries of gathering territories are only partially known.) Some territories could not have included portions of the Chaparral and Yellow Pine Forest plant communities, but these zones up to and including the Pinyon-Juniper Woodland were of primary importance and provided most of the sustenance of desert groups. env. diversity

A second factor which contributed to dietary diversity was the sedentary nature of Cahuilla occupation of Coachella Valley. Hunters and gatherers of the arid western United States were characteristically mobile, moving frequently in pursuit of seasonally ripening plant foods (Steward 1938). This both caused and required the fragmentation of larger winter village population aggregates into smaller units, usually consisting of one to three nuclear families, for most of the year. It was necessary for these scattered family clusters to focus on a few important food items as they became available in turn. Pursuit of minor resources that might have added variety to the diet was often not possible because every able-bodied person concentrated efforts on the more productive resources that had to be harvested, sometimes in a very short period of time. The little family clusters moved frequently, and sometimes over considerable distances, every summer. To concentrate effort on non-essential food items might mean missing the next harvest of an important one. Among the Cahuilla of Coachella Valley this annual break-up of the population did not occur. Resources were both abundant and concentrated in relatively convenient locations. It was possible for members of a given lineage village to go high in the mountains for a few days after an important resource while others could seek out less essential items elsewhere, and then exchange one for the other. Thus, both the large population units and the organization of them into sedentary villages (which were both possible because of the relatively productive environment for those who knew how to make a living from it) contributed toward increased dietary diversity and ultimately a more stable economy.]

With the exception of greens, most of the plant foods used by the Cahuilla in historic time were storable for extended periods of time, either in globular ceramic *ollas* or in large granaries woven from arrowweed (*Pluchea sericea*) and placed on elevated platforms. Ability storage

to store most of the food items helped to prevent shortages in seasons of lesser productivity.

Finally, the very structure of Cahuilla society included a series of built-in failsafe mechanisms to ensure that everyone always had enough food to go around. Society was organized into exogamous moieties, sibs, and patrilineages. *Social Safety-grounds* [Any given person's kin ties extended from his own village into perhaps a dozen or more others scattered across Cahuilla territory in sometimes markedly different environmental settings.] This created a broad network across which a person was not only able, but constantly required to reaffirm social ties and relationships through gift-giving, and the gifts were usually food. Such gift-giving was often a reciprocal arrangement, so everyone more or less had access, either directly or indirectly, to all resources available in Cahuilla territory, whether they occurred in the specific gathering territory of his village or not. Ceremonial exchanges usually took the form of redistribution of substantial quantities of food and other goods. And the primary ceremonies at which such redistribution of goods took place were conveniently held in the winter, the season of least abundance, when shortages were most likely to occur. Thus, the very solemn and reverent *nukil* (mourning) ceremony served a sometimes critically important economic function as well (cf. Blackburn 1974).

These adaptive aspects of Cahuilla Indian society that had arisen by early historic time are discussed in detail by Bean (1972). Which aspects of this adaptation were brought to Coachella Valley when the Cahuilla settled on the desert floor, and which of them developed after they got there, can only be speculated upon. But it would seem that a very effective cultural adaptation to a harsh and arid environment had evolved in the two or three centuries prior to Estudillo's arrival in Coachella Valley in 1823, when the prehistoric epoch drew to a close.

#### NOTES

1. Similar changes occurred in the southern end of Imperial Valley and the region of the Colorado Delta as the lake began to recede. A useful discussion of this event and the cultural adjustments that occurred in the delta region is presented by Aschmann (1966).

2. According to archaeological research strategy of the period, it was "necessary to rush about and save as many specimens as possible" (Campbell 1931:24). Data collected in such a manner simply are often not suited to answering questions raised a half-century later. I do not wish or intend to decry Mrs. Campbell's work; it is still one of the best available contributions to the prehistory of the region. A half-century from now researchers two generations up the road will probably wish I had collected my own data in a manner more suited to their needs.

3. The possible impact of this gravitation to the Lower Colorado (Aschmann 1959, 1966) in bringing about the chronic intertribal warfare that characterized the region in historic time is certainly one of the most interesting research problems in southeastern California prehistory. The problem is not pursued in this paper because the emphasis here is on developments in Coachella Valley. Lower Colorado warfare was treated



recently by White (1974), but he did not emphasize the significance of out-migration from the Salton Basin as a causal factor.

4. Meighan (1975), in reviewing the work done at Perris Reservoir (O'Connell et al. 1974), found it difficult to believe that the survey had located a representative sample of sites of various ages that were actually present there. (Almost all of the sites were assigned to the late prehistoric period.) He stated his view that older sites are present, but difficult to find. He thought older sites would be surface phenomena, even though younger sites do have considerable depth. The reason for such an improbable situation was not given. The various regional surveys in inland southern California were conducted by various teams, with varying survey experience, and undoubtedly with varying survey method and procedure; yet, their results are broadly similar. If the older sites are out there, why are they not more consistently found?

5. According to Mrs. Jane Penn of the Morongo Reservation, another village was located in Whitewater Canyon until it was destroyed by floods in about 1862, after which it was moved to *wanapiapa*, site of the Whitewater stage station. This village would have escaped the observations of the surveyors, who restricted their activity to comparatively flat land.

6. Estimates for Cahuilla population range from about 2500 to 6000. See Kroeber (1925:692), Hicks (1961), Harvey (1967), and Lovell (in Heizer 1974).

