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PRE-HISPANIC OCCUPANCE IN THE MIDDLE RIO SONORA VALLEY: FROM AN ECOLOGICAL TO A SOCIOECONOMIC FOCUS.

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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

# PRE-HISPANIC OCCUPANCE IN THE MIDDLE RÍO SONORA VALLEY: FROM AN ECOLOGICAL TO A SOCIOECONOMIC FOCUS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

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DOCTOR OF PHILOSOPHY

BY

WILLIAM EMERY DOOLITTLE III

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1979

PRE-HISPANIC OCCUPANCE IN THE MIDDLE RÍO SONORA VALLEY:

FROM AN ECOLOGICAL TO A SOCIOECONOMIC FOCUS

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PRE-HISPANIC OCCUPANCE IN THE MIDDLE RÍO SONORA VALLEY:

FROM AN ECOLOGICAL TO A SOCIOECONOMIC FOCUS

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MAJOR PROFESSOR: B.L. TURNER II, Ph.D.

Settlement patterns can be viewed as manifestations of specific levels of cultural development. Less complex cultures tend to maintain settlement patterns that are strongly influenced by ecological factors, whereas more complex cultures tend to exhibit settlement patterns in which socioeconomic factors are the dominant influences. Examinations of prehistoric settlement patterns by archaeologists have traditionally emphasized the ecological influences on less complex and developing cultures. Settlement research by geographers has tended to focus on the role of socioeconomic interaction factors among highly complex modern groups. These approaches can be merged to explain the evolution of settlement systems as they reflect changing levels of cultural development. It is suggested that a proportional shift occurs in the principal factors affecting settlement patterns as cultural development takes place. Introduced in terms of a hueristic concept called the "Ecological-Social Continuum", this shift involves a change from predominantly environmental influences to an emphasis on socioeconomic influences.

The settlement patterns and related features examined in this study are those of the pre-Hispanic ancestors of the Opata Amerinds of the middle Río Sonora Valley, northwest Mexico. The Río Sonora Valley lies between two north-south trending ranges in the southern end of the Basin and Range physiographic province. Although the area is geologically, biotically, and edaphically diverse, the areas most conducive to permanent settlement in ancient times are along the mesas overlooking the floodplain and largers arroyos. Evidence of past labor extensive agricultural practices is found in the form of numerous remnants of channel-bottom weir terraces in the larger arroyos. The ethnohistorical literature describes past labor intensive floodplain irrigation agriculture.

The field study and the laboratory work was conducted as part of a NSF project on prehistoric trade between Mesoamerica and the American Southwest. Data on settlements and agricultural features were collected throughout a 51 kilometer segment of the Río Sonora centered near the modern town of Aconchi, Sonora.

Settlements, agricultural sites, and other special sites were surveyed and described; relationships with physical features were determined; and functions were interpreted. In addition, a sequence of agricultural development was derived in concert with a settlement evolution sequence. The theoretical argument correlating the two sequences is that of population stress. Theories of settlement evolution and market development are discussed and the empirical evidence from the Sonoran data compared to the various models for explanatory purposes.

The agriculture and population evidence indicates that the pre-Hispanic Opata could have theoretically developed from part-time cultivators to intensive agriculturalists in less than a millenium. The evidence offered by changes in settlement hierarchies, and a shift from a gateway city-system to a central place system, however, indicates that contacts with greater cultures to the south were highly probable. Noting the changes in settlement patterns and agricultural practices according to stress theory reveals that a positive progression along the ecological-social continuum was characteristic of cultural development in the Río Sonora Valley. The earliest settlements were few in number, and randomly spaced with a focus toward extensive arroyo agriculture. The later settlements were greater in number, more uniformly spaced, hierarchically more complex with some sites displaying public architecture, and focused toward intensive floodplain agriculture. Through time, the population shifted from the environmentally more circumscribed southern segment of the valley to the broader northern segment. Settlement shifts progressed from a few environmentally favorable locales to the more spatially homogeneous mesas.

This study suggests that cultures can develop from rather low levels to relatively high levels of complexity in short periods of time without external contacts or immigration. It also shows that theories of settlement system evolution proffered by geographers have a great deal of applicability in explaining archaeological occurrances. In a broader context, the concepts of growth and development are discussed with the explanatory value of population stress being shown to be most applicable to less complex cultures, but requiring qualification when applied to more complex cultures.

## PREFACE

> We remain a part of the organic world, and as we intervene more and more decisively to change the balance and nature of life, we have also more need to know, by retrospective study, the responsibilities and hazards of our present and our prospects as lords of creation (Sauer 1952:104).

That I have been overly influenced by the works of the late Carl Ortwin Sauer (1889-1975) has been one of the most persistent observations made by my colleagues. I take such comments as the highest form of compliment. My interdisciplinary work with anthropologists, my interest in cultural ecology and underdeveloped regions, such as Mexico, and my belief that geographers need a broad training in both the physical and social sciences follow strongly from the views of Professor Sauer. Perhaps it was Dr. Sauer's comments on the relevance of prehistoric research, however, that led me to investigate a topic such as that covered here. By coincidence, the Río Sonora Valley is a region in which Sauer and his students conducted a great deal of field work. Although I never had the honor of meeting Carl Sauer, I have read his writings with great intensity. It is my sincerest hope that he would have approved this dissertation which is dedicated to him.

The research upon which this dissertation is based is part of a National Science Foundation funded project entitled Economic Networks: Mesoamerica and the American Southwest (BNS 76-16818). Under the direction of Dr. Richard A. Pailes, Department of Anthropology, University of Oklahoma, the Río Sonora project, as it is familiarly called, was granted permission by the Instituto Nacional de Antropologia e Historia, Hermosillo, Sonora, Mexico to conduct archaeological surveys and excavations throughout northeastern Sonora. The preponderence of the work, however, was carried out in the middle Río Sonora Valley.

Although archaeologists dominated the project, it was a fundamental aim to include participants from other disciplines. To this end, the project included the author of this dissertation--a geographer; botanists James Vaughn, University of Oklahoma, and Suzy Gerlach now of Brown University; and palynologist Adrianne G. Rankin, Arizona State University. Archaeologists and anthropologists serving on the project at various times have included Daniel T. Reff, Richard Crump, Kent Buehler, Jeanne Nespor, Robert Nespor, Jeanne Vaughn, Pat Hardin, and Stephen Gugler all of the University of Oklahoma; Richard Wilson, University of Nevada-Las Vegas; Marsha Smith and Kathleen Roy, Arizona State University; Victoria Dirst, University of Arizona; and Craig Gerlach now of Brown University. Volunteer workers from the University of Oklahoma included Charles

Pyle, Monte Tidwell, and Merle and Tooter Hunsaker.

This dissertation could not have been completed without the help of numerous people. As such I am indebted, above all others, to my principal advisor and doctoral committee chairman, Dr. B.L. Turner II, for his encouragement, supervision, and patience throughout both my advanced graduate work and the writing of this dissertation. I am also grateful to Dr. Richard A. Pailes for providing funding and the opportunity to carry out field work, and the other members of my doctoral committee, Drs. Edward J. Malecki and James M. Goodman, Department of Geography, University of Oklahoma, and Dr. William C. Johnson, Department of Geography and Meteorology, University of Kansas. I thank Dr. Thomas J. Wilbanks of the Oak Ridge National Laboratory, Oak Ridge, Tennessee, and Dr. James R. Bohland, who in their capacities as successive Chairmen of the Department of Geography during my tenure at Oklahoma provided both solicited and unsolicited assistance. I also thank Dr. Stephen I. Thompson, Chairman of the Department of Anthropology at Oklahoma, who also provided valuable assistance.

In Mexico my work was facilitated through the help of Arq. Beatriz Braniff C., co-principal investigator of the NSF project, and her husband, Dr. Arturo Oliveras M., Director of the Centro Regional del Noroeste, Instituto Nacional de Antropologia e Historia, Hermosillo, Sonora. Dr. Guillermo Salas, Professor de Geologia, Universidad de Sonora, and Sr. Edwin B. Surman B., IFEX Internacional, S.A., Hermosillo, Sonora, provided geological maps and aerial photographs, respectively. The Ricardo Loera family and Sr. Francisco Herrera Romo of Baviácora provided local assistance. Ing. Alfonso A. Daco, Jefe de Exploracion, Cia. Minera Trans-Río, S.A. (Campbell-Chibougamau Mines, Limited, Toronto, Canada) of Huepac, Sonora helped with the geological assessment and was instrumental in locating many archaeological sites. I thank all these people for both their courteous assistance and their friendship.

Many people in this country also provided essential help during the completion of this project. Dr. Campbell W. Pennington, Department of Geography, Texas A & M University provided cultural information about northwest Mexico that only he possesses. Professors Emeriti Donald D. Brand, University of Texas, and J. Charles Kelley, Southern Illinois University, offered suggestions about conducting archeological surveys that proved to be most beneficial. Dr. Fred Wiseman, Louisiana State University, offered suggestions concerning ecological analysis. Dr. Thomas L. Bell, Department of Geography, University of Tennessee, and Dr. Carole L. Crumley, Department of Anthropology, University of North Carolina-Chapel Hill, provided comments about the applicability of spatial models to prehistoric settlement data. Dr. Karl W. Butzer, Departments of Anthropology and Geography, University of Chicago, offered cogent comments concerning the ecological basis for emerging civilizations. Dr. T.H. Lee Williams, Department of Geography and Meteorology, University of Kansas, who initially served on my committee, provided assistance with remote sensing techniques. Dr. Johnnie Gentry, Bebb Herbarium, University of Oklahoma, provided a plant press for field use. Dr. Guy R. Muto of the Archeological Research and Management Center, Norman, Oklahoma, and Ms. Lois E. Sanders, Oklahoma Archaeological Survey, provided soil testing equipment. Drs. Clement W. Meighan and P.I. Vanderhoeven, of the Obsidian Hydration Lab, Department of Anthropology, University of California at Los Angeles, and R.C. Koeppen, Center for Wood Anatomy Research, Forest Products Laboratory, Madison, Wisconsin provided obsidian hydration analyses and wood identification, respectively. Mrs. Polly Hewitt, Oklahoma Geological Survey, provided technical advice concerning reproduction techniques. I thank these people for their suggestions, assistance, and services.

I thank all of the members of the Río Sonora project named previously and Linda Turner for helping my wife and children while I was in Mexico during the second field season. I also thank my closest colleague and friend, Robert C. Balling Jr. whose competitive spirit inspired me through completion of my doctoral program.

Finally, I thank my parents, and sister, Karen, for providing moral and financial support in times of need; and my wife Diane, and Sons, Billy, David, and John Galen, for their love, patience, and sacrifices made throughout my graduate education.

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# PRE-HISPANIC OCCUPANCE IN THE MIDDLE RÍO SONORA VALLEY

## FROM AN ECOLOGICAL TO A SOCIOECONOMIC FOCUS

> This man-land approach has been highly productive, especially when dealing with cultural systems of relatively low complexity . . . [but] when dealing with systems of greater complexity, man-man relationships take on increasing importance in the determination of the spatial distribution of activity loci and thus settlements (Johnson 1972:769).

## INTRODUCTION

Settlement patterns can be viewed as manifestations of specific levels of cultural (sociopolitical) development.[1] Less complex cultures tend to maintain settlement patterns that are strongly influenced by ecological, rather than socioeconomic factors, whereas more complex cultures tend to exhibit settlement patterns in which the socioeconomic factors are the dominant influences (Eidt and Woods 1974:4-5). Studies of settlement patterns and related systems in archaeology and geography have had a propensity to focus on one or the other type of culture-settlement relationship. Minimal efforts

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[1]Cultural development is used here to refer to the centralization of sociopolitical controls and can best be understood in terms of a continuum of socioeconomic stages that range in complexity from egalitarian hunting and gathering societies to stratified western states. This relative scheme and terminology is preferred so as to avoid the definitional problems encountered in more rigid usages.

have been directed toward bridging the ecological-socioeconomic dichotomy.

Examinations of prehistoric settlement patterns by archaeologists have traditionally emphasized the cultural-ecological relationships of less complex and developing cultures. Until recently, general theories of settlement evolution have not been developed by archaeologists in spite of the suitable diachronic (time-series) orientation of prehistoric studies. In contrast, settlement research by geographers has tended to focus on the role of socioeconomic interaction factors operative in modern, complex cultures while ignoring environmental factors.[2] Such research, although typically synchronic (cross-sectional) in nature, has led to the development of general theories of settlement location, spacing, interaction, and evolution. Geographic theories of settlement have not been extended to prehistoric or less developed situations in which ecological factors play a more important role.

The approaches from the two disciplines can be merged to explain the evolution of prehistoric settlements as they reflect changing levels of sociopolitical development. It is suggested that as this development took place among ancient cultures a shift occured in the principal factors affecting settlement patterns. This shift was from predominantly en-

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[2]To expedite discussion the terms "geographer" and "geography" refer to the spatial-economic tradition of the discipline. This usage is not reflective of the author's view as to what constitutes geographic research, but is convenient for this particular study.

vironmental to socioeconomic influences and is introduced here in terms of a hueristic concept called the "Ecological-Social Continuum."[3] Settlement evolution, following a developmental pattern as suggested by the proposed continuum, can be demonstrated by analyzing changes in settlement patterns over a long time span or by synthesizing occupance data from the phase(s) in which a proportional ecological-social shift occurred. The former approach requires detailed diachronic settlement data, while the latter approach involves the application of analogue models and knowledge of economic patterns. This study utilizes the occupance approach to establish the nature of settlement evolution in the middle Río Sonora Valley of northwest Mexico ca. A.D. 1000-1550.

## Regional Setting and Significance for Settlement Studies

The settlements examined in this study are those of the pre-Hispanic ancestors of the Opata Amerinds of the middle Río Sonora Valley, Mexico.[4] These people occupied all of

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[3]Continuums have been used by both anthropologists and geographers to illustrate that man-land and man-man relationships vary with specific levels of cultural development. Bennett (1976) uses an "Ecological Transition" to demonstrate that less complex cultures dominate and control the environment. Symanski, Manners, and Bromley (1975) employ the concept of a mobile-sedentary continuum to show how differences in various levels of cultural complexity are manifested in the spatial relationships of social activities.

[4]Opata is the name given to the historic Amerinds of eastern Sonora. Whether or not the pre-Hispanic inhabitants were actually Opata is still unresolved. At the very least we know that they were probably ancestors of the Opata and, therefore, will be addressed here by that name. The Opateria is a name often used in reference to their lands.

the valleys in a region known locally as the serrana (foothills) on the western flank of the Sierra Madre Occidental of eastern Sonora (Sauer 1935; Sandomingo 1953). The semiarid foothill valleys and their intermediary mountains form the extreme southern end of the Basin and Range physiographic province of North America (Hunt 1974; Fig. 1).

The middle Río Sonora Valley, unlike its upper and lower reaches, is characterized by an extensive floodplain, broad bajadas (alluvial slopes), and pediments (erosional surfaces) that experience seasonally scant rainfall. Flanked by ranges with peaks 30 kilometers apart, the 51 kilometer long study area displays considerable topographic and biotic heterogeneity. During pre-irrigation times the Río Sonora may have flowed continually through its middle course, although today the flow is often restricted during the rainfall deficient spring and autumn.[5] A significant portion of the region is composed of bajadas that terminate abruptly at the floodplain. These bajadas are dissected by several arroyos of varying lengths and widths, the largest of which contain relic agricultural features. The edge of these bajadas, overlooking the river, was a desired locale for permanent settlements in pre-Hispanic times. A sufficient number of ancient habitation sites have been found along the river and arroyos to indicate

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[5]The decrease in stream discharge is not the result of climatic changes but rather of increased use of surface and ground water with modern irrigation practices. This point is discussed in greater detail in Part II.

