Archaeological reconstruction of ancient Lake Cahuilla settlement patterns using GIS

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ASM Planning and Research Collaborative (PARC) is producing a complete archaeological data compendium of all Native American sites along or below the margins of ancient Lake Cahuilla during all periods of prehistory. These compiled data will provide the basis for addressing a wide variety of both archaeological research questions and environmental management issues. To date, no complete collection of Lake Cahuilla archaeological data has been produced, nor has the current condition of extant sites been adequately assessed. This leaves critical gaps in knowledge that hinder appropriate management decisions, both for land managers, archaeologists and interested Native Americans. Applying GIS to this project provides the opportunity to easily and accurately assess the level of current knowledge about the area, share information among researchers, managers, and Native Americans, and facilitate innovative research.

Introduction

The Lake Cahuilla basin provided a unique geographic setting to which early Native Americans adapted in changing ways during the late Pleistocene and Holocene epochs, from at least 11,000 years ago up until the late eighteenth century. A valuable but fragile record of prehistoric lifeways and events exists in the archaeological traces that have survived. Agencies that are charged with the responsibility for managing lands with prehistoric sites or for permitting projects that may affect sites need to understand the context of those cultural resources and the status of scientific studies concerning them, in order to be able to make appropriate management decisions. This paper briefly summarizes that context.

Modern Geographical Context

The Lake Cahuilla basin is, in effect, a northern arm of the Colorado River's delta, long cut off from the Gulf of California by a low but substantial wedge of Pleistocene and Holocene river deposits. Within the basin, a topographic contour that lies 40 ft. (12 m) above mean sea level (AMSL) corresponds to the maximum level of Lake Cahuilla during the late Holocene period. The present study area has been defined as including all areas within a boundary that extends 5 mi. (8 km) beyond the maximum lake level. It encompasses portions of the counties of Riverside, San Diego, and Imperial in California and the *municipio* of Mexicali in Baja California.

Most of the study area is characterized by very gentle topographic relief. The lowest land surface is 278 ft. (85 m) below mean sea level (BMSL) in the center of the basin, now submerged under the Salton Sea. The Salton Sea currently stands at an elevation of about 227 ft. (69 m) BMSL. Most of the study area lies below sea level. In addition to lowlands, the study area includes portions of several ranges of hills or mountains. Listed clockwise from the north, these include the Indio Hills, Little San Bernardino Mountains, Mecca Hills, Orocopia Mountains, Chocolate Mountains, Algodones Dunes, Sierra Cucapá, Superstition Mountain, Superstition Hills, Fish Creek Mountains, Vallecito Mountains, and Santa Rosa Mountains. Higher mountains lying to the west of the study area rise to elevations of 6,272 ft. (1,912 m) AMSL in the Laguna Mountains in the south and 10,804 ft. (3,293 m) in the San Jacinto Mountains in the north.

Under natural conditions, the flow of surface water into the basin would be slight, except for erratic contributions coming from the Colorado River. The more substantial drainages include the Alamo and New Rivers from the south, which occasionally receive Colorado River water; the San Felipe Creek and Carrizo Creek system on the west, draining portions of the Peninsular Range; and the Whitewater River in the north, with runoff from the San Bernardino and San Jacinto Mountains. In models for the prehistoric water budget of Lake Cahuilla, the contributions coming from surface sources other than the Colorado River have been judged to have been negligible.

This desert region's modern climate is hot and dry. For example, Indio has a mean January minimum temperature of 41.7°F (5.4°C), a mean July maximum of 106.9°F (41.6°C), and a mean annual precipitation of only 3.3 in. (8.4 cm), falling mostly between December and March. Farther south within the study area, the precipitation becomes slightly less, and a larger share of it falls as monsoonal rain between August and October.

Geologically, the study area is dominated by Pleistocene and Holocene sediments laid down by lacustrine, alluvial or aeolian processes. Local consolidated sandstone rock provided a material for prehistoric ground stone tools. Creek cobbles of various lithologies were additional sources for ground or flaked stone tools. A Pleistocene volcano, Obsidian Butte, is located on the southeast shore of the present Salton Sea. It was the only substantial source within southern California for the volcanic glass that was highly valued for making arrow points and other flaked stone tools. Notable among the other sources of fine-grained tool stone within the study area were the quarries of silica-rich "wonderstone" found at Rainbow Rock near Salton Sea Beach and at Cerro Colorado just south of the U.S.-Mexican border. The complex geology of the hills and mountains surrounding the basin offered a variety of additional tool stones, including granitic and metamorphic rock, various types of volcanic rock, cryptocrystalline silica, quartz, and quartzite.