## Chapter VI

### SUMMARY AND CONCLUSIONS

In parts of arid western North America where environmental conditions have not undergone major change for several thousand years, ethnographic descriptions of aboriginal groups are, with some reservation, useful in gaining insights into the nature of prehistoric cultural adaptations. This approach is commonly employed in much of the Great Basin and in the Mojave Desert of eastern California. In the Salton Basin of southeastern California, environmental conditions have varied substantially with the successive stands of Lake Cahuilla. This freshwater lake formed periodically and stood for extended intervals of time when the Colorado River wandered northward across its delta and entered the basin. The basin filled to a level somewhat above sea level forming a lake over 100 miles long that overflowed into the Gulf of California. The two most recent stands of Lake Cahuilla are thought to have occurred between A.D. 900 and 1500. Thus, insight into cultural adaptations in the Salton Basin during stands of Lake Cahuilla cannot be drawn from ethnographic observations of Indians living on the dry lakebed in historic time.

There are, however, indications of the nature of prehistoric lakeside adaptation that can be gleaned from the oral tradition of the historic Cahuilla Indians of Coachella Valley, the northwest portion of the Salton Basin. The lake is recalled with remarkable clarity in these traditions, and hunting and fishing are said to have been important subsistence activities. The oral tradition is sufficiently detailed that it seems highly probable the aboriginal occupants of the Lake Cahuilla shore in Coachella Valley at least 450 and perhaps as much as 1000 years ago were ancestral to the historic Cahuilla. This is a long time for unwritten history to be transmitted by nothing more than the spoken word, at least in western North America.

Studies of oral tradition provide a basis for understanding how historical fact can be maintained among non-literate peoples for hundreds of years. Two factors that have contributed to survival of the tradition and continuity of historical fact seem to be the fixed poetic structure of Cahuilla ceremonial songs and the repeated formation of minor ephemeral lakes in the basin. In the former instance, songs were often sung only by specialized esoteric male singers. These men would, in their advanced years, teach their specialization to younger men. Thus, the number of men who have actually sung the songs since the drying of Lake Cahuilla has been few and the songs have probably not changed much, except that some words and phrases in them have become archaic or lost their meaning entirely. But the limited number of singers has served to maintain historical fact in the tradition. As might be expected, references to subsistence activities are those associated with men, rather than women. Hunting and fishing are mentioned, but not plant collecting, which in hunting and gathering societies is frequently the work of women.

Hunting and fishing are mentioned, but not plant collecting, which in hunting and gathering societies is frequently the work of women. Repeated formation of minor ephemeral lakes in the Salton Basin is seen as a mnemonic mechanism that prompted the retelling of the tradition of Lake Cahuilla.

With this background, archaeological research was conducted to discover the nature of cultural adaptations during the last stand of Lake Cahuilla. Present plant communities of the Salton Basin are assumed to have existed during that time. From the summit of the Santa Rosa Mountains across the Coachella Valley and on up to the crest of the Little San Bernardino, these plant communities are as follows: Yellow Pine Forest, Chaparral, Pinyon-Juniper Woodland, Creosote Bush Scrub, Alkali Sink, Creosote Bush Scrub, Joshua Tree Woodland, and Pinyon-Juniper Woodland. The only marked change in the biotic environment occurred on the floor of the Salton Basin when the formation of Lake Cahuilla gave rise to a vast expanse of open water and a Freshwater Marsh plant community in shallow waters.

Analysis of the hydrologic regimen of Lake Cahuilla indicates that the lake was essentially a stable body of water, with a nearly constant water level and freshwater conditions maintained by overflow into the Gulf of California. This gave rise to a substantial marsh at the northwest end of the lake with abundant economically important plants, such as cattail and bulrush. The lake abounded in fish and waterfowl. There were also shellfish in shallow waters.

Investigation of 109 human coprolites and faunal and floral remains, mostly from the Myoma Dunes in Coachella Valley, reveals the nature of aboriginal subsistence practices. Identified food residues indicate that subsistence was oriented primarily to the open waters and marshes, with heavy reliance also on the adjacent low desert flora. Seed of bulrush of several species, cattail, witchgrass, cattail pollen, fish, and aquatic birds were all derived from the aquatic setting. Screwbean pods, seeds of lowland purslane, *Dicoria canescens*, and a variety of others, jackrabbits, small rodents, etc., were all obtained on the desert floor and lower mountain slopes. Pinyon nuts and a few other resources were taken in season in the surrounding uplands. The restricted seasonal availability of certain plant foods and aquatic birds suggests that the Myoma Dunes locality was occupied the year round.

Other sites that may have been used by the same groups living at the Myoma Dunes were Wadi Beadmaker on the northeast shore and the Bat Caves Buttes. The former was primarily a fishing site and may have been used only seasonally. The latter was an island communal nesting ground for large aquatic birds, and was located more than four miles from shore. It was raided by parties from shore who obtained flightless young herons. With the exception of plant foods, which were on the whole the mainstay of the diet, there are significant parallels that can be drawn between the archaeological data and the record of prehistoric occupation revealed in the oral tradition. When the proper mechanisms are operating to promote continuity in traditions and the historical fact contained in them, it would appear that this kind of information can be used to good advantage in prehistoric studies.

While a substantial body of information is now available on the nature of prehistoric human ecology in Coachella Valley, little is known regarding occupation of that portion of the lakeshore in Imperial Valley. Where similar environmental conditions occurred, adaptations in the two regions may have been generally similar.

There seems little question that the Indian population at Lake Cahuilla was a substantial one. When the Colorado River was diverted once again to flow directly into the Gulf of California, which is believed to have occurred within 50 years of A.D. 1500, the entire complex of aquatic plants and animals disappeared within little more than 25 years, and the lake itself was gone by evaporation within about 55 years. The marsh vegetation and shellfish vanished within the first few years of the drying episode. Fishing continued at least on a seasonal basis for about 25 years, as documented by weirs constructed annually along the receding shorelines and by fish bones from house ruins at the same locality. But there is good reason to believe that within the first few years of the drying of the lake significant population movements into the nearby uplands occurred. Late prehistoric changes in settlement patterns appear to be documented in archaeological literature on inland southern California. These changes are seen as resulting in part from the decline of aquatic conditions in the Salton Basin. Available evidence suggests that the drying of Lake Cahuilla had grave consequences across much of southeastern California.