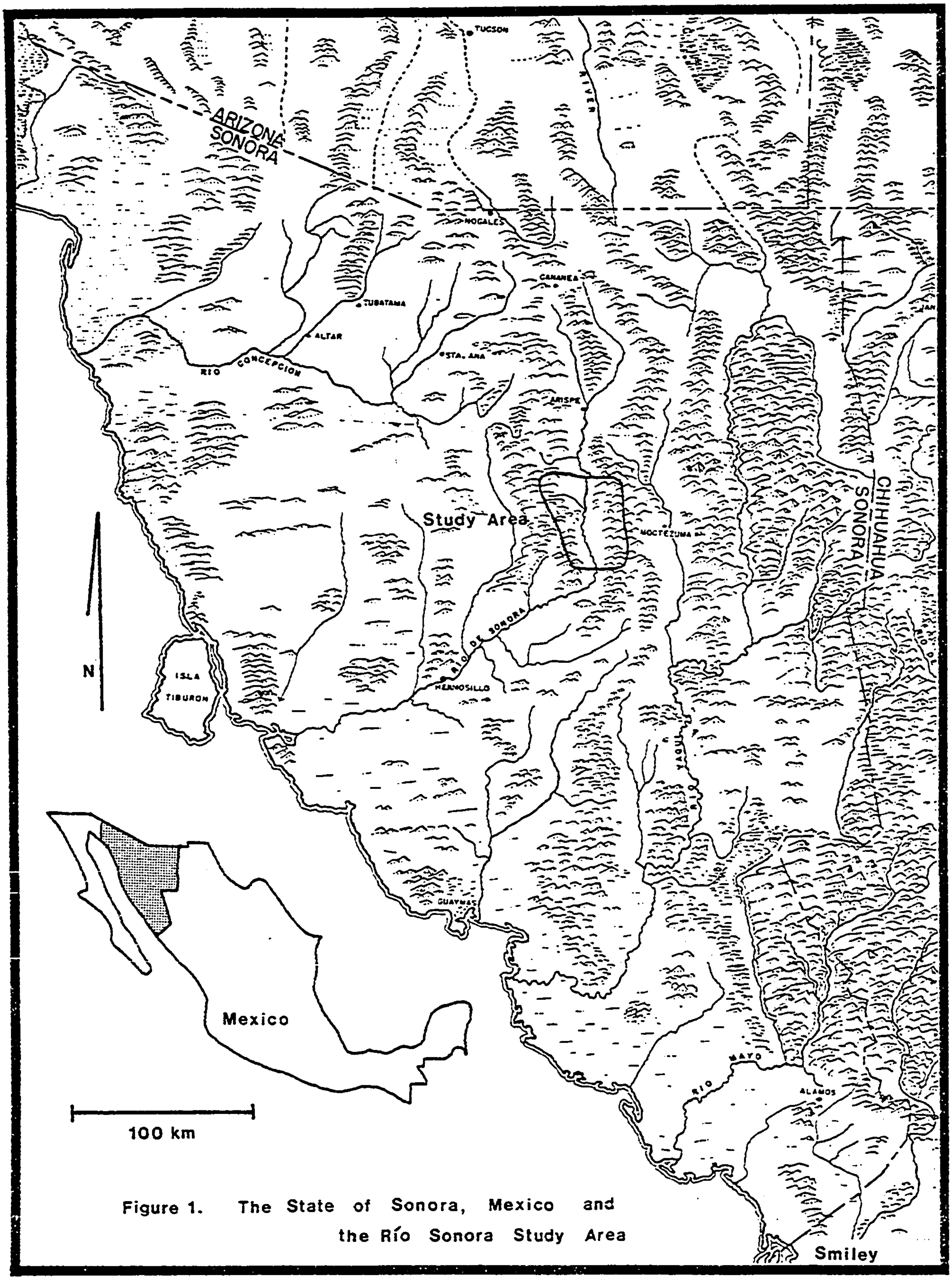


Figure 1. The State of Sonora, Mexico and the Río Sonora Study Area

that the study area was marked by a substantial pre-Hispanic population that utilized numerous environmental zones.

Ethnographically defined, the Opateria occupied the total northeastern quarter of the State of Sonora. Its range extended from the Chihuahua-Sonora border on the east to the Sonoran Desert west of the Río San Miguel drainage; and from the United States-Mexico border on the north to about the 28° 30' longitude in the south (Fig. 2). Although the area was ethnographically and linguistically homogeneous (Sauer 1934), its archaeological history is still unclear. The prehistory of eastern Sonora has been identified as having both a distinctive archaeological tradition tentatively called the Río Sonora Culture (Amsden 1928; Pailes 1972), and as being peripheral to other southwestern cultures (Sauer and Brand 1932; Brand 1935; DiPeso 1974). Amsden (1928) considers the eastern half of the region as peripheral to the Casas Grandes Culture (centered in Chihuahua) and the western half as Río Sonora Culture. These distributions are currently unresolved, but they do not have a major effect on the problems considered in this study.

Amsden (1928:49) was the first to establish periods of occupation in the Río Sonora Valley. He considered this occupation to be both late, A.D. 1300 to 1540 (Pueblo 4), and brief, the latter proposition based on the lack of rubbish mounds. He considers the people of this culture to have immigrated during the decline of the upper southwestern cul-

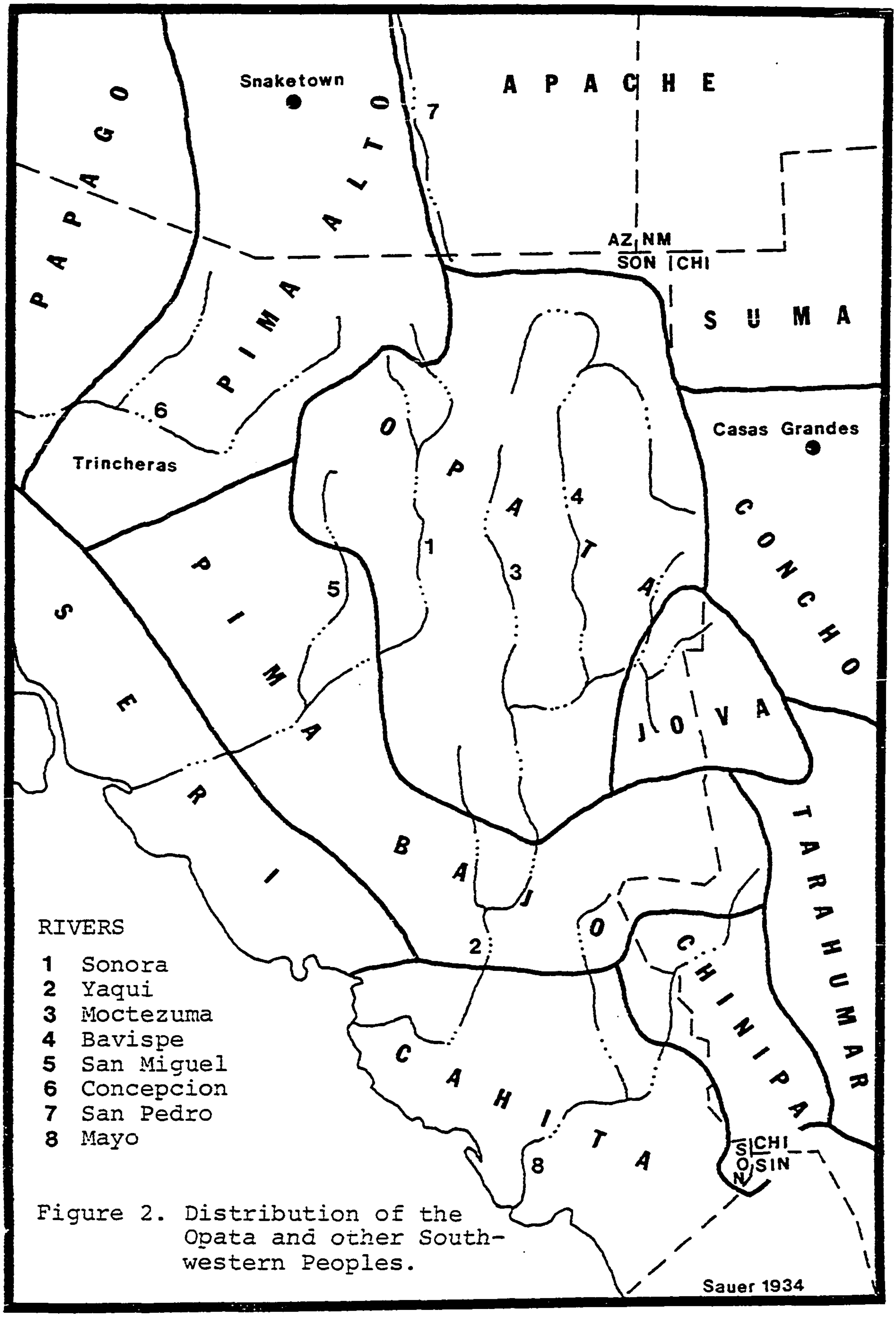


Figure 2. Distribution of the Opata and other Southwestern Peoples.

tures. Recent investigations have revealed that Amsden was only partially correct at best. The new evidence indicates an occupation beginning as early as A.D. 1000 and probably earlier (Pailes 1978a).

Two distinct periods of prehistoric cultural development are now discernible from the chronological sequence. Prior to A.D. 1200 the valley was probably marked by internal, albeit limited, development with little or no evidence of outside influence. From A.D. 1200 until the arrival of the Spanish, however, the ancient residents of the Río Sonora Valley were strongly influenced by contacts with other New World peoples, especially the Hohokam of southern Arizona (Haury 1976), the Casas Grandes culture of Chihuahua (DiPeso 1974), and the Mesoamerican cultures of central Mexico (Sanders and Price 1968) (Fig. 3). The intrusion of outside forces into the valley about A.D. 1200 is also contemporaneous with the florescence of the Mesoamerican cultures of western Mexico, a culture known for its long-distance traders, the _Pochteca_-type _Trocadores_. From the time of this intrusion to the time of the Spanish arrival, rapid population growth and cultural development among the Opatas of the Río Sonora Valley was experienced (Sauer 1935). This growth was the result of several factors, not the least of which may have been cultural intrusion and, perhaps, immigration from the east or Mesoamerica (Pailes 1976). The arrival of the Spanish marked the termination of indigenous cultural development in the

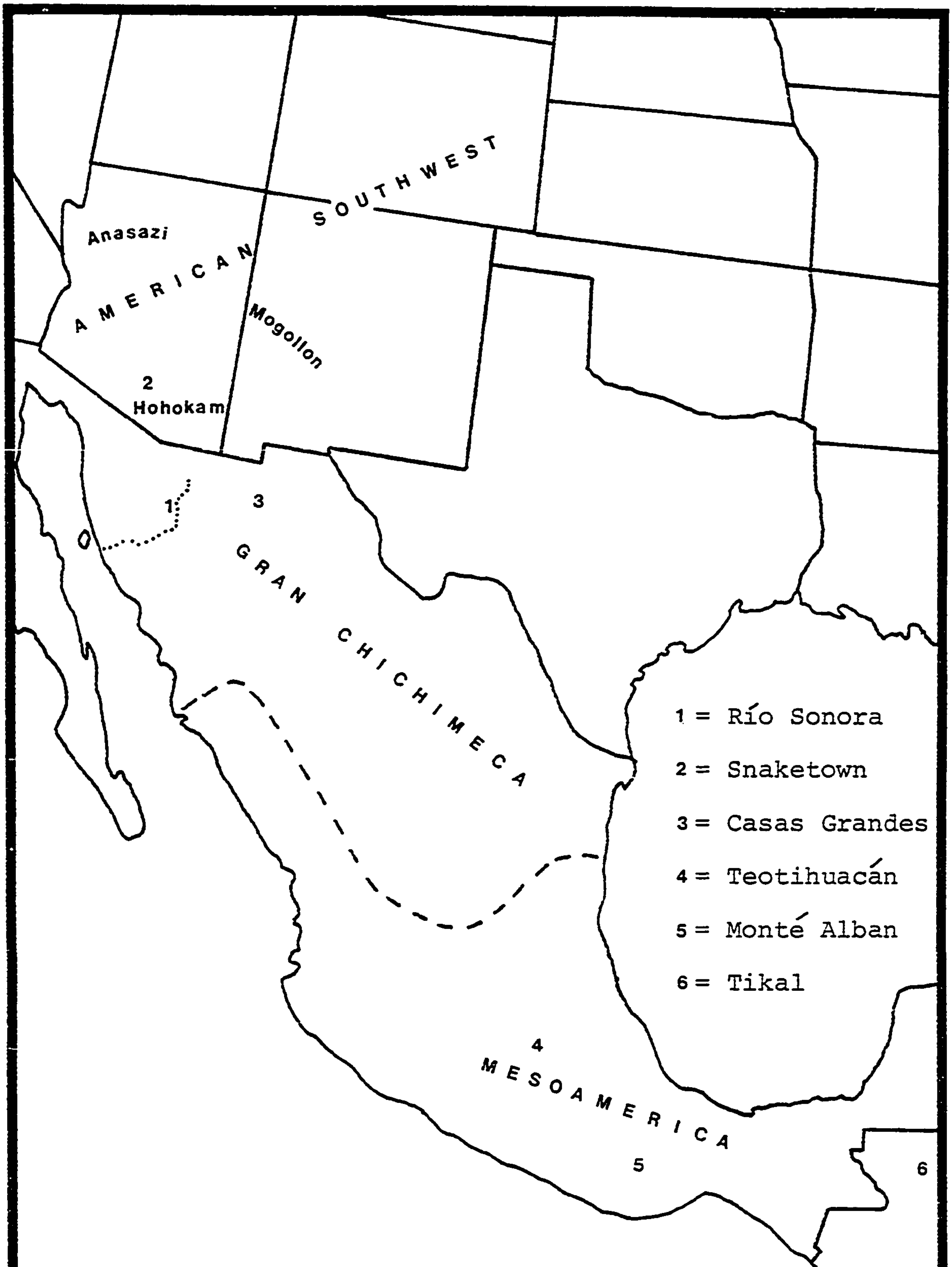


Figure 3. Río Sonora Valley in Relation to the American Southwest and Mesoamerica.

Sonora Valley. If the accounts of the first Spanish are accurate, the level of cultural development experienced today has only recently caught up with that attributed to the pre-Hispanic habitants. The Spanish influence, of course, disrupted the entire pattern of occupance, including settlement patterns. Such disruptions resulted from resettlement schemes, disease, and forced institutional changes.

Although eastern Sonora and most of northern Mexico were not a focal point of cultural achievement equal to that of the central highlands of Mexico or the tropical lowlands of Mesoamerica, it is important archaeologically for several reasons. The region, especially the Río Sonora Valley was: (1) in alignment with and centrally located between other areas of major cultural achievement (Figs. 2 & 3); (2) an area through which pre-Hispanic long-distance trade routes passed (Brand 1938); (3) reported to have contained a large pre-Hispanic population (Pfefferkorn 1949; Nentvig 1971); (4) occupied by people with distinctive cultural characteristics (Bandelier 1892; Sauer and Brand 1932; Ekholm 1939; Amsden 1928); and, (5) marked by a semi-arid environment not too unlike other areas where major early civilizations have arisen.

In addition to its archaeological significance, this region is suitable for investigating various settlement evolution theories because of: (1) the linearity of settlement patterns (one-dimensional) created by the parallel drainage network eliminates logistic and theoretical problems that arise in studying two-dimensional settlement systems (Dacey, et al. 1974), (2) the incipient level of cultural development allows for settlement systems to be studied using models of cultural and economic interaction rather than having to subscribe to the strict assumptions necessary for settlement system models developed for modern societies, and (3) the region is situated such that the effects of exogenous forces vis-a-vis internal growth can be investigated.

## Data

The basic settlement data for this study were collected from the identification of archaeological sites in the central 51 kilometer section of the middle Río Sonora Valley. These data were compiled in two separate phases. A pilot research team of which the author was not a part conducted an archaeological survey largely within a 5 kilometer square quadrant north of the modern pueblo of Baviácora during the summer of 1975. The results of this intensive but spatially limited Type IV survey (Ruppé 1966) provided information utilized in planning subsequent research strategies.[6]

[6] Ruppé (1966) outlines four types of archaeological surveys. Type I is an extensive reconnaissance that involves the cataloging of sites over a wide area. Typically, such surveys are exploratory, such as that of Bandelier (1892). Type II surveys are limited to local areas and are usually conducted in conjunction with a large-scale excavation program. A Type III survey is problem oriented and limited to the collection of data concerning a specific topic. Surveys of Type IV are intensive programs to obtain a maximum amount of information from a specified area.

During the summers of 1977 and 1978 the author, with the help of a local assistant, carried out a combined Type III-IV survey from approximately La Labor to north of Banámichi, Sonora. Within these limits the entire bajada edge overlooking the river was surveyed, as were selected arroyos (both floors and overlooks). Surveys were limited largely to these areas because the results of the 1975 survey indicated that archaeological sites, especially permanent habitation sites, are most numerous in these overlook situations (Fig. 4). The original survey also showed that some prehistoric activity, evidenced by limited surface debris, took place away from the river on the bajadas and pediments. During the 1978 survey a stratified sample of 1 km X 1 km quadrants in various environmental zones away from the river were surveyed using the random walk and the strip transect techniques (Fladmark 1978).[7] Both of these sampling procedures were found to be counterproductive, therefore, they were abandoned in favor of utilizing the subjective approach based on the findings of the 1975 survey. This approach proved fruitful in producing data, but might have biased the sample. A

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[7]The random walk technique involved surveying a randomly selected azimuth from an arbitrary point of origin to the limits of the quadrant. At this point another azimuth was chosen and the procedure repeated. This random walking continued until six transects were made across the quadrant. The strip transect technique involved intensively surveying a randomly selected 100 meter by 1.0 kilometer strip from the selected quadrant. Each kilometer quadrant contained 20 such strips (10 north-south and 10 east-west strips).

A. Son K:8:34 OU. Pueblo of Suaqui is on the right.

B. Son K:4:24 OU. Arrow indicates location of public architecture.

Figure 4. Two Pre-Hispanic Settlement Locations.

total of 227 archaeological sites were recorded in the middle Río Sonora study area (Appendices II, III and IV).