Lake Cahuilla

When Lake Cahuilla was present, it was a factor of overriding importance in the region's prehistoric human geography. Although there have been substantial advances in working out the chronology of the lake's rises and falls, many uncertainties still exist and will need to be addressed through future archaeological and geological investigations. A modern hydrologic model suggests that under natural conditions, if the entire flow of the Colorado River were diverted into the basin, it would have taken about 18 years for the basin to fill. During this period, the normally well-watered southern delta of the river may have become desolate.

Once the filling of the lake was seriously begun, it seems likely that it would have continued until it was complete, because the Colorado River's new channel, perhaps following a course similar to the Alamo River or the New River, would have been entrenched into the soft lake sediments. When the lake was finally full, about half of the inflow would have been lost through evaporation, and the other half would have flowed out of the basin to the south, into the Río Hardy, the main delta, and the Gulf of California. With modern average rates of seasonal inflow, evaporation and precipitation, the lake would have overflowed during every month of the year except September and October, when an excess of evaporation over inflow would have lowered the lake level by only about 2 in. (5 cm). With the muddy waters of the river now entering the lake along a reduced topographic gradient, the once-steep channel would have begun to fill with sediment, creating the preconditions for a new shift of the river back to the south. If the entire flow of the Colorado River were diverted away from the basin, it would have taken approximately 56 years of uninterrupted evaporation before the lake finally disappeared. However, this model for the lake's recession may be too simple. The lake's life may have been extended by partial diversions of some water back into the basin, as happened on several occasions during the nineteenth century.

It was once thought that there was a single prehistoric stand of Lake Cahuilla, between about A.D. 1000 and 1500. Subsequent geological and archaeological studies have shown that the true picture must be considerably more complex. Stratigraphic observations, radiocarbon dates, and historical evidence require that there have been a minimum of three full stands and three substantial or complete recessions between A.D. 1200 and 1700. There is evidence, although it is as yet less clearly defined, for one or more cycles of filling and recession during the millennium prior to A.D. 1000. Stratigraphic evidence of a Late Pleistocene lake stand has been found at higher elevations in the basin, although without associated evidence of a human presence. Evidence from archaeology and oral traditions has documented the use of a range of resources made available by the lake. These included at least five species of freshwater fish otherwise found on the lower Colorado River, a freshwater mollusk (*Anodonta dejecta*), and at least 22 species of migratory or resident aquatic birds. The plant species associated with the margin of the lake, such as cattail, tule, and reed, were exploited. Presumably nonlacustrine Colorado Desert animals and plants were also made more abundant locally by the availability of drinking water at the shore or by the elevation of the nearby water table.

Regional Prehistory

A human presence in the study area can confidently be projected back at least 11,000 years. Some investigators have argued for the presence of a pre-Clovis occupation of the region, dating from several millennia prior to 11,000 B.C. Purported pre-Clovis remains have been reported within or near the study area, for instance at Truckhaven by the Salton Sea and in the Yuha Basin west of Mexicali and Calexico. However, none of these claims has yet met with any general professional acceptance. The issue of the timing of the initial occupation of the Americas continues to be among the most-debated topics in New World prehistory, and any archaeological evidence in the study area that might bear on this issue would have a high importance.

Archaeological sites and artifacts dating from the terminal Pleistocene and early Holocene periods (ca. 11,000-6000 B.C.) have been categorized as belonging to the Clovis and San Dieguito patterns. The Clovis pattern, characterized by large, skillfully worked, fluted-based projectile points, is well attested in Arizona to the east of the study area and in the Mojave Desert to the north, but not as yet within the Lake Cahuilla basin. Artifacts of the San Dieguito pattern are somewhat less distinctive but include large stemmed projectile points, heavy unifacial scraping tools, and enigmatic crescent-shaped flaked artifacts. Some archaeologists have attributed many of the surface archaeological sites in the Colorado Desert, including quarry areas and circular rock rings or clearings on desert pavement surfaces, to the early San Dieguito pattern, but this is now often disputed.