Coachella Valley was ultimately reoccupied by the historic Cahuilla, the probable descendants of the former lakeshore inhabitants. Reoccupation was dependent on the establishment of desert vegetation, primarily mesquite and screwbean, on the now-dry lakebed. It probably occurred within a century after the drying of Lake Cahuilla. And it was these Cahuilla, part-time cultivators of the soil, whose traditions tell of life at Lake Cahuilla in the remote past.

The origin of agriculture in Coachella Valley in early historic time remains an unsolved problem. Evidence of cultivated plants found at Lake Cahuilla was limited to a few squash seeds. A lack of pollen of any cultivated plants in the human coprolites from the same deposit suggests that the squash were obtained in exchange, perhaps from groups to the east in Arizona, rather than grown locally. It is entirely possible that agriculture spread to Coachella Valley in early post-Lake Cahuilla time from the Lower Colorado by way of the Imperial Valley, and that it served to minimize irregularities in the availability of naturally occurring plant resources.

Although new data have been presented here, the basic ideas underlying this research are not my own. Credit for recognizing the importance of the rise and fall of Lake Cahuilla in the prehistory of southeastern California must go to Malcolm Rogers (1945) and Homer Aschmann (1959), whose seminal arguments I have only tried to expand upon. If I have dwelled excessively on matters of history, environment, or chronology, it has only been to make the work of others in this most interesting region for prehistoric studies a bit easier.

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## Appendix A

## PROCEDURE EMPLOYED IN ANALYSIS OF HUMAN COPROLITES

Several analyses can be performed in the study of archaeological coprolites, each with its own specific objectives. This project was concerned primarily with recovering macroscopic dietary remains, and from those data drawing certain conclusions on the nature of the aboriginal diet, the paleoecological setting of the sites from which the samples were derived, and, where possible, the season of site occupation. In a separate study (Hattori 1975), an investigation was made of the pollen content of Lake Cahuilla coprolites. Other analyses sometimes performed on human coprolites investigate patterns of ancient parasitism (currently being undertaken on Myoma Dunes coprolites by H. J. Hall of the University of Queensland), nutrition, etc. These are beyond the scope of the present study. Over the years an abundant literature has accumulated on the analysis of human coprolites the world over. This literature is summarized elsewhere (Wilke and Hall 1975) and will not be reviewed here.

The following is a brief summary of the procedure employed in the analysis of Lake Cahuilla coprolites. Three phases were involved in the analysis: rehydration, separation, and identification. Interpretation logically follows from analysis, but is not here considered a part of it.

The procedure employed followed initially that of Callen and Cameron (1960). These researchers rehydrated coprolite samples in an aqueous solution of trisodium phosphate. In many cases, this causes the sample to gently break apart into its constituent particles, which facilitates identification of dietary components. The solution does not seem to damage fragile objects like seeds, which might be destroyed by simply breaking the sample apart mechanically, as some researchers have done in the past and still continue to do.

Following rehydration, the samples were filtered, dried, and screened through a series of graded sieves. Each grade of screenings was sorted manually into classes of constituents (bone fragments, sedge seeds, charcoal fragments, etc.) under an illuminated binocular dissecting microscope. Classes of dietary components were then stored in small vials for identification.

All recognizable dietary components were separated from the unidentifiable residue in most of the samples. A few, however, were only partially sorted. In these cases, all of the faunal remains were sorted out, but samples only were taken of the plant remains. Relative abundance of dietary components was estimated by scanning the residues collected in the graded sieves in much the same manner that wildlife biologists assess the dietary components in crop, stomach, and fecal samples (Martin, Zim, and Nelson 1951:23-30).

## REHYDRATION

Rehydration is accomplished through the following steps:

(1) Prepare a 0.5% w/v aqueous solution of trisodium phosphate ( $\text{Na}_3\text{PO}_4$ ) by weighing 5 g. of this chemical and dissolving it in 995 ml. of distilled water. Dissolution is hastened by warming and agitation.

(2) Ascertain that the sample to be rehydrated is probably of human origin. This is not always an easy decision to make, but should include consideration of form, size, presence of food residues known to have been consumed by aboriginal peoples, evidence of food preparation such as burned bone fragments, parched seeds, fragments of charcoal, etc., as well as the context in which the sample was recovered. Large numbers of coprolites originating in definite latrine deposits, such as those at the Myoma Dunes (described herein), or the very large collections recovered in a deep crevice in Lovelock Cave, Nevada (Heizer and Napton 1970:29), are probably all, or nearly all, of human origin.

(3) Record preliminary observations of the specimen, including its appearance and the presence of any probable food items visible on the surface and in a fresh break. Remove any material adhering to the sample but not actually part of it. Clean out the contents of any tunnels or burrows of coprophagous insects as these may include extraneous material.

(4) Weigh the portion of the specimen selected for rehydration (the specimens rehydrated for this study weighed, on the average, from 15 to 35 g.). It is advisable to save additional samples from each specimen for future analyses (parasitological, palynological, etc.).

(5) Place the specimen in a clean glass jar with a screw-cap lid. Wide-mouth pint jars are satisfactory. Add about 100 ml. or more of the trisodium phosphate solution to completely cover the specimen. Seal the container, labelling it with a specimen number. Self-adhesive Avery brand labels are recommended. Record on data sheets pertinent information including the date of rehydration.

(6) Rehydrate the sample for several days until it has broken down. Vigorously shaking the container at intervals hastens the breakdown process. If, after a week or more, the sample is still intact, it may be gently broken apart with a spatula and allowed to soak for an additional period of time until it appears to be completely broken down.