A subsequent Type III survey was conducted in portions of the upper Río Sonora, the Río Moctezuma, and the Río Sahuaripa Valleys to ascertain whether or not similar settlement patterns and cultural manifestations were typical in neighboring regions. Results of a survey in the Río San Miguel Valley (Braniff 1978) were also consulted for the same purpose. A sample of the site survey form utilized during the field work can be found in Appendix XIII. The archaeological sites, as surveyed, were numbered consecutively using the Arizona State Museum system (Wasley 1964).[8]

Site mapping was carried out on two scales. Those locations of known or discovered pre-Hispanic and early historic occupance were plotted by coordinates on commercially available maps of the region. Such a technique was proposed by Dills (1970). The master site map (Appendix II) is the re-

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[8]In this system the entire "Southwest" is delimited by quadrants of 1.0 degree of longitude and latitude, and the resultant squares are broken into 15 minute grids. The larger quadrants are designated by state name abbreviations, and letters, the smaller grids by numbers. Sites within the smaller grids are numerically designated by the sequence in which they were discovered. For example, Son K:8:26 OU refers to: Son = Sonora, Mexico; K = the specific 1.0 degree quadrant; 8 = the 15 minute grid within the quadrant K; 26 = the 26th site found in grid 8; OU = University of Oklahoma project. For convenience, some sites were also named, most often after neighboring pueblos or physical features.

sult of this endeavor. Those locations that were verified as, or suspected of being, pre-Hispanic or early historic settlements were individually mapped by meter tape, pacing, and Brunton pocket transit. These individual settlement maps (Appendix V) were compiled from sketches made in the field notes. These maps are not to be construed as accurate representations of the relic features. They are presented to show the number, style, approximate size, relative location of structures on the sites, and the approximate areal extent of the sites. The extent and proximity of modern disturbances to remnant structures is also shown. The geographical limits of sites were determined by the areal extent of cultural debris on the surface. It has been argued (Tolstoy 1958) that surface evidence may not always render an accurate picture of subsurface materials. Recent excavations conducted by other members of the Río Sonora NSF project, and by Redman and Watson (1970), however, have shown that cultural debris from each phase of a site's respective occupations is typically found on the surface. These findings suggest that surface data may be reflective of the entire occupational sequence.

By noting the surficial distribution, types, and periods of debris and structures, it is possible to measure changes in the site through time in terms of size, morphology, and function. Such a methodology is commonly utilized in araeological studies, although results must be viewed with caution (Millon 1973). Blanton (1978:19) has concluded that this method was acceptable for assessing settlements at Monté Alban (Oaxaca, Mexico) because

> for the most part the differential occurrance of artifacts on the surface . . . is not attributable to variation in modern conditions that affect surface collecting, but is due for the most part to differential patterns of artifact deposition in the past.

A major weakness of this study involves site chronology. Dating techniques utilized for completion of this work include artifact seriation, obsidian hydration, and radiocarbon ($C^{14}$) dating. A list of samples, provenience (location in space and depth), dates, and testing laboratories appears in Appendix VI. A substantial amount of worked obsidian was collected for dating purposes but because of the expense involved only twelve pieces were dated, six from excavation, and six from surface collections. Datable charcoal was also collected from excavations, but the cost of $C^{14}$ dating again limited the number of samples analyzed to 33 throughout the tenure of the Río Sonora project. Another problem incurred was a clear discrepancy of some carbon dates with the stratigraphy of the samples. Such obvious errors render a few dates suspect. Artifact seriation also has proven to be a problem. The preponderence of the local ceramics are plainware and monochrome pottery. Decorated pottery, especially trade ware, is easily seriated because so much ceramic dating has been conducted from the source areas of such ware (e.g. Casas Grandes). The local ceramic sequence, however, is only in the infant stages of identification.

For this study, archaeological sites have been chronologically classified by associating dated materials with architectural styles in the study area with similar dated structures in neighboring regions. It is realized that such a practice is questionable, but alternatives are lacking until such time that the larger project is able to provide a ceramic sequence. It should be noted that the excavated evidence tentatively suggests that the method utilized is relatively accurate.

The preponderence of the archaeological data uncovered and, hence, the culture period of concern, involves roughly 500 years from ca. A.D. 1000 to the arrival of the Spanish. Occupance patterns prior to A.D. 1000, however, are not ignored in this work. Results from this period are based on limited data and inferences made from analogous data. Data concerning the occupance patterns of the early Spanish era were also found during the course of the fieldwork and their implications are discussed, but only insofar as they have affected (terminated) the pre-Hispanic populations' mode of existence.

Various remote sensing techniques were employed to map the regions' physiographic and biotic zones. Initially, ecological zones were tentatively identified from LANDSAT images. These zones were then ground-truth verified by using the quadrant method often employed in ecological and botanical studies (Müeller-Dombois and Ellenberg 1974). Transects were laid out through the various ecological zones. Using the quadrant method, environmental data including vegetative, physiographic, geologic, and soil properties were collected from 10 meter squares.[9] Plant surveys included only perenniels. Ephemerals, because they fill a buffer role, experiencing growth only when sufficient moisture exists (Walter 1973), were not included. Plant identification was determined by personnel of the Bebb Herbarium, University of Oklahoma, and with the aid of Arnberger (1974), Dodge (1963, 1976), Gentry (1942), Hastings and Turner (1965), Little (1950), Patraw (1970), Pesman (1962), and Shreve and Wiggins (1964). A copy of the environmental survey form appears in Appendix XIII with the tabulated and explained ecological and soil data in Appendices VII, VIII and IX. A list of common plants appears in Appendix X.

Color, color infrared, and 1:50,000 scale black and white stereoscopic aerial photographs were utilized to com-

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[9] It was recognized after the 1977 season that rectangles rather than squares are considered by ecologists as being more accurate for sampling purposes. Squares, however, were utilized again in 1978 to maintain research consistency. Intuitively, characteristics of the regional vegetation are not observably different for a 10 meter square than for a 10 X 20 meter rectangle. If such differences do exist they would probably not be detectable by the small number of samples incorporated here. A more intensive and precise survey would be necessary for a study of plant ecology, but was considered counterproductive for this work.

plement the satellite imagery. Although these photographs were also employed in planning the archaeological site surveys, no sites were located using this method.

It is recognized that the environmental conditions during the period in question (ca. A.D. 1000-1550) may have been different from modern conditions. Mapping the contemporary environment, however, is an accepted technique on which to base paleoenvironmental studies (Coe and Flannery 1964; Sanders 1976). Four particular lines of investigation were carried out in order to measure the differences between modern and ancient conditions for this study. (1) The dendrochronology literature pertaining to this region was perused to detect periods of climatic fluctuation and evaluate their possible effects in the Río Sonora Valley. (2) The relationship between relic cultural features, such as houses and weirs, and physical evidence of the region's aggredation-degradation sequence was noted and analyzed. (3) Pollen samples were collected from the various ecological zones and compared with excavated pollen data. This analysis was conducted by personnel at the Pollen Lab, Department of Anthropology, Arizona State University. (4) Soil samples from the various ecological zones were analyzed relative to their respective flora in order to determine if the existing soils developed under the present vegetation or under a previously different vegetation.

## Organization of the Text

The text has been structured into four major segments. Part I is a discussion of the previous work and theories concerning the evolution of settlement systems. The ecological basis for explaining settlement patterns has maintained a strong tradition in both cultural geography and anthropology, and until recently, was the predominant approach to archaeological settlement studies (e.g. Willey 1956; Chang 1968). During the past twenty years, practitioners of the "spatial tradition" in geography have greatly advanced our knowledge of settlements (Pattison 1964). In so doing, the operations of settlement systems became a principal research theme and environmental explanations have been largely replaced by spatial (social interaction) explanations. The spatial approach has recently exceeded the bounds of geography and has become a popular research theme among archaeologists (Hodder and Orton 1976). It is argued here that concepts drawn from both the environmental and the spatial approaches are essential to understand temporal changes in settlement systems.

Part II is a case study of the pre-Hispanic occupance in the middle Río Sonora Valley of northwest Mexico. Included are the results of a contemporary environmental analysis with a discussion of paleoenvironmental conditions of the region. This section is followed by a description and analysis of the forms, frequency distribution, and dates of the numerous relics of permanent habitation sites and a few relic subsistence-agricultural features of various ages that involve various levels of agricultural intensity. It is demonstrated that throughout their history the Opata people of this valley had settlement systems that differed with various changes in agriculture.

Part III is devoted to the implications of the field data to pre-Hispanic occupance in the Río Sonora Valley. It is proposed that relic agricultural and habitation features are rather conclusive evidence that ancient Opata of the Río Sonora Valley were a viable and growing population that had a settlement history of marked changes evolving from an environmental focus to an intersite cultural focus. In addition, it is argued through the settlement patterns and their genetic manifestations that the Opata culture had contacts, both long-distance contacts in the form of trade networks with other cultures and intervalley cultural contacts.

Part IV addresses the theoretical ramifications of the evolution of settlement systems. Related questions of population growth, agricultural intensity, and the development of culture as reflected in the Río Sonora data are also addressed. These concluding remarks are focused on the ecological-social continuum and its benefit in understanding the development of culture.

## Geographic Framework

Man-land or cultural ecology studies have long composed a major sub-discipline of geography. The "Berkeley School" under the influence of Carl O. Sauer has been a major contributor to this sub-discipline, emphasizing prehistoric, historic, and contemporary cultural ecological problems, particularly in the New World. Significant contributions have been made concerning problems of population, agriculture, and human impact on the physical environment. More specifically, topics have included, among others, the origins of agriculture and plant domestification (Sauer 1952), prehistoric and historic Amerind agriculture (Carter 1945), prehistoric Amerind demography and settlement (Sauer and Brand 1932; Sauer 1935; Aschmann 1959; Denevan 1966, 1970), and the impact of European contact with Amerind cultures (Sauer 1966). This study follows in the tradition of the cultural ecology sub-discipline of geography by emphasizing the synthesis of material necessary to understand the interrelationships among physical environment, population, agriculture, and settlement.

General theories applied to spatial phenomena have in the past twenty years become a dominant theme in geographic research. Mathematical modeling, computer applications, and statistical techniques have played a major role in advancing the analysis of spatial data. Settlement pattern studies have not escaped this research approach but rather created much of the interest in spatial problems. Walter Christaller pioneered spatial settlement studies with his landmark work, Central Places in Southern Germany (1933). Contributions dealing with settlement patterns generally have been concerned with temporally static topics, including settlements as nodes of economic regions (Brush and Bracey 1955), hierarchies of city systems (Beckmann 1958; Berry and Garrison 1958a), spacing of towns (Dacey 1960), geometric properties of settlement patterns (Dacey 1965), and the structure and sizes of urban centers (Berry 1964, Parr 1973). Many of these works have had as their base the economic behavior of consumers and have, therefore, considered topics such as the ranges of demand and thresholds for supply (Berry and Garrison 1958d; Getis and Getis 1966).

Even though the bulk of settlement studies have dealt solely with the operations and characteristics of such systems, a few studies have looked at the evolution of settlement patterns either in colonization situations (Bylund 1960; Morrill 1962; Hudson 1969) or in theoretical, data-free situations (White 1974, 1975, 1977, 1978). This dissertation follows in the spatial tradition of geography by attempting to understand the implications of intersite relationships and settlement evolution, and adds an often ignored dimension by applying spatial theory in a prehistoric context.

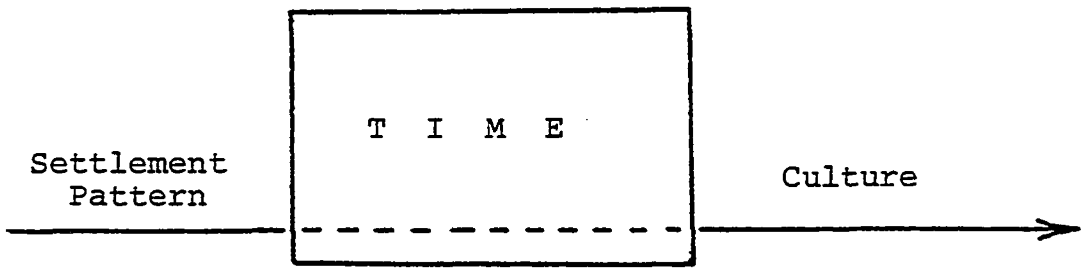
# PART I

## SETTLEMENT SYSTEMS:
## RESEARCH AND THEORIES OF EVOLUTION

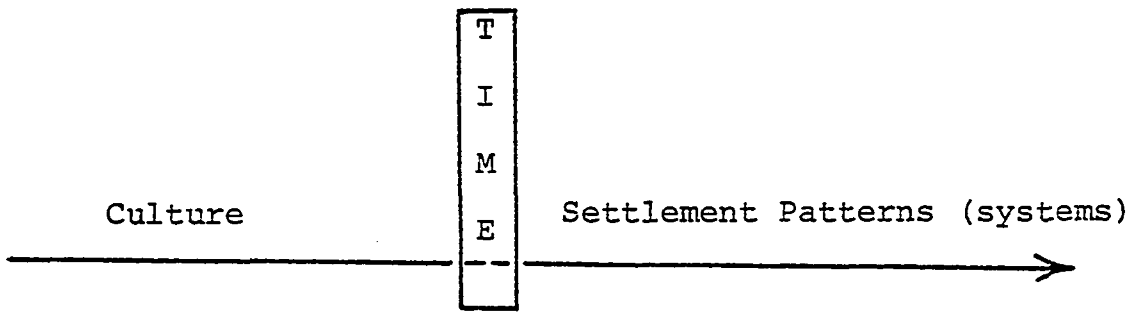
Even though the study of settlements has been an integral research area in both archaeology and geography, relatively little emphasis has been placed on understanding the causal agents that influence prehistoric settlement patterns and even less emphasis has been placed on the evolution of settlement systems. One of the archaeologists' greatest contributions to settlement studies involves diachronic analyses that are aimed at an understanding of cultural development. Accordingly, settlement patterns are considered as only one type of data necessary to understand culture (Willey and Sabloff 1974; Fig. 5). Such studies have shown an intrinsic relationship between settlements and culture, and settlements and environment. This point was made by Willey (1956:1) who stated that:

> In settlement, man inscribes upon the landscape certain modes of his existence. These settlement arrangements relate to the adjustments of man and culture to environment and to the organization of society in the broadest sense.

General explanations of these patterns and settlement evo-




ARCHAEOLOGICAL APPROACH




GEOGRAPHICAL APPROACH

Arrow shows orientation of research. The head indicates the topic of investigation and the tail indicates the type of data employed.

Figure 5. The Focus of Disciplinary Approaches to Settlement Studies.

lution, however, have been largely neglected. In temporally structured studies, such as those concerned with the development of civilization (e.g. MacNeish 1964), there are often implicit assumptions about feedback loops whereby settlement patterns in one time period are affected by conditions in the previous time period. Explanations, however, are typically limited to discussions of how changes in settlement patterns reflect changes in other cultural phenomena over a long period of time. The reason for the paucity of explanations is probably a function of the disciplinary orientation.

Geographic research concerned with settlements, settlement patterns, and settlement systems have been largely limited to understanding functions and operations with only a limited number of works focusing on evolutionary trends. Although changes between temporal sequences are typically ignored, geographic research, unlike that of the settlement archaeologists, has tended to investigate the causal effects of culture on settlement patterns (Fig. 5). Geographers have tended to consider intersite interaction, and, especially, the behavior of consumers as the principal causal factors influencing the location and spacing of settlements in a region. In these schemes environment is usually held as a constant and the time depth of these studies rarely approaches that of associated archaeological studies.

## Archaeological Approaches

Settlement studies have had a relatively short history in the study of New World archaeology. The earliest studies were concerned with understanding settlements relative to the total complexity of specific cultures. Later, settlement studies became oriented more toward process, rather than toward function, in their concern with sociopolitical development. Most recently, methodological developments and philosophical restructuring can be seen in the works of the so-called "new" archaeologists who have borrowed models, theories, and concepts from other disciplines, most often geography and economics (e.g. Hodder and Orton 1976). It has been only in this latter form of research that archaeologists have begun to specifically address the problem of evolving settlement systems in a theoretical framework. The ensuing discussion is a topical-historical account of archaeological settlement studies emphasizing their contributions and shortcomings. For the most part the shortcomings are illusionary in that they are not a function of the work or the researcher but are largely a function of the state of the science at the particular time.

## Settlements and Cultures

> "What pattern is discernable in the distribution of sites in your sample?" Then he [the ficticious Real Mesoamerican Archaeologists] rolls out his maps, as he did for me one snowy January morning in his office at the university, and easily points out the pattern by inspection.
>
> "All the early sites are down here by the San Jacinto River," he said, "where the best agricultural land is. By the Late Formative, we have a couple of hilltop sites with stone masonry architecture, probably located on high points that could be easily defended. All in all, we have about 38 Formative sites of all sizes and periods."
>
> "You can't fool him on settlement patterns," said the Skeptical Graduate Student, looking over his shoulder. "There's <u>nothing</u> he likes better than a lot of black dots on a map." (Flannery, 1976:161).

Gordon Willey, encouraged by Julian Steward, laid the groundwork for interest in settlement studies by New World archaeologists. His initial work, conducted in the late 1940s and early 1950s, culminated in the volume entitled <u>Prehistoric Settlement Patterns in the Virú Valley, Peru</u> (Willey 1953). The central objective of this investigation was to establish the context and function of communities as attested by the settlement pattern of the Virú Valley. In qualifying his definition of settlements (which is not significantly different from the definition used here) Willey (1953:1) stated:

> These settlements reflect the natural environment, the level of technology on which the builders operated, and various institutions of social interaction and control which the culture maintained. Because settlement patterns are, to a large extent, directly shaped by widely held cultural needs, they offer a strategic starting point for the functional interpretation of archaeological cultures.