The long Archaic period extending through the middle Holocene and early late Holocene (ca. 6000 B.C.-A.D. 500) has found surprisingly little representation within the Colorado Desert. The region may have become too inhospitable during periods of elevated temperatures or extended droughts, or much of the evidence of Archaic occupations may have been buried or destroyed by subsequent geomorphic processes, notably those associated with the cycles of Lake Cahuilla. Some large projectile points have been found in the study area that match the Archaic-period Pinto (eared), Gypsum (stemmed), and Elko (corner-notched) forms of the Mojave Desert.

The region's archaeology comes into its own during the final period of prehistory, between about A.D. 500 and 1770. Hallmarks of the period include pottery (commonly classified as Lower Colorado Buffware, Tizon Brownware, and Salton Brownware), arrow-size projectile points (Cottonwood Triangular, Desert Side-notched, and Dos Cabezas Serrated forms), and the practice of human cremation rather than inhumation burial. The chronology of this period has commonly been divided into three phases (variously labeled Yuman I, II, and III, or Patayan I, II, and III, corresponding roughly to A.D. 500-1000, 1000-1500, and 1500-1770 respectively). This scheme was originally based on a belief that Lake Cahuilla was present during the second phase but absent during the first and third phases, and that recognizably diagnostic pottery types were manufactured during each of the phases. Doubt has now been cast on both of these assumptions: a longer and more complex sequence of rises and recessions has emerged for Lake Cahuilla, and there are indications that the previously proposed ceramic sequences may need to be substantially revised. Issues of chronology and of the human responses to the lake's arrival, its presence, its gradual decline, and its absence are in the forefront of regional archaeological research issues.

Research Questions

The scientific value of the prehistoric archaeological sites in the study area lies in their potential to contribute information that will advance the understanding of the region's past. The most promising research directions can be summarized under a few main headings:

- Early Occupations. When did people first occupy the Lake Cahuilla basin? What were the characteristics of early occupations, in terms of their settlement and mobility strategies, patterns of resource use, and technologies? Did hiatuses exist in the region's occupation? What factors can account for the apparent scarcity of Pleistocene and Early to Middle Holocene remains: an excessively challenging physical environment, unfavorable conditions for the survival and modern discovery of such remains, or difficulties in recognizing the chronological position of the early archaeological remains that are present?
- Lake Cahuilla. What is the full sequence of the lake's cycles of filling and recession? How many such episodes occurred? Was the Lake Cahuilla basin characterized during most of the Late Holocene period by full lake stands, by the lake's absence, or by unstable states of advancing and retreating waters? How did the region's available resources change as the Colorado River shifted its course away from its lower delta, as the lake rose, as it stood at its maximum stand, and as it shrank in area and increased in salinity during recessions? How did human groups respond to those changes?
- Late Prehistory. Was Lake Cahuilla a focus of substantially permanent human settlement during the late period, or merely a subordinate element in wider regional settlement systems? Were there important differences between adaptations to the

basin's eastern and western, northern and southern subregions? Can the prehistoric archaeological remains of the Cahuilla, Kumeyaay, Cocopa, and possibly other ethnic groups be distinguished, and can the archaeological record confirm, refute, or add nuance to the picture of Takic and Yuman prehistory that is suggested by linguistic evidence? What cultural changes can be recognized during successive phases (e.g., Patayan I-III) of the late period? What relations of seasonal migration, cultural diffusion, or exchange of goods linked the late prehistoric inhabitants of the Lake Cahuilla Basin to the peoples in surrounding regions?

GIS Model Data Types

A wide range of different kinds of archaeological sites, features, artifacts, and analytical data have the potential to contribute in various ways toward the resolution of the research questions discussed above when analyzed using a Geographic Information System.