## SEPARATION

Separation refers to the isolation of dietary items from the rehydrated sample. The following procedure was employed in separation:

(1) Carefully filter the rehydrated sample. A suitable apparatus consists of a cone-shaped screen suspended over a container to catch the solution which drains off. Into this screen is placed a sheet of fluted, circular filter paper. Residue is washed from the jar into the filtering apparatus with a stream of water from a squeeze-type washing bottle.

(2) When all of the solution has passed through the filter paper leaving behind all particles too coarse to pass through, the filter paper is transferred to a flat screen to air-dry. Drying may be hastened with heat lamps, but this frequently results in the formation of lumps, and a crust may form on the residue; these must then be broken up manually. Transfer the jar label to the screen adjacent to the drying sample. The filtered solution is discarded. Some researchers examine the filtered solution for parasite ova and cysts at this point, but if this is attempted, it is advisable to wash the coprolite sample from the rehydration jar into the filter paper (as described in step one above) with the trisodium phosphate solution rather than water. This is thought to prevent changes in the osmotic pressure within the cysts or ova which might cause distortion or rupturing.

(3) Transfer the filter paper containing the dried sample residue to a large (e.g., 140 mm. diameter) glass petri dish with a cover, and attach the self-adhesive label. Place the specimen aside for later examination, or, if separation is to continue at this point,

(4) Pour the dried coprolite residue into a tower of nested brass Tyler Standard Screens of decreasing mesh size. The following meshes were regularly used with satisfactory results: 1.651 mm., 1.168 mm., 0.833 mm., 0.589 mm., and 0.417 mm. (meshes 10, 14, 20, 28, and 35). Agitate the tower manually.

(5) Begin sorting the residue collected in the coarsest screen by transferring it to a large glass petri dish, and under suitable illumination picking out recognizable bone fragments, seeds, etc. Transfer these to watch glasses or small petri dishes. Use of a dissecting microscope is essential for smaller items and for all work in sorting material from the smaller mesh screens.

(6) Proceed through the tower of screens sorting all identifiable items from each. A large portion of the screenings in each sieve may be unidentifiable. Record the materials recovered on analysis forms. Larger items may be handled with a finely pointed forceps. For handling smaller items or very delicate objects (such as minute bone fragments or small seeds), a photographers' retouching brush stroked over a wet sponge is satisfactory. The small items adhere to the dampened bristles.

(7) Assess the relative abundance of items recovered. The following categories were used: abundant (A), frequent (F), infrequent (I), and trace (T). These categories refer to the relative frequency or abundance of a particular item in the sample by bulk. Some researchers prefer to weigh each class of dietary components on an analytical balance.

(8) Transfer the identifiable items to appropriate containers. Small glass screw-cap shell vials are ideal for seeds and small bones. Plastic vials with snap-on lids are useful for storing the various grades of unidentifiable residue. Containers should be labelled with small Avery brand labels affixed to the cap. Record coprolite number and tentative identification. The whole collection of containers from

a given sample can be stored for future analysis and reference in labeled plastic bags stapled shut.

#### IDENTIFICATION

Identify the species represented in the various classes of dietary items recovered. This usually is a time-consuming and difficult process. Competent specialists in faunal and floral analysis having existing collections of comparative material should be sought out. The researcher should be aware that such persons probably have already been sought out by numerous archaeologists and identifications may not come easily or quickly. Recourse to herbarium specimens and identification keys, such as Martin and Barkley's *Seed Identification Manual* (1961), can often provide at least tentative generic identifications of seeds and other plant remains. Consultants should be provided with information on the location of the site and the age of the deposits from which the samples originated in order to determine whether known alien species should be considered or eliminated. The reconstructed environmental setting (adjacent and nearby plant communities) at the time the site was occupied is useful in narrowing down the range of possible candidates for an identification.

## Appendix B

IDENTIFIED COMPONENTS OF HUMAN COPROLITES  
FROM THE MYOMA DUNES, BED A

[NOTE: Listed by specimen numbers with abundance of identified items given as follows: abundant (A), frequent (F), infrequent (I), trace (T).]

- MDA-1 *Scirpus acutus* seed, parched, lightly milled (A); *Typha* sp. seed (A); fish bones, including *Gila elegans*, burned fragments (F); charcoal fragments (I). Much of the screenings consist of *Scirpus* seed hull fragments.
- MDA-2 *Scirpus acutus* seed, probably milled (F); *Typha* sp. seed (A); *Monardella exilis* seed, 1 only (T); fish bone fragments, including *Gila elegans*, few fragments burned (A); charcoal fragments (I). Mostly the remains of *Typha* seed.
- MDA-3 *Typha* sp. seed (A); *Scirpus californicus* seed (T); unidentified fish bone (F); charcoal fragments (T).
- MDA-4 *Sesuvium verrucosum* seed (A); *Prosopis pubescens* pod fragments (A); *Scirpus acutus* seed (I); *Panicum capillare* seed (T); *Dicoria canescens* seed (T); unidentified fish bone (F).
- MDA-5 *Typha* sp. seed (F); fish bone, including *Mugil cephalus* and *Gila elegans*, some burned (A); charcoal fragments, to 1 cm. diameter (A); insect remains (T).
- MDA-6 *Chenopodium glaucum* var. *salinum* seed (A); *Sesuvium verrucosum* seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); *Prosopis pubescens* pod fragments (I); insect remains (T); charcoal (T).
- MDA-7 *Prosopis pubescens* pod fragments (A); *Panicum capillare* seed (T); *Dicoria canescens* seed (T); unidentified seed (T); unidentified fish bone fragments (I); insect remains (T).
- MDA-8 *Panicum urvilleanum* seed, milled (A); *Scirpus* cf. *validus* seed (T); *Oligomeris linifolia* seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); unidentified fish bone fragments (F); charcoal fragments (T).
- MDA-9 *Oligomeris linifolia* seed (A); *Chenopodium chenopodioides* seed (T); *Scirpus validus* seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); *Typha* sp. seed, 1 only (T); non-diagnostic fish bone fragments (T); hair or fiber (T); charcoal fragments (T).