It should be noted that two major themes laid out by Willey, the significance of cultural ecological relationships to settlement systems, and the idea that cultures can be understood through settlements, remain the prevalent themes in archaeological settlement studies today.

Following his 1955 Belize Valley settlement study (Willey, et al. 1965), which was not significantly different from his Virú Valley Study, Willey attempted to place settlement studies in a broader perspective. This endeavor resulted in his editing of Prehistoric Settlement Patterns in the New World (Willey 1956). Willey provided only a brief introduction and "failed thereby to give the book the theoretical setting that is needed" (Willey and Sabloff 1974:150). The principal failure was in establishing a firm concept of the settlement pattern approach. This lack of clarity led to three different usages of the term "settlement" in future studies, each based on the individual contributor's idea of settlement and settlement patterns. The three identifiable concepts of settlements are differentiated on the level or scale of investigation: (i) analyses of individual domestic dwellings (Whiting and Ayres 1968; Winter 1976),(ii) analyses of communities--the spatial arrangement of two or more dwellings on a single site (Adams 1968; Whalen 1976), and (iii) analyses of the spatial arrangements of several communities over a large area (Trigger 1968; Johnson 1972). This dissertation is concerned with the third usage.

Early settlement pattern studies conducted by American archaeologists were rather holistic, being principally concerned with describing the locational characteristics of archaeological sites relative to resource zones and discussing how the anthropolotical elements of the society, such as political organization, are evidenced in site distribution (e.g. Bullard 1960).

Perhaps the best example of this type of settlement pattern analysis is that provided by Kelley (1956). In discussing four different regions, cultures, and occupations in north-central Mexico, Kelley gives no fewer than fifteen statements concerning the relationships between prehistoric settlements and environmental features. The implicit explanation is proximity to resources, most typically agricultural areas. For example, Kelley (1956:129-132) states:

> The largest settlements occur on the foothills along the south side of the Río Tunal and on the adjacent lowland . . . Here are almost continuous occupation sites extending 3 or 4 miles along the river . . . .
>
> The sites lie on the top of isolated hills with farmland below . . . . The basic settlement pattern involved areas of intensive settlement, perhaps colonies, spotted at distant intervals along the occupied zone and sparse occupation in the intervening areas.
>
> Within the zones of heaviest occupance, which most certainly have been supported by intensive agriculture, the settlement pattern included one or more central villages or ceremonial centers, usually located on hilltops and slopes, and a number of neighboring smaller dwelling areas on lower hills or in the valleys.

In such studies, changes overtime in settlement patterns were only superficially treated and then so only in the context of showing differences between one area and the next, or from one time period to the following. Discussions of such changes were summarized briefly. For example:

> . . . we can say that there were three successive patterns of settlement in the pattern, characterized by a distribution of sites over most of the arable land, with one very large, centrally located town, and by a typical open assemblage of large ceremonial buildings; second, the Classic pattern with a limited site distribution in the valley and Late Classic times almost invariably includes at least one ball court; and third and last, the pattern of conquest times, of only small settlements in the valley and of towns strategically located on high ground and protected by outposts (Shook and Proskouriakoff 1956:99).

Explanations of settlement changes were either explicitly or implicitly related to sociopolitical manifestations rooted in changes in subsistence practices and population changes. This situation can be best seen in MacNeish's (1956) work dealing with settlement patterns on the northeast periphery of Mesoamerica. MacNeish outlines seven classes of settlement patterns and discusses them relative to their respective subsistence pattern, mode of life, the estimated size of settlements, the kinds of settlements, and the material culture.

The trend in settlement archaeology remained basically the same during the fifteen years following Willey's Virú volume. The delineation of three different levels of settlement studies was becoming more pronounced in the literature (Chang 1968). Works dealing with the macro-settlements (zonal or distributional) remained culturally-ecologically linked, as demonstrated by Trigger (1968:66) who stated that:

> The overall density and distribution of population of a region is determined to a large degree by the nature and availability of the natural resources that are being exploited.

Willey's closing appraisal of the papers in Chang's edited volume on settlements (1968) is a cogent evaluation of macro-settlement studies of the time.

> The determinants of zonal patterns, or macro-patterns, also include natural environmental and natural-resource conditions. What we are contemplating here is the phenomenon of the "culture area". Trade, particularly in raw materials, helps set the limits to a zonal pattern. Political organization, warfare or the lack of it, the invasions of foreign peoples, and religious and ideational factors are all to be considered (Willey 1968:217).

That the concept of culture area has pervaded settlement pattern studies in archaeology up to this time is not without reason. The preponderence of archaeological studies conducted prior to mid-1960s were concerned with defining the chronology, material culture, and social, economic, political, and religious activities of ancient peoples in distinct regions. Through the 1960s the spatial aspects of inter-settlement socioeconomic interaction were treated rather casually. The entire settlement pattern discussion of many archaeological reports was usually limited to the second paragraph following an introductory paragraph describing the physical environment. This cursory format exemplifies the environment-settlement linkage envisioned by archaeologists of the time.

The concept of regionalizing cultures also has implications concerning specific archaeological problems such as inter- and intraregional exchange and trade. The work of Sanders (1956) was the first to illuminate the relevance of specific problems, especially trade, in settlement analysis. In his delineation of the central Mexican symbiotic region, Sanders looked at differences in environmental zones (resource base) relative to each other and to specific settlements. He concluded that variations in regional agricultural practices, such as the utilization of more intensive techniques, allowed for a denser population which, in turn, provided a basis for an extraordinary development of commerce on the inter-settlement level as well as growth of urban centers.

That population growth, intensification of agriculture, the development of culture, and increasing complexity of settlement patterns and systems are interrelated is axiomatic. In our search for the causal factors in the evolution of settlements, we must investigate cultural patterns in a diachronic framework. As has been discussed, the Virú Valley study was the first of many studies to investigate settlement patterns through a chronological sequence. Studies following Willey's investigated the functions of individual settlements and settlement patterns rather than the evolution of settlement systems. It is the emphasis on evolution of settlement systems that distinguishes the work of Sears (1956, 1968), and Beardsley and his colleagues (1956) from other settlement studies of this time. Sears (1956:48-50) defined and discussed several types of archaeological settlements, including camps, villages, towns, ceremonial centers, and village clusters, and then outlined a simple model of temporal progression and settlement development:

> First, the earliest and simplest settlements, the camps, reflect in their small size, impermanence, and lack of organization into complex patterns, the hunting-gathering economic basis otherwise demonstrated . . . .
> Second, when villages do appear, they initiate a trend of continual and ever more rapid increase in unit pattern, size, number, and complex-pattern development.
> Certainly there is no doubt of increases at this time in population density, social complexity, dwelling size, and permanence, as well as in religious formality . . . .
> The food could have come from new crops and techniques, or more simply, from utilization of existing crops and techniques on more and more of the arable land.

Although the details of his argument can be disputed, the evolutionary concept remained a sound one and set the stage for future work. In his scheme, Sears points out the importance of environmental (subsistence) factors in the early stages and progresses to a level where intersettlement relationships, whether social, economic, political, or religious, become the dominant determinants for settlement patterns. In a similar evolutionary vein, the work of Beardsley and his colleagues (1956) was the result of a symposium dealing essentially with a settlement pattern theme. This joint effort was the result of one of the 1955 Seminars in Archaeology and was entitled "Functional and Evolutionary Implications of Community Patterns".[10] The

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[10]Beardsley, et al. discuss settlements in the context of being physical manifestations of the community. They outline an evolutionary community development scheme that is based on changes in settlement patterns and subsistence patterns.

seminar group established a series of community types--free wandering, restricted wandering, central-based wandering, semi-permanent sedentary, simple nuclear centered, advanced nuclear centered, and supra-nuclear integrated that constitute stages or levels of development in an evolutionary sequence. In this scheme each level evolves from the previous level. This study not only outlined various levels of development but also offers explanations--what Beardsley calls "dynamics producing qualities"--for changes from one level to the next. The approach utilized was comparative and historical, and concerned with both ethnographical and archaeological data. Although settlements per se were not an integral part, the importance of this model is its temporal and cultural comprehensiveness, its evolutionary framework, and its relevance in understanding sociopolitical development.

## Sociopolitical Development

> It is a truism that complex, civilized societies depend upon a subsistence base that is sufficiently intensive and reliable to permit sedentary, nucleated settlements, a circumstance that under most circumstances, and certainly in the long run, has implied agriculture (Adams 1965:38).

A series of works have appeared in the past fifteen years that no longer use settlements to aid in the interpretations of broad cultural manifestations but specify the importance of settlements in understanding the development of civilization. The shift from studying functions and patterns to evolution and systems was completed at this time.

These studies, which tended to deal with a limited area over long periods of time, isolated particular problems that were manifested in the various stages of sociopolitical development and identified the causes of changes in settlement patterns in preceding and subsequent phases. Flannery and his colleagues were specifically concerned with the development of farming systems that were simultaneously developed with sociopolitical growth in Oaxaca, Mexico (Flannery, et al. 1967). Spores (1969), like Flannery, was interested in agriculture and how it could be understood relative to settlements and the environment in the Nochixtlan Valley. Parsons' work dealt with population shifts and urban growth in the Valley of Mexico (Parsons 1968). The work of Blanton (1972b) was more directly oriented to cultural ecology, dealing with settlement patterns as an indicator of adaptation in the Valley of Mexico. MacNeish (1971, 1972) followed up his early work (1964) by reinvestigating the specific location of settlements relative to each other and to environmental zones in order to understand changes in subsistence strategies in the Tehuacán Valley. The works of Allen (1972) and Harris (1972) offer theoretical models of settlement location based on the types of settlements relative to different resource areas (especially arable land), and the changes in settlement patterns with changes in agricultural practices. Grove and his colleagues (1976) reconstructed the diachronic settlement sequence at Chalcatzingo and traced the evolution from a farming village to a regional center as a consequence of expanded long-distance trade. The concept of looking at one major site and surveying surrounding areas was also employed by Blanton (1978) in his analysis of the function of Monté Alban. Examples of similar works that deal explicitly with changes in settlement patterns coevally with the development of civilization in the Old World are those of Adams (1962) in southwestern Iran, Hole (1966) in Mesopotamia, and Butzer (1976) in Egypt.

The significance of these studies is twofold in nature. (1) The impetus for change in settlement patterns was found to be similar, if not identical, to those exemplified by the general theories of sociopolitical development. (2) Changes in settlement patterns during the earliest periods were linked to changes in subsistence strategies, while changes in later eras were marked by social, economic, religious, and political changes. Flannery (1972:419) later alluded to the ecological-social continuum approach stating that:

> . . . the settlements of simpler societies are likely to be highly correlated with such resources, and not necessarily regularly spaced. With the evolution of complex societies, "service functions" become increasingly important, and villages which are appropriately located become "nodes" in the integrated lattice [sic] may grow into towns, while their neighbors languish at the village level.

## *New* Archaeology

The introduction of quantitative techniques and advances in computer technology during the 1960s helped to facilitate a paradigmatic shift amongst a school of prehistorians referred to as the *new* archaeologists (Martin 1971). These archaeologists focused on culture, not as an aggregation of traits but as an adaptive mechanism for survival. Typically, such research called for the study of prehistory through the use of a deductive nomothetic approach rather than the formerly more popular empirical approach. This approach often required large amounts of quantitative data and rigorous statistical tests which led to the construction of general theories of specific cultural phenomena (Fritz and Plog 1970). Some archaeologists have argued that a division between "old" and *new* archaeology is merely the application of statistical techniques to questions of prehistory.

The arguments of both camps have some measure of validity. The *new* archaeologists, like researchers in many disciplines, have applied (perhaps often without judiciousness) statistical techniques to a multitude of problems (e.g. Thomas 1976). Such applications have often resulted in little more than a statistical verification of what was already known or a demonstration of the obvious. A principal criticism of the employment of statistical techniques has been that researchers often would be embarrassed by the simplicity of their results were it not for the prolific discussion on methodology (Spate

1960). For example, the Great Synthesizer, a fictitious character in Flannery's Early Mesoamerican Village (1976), summarized in one page the results of 191 pages of the text devoted to analyzing the macrostructure of settlement patterns.

It also can be argued that the approach utilized by new archaeologists constitutes a philosophical shift from the traditional, inductive approach, which emphasized the production of inferences from data. The existence of a city-system, for example, could be established by evidence of trade goods from other cities. The nature of the system, however, could be explained only by more evidence from which further inferences could be drawn. The deductive approach assumed that inductively derived explanations and models could be arranged in a nomothetic syntax and applied to specific problems. The nature and functions of the city-system (previous example), then, could be deduced and specific data gathered from which deductions could be verified or falsified. Numerous models were available in other disciplines for the practitioner of the deductive approach to utilize.

Smith (1979) like Johnson (1972) who presented the first use of central place theory by a new archaeologist, states that the theory furnishes a potentially useful analytical model for testing hypotheses of intra- and interregional economic relationships.[11] Johnson applied his test to the Early Dynastic I phase from the Diyala Plain, Iraq, and Smith investigated Aztec marketing systems in the Valley of Mexico. That central place theory is a temporally static model and can be applied to only one cultural phase has been the foremost argument against its application in archaeology (Crumley 1976). Crumley also argues that the basic assumptions are too restrictive and seldom met in prehistoric situations, especially those involving less complex cultures where modern consumer behavior might not apply. She suggests that rather than trying to fit the theory to the data as Johnson did, archaeologists should attempt to construct theories from their data. This approach is suggested for studying both the cultural ecological relations and intersite interactions. Perhaps the model most often constructed by the new archaeologists to understand the location of settlements relative to environmental features is that of the "catchment area." This approach was pioneered in archaeology by Vita-

[11]Central place theory attempts to explain the number, size, and distribution of towns by postulating that all cities (other than specialized places such as mining or resort towns) function as nodes providing goods and services to a surrounding market area (Christaller 1933). It assumes (i) an unbounded homogeneous plain, (ii) an even distribution of population and demand, (iii) uniform transportation with movement possible in all directions, and (iv) that consumers patronize the closest center. Within these assumptions and constraints, centers (i) are evenly spaced, (ii) have hexagonal market areas, and (iii) are arranged hierarchically with centers providing greater numbers of goods and services being larger and having larger hinterlands than centers supplying fewer numbers of goods (Berry 1967).

Finzi and Higgs (1971) and is a direct take-off from von Thunen's isolated state (1875), and an elaboration of Sanders' symbiotic region (1956).

The use of catchment concepts is currently a popular initial step undertaken in archaeological studies concerned with the resource base surrounding specific sites. In a recent study, Rossman (1976) employed the format introduced by Vita-Finzi and Higgs, complete with differential weightings for areas more distant from the site. In this analysis Rossman reconstructed the resource base by comparing crop yields, by distance, with the estimated population. Flannery (1976b) takes resources as given and reconstructs the size of the catchment areas. The concept of the catchment area is not unlike that of the hinterland used by geographers. There is considerable similarity of Rossman's methodology and Huff's (1962) probability model for center-hinterland interactions. In a similar vein, Flannery's results can be reproduced utilizing the breaking point formulation from Reilly's law of retail gravitation (Reilly 1929, 1931).

Reilly's law has been utilized in recent archaeological investigations (Plog 1976). Plog justifies his experimentation with the gravity model to estimate the interaction between communities by noting that archaeologists have suffered from a scarcity of methods to obtain intersite relationships in prehistoric societies. He adds that this condition has forced archaeologists to rely on an environmental emphasis to their research. Plog compares the predictability of the gravity model with the coefficients of ceramic design similarities. He concludes that similarity coefficients vary directly with the populations of the communities and inversely with distance.

The nearest-neighbor analysis, an analytical statistic applied to archaeological studies from plant ecology (Clark and Evans 1954), via economic geography, is another one of the "adopted" techniques. Washburn (1974) and Earle (1976), following a research design utilized by Getis (1964) to study grocery store spacing, employed the technique to determine if spatial regularities existed between site hierarchies and their respective political significance. Washburn and Earle both found that the spacing of sites in various hierarchies changed through time. As population increased, a higher-tiered hierarchy developed with greater uniformity of site spacing at all levels, but especially in the higher tiers of the hierarchy. It was concluded that this greater regularity of spacing among higher order sites indicated a regional political dominance.

Another archaeological application of the nearest-neighbor statistic is that of Hammond (1974) and his study of the distribution of Late Classic Maya ceremonial centers. Hammond found a clustering of settlements in the "core area" of the central Maya in northeastern Petén, Guatemala. He concludes that this packing of sites is equivalent to the higher population densities surrounding modern-day cities and is explained by the same demographic and political factors that are inextricably bound to resources and services.

In the three examples of works dealing with the nearest-neighbor statistic, the distribution of settlements in various cultural phases were aggregately studied without reference to settlements in previous phases. The need to study settlement locations relative to preceding settlement conditions was noted by Reynolds (1976) in his work from the upper Grijalva River, Chiapas, Mexico. Using a statistical method for studying nonrandom sequential distributions developed by the Russian mathematician A. A. Markov, Reynolds determined the significance of the degree to which settlement locations in one cultural phase affected settlement locations in the following phase.[12] Reynolds found that initial sites were randomly located, but evenly spaced, and that later sites were influenced by the location of early sites with a denser packing of settlements while retaining spacing regularities.