The availability of archaeological contexts or individual artifacts and ecofacts that can be placed chronologically is a key to being able to address many of the research questions posed above. Organic materials can provide the radiocarbon dates that are the basic tools for building an absolute regional chronology. Additional absolute dating methods, currently in varying stages of verification and refinement, include other radiometric methods (uranium series, potassium-argon), obsidian hydration, luminescence, and cation-ratio dating. Relative dates, which can be linked into the region's absolute chronology, come from technological attributes (e.g., the use of ground stone, modes of lithic reduction, projectile delivery systems, ceramics), stylistic attributes (e.g., particular projectile point forms, pottery types, shell bead and ornament types), condition (e.g., weathering, patination), stratigraphic contexts (e.g., superposition within middens, burial within lacustrine or aeolian deposits, embedding in desert pavements), locational associations (e.g., sites at Lake Cahuilla shorelines, particularly in areas that would otherwise have been inhospitable), and associations with other datable remains. Archaeological remains that cannot be placed within the region's prehistoric chronology are less likely to be able to make significant research contributions.

Artifacts and materials of nonlocal origin can attest to patterns of mobility and the existence and importance of intercommunity, interethnic and interregional exchange networks. Items of particular interest may include vertebrate and invertebrate faunal remains (notably Gulf of California or Pacific coast marine shellfish and fish), floral remains (such as pine nuts or agricultural crops, including macrofloral remains, pollen, and phytoliths), lithic materials (e.g., obsidian, varieties of cryptocrystalline silica, steatite), ceramic artifacts assignable to wares or types that were not produced locally, and beads and ornaments.

Special-function sites or distinct activity areas within multipurpose sites may be particularly important in isolating and analyzing evidence concerning prehistoric cultural patterns of behavior. A wide range of feature types are represented in the region, including middens, hearths, roasting features, bedrock milling features, house structures, cleared or ringed circles, rock art, geoglyphs, trails, fish traps, caches, and coprolite deposits. Because the information content of features, unlike that of individual artifacts, can only be preserved either through leaving them in situ or by their careful archaeological documentation, thorough recordation and study of features in the field is critical.

Buried archaeological deposits are particularly likely to be important, because of their potentially superior state of preservation and their potential for stratigraphic chronological placement. Some sites have been buried and preserved by alluvium or colluvium, but Holocene lacustrine and aeolian deposits are especially promising contexts within the study area. Where circumstances suggest that there is a high potential for buried sites to be present, the use of geophysical prospecting methods (such as ground-penetrating radar) or archaeological coring may be useful strategies for locating them. In many other cases, the most effective method for discovering and documenting buried deposits is likely to involve careful archaeological monitoring of all ground-disturbing work.

Noncultural deposits may answer many of the questions about paleoenvironmental conditions that are critical to understanding the region's human prehistory. Packrat middens and stratigraphic exposures of lacustrine and non-lacustrine sediments may be particularly useful. In conducting inventory, testing, and monitoring work with respect to cultural resources, due attention should also be given to documenting the presence of potentially significant noncultural deposits.

A wide range of chemical and physical methods of analysis have become available in recent decades and are now basic in advancing the understanding of regional prehistory. In addition to dating techniques, several methods of chemical characterization have been applied to obsidian, other lithic materials, and ceramics. Other chemical methods may be applicable to organic materials, to evaluate such variables as temperature, seasonality, perhaps salinity, diet, and genetic affiliation. Petrographic methods have been applied to both stone and ceramic artifacts.

Data Collection

The ASM Planning and Research Collaborative has already obtained the approval of the California State Historic Preservation Officer and the Archaeological Information Centers for San Diego, Riverside and Imperial Counties to initiate the project. ASM PARC is also working with our Mexican colleagues at Centro INAH Baja California to establish a data-sharing cooperative agreement. We have already generated some of the necessary archaeological data from previous archaeological projects we have worked on associated with different canal construction projects in the area, such as the L-Line, Coachella and All American Canals. Currently, we are in the process of compiling and digitizing the archaeological site record information from the information centers for analysis in a GIS and identifying potential recipient agencies, managers and users for the results of our analyses.

Conclusions

The aim of this project is to produce a Cultural Resources Management Plan and accompanying GIS database for the Lake Cahuilla basin. This management plan will identify sensitive cultural resource areas that should be taken into consideration by governmental agencies in the region in their efforts to appropriately manage and preserve these resources and balance preservation with development in this unique environment.