- MDA-10 *Scirpus validus* seed (A); *Panicum capillare* seed (T); *Typha* sp. anthers (I); fish bones (I); insect remains (T); *Scirpus* seed is heavily parched and appears to be partially milled.
- MDA-11 *Prosopis pubescens* pod fragments (A); *Dicoria canescens* seed (F); *Panicum capillare* seed (T); *Sesuvium verrucosum* seed (T); *Scirpus acutus* seed (T); *Scirpus validus* seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); charcoal fragments (T); fish bones, burned and non-diagnostic (T); insect remains (T).
- MDA-12 Fish bones, non-diagnostic, some charred (A); charcoal fragments (F).
- MDA-13 Fish bones, including *Gila elegans*, some charred (A); charcoal fragments (F); hair or fiber (T).
- MDA-14 *Prosopis pubescens* pod fragments and seed (I); *Scirpus acutus* seed (T); *Scirpus californicus* seed (I); *Dicoria canescens* seed (I); *Sesuvium verrucosum* seed (T); *Chenopodium* sp. seed (I); *Prosopis glandulosa* var. *torreyana* seed (T); *Panicum* cf. *urvilleanum* seed (T); *Typha* sp. seed (I); *Oligomeris linifolia* seed (T); *Eragrostis?* sp. seed (T); hair (T); immature *Fulica americana* bones (F); pin feathers (T); small mammal (*Sylvilagus?* sp.) bones (T); fish bones, including *Gila elegans* and *Xyrauchen texanus* (A); insect remains (T); charcoal fragments (F). This sample consisted of several fragments thought, at the time of collection, to represent a single coprolite. In view of the diversity of items identified in it, the fragments may represent two or more coprolites.
- MDA-15 *Typha* sp. seed (A); *Scirpus* sp. seed (T); immature *Fulica americana* bones (I); non-diagnostic fish bones, some burned (F); charcoal fragments (F); insect remains (T).
- MDA-16 *Typha* sp. seed (A); adult female *Fulica americana* bones (A); non-diagnostic fish bones (T); charcoal fragments (F); hair (T).
- MDA-17 Fish bone, including *Xyrauchen texanus* (A); charcoal fragments (F); insect remains (T).
- MDA-18 *Typha* anthers (A); *Scirpus* sp. seed (I); unidentified fish bone fragments (F); charcoal fragments (I).
- MDA-19 *Typha* sp. seed (A); *Scirpus validus* seed (T); *Pinus* cf. *monophylla* nut hull fragments (I); non-diagnostic fish bone fragments (I); charcoal fragments (I).
- MDA-20 *Typha* sp. seed (A); non-diagnostic fish bone fragments (F); charcoal fragments (I).
- MDA-21 *Typha* sp. seed (A); immature *Sylvilagus audubonii* bones (F); charcoal fragments (T).

- MDA-22 *Scirpus* sp. seed (T); unidentified seed (T); fish bone, including *Gila elegans* (A); charcoal fragments (F).
- MDA-23 *Prosopis pubescens* pod fragments and seed (I); *Chenopodium nevadense* seed (T); *Ferocactus acanthodes* seed (T); *Scirpus acutus* seed (T); *Scirpus validus* seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); *Chenopodium* sp. seed (T); *Prosopis glandulosa* var. *torreyana* seed hull (T); *Dicoria canescens* seed (T); *Oligomeris linifolia* seed (T); *Sesuvium verrucosum* seed (T); *Typha* sp. seed (T); fish bones, including *Gila elegans* and *Xyrauchen texanus*, unburned, very small bones representing fingerlings (A); charcoal fragments (F); insect remains (T). The several fragments comprising this sample may represent more than one coprolite.
- MDA-24 *Scirpus* sp. seed (I); *Typha* sp. seed (A); unidentified bone fragments of bird or small mammal (T); fish bone, including *Xyrauchen texanus* (F); charcoal fragments (I).
- MDA-25 *Dicoria canescens* seed (I); *Pinus* cf. *monophylla* nut hull fragments (T); *Scirpus acutus* seed (I); *Prosopis pubescens* pod fragments and seed (A); *Sesuvium verrucosum* seed (T); *Panicum capillare* seed (T); non-diagnostic fish bone fragments (T); charcoal fragments (I); insect remains (T).
- MDA-26 *Typha* sp. anthers (F); fish bone, including *Gila elegans* (A); charcoal fragments (I); dung of coprophagous insects (A).
- MDA-27 *Sesuvium verrucosum* seed (A); *Dicoria canescens* seed (A); *Prosopis pubescens* pod fragments (F); *Typha* sp. seed (T); *Chenopodium* sp. seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); insect remains (T); burned bone fragments, probably lagomorph (I).
- MDA-28 *Scirpus validus* seed (T); *Chenopodium* sp. seed (T); *Panicum capillare* seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); *Sesuvium verrucosum* seed (T); *Prosopis pubescens* pod fragments and seed (A); burned bone representing small, immature rodent and probably *Sylvilagus audubonii* (A); insect remains (T); charcoal fragments (T).
- MDA-29 *Prosopis pubescens* pod fragments (I); *Chenopodium* sp. seed (T); *Amaranthus?* sp. seed (T); *Pinus* cf. *monophylla* nut hull fragments (F); *Panicum capillare* seed (T); *Dicoria canescens* seed (A); *Fulica americana* bones (F); unidentified fish bone (F); insect remains (T); charcoal fragments (I).
- MDA-30 *Scirpus acutus* seed (A); *Chenopodium glaucum* var. *salinum* seed (F); fish bones, including *Gila elegans* (I); charcoal fragments (T); insect remains (T);
- MDA-31 *Prosopis pubescens* pod fragments (F); *Sesuvium verrucosum* seed (T); *Chenopodium* sp. seed (F); *Pinus* cf. *monophylla* nut hull fragments (T); unidentified fish bone fragments (T); charcoal fragments (T); insect remains (T).