Earle and Reynolds claim not to be concerned specifically with explaining the evolution of settlement systems. They state:

> The point of the exercise, after all, is not to provide a conclusive and final explanation for Formative settlement . . . but to demonstrate a methodology using "real" archaeological data (Reynolds 1976:192).

> The purpose of this study is not to examine any specific model but rather, to investigate a means by which to describe site distribution so that the applicability of a given model can be tested in an archaeological case (Earle 1976:197).

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[12]Sequences (chains) in which each observation is dependent upon the prior observations are said to possess Markov properties.

Their respective studies, however, are substantial contributions by archaeologists in advancing generalizations about settlement development. Both studies suggest that randomness, spacing, and environmental limitations were the initial determinants of settlement locations. Initial sites were equal in size; as population grew, the settlement system became more complex, first with an increase in the number of sites and later with the development of a hierarchy of settlement types. The sites on the upper tier of the hierarchy were not necessarily located in accordance with environmental factors, but rather displayed a kind of regular spacing suggestive of some form of competition. There is a striking similarity between the results of Earle and Reynolds, and Semple and Golledge's (1970) application of Medvedkov's (1967) entropy model with twentieth-century Canadian cities.[13]

Indeed, much of the work dealing with settlements and the development of civilization draw similar entropy-type conclusions, especially where internal growth independent of external influences occur. For example, Carniero (1970: 735) noted that:

> . . . with neolithic communities generally . . . autonomous villages are likely to fission as they grow, [sic] as long as land is available for the settlement of splinter communities, these villages undoubtedly split from time to time. Thus, villages tend to increase in num-

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[13]Entropy, derived from the second law of thermodynamics, is the measure of randomness, disorder, or chaos in a system. It was applied to settlement studies to map the changes from random to uniform spacing of cities.

ber faster than they grow in size. This increase in the number of villages occupying a valley probably continued without giving rise to significant changes in subsistence practices, until all the readily arable land in the valley was being farmed.

The entropy-type models discussed above follow Lösch's (1954) suggestion that the spacing of settlements is the result of a process that begins with the low order centers and increases through a hierarchy. By contrast, Flannery (1976c) follows Christaller's (1933) lead, viewing the spacing of settlements as a process that begins with the high order centers and works downward through the settlement system. In his concluding comments Flannery notes that probabilistic models are superior to deterministic models for evaluating the evolution of settlements not arising in the modern western world. The difference, of course, between probabilistic and deterministic models is the element of randomness in the range of sizes and locations of settlements not evident in the latter scheme.

Using a probabilistic approach, Flannery (1976d:173) also investigates linear settlement patterns and concludes that the results of geographer Burghardt (1959) hold merit for Formative Mesoamerican studies. Briefly, the results are that: (1) river towns are often founded as ports; (2) if the river was a travel route, towns are evenly spaced; (3) if the river was a barrier, towns developed at crossing points; (4) the side of the river chosen for the site is a function of the most accessible hinterland; (5) no competing site arises across from successful sites; and, (6) larger towns show a propensity toward regular spacing. Two findings probably unique to internally evolving (as opposed to colonial) settlements that were uncovered by Flannery but not considered by Burghdt were: (1) that expansion of settlement was symmetrical upstream and downstream with daughter communities arising in locales according to a "space-filling" uniform sequence; and (2) that as the pattern begins to fill in, some villages may place outlying settlements at or near some special resource areas.

In both studies, Flannery implicitly assumes that as population moves into an area it agglomerates at some location. In such a framework, the largest site is always the oldest site, and site growth is a function of time. This evolutionary concept of a settlement cluster is different from the settlement dispersion scheme demonstrated by Earle and Reynolds and implicitly considered by researchers involved with settlement-civilization topics. Briefly, Flannery's scheme holds that the earliest settlement will emerge as a dominant center. Vining (1977) has also offered some theoretical support for this notion. Earle and Reynolds suggest that settlement sizes remain equal while the number of sites increases, until stress is exerted on the resource base (agricultural land). Both of these models terminate at a relatively early developmental stage and do not include how or why certain centers become dominant or what factors cause hierarchical differentiation. Political ramifications are alluded to either in terms of local control or external contacts, but the factors determining the specific locations of such sites remain unexplored(e.g. Carniero, 1972).

In summary, Binford (1968:5-32) reiterating Taylor (1948) states that the three goals of archaeological research are: (i) to reconstruct culture history, (ii) to reconstruct past lifeways, and (iii) to understand cultural processes. The archaeologists of the 1950s employed an empirical inductive approach investigating settlement patterns in an holistic attempt to achieve the three goals of archaeological research. Although archaeologists have a long tradition for constructing general theories of many kinds of cultural phenomena and their processes, they did not focus their attention toward explaining the evolution of settlement systems. Settlements were viewed largely as artifacts which contributed to the understanding of other facets of the culture and its lifeways. Archaeologists only recently have begun to investigate models of settlement systems and to construct theories of settlements and settlement evolution in a general explanatory framework. This type of research has been facilitated largely by the philosophical-methodological shift of the <u>new</u> archaeologist. The increased emphasis on the interdisciplinary borrowing of settlement models in recent years, however, might have led to this research approach without any paradigmatic shifts in the discipline. Much of the spatial modeling work can be criticized. In their zeal to apply these approaches the <u>new</u> archaelogists have not always thoroughly followed the research in the fields from which the models have been borrowed and, as a result, have often oversimplified spatial concepts and models in situations that are more suitable for testing in modern situations. Too, this work may promote the further development of general models of settlement evolution.

## Geographical Approaches

In contrast to archaeologists, geographers have long maintained a tradition of research on the spatial aspects of intersettlement interaction. Geographers, especially those of the so-called spatial and economic school of the discipline have dealt predominantly with contemporary city-systems in a synchronic structure. Christaller (1933) and Lösch (1954) are the pioneers of this type of research. Unfortunately, the works of several other geographers have received less attention than they merit and their impact has been minimal to the general field of settlement studies.

Even though some geographers have considered the development of settlement hierarchies as an implicit approach to the evolution of settlement systems (Beckmann 1958; Berry 1967; Vance 1970), few have been concerned with exploring the mechanics of settlement evolution. The works of Bylund (1960), Morrill (1962, 1963), Hudson (1969), Webber (1972), and White (1974, 1975, 1977, 1978) are the most prominent of geographic studies in the spatial tradition that search for explanations of evolution of settlement systems, proceeding beyond the study of spatial regularities of settlements. These works focus on the concept of space-filling in that they assume the existence of a homogeneous region and investigate the effect of population growth on the development of settlement hierarchies. The models utilized assume the existence of either a nucleated or a dispersed population and attempt to show <u>how</u> hierarchies develop.

### Growth of Nucleated Populations

<u>Deterministic models</u>. Bylund's (1960) historical study of colonization in the central Lappland area of Sweden prior to 1867 led him to consider the way in which waves of settlement moved within the area. He produced a simple model of development which postulated that settlements arose as population agglomerations (daughter communities) from a previously dominant (mother) community. According to this scheme new settlements were placed where there were no settlements before. Two basic assumptions pervade Bylund's model: (1) the physical conditions of the land are uniform (settled and unsettled), and (2) the more distant portions of the area will not be settled until those close to the mother settlement have been occupied. These ideas are similar to those used in diffusion studies, especially those concerned with expansion diffusion (Gould 1969, Fig. 6). The impli-

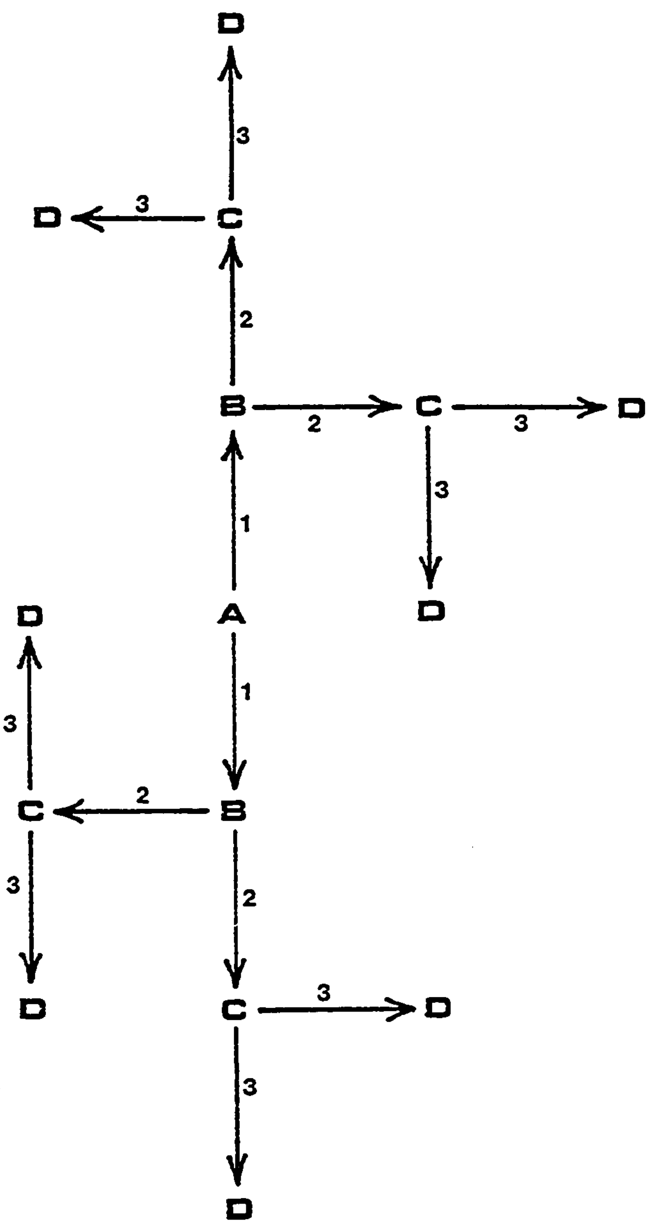



Figure 6. Bylund's Deterministic Model of Expanding Nucleations.

cation from Bylund's study is that a "mother" settlement must have a substantial population prior to producing outlying "daughter" communities. The "offspring" settlements then have smaller initial populations than the original settlement. The hierarchical structure of such a settlement system will be either uniform with all mature settlements equal in size or of a rank-size distribution. In the latter case the dominance of any one settlement is not only a function of population growth but also of age (Norton 1977).

Bylund-type models have been successfully applied to historic colonial situations, such as the development in East Anglia (Mitchell 1954), Spanish colonization in Costa Rica (Sandner 1961), and waves of settlement across Pennsylvania (Gould 1969). In addition, Taaffe, Morrill, and Gould (1963) utilized this model to explain population expansion and settlement formation in developing countries, interjecting transportation linkages as mechanisms along which growth takes place.

Stochastic models. An alternative approach to the evolution of settlement systems can be developed through the use of a Monte Carlo simulation. In such a probabilistic formulation, growth is stimulated by random processes which are restricted by the operation of certain rules based on empirical observations. A typical example of the simulation approach to settlement evolution is provided by Morrill (1962). Morrill begins with an initial settlement and observes the build-up of a settlement hierarchy around it as governed by a sequence of random numbers. The three basic rules followed by Morrill are: (1) in each time period or generation, every place generates at least one migrant from each place proportional to its size; (2) any place may be settled more than once and enlarged in size, provided it does not clash with the "distance-compatability rule" which restricts the size of a place according to its distance from the larger places; (3) the distance and direction of each migrant's move is governed by the numbers in a probability matrix based on empirical studies of local population movements. By following these rules and re-centering the matrix over the settlement from which migrants are originating a randomly derived hierarchy can be constructed which allegedly simulates a general pattern of settlement. Hierarchies and rank-size distributions are created in realistic imperfect and asymmetric forms.

The major points of deviation between the stochastic and the deterministic model are that the probabilistic model contains an element of temporal and spatial randomness, and the possibility for a back-wash effect. Where Bylund relies on expansion to fill-in bypassed areas, Morrill allows for what is called the "hollow frontier" concept (Casetti and Gauthier 1977). In this scheme the first wave of settlement may jump a considerable distance and then act as a point of origin for later stages of development (Fig. 7). The stoch-

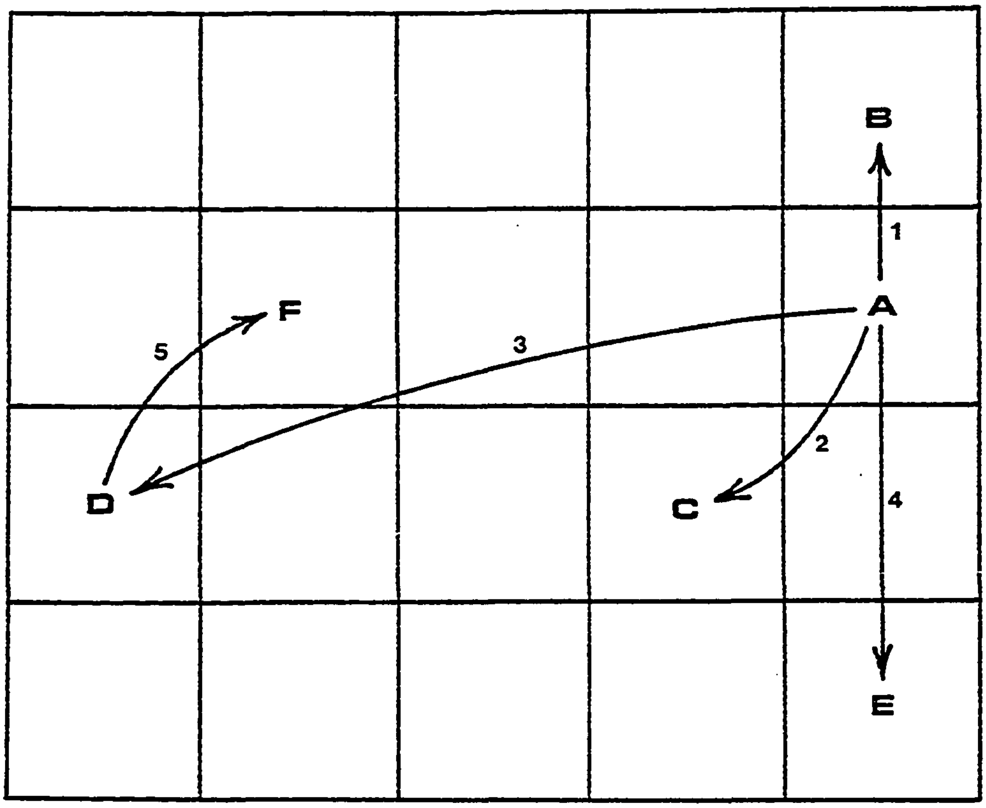



Figure 7. Morrill's Stochastic Model of Expanding Nucleations.

astic model, like the deterministic model, relies heavily on the process of diffusion and also on the technique of simulation to illuminate the concept of hierarchical growth. The idea is to compare the empirical situations with randomly generated schemes based on simulation rules (Amedeo and Golledge 1975:251-256). Unlike the deterministic models, the resultant hierarchy in Morrill-type models, might take on any form because of the lack of predictability inherent from any random processes.

### Growth of Dispersed Populations

Theories pertaining to the agglomeration of a uniformly distributed population also have been considered theories of rural settlement. In the rural settlement scheme proposed by Hudson (1969),spatial processes similar to those found in plant ecology are used to explain settlement spacing.

The spatial properties of theories pertaining to plant ecology and settlements are similar despite their contrasting subject content. Ecologists postulate that several processes operate to affect the distribution and spatial pattern of plants at any moment in time. Although these processes are not always clearly identified, it seems that plant distributions characteristically pass through three phases: (1) colonization occurs in which the species invades a new area, extending in habitat beyond the borders of its former environment; (2) biological renewal produces a regeneration of the species through an increase in numbers with a general tendency to short distance dispersal, filling in the gaps in the distribution formed by the original colonizers; (3) weak individuals are forced out by their stronger neighbors, thus density tends to decrease and the distribution stabilizes in a regular pattern.

As applied to settlement studies, the first phase is equated with the process of colonization (Fig. 8). It is associated with the locating of settlements into a new environment, or an unoccupied portion of the old environment. The second phase is termed spread. Increasing population density, growth of settlements, and eventual pressure on the environment, both physical and social, are characteristics of this phase. The third phase, competition, results in the uniform spacing and is best documented in geographical location theory (Lösch 1954). Marginal settlements are eliminated and those that are left gain little from competing for space because of their equal ability. Semple and Golledge (1970) verified this occurance through the use of entropy tests.