- MDA-32 *Typha* sp. seed (A); *Scirpus acutus* seed (I); unidentified seed (T); adult female *Fulica americana* bones, some burned (A); charcoal fragments (I); insect remains (T); insect dung (T).
- MDA-33 *Prosopis pubescens* pod fragments (F); *Chenopodium glaucum* var. *salinum* seed (A); unidentified seed (T); *Dicoria canescens* seed (T); fruits, apparently of *Phoradendron* (I); bone fragments comparable with *Fulica americana*, small, immature (I).
- MDA-34 *Typha* sp. anthers (F); unidentified fish bone (F); charcoal fragments (T).
- MDA-35 *Prosopis pubescens* pod fragments (I); *Chenopodium* sp. seed (I); Screenings of this sample consisted largely of unidentifiable detritus.
- MDA-36 *Prosopis pubescens* pod fragments (A); *Scirpus acutus* seed (T); *Scirpus validus* seed (T); *Sesuvium verrucosum* seed (T).
- MDA-37 *Typha* sp. seed (A); fish bones, including *Gila elegans* (F); charcoal fragments (T).
- MDA-38 *Amaranthus* sp. seed, partially milled (F); *Prosopis pubescens* pod fragments and seed (I); *Scirpus validus* seed (T); unidentified fish bone fragments (T); insect remains (T); charcoal fragments (T).
- MDA-39 *Prosopis pubescens* pod fragments (A); *Scirpus* cf. *californicus* seed (T); *Chenopodium* cf. *chenopodioides* seed (A); *Sesuvium verrucosum* seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); insect remains (T); charcoal fragments (T).
- MDA-40 *Typha* sp. anthers (A); *Scirpus validus* seed (A); unidentified fish bone fragments (T).
- MDA-41 *Prosopis pubescens* pod fragments (A); *Sesuvium verrucosum* seed (A); *Dicoria canescens* seed (I); *Panicum capillare* seed (T); hair (T); bone fragments, probably lagomorph (F); charcoal fragments (T).
- MDA-42 *Prosopis pubescens* pod fragments (A); *Sesuvium verrucosum* seed (A); *Chenopodium* sp. seed (T); *Dicoria canescens* seed (T); *Lepus californicus* bones (A); charcoal fragments (T).
- MDA-43 *Prosopis pubescens* pod fragments (A); *Sesuvium verrucosum* seed (A); *Scirpus californicus* seed (T); *Panicum capillare* seed (T).
- MDA-44 *Scirpus validus* seed (I); *Typha* sp. anthers (I); fish bone, including *Xyrauchen texanus* (A).
- MDA-45 *Sesuvium verrucosum* seed (A); *Dicoria canescens* seed (T); *Prosopis pubescens* pod fragments (F); *Pinus* cf. *monophylla* nut hull fragments (T); *Prosopis glandulosa* var. *torreyana* seed hull (T); *Panicum capillare* seed (T); insect remains (T).

- MDA-46 *Prosopis pubescens* pod fragments (A); *Chenopodium glaucum* var. *salinum* seed (F); *Ferocactus acanthodes* seed (T); *Scirpus acutus* seed (T); *Dicoria canescens* seed (T); *Scirpus validus* seed (T); *Panicum capillare* seed (T); cactus spine? (T); unidentified seed, possibly of the family Fabaceae (T); single seed of grass, possibly an introduced (and therefore intrusive) *Digitaria* sp. (T); *Fulica americana* bones, small adult (F); unidentified fish bone (T); pin feathers (I); small unidentifiable rodent bones (T); charcoal fragments (T). A single, large, well-formed coprolite.
- MDA-47 *Scirpus acutus* seed (A); *Dicoria canescens* seed (T); *Prosopis pubescens* seed and pod fragments (I); fish bone, including *Gila elegans* and *Xyrauchen texanus* (F); insect remains (T); charcoal fragments (T).
- MDA-48 *Scirpus acutus* seed (F); *Sesuvium verrucosum* seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); *Echinochloa* sp. seed (T); *Prosopis pubescens* pod fragments and seed (I); fish bones, including *Gila elegans* and *Xyrauchen texanus* (A); insect remains, probably *Tribolium* sp. (T); charcoal fragments (T).
- MDA-49 *Prosopis pubescens* pod fragments (F); fish bones, including *Gila elegans* (F); insect remains (T); charcoal fragments (T).
- MDA-50 *Prosopis pubescens* pods (A); *Dicoria canescens* seed (T); *Panicum capillare* seed (T); unidentifiable fish bones (F); unidentified bird remains (I); pin feathers (T); insect remains (T); charcoal fragments (T).
- MDA-101 *Prosopis pubescens* pod fragments (A); *Chenopodium* cf. *nevadense* seed (T); *Sesuvium verrucosum* seed (T); *Dicoria canescens* seed (T); *Scirpus validus* seed (T); *Lepus californicus* bone fragments (F); insect remains (T); insect dung (T); charcoal (T).
- MDA-102 *Sesuvium verrucosum* seed (A); *Prosopis pubescens* pod fragments (T); *Amaranthus* sp. seed (T); bone fragments, comparing favorably with *Lepus californicus*, immature and burned (A), and *Dipodomys* sp., immature and burned (A); charcoal fragments (T).
- MDA-103 *Dicoria canescens* seed (A); unidentified seeds (T); unidentified fish bone (T); unburned bone fragments, comparing favorably with immature *Lepus californicus* and immature *Dipodomys* sp. (F); charcoal fragments (T). The bulk of the sample consisted of *Dicoria* seeds and fragments thereof.
- MDA-104 *Prosopis pubescens* pod fragments (A); *Scirpus validus* seed (T); bone fragments representing unidentifiable fish and small mammals (F); charcoal fragments (T).
- MDA-105 *Chenopodium*, possibly *C. nevadense*, seed, partially milled (A); *Sesuvium verrucosum* seed (T); *Scirpus* sp. seed (T); insect remains (T); charcoal fragments (T).
- MDA-106 *Typha* sp. anthers (A); *Typha* sp. seed (T); charcoal (T).