The three basic processes and their associated phases need not operate exclusively of one another. The initial colonization of a new area takes place as described by a density function which relates initial density of settlement to the independent variables that collectively influence it. When the colonization process is at its height, it is likely to generate either a random distribution of settle-

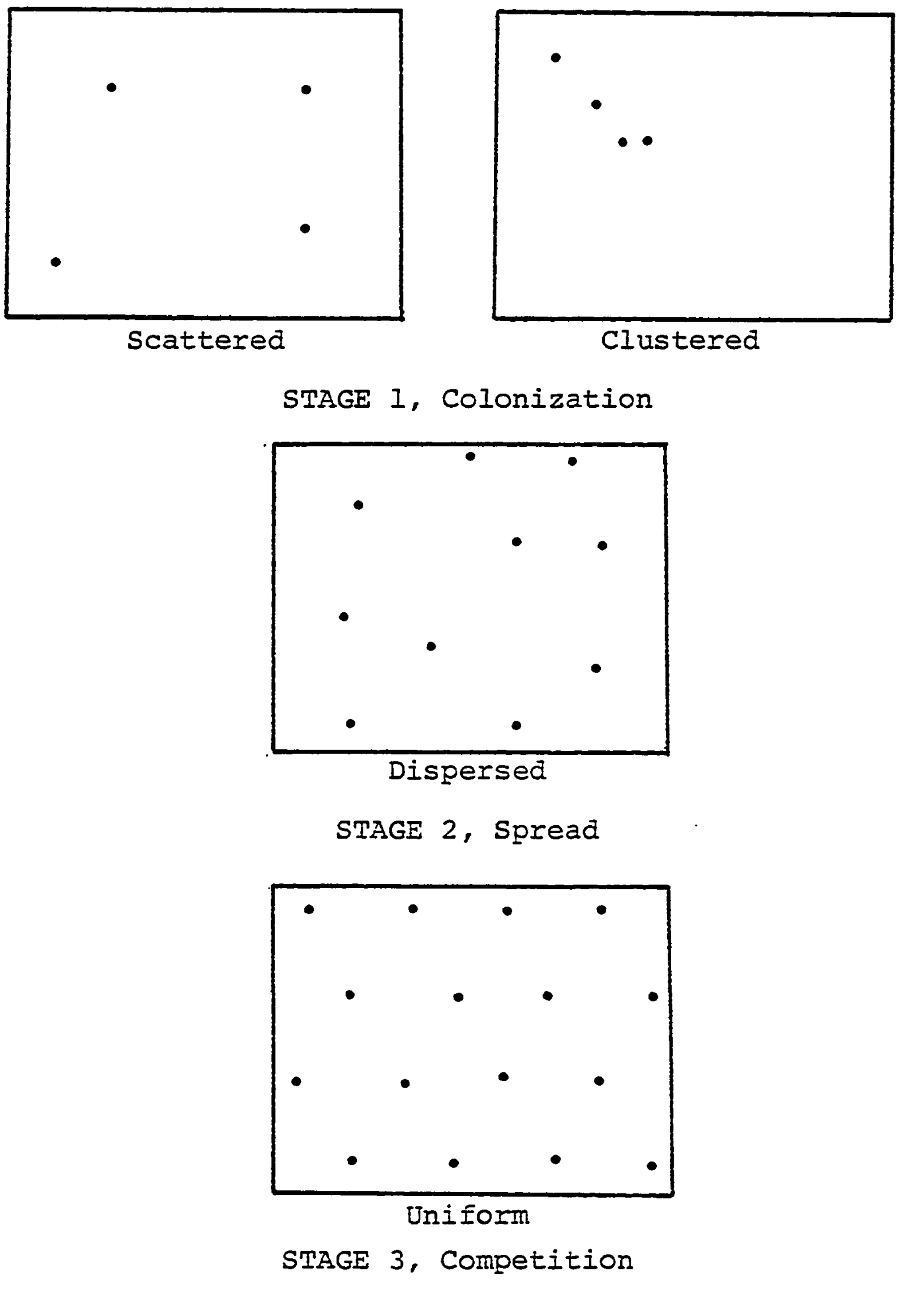



Figure 8. Hudson's Model of Rural Settlement

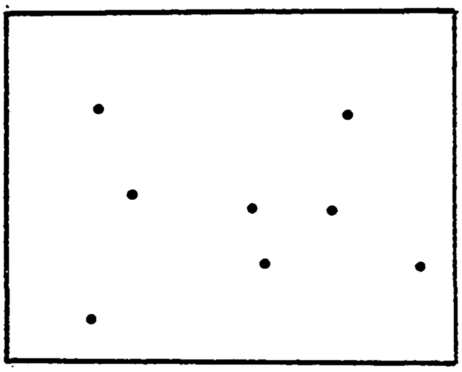
ments, or if some areas are optimal, a gradual clustering in the patterns of colonizers. Gradually, through the operations of the two processes of colonization and spread, the density of settlement builds to a point at which the third process, competition, becomes acute. This process describes a competition for space that is most often economically motivated. Equilibrium results in a uniform distribution of settlement.

Webber (1972b) carries Hudson's argument for settlement spacing one step further by modeling and testing hypotheses of rural population and settlement. He derives four equations which state: (i) that the rural population is a specified function of time, (ii) that the ratio of the number of towns (less one) to the rural population is a linear increasing function of time, (iii) that the ratio of the number of regularly located towns (less one) to the rural population is a linear increasing function of time, and (iv) that the probability that a region contains a specified number of towns is determined by a probability model for point patterns more regular than random (Dacey 1964). The equations are cumulatively linked together in an equation that considers point patterns (settlements) as a function of time and demonstrates that the regularity of settlement spacing increases in a regular fashion.

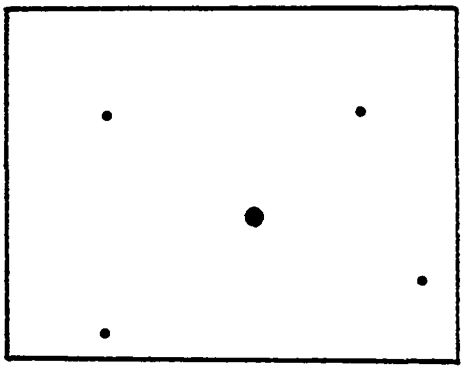
Central to the Hudson-Webber scheme is the idea that space is filled to its horizontal limits. Vertical evolution, or what might be called the development of settlement hierarchies, is not considered.

In a series of recent works dealing with the dynamics of central place systems, White (1974, 1975, 1977, 1978) employs computer simulation techniques to investigate the genetics of hierarchical development given a randomly distributed population as a starting point. The basic premise of the dynamic central place theory is that any central place pattern is the result of differential growth (or decline) of the various centers making up the system. In addition, White assumes that the growth (or decline) of each center depends upon its profitability. When revenues exceed the costs of providing goods and services, the center will grow. If costs exceed revenue, the center will decline (Fig. 9).

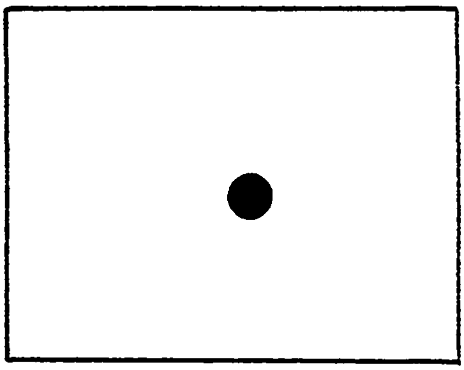
White's dynamic central place system is based on a fusion of microeconomic theory of the firm and consumer behavior theory. His simulation results for both one and two dimensional surfaces yields two significant conclusions that are applicable to prehistoric or incipient development situations. (1) The configuration of the central place system depends primarily on the nature of the interaction. For a two-dimensional surface with low-technology transportation, the centrality of a center with respect to the entire region is the primary determinant of center size, with nodality, or the aggregate distance to neighboring centers, a secondary factor (e.g. Bennison 1978). On a one-dimensional surface, nodality is the dominant determinant. Renner (1935) was the



STAGE 1, Random



STAGE 2, Emergent Center



STAGE 3, Central Place

Interaction equation parameter n=1

Figure 9. White's Dynamic Central Place Model

first to suggest the importance of nodality for such one-dimensional situations. (2) When fixed costs of suppliers are set at levels greater than zero some centers are eliminated. Therefore, center size effects are equated to locational patterns: in low-level transportation technology situations, centers tend to be few and relatively large, and correlated with the middle of the region; centers in areas with high levels of transportation technology are equal in size, dispersed, and relatively evenly spaced. The basic premise of the dynamic central place theory, that the economic characteristics of tertiary activities and consumer behavior together determine the form and structure of the central place system, is supported because the results are largely independent of the initial sizes and location of centers.

That the theory of the firm and consumer behavior theory were both utilized in these simulations lends additional credibility to the concept of the "ecological-social continuum." If we assume, for example, that the earliest sites were located relative to specified resource zones (as has been documented), then for simulation purposes these initial locations would equate to input variables (as was the case in White's work). Theoretically, in low-technology situations all travel was by foot and, therefore, accessibility from all areas surrounding the center was nearly equal. Distance decay functions were not linear but rather had a plateau effect with a point of rapid fall-off quite distant from the center (Eighmy 1972). With a population increase through time the resultant settlement pattern would be one marked by the "primacy" of centrally located centers. In effect, where populations were small and a subsistence economy was the rule, site locations were most likely determined by physical resources with sites centrally located to the population eventually becoming dominant through time. This development, demonstrates the shift in a culture from a situation in which settlements are more directly involved with the environment to one in which complexity increases such that settlement interactions, to a large extent, replace environmental linkages.

In summary, the models of Bylund, Morrill, Hudson, Webber, and White all describe how settlement hierarchies evolve. Implicit in these schemes are the concepts of a population growth and economic development. Indeed, one review of Hudson's scheme correlated the development of a settlement hierarchy with the stages of economic growth (Blouet 1972). The concept of economic growth is interesting but the term "economic", as it is used, does not necessarily have the same meaning in all phases of development. It often implies an exchange of goods which by definition do not occur in subsistence systems. Paradoxically, settlement hierarchies are not uncommon in subsistence oriented societies. This condition leaves one to wonder how differential settlement growth could occur without exchanges. It is assumed here that political, social, and religious activities are associated with settlements in a hierarchical manner. Accordingly, cultural activities other than economic exchanges also might be considered as the causal agents of settlement evolution. The following discussion is a review of the general factors that often are associated with explaining why certain settlements grow while others remain constant or decline in size.

## Evolution of Markets

The term "markets" as used in this discussion is not necessarily a reference to places of economic exchange. Rather, it refers to the general mechanisms of increased societal interaction of an economic, social, political, or religious nature. In effect, this discussion does not involve markets per se but rather a discussion of the relevance of marketing principles which are rooted in economic concepts of consumer behavior. The models discussed here were originally proposed in economic terms. They also have applicability, however, to situations in which exchanges involve non-economic services.

White's (1977) theory of settlement evolution considers the respective center's rate of growth to be a function to the revenue generated from the hinterland. Accordingly he considers the amount of revenue generated to be a function of hinterland-center interaction and employs a gravity model to estimate this interaction. The hinterland-center relationship and its corresponding growth equation have also been used in other types of evolutionary studies, especially those concerned with the evolution of markets, and the shift from market periodicity to market permanence. Basic to this argument are the concepts of the range of demand and the threshold level of supply. The range of demand is the maximum distance that a consumer is willing to travel in order to patronize a center. The threshold level of supply is the minimum number of consumers necessary to support a center. When the range of demand is greater than or equal to the threshold level of supply there will be center-hinterland trade, and the center will either remain a constant size or will grow. Two alternatives exist when the range of demand is less than the threshold level of supply: (i) there will be no trade, or (ii) traders will become mobile, rather than be located at one center as in a periodic market (Stine 1962).

In a market evolution perspective, it is necessary to delineate hinterlands rather than to estimate the volume of hinterland-center interaction because the hinterland limit is equal to the range of demand. A center of a specified size requires a specific hinterland (population) size to support it. Perhaps the earliest and most often utilized approach to study hinterland sizes is the breaking point formulation from Reilly's Law of Retail Gravitation (1929, 1931). The original gravitational interaction equation was used by White (1977) to estimate movement between centers of retail activity and the residences of the consumers. One modified version of this formulation is designed to calculate that point between centers at which consumers are indifferent about which center they will patronize. Accordingly, two centers attract trade from intermediate places approximately in direct proportion to the sizes of the centers and in inverse proportion to the square of the distance from these two centers to the intermediate place.[14] Another modification of the formula is designed to calculate the potential interaction between a center and all other settlements in the region (Cloher 1978).[15]

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[14]Reilly (1929, 1931) used a breaking-point formulation as follows:

$$D_{xi} = \frac{D_i{}^{j^b}}{1 + \sqrt{P_j/P_i}}$$

where, $D_{xi}$ = distance separating the smallest center from the outer edge of its hinterland, p = population (mass), i = smaller center, j = larger center, d = distance, b = parameter.

[15]The potential interaction model is concerned with the sum of the population of all places and the distances which separate each point from all points, the emphasis is on aggregate accessibility and, therefore, can be used as a regionalization model. The potential interaction model is expressed:

$$iV = \sum_{j=1}^{n} \frac{P_i P_j}{d_{ij}}$$

where, iV = potential interaction, i and j = centers, P = population, and d = distance.

That a hinterland needs to be a specified size for a market to become permanent was verified by Stine (1962) and accepted by others as a premise for market development (Good 1970, 1972; Symanski 1973; Symanski and Bromley 1974; and Bromley, et al. 1975). In settlement evolution terms, the hinterland needs to be uniformly occupied (assuming a homogeneous plain) to some minimum density before nucleation and, hence hierarchical growth, can occur. The marketing premise is, therefore, in agreement with the Hudson-Webber scheme where colonization, spread, and competition must occur before disparity in settlement growth comes about.

The evolution of markets cannot be considered a process synonomous with the evolution of settlements. As has been demonstrated, however, settlements and markets are not only closely linked but the factors that influence the development of markets are similar, if not identical, to those that influence the development of settlements. Bromley and his colleagues (1975:534), in alluding to the association between settlement growth and market evolution, note that markets do not originate as places for local subsistence producers to dispose of their surplus products; rather their growth signifies an increasingly specialized division of labor and a growing exploitation of regional complementarity. In the evolution of settlement systems, early markets are seen as playing only a limited socioeconomic role, and market sales are not the dominant source of livelihood for an entire society. In the incipient stages of development only a small part of production is market oriented. It is only during the more advanced stages of development that a recognizable shift from predominantly subsistence to a predominantly market production and, hence, exchanges occur (Bohannan and Dalton 1962: 7). Market structure originally came to coexist with existing sociopolitical systems and is often interlinked with them (Belshaw 1965). Assuming that certain centers begin to grow out of a uniformly spaced population it must then be asked why some emerging centers grow faster than others. White (1977) argues the case of centrality and nodality. Centrality and nodality are recognizable factors; but are they the only factors, major factors, or perhaps even factors of lesser significance?

Contemporary evidence from Africa points to a close association between the growth of marketing centers and the development of regular interegional contacts (Hodder 1965, Wood 1974). Accordingly, local markets are seen to originate from the stimulus of outside traders and the availability of non-local goods (Polanyi, et al. 1957). Such a theory requiring exogenous forces is supported by the lack of markets in areas where economic relations are largely person to person, and where foreign intervention is not pronounced. The exogenous theory is also complemented by the number of markets located along borders of competing economic zones. This locating of settlements near zonal boundaries is in disagreement with White's centrality findings. Another argument against market centrality and for interregional exchange, is that of the gateway city (Burghardt 1971). According to this scheme the largest site (market center) in a region is not located centrally to either the physical or the hinterland population but is located near the end of the region in the direction of the source of exogenous forces.

Exogenous factors do not, however, have to be manifested in a non-central location. In many cases certain centrally located sites may enjoy amenities that attract foreign attention. For example, a centrally located site that attracts a hinterland population to agglomerate during certain times (such as religions activities) might also attract outsiders. In addition, the agglomeration may itself be the attraction.

Another possibility exists that may explain why a site with external contacts may be centrally located in its hinterland. This possibility is the situation in which several such sites are located along a principal trade route between two interacting regions. In such a situation, the sites under consideration may not be principal termini of the larger network, but rather only intermediate nodes. Assuming a homogeneous plain with trade that is approximately equal in two directions, it follows that the intermediate site in the network most centrally located within its respective hinterland will have the highest growth rate.

Market centers do not necessarily have to emerge only under exogenous influence. It is highly probable that certain centers can grow according to the internal marketing conditions that were elucidated by White (1977). Using an internal growth assumption, Eighmy (1972) developed a simulation model to demonstrate settlement system growth and hierarchical development by employing theories of market periodicity and space-filling concepts. Testing both deterministic and stochastic approaches to locate markets, Eighmy found that the initial site to hold a market has the greatest opportunity for long-term steady growth and that it will be the largest market in the system (Webber 1972a: Ch. 7). In summary, three possible factors are available to explain unequal growth of certain settlements: centrality/nodality, age, and external forces.

### Internal Growth and External Contacts

Thus far the discussion of settlement evolution has dealt largely with situations in which population growth has been implicitly considered. Growth, however, is not a simplistic concept and can occur in different magnitudes, at different places, and at different times. Some models (e.g. Bylund's) infer that the oldest settlement is often the largest, others (e.g. White's) state that the most centrally located site has a propensity of dominance. In models where size is a function of age, it is usually assumed that the rate of growth is constant for all settlements (Vining

1977). Models emphasizing the importance of site location implicitly argue for disparities in the growth rate among settlements.