- MDA-107 *Prosopis pubescens* pod fragments (F); *Sesuvium verrucosum* seed (A); *Panicum capillare* seed (T); *Amaranthus* sp. seed (T); *Chenopodium* sp. seed (T); single seed of *Opuntia* sp. (T); *Lepus californicus* bone fragments, some burned (A); insect remains (T); charcoal fragments (T).
- MDA-108 *Prosopis pubescens* pod fragments (A); *Scirpus acutus* seed (T); *Panicum capillare* seed (T); bone fragments, burned, probably lagomorph (F); insect remains, including *Tribolium castaneum* (T); insect feces (T); adult *Fulica americana* bones (F); charcoal (T).
- MDA-109 *Sesuvium verrucosum* seed (A); *Chenopodium glaucum* var. *salinum* seed (T); unidentified seeds (T); *Sonchus oleraceus* seed (T); insect remains (T); bone fragments, comparing favorably with unspecified small rodent and lagomorph (F). *Sonchus* intrusive.
- MDA-110 *Sesuvium verrucosum* seed (A); *Dicoria canescens* seed (F); *Scirpus* cf. *acutus* seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); *Gopherus agassizi* toe bone (T); insect remains (T); charcoal fragments (T); pin feather (T).
- MDA-111 *Chenopodium glaucum* var. *salinum* seed (F); *Scirpus acutus* seed (F); unidentifiable bone fragments, possibly bird (I); insect remains (T); charcoal fragments (I).
- MDA-112 *Dicoria canescens* seed (A); *Sesuvium verrucosum* seed (T); *Panicum capillare* seed (F); *Prosopis pubescens* pod fragments (F); several seeds resembling those of the introduced grass *Dactyloctenium aegyptium*, identification not verifiable (I); fish spine (T); small, unidentifiable rodent bones (T); insect remains (T); charcoal fragments (T).
- MDA-113 *Sesuvium verrucosum* seed (A); *Prosopis pubescens* pod fragments (F); *Scirpus validus* seed (T); *Sonchus oleraceus* seed, intrusive, 1 seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); insect remains (T).
- MDA-114 *Dicoria canescens* seed (F); *Sesuvium verrucosum* seed (F); *Chenopodium glaucum* var. *salinum* seed (F); *Pinus* cf. *monophylla* nut hull fragments (T); *Scirpus validus* seed (T); *Prosopis pubescens* pod fragments (I); bone fragments, probably lagomorph (I); insect remains (T).
- MDA-115 Unidentifiable fish bones (A); charcoal fragments (T).
- MDA-116 Unidentifiable fish bones (A); charcoal fragments (T).
- MDA-117 Fish bones, including *Gila elegans* (A).
- MDA-118 Fish bones, including *Gila elegans* (F); charcoal fragments (T).
- MDA-119 *Scirpus acutus* seed (T); fish bones, including *Gila elegans* (A); charcoal fragments (T).

- MDA-120 Unidentifiable fish bones (A); charcoal fragments (T).
- MDA-121 *Typha* sp. anthers (A); unidentifiable fish bone fragments (T); charcoal fragments (T).
- MDA-122 Insect remains (I); unidentified fibrous material (A). The sample is almost entirely fibrous material and appears to have been partially altered by coprophagous insects.
- MDA-123 *Typha* sp. anthers (A); unidentifiable fish bone fragments (F); insect feces (T); charcoal fragments (T).
- MDA-124 *Dicoria canescens* seed (A); *Prosopis pubescens* pod fragments (F); *Chenopodium* sp. seed (I); bones of small rodent (I); *Podiceps caspicus* bones, immature (I); *Fulica americana* bones, immature (I); insect remains (T); hair (T).
- MDA-125 *Typha* sp. anthers (A); *Scirpus* cf. *acutus* seed (T); non-diagnostic fish bone fragments (I); insect pupa (T); charcoal fragments (T).
- MDA-126 *Typha* sp. seed, apparently parched (A); *Scirpus* cf. *validus* seed (T); unidentified seed (T); small mammal bones, possibly *Lepus californicus*, some burned (A); charcoal fragments (T).
- MDA-127 *Typha* sp. seed (A); unidentifiable small mammal bone (T); charcoal fragments (T).

## Appendix C

IDENTIFIED COMPONENTS OF HUMAN COPROLITES  
FROM THE MYOMA DUNES, BED B

[NOTE: Listed by specimen numbers with abundance of identified items given as follows: abundant (A), frequent (F), infrequent (I), trace (T).]