Beckmann (1958) and Nordbeck (1971) suggest that the law of allometric growth can be applied to empirical data to show the evolution of rank-size relationships in settlement systems. This law, which notes that the relative rate of growth of an organ is a function of the rate of growth of the total organism, can be restated:

$$y = a \cdot x^{b}$$

where,

y = size of an organ a = constant

x = size of an organism b = parameter

Instead of measuring the growth of individuals, Nordbeck assumes that a series of individuals (sites) all have the same shape (characteristics), differ in size, but grow at a constant rate. In this case the law of allometric growth states that the value of _y_ is estimated by measuring the value of _x_.

The formula for the rank-size rule

$$n = c \cdot p^{-k}$$

where, n = population rank of the city

p = population size of the city

c = constant k = parameter

is strikingly similar to the general allometric formula.

Three problems exist with the theory of allometric growth when attempts are made to apply the law to populations rather than organisms. These problems are magnified when it is applied to settlement evolution studies. First, the basic assumption that the rate of growth of an organ is a constant fraction of the relative growth of the total organism is not necessarily valid (Reeve and Huxley 1945:132), especially when applied to populations (Thompson 1945: Ch. 3). That the law is always valid when applied to settlement systems is doubtful because growth is not usually constant for all settlements in the system (Marshall and Smith 1978). Secondly, there are qualitative differences among settlements, such as political activities being limited to certain sites, that cannot be accounted for by a simple quantitative analysis. Thirdly, regression lines, which are used by both Beckmann and Nordbeck are less accurate than the reduced major axis of functional analyses (Mark and Peucker 1978).[16] The fact of the matter is simply that the rank-size rule is a syncronic description of a settlement system. The reconstruction of evolutionary trends from static-patterns must be conducted with great caution.

For evolutionary studies of settlement systems the growth rate of each settlement is more likely to be variable rather than constant as the allometric growth law assumes.

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[16]The reduced major axis is the superimposed intermediate line constructed between two regression lines when the dependent variable and the independent variables are interchanged for their respective analyses. Such a line shows a relationship free of causality.

This circumstance is especially important for settlement systems that are anything other than those found in modernized urban countries. Indeed, differential growth and the emergence of primacy of one city over all others is typical in developing situations (Mehta 1964; Linsky 1954). El-Shakhs (1972:30) notes:

> Beginning with the rise of cities amid dispersed and isolated subsistence settlements, population growth, development in technology, and the economic means of production, and shifts in the distribution of authority tend to centralize and concentrate nonagrarian functions and population in cities. In a system of cities, this centripetal process of concentration shifts steadily, and at an <u>increasing rate</u> . . . . (emphasis mine)

These comments support Bohannon and Dalton's (1962:7) position that it is only in the more advanced stages of development that a recognizable shift from subsistence to market production and its resultant exchanges occur.

Vapnarsky (1968) lends additional input into the primacy-rank-size argument by emphasizing the interegional contacts between regions or settlement systems. In his scheme two factors are considered relative to primacy and rank-size relations, <u>interdependence</u> and <u>closure</u>. Interdependence is the total amount of interaction that takes place between all possible pairs of units, divided by the total population living in these units. Low interdependence means relative isolation of units from each other within a specified region. Closure is defined as the proportion of all existing interactions beginning and terminating within a particular system.

Accordingly, closure is high if no interaction occurs between the system and the external world. Vapnarsky found a high degree of closure and low interdependence in underdeveloped areas in near isolation. Such areas possessed equality among settlement ranks and no dominant center. When one center becomes dominant and all other centers remain near equal we find a situation where closure breaks down (low closure), but a low degree of interdependence is still in evidence. As interdependence increases (low closure and high interdependence) the largest city will continue to show primacy, but the rest of the distribution will show a ranked progression in size. At the highest level of development, that stage in which the rank-size rule defines the settlement hierarchy, a high degree of closure and a high degree of interdependence are found. Vapnarsky found this sequential progression from equality through primacy to rank-size distribution to be evident in the historical development of Argentinean cities.

The importance of Vapnarsky's work is twofold. His scheme shows a developmental sequence and the conditions that dictate settlement relationships at different levels of development, and it is the first to show that differences in settlement systems occur under internal growth as opposed to external influences.

For the emergence of regional centers, two schemes can be envisioned. The first of these is that centers grow through internal demand. In such a scheme, change is endogenous, requiring internal growth of population and incomes (Vance 1970:141). The process is comparable to that suggested in the early work on the development of market centers. Recent work dealing with agricultural growth has suggested that subsistence farmers utilize the most efficient form of cultivation available even though greater yields can be produced by intensifying their endeavors (Boserup 1965). Based on the concepts of supply and demand, surpluses are theoretically impossible because a market surplus would not be produced witout a previous demand (Harris 1959). If this argument is correct, it can be concluded that markets did not originate as places for subsistence cultivators to dispose of their surplus, because the production of surpluses is neither logical nor desireable. Accordingly, if markets (centers) grew from internal impetus, then the nucleation of the populations came about for reasons other than food and other economic exchanges--perhaps social, political, of religious reasons or non-economic exchanges. Such a situation is what Belshaw (1965) envisioned when he noted that markets originally came to coexist with existing systems. In addition, recent work from the Valley of Oaxaca suggests that Monté Alban may have arisen as a political rather than economic center (Blanton 1978; Fisch 1978), although this assessment is by no means established.

Although such internal processes may often occur, the initial impulse to the growth of centers may also be trade or other outside contact (Pirenne 1936; Polanyi, et al. 1957). This external impulse may take a number of forms which can be considered in three groups. The first is the impact of long-distance trade on the emergence of regional centers and markets (Jackson 1971:31-32). Vance (1970), on the basis of medieval European and early American examples, has suggested that important service centers may grow up through close external ties in long-distance trade. Such centers may act as collecting points for the syphoning-off of goods from internal networks and the articulation of these goods with external centers. They may also act as nodes for the redistribution of imports to surrounding areas.

The second instance of external contact occurs at the boundaries between ecological zones where differing products of adjacent areas can be most easily exchanged. Active exchanges of this sort may well lead to the growth of markets as local service centers (Meillassoux 1962). The boundaries between tribal groups provide a third area in which external exchange may occur. It is in these contact areas that there is likely to be any great need of exchange, especially when there is some cultural or ecological variety between the groups (Benet 1957).

## Evolutionary Dilemmas

In summary, a re-examination of the various theories of settlement evolution and the empirically observed diachronic changes in settlement patterns reveals that several alternative concepts exist within the various characteristics of evolving settlement system.

1. Concerning initial occupance, population is seen as being either (a) dispersed (Hudson 1969; Reynolds 1976) or (b) nucleated (Bylund 1960; Morrill 1962; Flannery 1976c).

2. Concerning population growth, settlements either (a) increase in number before they increase in size (Hudson 1969; Reynolds, 1976), or (b) increase in size, then splinter and increase in number (Bylund 1960; Morrill 1962; Flannery 1976c).

3. Concerning market development (center growth), exchanges (economic or non-economic) are considered to be either (a) internal processes resulting from a society becoming increasingly more stratified (Belshaw 1965; Blanton 1978; Fisch 1978), or (b) developed out of interegional contacts and external processes (Polanyi, _et al_. 1957; Jackson 1971).

4. Concerning settlement growth, hierarchies either (a) develop with rank-size regularities (Beckmann 1958; Nordbeck 1971), or (b) are marked by a temporal progression from uniformity through primacy to a rank-size distribution (Vapnarsky 1968; El-Shakhs 1972).

Each of the alternative concepts has been demonstrated to be accurate in specific cases. That any one alternative is generally more correct than any other is unlikely. The various characteristics and their alternative concepts have been reviewed, however, to outline the possible paths along which a settlement system may evolve. In the present case study from the middle Río Sonora Valley, the applicable alternative concept of each dilemma will be identified and its specific ramifications discussed in terms of the data. A major problem, however, arises from the application of these spatial concepts to archaeological situations. The evolutionary schemes outlined by geographers involve relatively short time periods (less than 100 years) even though evolution generally connotes a much longer temporal sequence. By considering such short time periods, changes in subsistence practices have largely been overlooked. Hudson's (1969) work, for example, involves the demonstration of a shift from randomly located to uniformly spaced settlements under a constant market production agricultural system. In a prehistoric context, we often see major shifts in production, especially from subsistence to marketing. This shift, as well as the settlement shift, can be accounted for along the ecological-social continuum.

Thus far the discussion has been concerned specifically with theories of settlement evolution. Theories dealing with the importance of agriculture to settlement have not been stressed. The sociopolitical development of culture, the evolution of settlement systems, and advances in agriculture are, however, inextricably interwoven. Farrington (1974) and Moseley (1974) lend significant insight into organizational relationships to irrigation and the relationship between irrigation and settlements. Farrington (1974) hypothesized a relationship between (a) irrigation and settlement patterns and (b) settlement patterns and social organization. In his example from the coastal valleys of northern Peru, he speculated that there is a technological relationship between irrigation or land use and ecological zones, and secondly, there is a correlation between settlement pattern and water management.

Farrington estimated the area of land under cultivation during each cultural phase by plotting the distribution of sites during the respective time periods. Farrington found that settlements increased in number, not size, as agriculture intensified (evidenced by sequencially expanding canals), concluding that a very strong relationship existed between settlement patterns and irrigation, and that the related social organization is reflected in settlement patterns. Chisholm (1968), although not concerned with social organization, noted similar settlement-agriculture relationships.

It has been argued that changes in agricultural or resource procurement systems can cause changes in sociopolitical organization (Childe 1951; Wittfogel 1957). It has also been demonstrated that changes in sociopolitical organization and changes in agricultural systems result in changes in settlement patterns (Adams 1972; Smith 1972). Settlement patterns, therefore, are manifestations of, or secondary factors dependent upon, the level of cultural development (Fig. 10; Turner and Harrison 1978:366).[17] This scheme then begs the question of what causes changes in agriculture or resource procurement.

The most often cited cause for agricultural, and hence, settlement changes has been population pressure or "stress" (e.g. Boserup 1965; Spooner 1972; Cohen 1977). With few exceptions (e.g. Bronson 1972, 1975), recent research has been structured in a stress framework. The basic assumption of the stress theory is that human groups attempt to maintain their integrity through the operation of adjustive mechanisms to environmental pressures (Alland 1967:120). The concept of stress is rooted in the economic concept of supply and demand. That is, action is not taken

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[17] They actually state that "urbanization can be viewed as a secondary result of the factors that lead to state formation. Urbanization is viewed here as a secondary process because it depends on the development of sociopolitical organization." Although settlements and urbanization are not the same, the principles of their growth are not dissimilar.

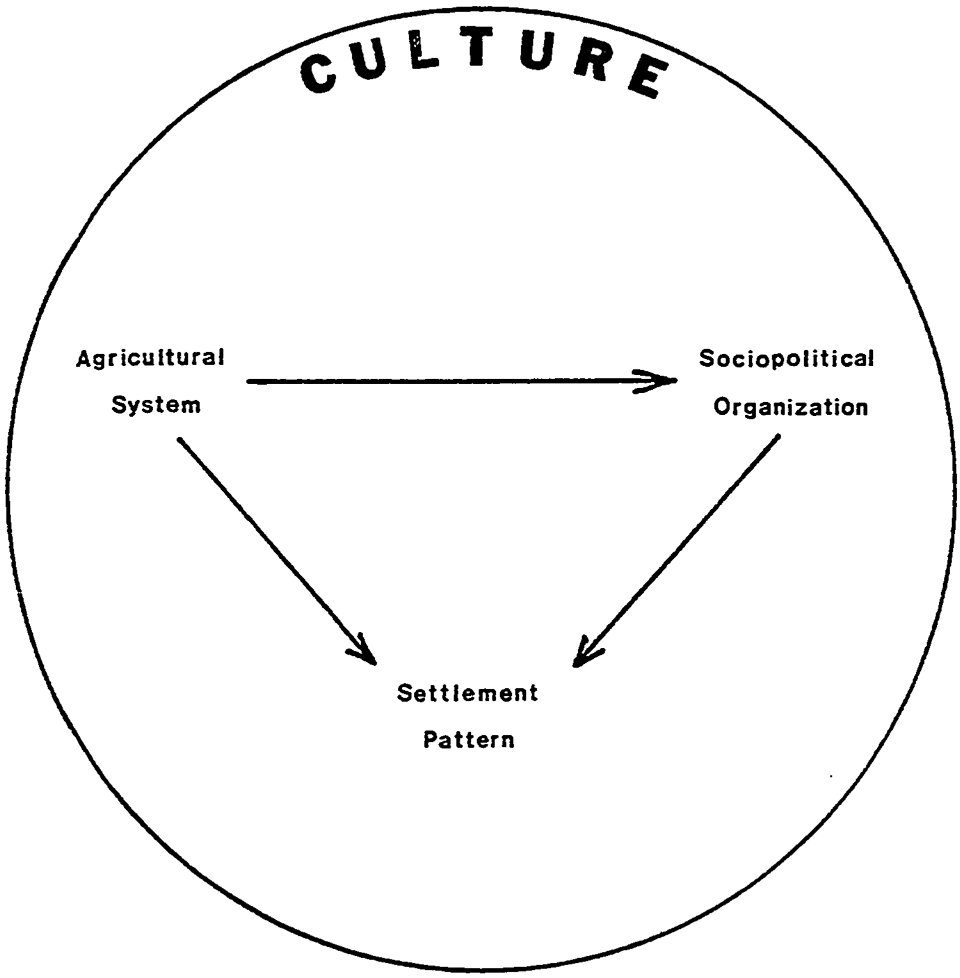


Figure 10. Occupance Relationships

by a group unless motivated by some readily available reward or uncontrollable force. Operationalized, population growth increases resource scarcity, and increased scarcity brings about agricultural advancements and social change (Kappel 1974).

Although stress often has been referred to as population pressure, it might be more accurately defined as production pressure (Turner, et al. 1977; Doolittle 1978a). Less complex levels of sociopolitical development are generally associated with low population densities, and subsistence agriculture. In these situations the interaction of population with the physical environment is the key factor creating stress and concomitant settlement patterns. More complex levels of sociopolitical development are generally associated with high population densities. As cultures become more complex, such factors as taxation, market production, coercion, and increased standards of living combine with population and environment to create production pressure that tends to alter settlement patterns.

To simplify discussion, however, it is assumed that levels of stress are largely attributed to the density of population and the quality of the physical environs.

The concept of the agricultural feasibility continuum (Turner, et al. 1977:392) is useful to illuminate the stress argument for cultivators. Habitats that are marginal for agriculture require considerable manipulation to cultivate such that incipient agriculture in these environs requires large amounts of labor and skills. In such circumstances, even low levels of population density will create a high level of stress and, presumably, high levels of sociopolitical organization to counter the stress. Optimal habitats for cultivation, given the same low levels of population density, will incur lower levels of stress and less sociopolitical organization because the cropping conditions are superior to marginal habitats. In this scheme, it takes increasingly higher population densities to create equivalent stress as habitats range in agricultural feasibility from marginal to optimal conditions.

The implications of the agricultural feasibility continuum to settlements is simply that given identical environments, various levels of stress will result in various settlement patterns. Likewise, equivalent levels of stress in differing environments will also result in various settlement patterns. For example, it would be expected to find different settlement patterns in the Maya Lowlands, the Valley of Mexico, and the Río Sonora Valley given similar levels of stress.

Rostow's (1960, 1971) levels of economic growth correspond rather closely to the stress thesis. Rostow proposes five stages of growth, one of which is called the take-off stage. Take-off is defined as the interval during which the rate of investment increases in such a way that real output per capita rises and this initial increase carries with it radical changes in production techniques and the disposition of income flows which perpetuate a new scale of investment thereby perpetuating a rising trend in per capita output. The take-off stage comes only after a series of preceding stages that 'set the stage' for sustained growth. In following studies, Leibenstein (1963) verified the connection between population growth and the take-off stage, and Boserup (1963) confirms the parallels between changes in agrarian structure and take-off. The take-off stage, therefore, can be compared to both a cause, and especially, a consequence of stress. Stress is normally believed to create sequential shifts in various systems. Under certain conditions, however, stress can occur rapidly, thereby significantly modifying the entire structure and operations of a system. Such situations have characteristics of a take-off stage and recently have been noted in settlement studies by the use of catastrophe theory (Mees 1975; Wagstaff 1978). Catastrophe theory states that the succession of forms (morphogenesis) is displayed through discontinuities in otherwise continuous systems (Thom 1975). It might then be envisioned that under catastrophic circumstances (stress, or take-off?) elaborate changes would be manifest in the cultural system, including changes in agricultural intensity and settlement systems. Turner's stress, Rostow's take-off, and Wagstaff's catastrophe are not totally dissimilar. All three phenomena correlate with the shift from the environmental dominion to the spatial orientation along the ecological-social continuum.

In the following section the pre-Hispanic occupance data from the middle Río Sonora Valley is examined to identify the path which settlement evolution followed. The shift in settlement patterns will be discussed relative to changes in population and agriculture, either internally or externally induced.