- MDB-1 *Panicum capillare* seed (A); *Chenopodium* sp. seed (I); *Prosopis pubescens* pod fragments (I); unidentified fish bone fragments (T); charcoal fragments (I); insect remains (T).
- MDB-2 *Prosopis pubescens* pod fragments (A); *Panicum capillare* seed (T); *Scirpus californicus* seed (T); *Sesuvium verrucosum* seed (T); unidentified seed hull fragment (T); unidentified fish bone (I); insect remains (I); charcoal fragments (T).
- MDB-3 *Panicum capillare* seed (A); *Amaranthus* (?) seed (I); *Scirpus* cf. *validus* seed (T); *Chenopodium glaucum* var. *salinum* seed (T); insect remains (T); charcoal fragments (T).
- MDB-4 *Panicum capillare* seed (A); probable *Prosopis glandulosa* var. *torreyana* seed hulls (I); unidentified fish bone (I); charcoal fragments (T); insect remains (I).
- MDB-5 Unidentified fish bone (F); charcoal fragments (I).
- MDB-6 *Panicum capillare* seed (A); *Scirpus acutus* seed (T); *Calyptidium* cf. *umbellatum* seed (I); unidentified bone (T); insect remains (T); charcoal fragments (T).
- MDB-7 *Panicum capillare* seed (A); *Prosopis pubescens* pod fragments (A); *Calyptidium* cf. *umbellatum* seed (F); charcoal fragments (T); unidentified seed hull fragment (T); insect remains (T).
- MDB-8 *Panicum capillare* seed (T); *Scirpus* cf. *californicus* seed (T); unidentified fish bone (I); charcoal fragments (T).
- MDB-9 *Prosopis pubescens* pod fragments (F); *Scirpus acutus* seed (T); *Chenopodium* sp. seed (T); *Panicum capillare* seed (I); *Typha* sp. seed (F); unidentified fish bone (T); insect remains (T).
- MDB-10 *Prosopis pubescens* pod fragments (A); *Panicum capillare* seed (F); *Sesuvium verrucosum* seed (T); *Scirpus acutus* seed (T); charcoal fragments (T); insect remains (T).

## Appendix D

IDENTIFIED COMPONENTS OF HUMAN COPROLITES  
FROM THE MYOMA DUNES, BED D

[NOTE: Listed by specimen numbers with abundance of identified items given as follows: abundant (A), frequent (F), infrequent (I), trace (T).]

- MDD-1 *Typha* sp. anthers (A); fish bones, including those of *Gila elegans* (F); charcoal fragments (T).
- MDD-2 *Typha* sp. anthers (F); *Prosopis pubescens* pod fragments (T); *Scirpus* sp. seed (T); unidentified fish bone fragments (F); charcoal fragments (T).
- MDD-3 *Typha* sp. anthers (A); *Scirpus acutus* seed (T); unidentified fish bone (A); charcoal fragments (T).
- MDD-4 *Typha* sp. anthers (A); *Rumex* cf. *salicifolius* seed (I); *Scirpus acutus* seed (T); unidentified fish bone (F); charcoal fragments (T).
- MDD-5 *Dicoria canescens* seed (A); *Panicum capillare* seed (T); *Pinus* cf. *monophylla* nut hull fragments (T); *Scirpus* cf. *acutus* seed (T); *Chenopodium* sp. seed (T); unidentified fish bone (I); insect remains (T); charcoal fragments (T).
- MDD-6 *Typha* sp. anthers (A); *Panicum capillare* seed (A); fish bones, including *Gila elegans* (A); insect remains (T); charcoal fragments (T).
- MDD-7 *Typha* sp. anthers (A); *Panicum capillare* seed (T); unidentified fish bone (F); insect remains (T); charcoal fragments (T).
- MDD-8 *Prosopis pubescens* pod fragments (F); *Scirpus acutus* seed (T); *Panicum capillare* seed (T); unidentified fish bone (T); insect remains (T).
- MDD-9 *Scirpus acutus* seed (A); *Panicum capillare* seed (A); *Prosopis pubescens* pod fragments (I); *Dicoria canescens* seed (T); unidentified fish bone (I); charcoal fragments (I); insect remains (T).
- MDD-10 *Typha* sp. anthers (F); *Scirpus acutus* seed (I); *Panicum capillare* seed (T); fish bone, including *Gila elegans* (A); small adult *Fulica americana* bones (A); charcoal fragments (T).
- MDD-11 *Panicum capillare* seed (A); *Prosopis pubescens* pod fragments (A); *Pinus* cf. *monophylla* nut hull fragments (T); *Scirpus*



*acutus* seed (T); *Scirpus validus* seed (T); unidentified seed (T); unidentified fish bone (T); small immature *Fulica americana* bones (F).

MDD-12 *Prosopis pubescens* pod fragments (F); *Dicoria canescens* seed (F); *Scirpus acutus* seed (T); *Panicum capillare* seed (T); unidentified seeds (T); *Prosopis glandulosa* var. *torreyana* seed (I); unidentified fish bone (T); insect remains (T).

## Appendix E

IDENTIFIED COMPONENTS OF HUMAN COPROLITES  
FROM WADI BEADMAKER

[NOTE: Listed by specimen numbers with abundance of identified items given as follows: abundant (A), frequent (F), infrequent (I), trace (T).]

- WB-1 Unidentified fish bone, some burned (A); charcoal fragments (I).
- WB-2 Unidentified fish bone, some burned (A); charcoal fragments (T).
- WB-3 *Panicum capillare* seed (A); *Scirpus acutus* seed (T); unidentified (cf. *Scirpus* sp.) seed (T); *Cuscuta* sp. seed (T); *Amaranthus* (?) sp. seed (T); insect remains (T); charcoal fragments (I).
- WB-4 Unidentified fish bone, some burned (A); charcoal fragments (I).
- WB-5 Unidentified fish bone, some burned (A); *Anodonta dejecta* shell fragments (T); charcoal fragments (F).
- WB-6 Unidentified fish bone (F); charcoal fragments (I).
- WB-7 Fish bone, including *Gila elegans* and *Xyrauchen texanus* (A); charcoal fragments (T).
- WB-8 Fish bone, including *Xyrauchen texanus* (F); charcoal fragments (I).
- WB-9 Fish bone, including *Gila elegans* (A); charcoal fragments (I).
- WB-10 *Panicum capillare* seed (A); unidentified fish bones and scale fragments (I); charcoal fragments (I).