## PART II

## THE CASE STUDY

### Background

The pre-Hispanic Opatas, including the inhabitants of the Río Sonora Valley, have long been recognized as being a larger, wealthier, and agriculturally superior population than other peoples in northwest Mexico. In 1835 Alvar Nuñez Cabeza de Vaca first heard of a "great maize country" to the west while he and his three surviving companions were traveling westward across Mexico (Sauer 1932, Bishop 1933). Upon arriving in the Opateria, de Vaca noted that his party

> . . . passed from pueblo to pueblo for a distance of more than eighty leagues . . . the most densely settled part of old Sonora (Sauer 1932:68).

De Vaca reported the existence of an Amerind trade route through this area in which turquoise from the north was exchanged for parrot feathers from the south (Sauer 1932: 70, Bandelier 1973:49).

Between 1538 and 1539 Fray Marcos de Niza and the Moor, Estevan de Dorantes entered the Opateria on their way to "Cibola." Fray Marcos reported of the region:

> And thus I returned to follow my road and went along this valley for five days, it being so largely peopled by intelligent people and so well provided with food . . . . It is all under irrigation and is like a garden, the compact settlements being one half or a quarter of a league distant from each other (Sauer 1932: 80).[18]

The chronicler Pedro de Castañeda de Najeria accompanied Francisco Vasques de Coronado on his 1540-1542 expedition to the mythical seven cities of gold. In the Opata country Coronado found extensive, planted fields and more people than anywhere in the country thus far traversed. Traveling northward Castañeda reports:

> Señora is a river and valley thickly settled by able-bodied people . . . . All about this province toward the mountains there is a large population in separate little provinces containing ten or twelve villages (Winship 1904:88).

> The best settlement of all is the valley called Señora . . . . There was no corn the whole way except at this valley of Señora (Winship 1904:198).

In 1565 the silver prospecting party of Francisco de Ibarra traveled through the Sonora River Valley (Hammond and Rey 1928). The chronicler of this expedition, Baltazar Obregon, noted the Río Sonora Valley as follows:

> The next day the governor with his party entered the valley of Señora . . . . From here the party marched by this valley and river upstream four short journeys, the greater part of the distance being inhabited by peoples and villages, at three and four leagues from

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[18] Sauer claims this to be a description of the Río Sonora Valley. Undreiner (1947) claims that de Niza never entered the Río Sonora but was describing another valley. In either case the valley described here lies in the Opateria and is much different than surrounding areas of northwest Mexico.

each other and on both sides (Sauer 1932:94-95).

> The party marched three days through small pueblos of flat-roofed houses . . . of mud wall, in temperate lands having clusters of small oaks and after another day's journey reached Guaraspi (modern-day Arispe), a pueblo well settled. . . . It consists of six hundred houses of flat roofs and mud walls with regular streets, irrigation ditches for their fields. . . .

Glowing reports such as these seem to have attracted the attention only of historians and other scholars interested in tracing the routes of early explorers. Their impact on archaeologists has been limited. It can hardly be disputed that the pre-Hispanic Opata, especially those in the Río Sonora Valley, were successful agriculturalists who maintained a reasonably high level of cultural development. Recent archaeological work confirms this assessment as well as verifying the existence of pre-Hispanic trade through the Río Sonora Valley (Pailes 1978b).

## Exploration and Research

The Río Sonora Valley first received archaeological attention in the late nineteenth century when Bandelier (1982) surveyed New Mexico, Arizona, Chihuahua, and Sonora. His reconnaissance in the 1880s took him down the Río Sonora from its head to Baviácora where he turned eastward and crossed into the Moctezuma valley. In 1927 Amsden (1928) conducted a brief survey traveling in the opposite direction as Bandelier, covering the same territory. Sauer and Brand (1932) entered the Río Sonora during their survey of settlements and Cerro de Trincheras. Later in the 1930s Ekholm conducted a survey and limited excavations that included the Río Sonora Valley. His results have not been published except for brief comments (Ekholm 1939, 1940, 1942). The most recent research, a survey conducted by William Wasley in 1967-68 remains unpublished due to Wasley's untimely death. Lumholtz (1902), Lister (1958), and Braniff (1978) conducted surveys in other parts of the Opateria but did not include the Río Sonora Valley.

There are two noticeable characteristics of these surveys. First, with the exception of Braniff, they all include large portions of eastern Sonora and often neighboring regions. Second, northwest Mexican cultures were viewed as being peripheral to cultures of the southwestern United States. Much of this research was aimed at defining the borders of the Southwestern culture area.

## Culture History

There is little doubt that the culture phase identified by Amsden (1928) in the Río Sonora Valley was of relatively late pre-Hispanic times. Indeed, the numerous surface structures which he reports were probably all contemporaneously occupied in what he considered to be of the Pueblo IV period. The absence of rubbish that he used as evidence for a brief occupation is, however, fallacious. Recent excavations have found that a house-in-pit phase preceded the surface structure phase and that these earlier houses were filled with debris from later phases. One such early house contained in excess of 100,000 sherds from later phases (Pailes 1978a).

Pailes (1978a) has recently outlined an occupational sequence for the Río Sonora Valley in which he has tentatively identified four phases at the San Jose site (Son K:4:24 OU) north of present-day Baviácora.[19] Based primarily on architectural superposition, the sequence begins with houses-in-pits _ca_. A.D. 1000 and terminates with public architecture in late pre-Hispanic times (Table 1). Evidence suggests occupation occurred prior to the above sequence, but datable materials older than A.D. 1000 have not been recovered.

The earliest phase, noted by house-in-pits, existed from _ca_. A.D. 1000 through the first half of the 12th century. This phase was identified by a large house-in-pit measuring eight and one half meters in diameter and 90 centimeters deep. A plastered, sloping entry and plastered floor characterize this house. Apparently destroyed by fire, burned timbers from this structure pro-

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[19] Pailes did not assign absolute dates to all the phases he outlined. The dates employed here are derived partially from $C^{14}$ dates, partially from obsidian hydration rates, and partially from logical reasoning and conjecture.

| Year A.D. | Central Mexico | | Anasazi | Mogollon | | Hohokam | | Casas Grandes | | Río Sonora Valley | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Postclassic | Aztec II | Pueblo IV | 5 | White Mountain Series | Classic | Civano | Tardio | Robles | Surface Structure | Late |
| 1400 | | | | | | | | | | | |
| 1300 | | | | | | | | Medio | Diablo | SS | Trans. |
| 1200 | | | Pueblo III | | Regional Varieties | | Santa Cruz | | Paquimé | HP | |
| 1100 | | Aztec I | | | | | | | Buena Fé | House -in- Pit | Early |
| 1000 | | | Pueblo II | 4 | Three Circle | Sedentary | Sacaton | | Perros Bravos | | |
| 900 | | Toltec | | | | | | Viejo | Pilon | | |
| 800 | Classic | Teotihua-cán IV | Pueblo I | 3 | San Francisco | Colonial | Santa Cruz<br>Snaketown<br>Estrella | | Convento | | |
| 700 | | | | | | | | | | | |
| 600 | | | Basketmaker III | 2 | Pine Lawn<br>Georgetown | | | | | | |

Table 1. Comparative Regional Chronology

vided $C^{14}$ dates of ca. A.D. 1100.[20] The second phase which included the second half of the 12th century, the 13th, and early 14th centuries is a transitionary phase in which houses-in-pits were occupied contemporaneously with surface structures. Datable material for this phase came from a reoccupation of the house-in-pit described for the first phase. This structure was rebuilt with a raised floor, indicated by numerous postholes, and a new entry flanked by two massive adobe blocks. Like its predecessor, this house also burned, providing $C^{14}$ dates of ca. A.D. 1320.[21] The third phase which extends through the later half of the 14th century into the 15th century is represented predominantly by rectangular surface structures. Although houses-in-pits never completely fell from use (Appendix VI), their relative frequency probably declined rather significantly in later phases. The fourth phase extended through the 15th century until the arrival of the Spanish ca. 1550. This phase also includes surface structures but is distinguished by the presence of a large public structure. Results of excavations con-

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[20] Pailes reported $C^{14}$ dates of A.D. 1075 and A.D. 1085. His dates were uncalibrated, being measured in radiocarbon years. Based on the MASCA correction factor (Ralph, Michael, and Han 1974) these dates could read anywhere between A.D. 1090 and A.D. 1140--A.D. 1100 will suffice, however.

[21] Pailes' two uncalibrated dates were A.D. 1305 and A.D. 1315 (See footnote 20).

ducted during the summer of 1978 are beginning to demonstrate that a fifth phase possibly existed. This phase is marked by adobe surface structures with multiple row foundations and structures with multiple rooms. Preliminary ceramic evidence seems to place such structures in early historic times, possibly ca. 1650.

Even though there is a considerable amount of contemporaniety between houses-in-pits and surface structures, especially during phase two, a chronological seriation of house types can be postulated. At least one clear case of superposition exists in which a surface structure overlies a house-in-pit; there is no known case where surface structures are early, or where houses-in-pits overlie surface structures. Radiocarbon ($C^{14}$) dates, and the results of recent obsidian hydration analysis also tend to support this house-type seriation (Appendix VI).

Certain preliminary cultural inferences can be made from this occupational sequence. During the earliest house-in-pit and possibly during earlier phases the inhabitants of the Río Sonora Valley were probably an indigenous group that lived in relative isolation. A few loosely structured, if any, external contacts were existent in these Formative or Preclassic type phases. Pailes (1976) tentatively suggests that the architectural and ceramic characteristics of this time are more like Mogollon than any other culture. No speculation, however, is herein offered as to the place of origin of these people. The paucity of data from these phases suggests that a small population with a low level of cultural complexity were typical. Settlements were few and scattered, possibly only semi-sedentary in earliest times, becoming permanent toward the end of the phase (Sandomingo, 1953:29). Agriculture was probably being practiced, but only on a limited scale and typically in the large arroyos rather than along the river.

The transitionary and surface structure phases might be considered comparable to a florescent or classic-type period. The population grew rapidly during this time (Doolittle 1978b), resulting in numerous, equal-size, uniformly-distributed settlements along the river in the earlier phases with a few sites becoming dominant over all other sites in the later phases. The architectural trend shifted from subterranean houses to above ground structures. Public architecture was developed during the later phases. Agriculture probably intensified out of the need to feed more people. In so doing, farming the floodplain rather than the arroyos became increasingly common. It was probably during this period that external contacts were at their height.

From a combined architectural-ceramic analysis Pailes (1978a) has tentatively concluded that the Río

Sonora Valley during these phases experienced a cultural sequence comparable to that experienced during the early phases at Casas Grandes, Chihuahua. The Río Sonora, however, lags somewhat behind the Casas Grandes sequence temporally.

That an intrinsic link between Chihuahua cultures and Sonoran cultures existed during later phases has long been argued (Amsden 1928). In fact, a considerable amount of the research that has been done has considered eastern Sonora cultures to be peripheral to other areas. Sauer and Brand (1932) viewed the eastern half of the region to be Chihuahuan and the western half to be influenced by Trincheras cultures. Whether the Opata were characterized by a separate culture, or were peripheral to a larger culture remains unresolved. There is little doubt, however, that during their florescence the peoples of the Río Sonora Valley were in contact with surrounding cultures. The beginning of such contact can probably be equated with the Pueblo II and Three Circle phases of the Anasazi and the Mogollon cultures, respectively; the Casas Grandes Viejo Period; and, the beginning of the Hohokam Sedentary Period (Table 1).

The speculated post-1550 phase might be equated to either a Postclassic-type or an early historic phase. It was during this phase that the first Spanish explorers entered and reported on the region. Later, the indigenous population declined in numbers, and cultural complexity. During the height of this phase the missionaries collected the ancient Opatas into a few, large, and widely spaced pueblos (Bannon 1953; Spicer 1962). Agricultural lands were taken over by the Spanish settlers in the later phases. The Opata assimilated with the onslaught of the Apache raids and the increase in Spanish influence.

## Physical Environment

> The Valle de Sonora, beautiful and fertile beyond anything else in this part of the country, beginning above Banámichi extends to a dozen miles below Babiácora (Sauer 1932:88).[22]

### Topography and Drainage

The middle Río Sonora Valley is the name given to the largest of four valley segments that mark the course of the river as it passes through the *serrana*. It is through this section that the Río Sonora exhibits extensive floodplain development.[23] The landscape is charac-

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[22]The middle Río Sonora Valley as it is referred to here has at various times been referred to as the Valley of Sonora, the Valle de Sonora, the Valle de Señora, and even Señora. This historically well populated valley provided the name by which the entire modern state is known.

[23]The Río Sonora has three reaches, the upper, middle, and lower. The upper course cuts through extensive volcanic terrain between Cananea and Sinoquipe. Through this section only limited floodplain development is noted. In three such places, near the pueblos of Bacoachi, Chinapa, and Arispe, floodplain development is approximately 6.0 kilometers long and less than 1.0 kilometers wide. These are probably the other three segments to which Sauer and Brand refer. The lower course is separated from the middle

terized by the river and its floodplain, cut through a broad basin situated between peripheral mountain ranges (Fig. 11). The lowest elevation in the middle Río Sonora, 520 meters above sea level, is along the channel bottom at the southern end of the region. The highest point is atop the Sierra Aconchi west of the river near the center of the region. This peak rises 2,185 meters above sea level. The remainder of this western range, known as the Sierra de San Antonio averages about 1,200 meters. The Sierra Santa Margarita to the east are slightly higher than the western range averaging 1,600 meters.[24]

The middle Río Sonora study area lies within the Mexican Transition Zone (King 1939; Nye 1972) of the North American Basin and Range physiographic province (Hunt 1974). This region is marked by structural basins and block-faulted north-south trending ranges in the U.S.

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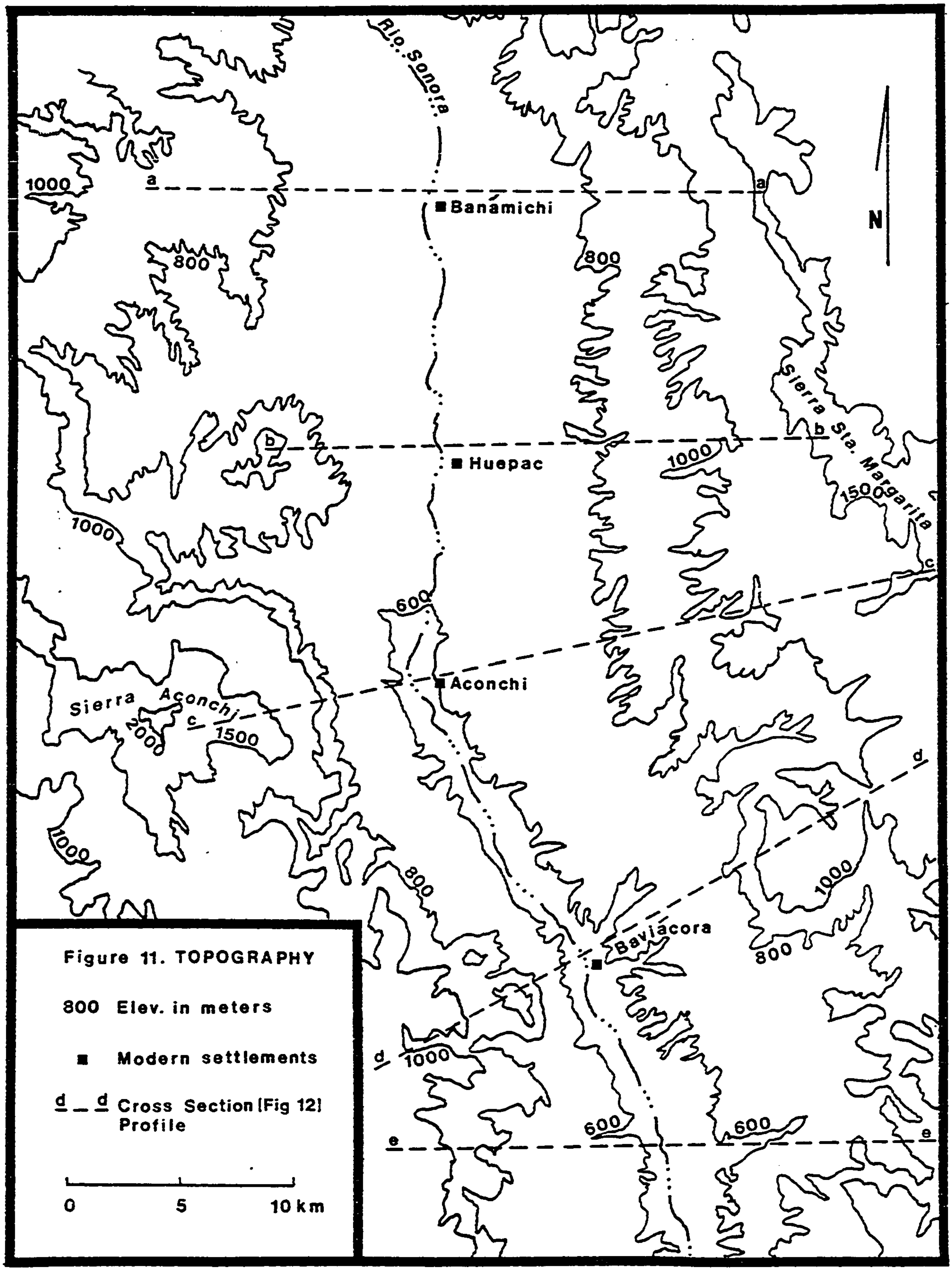
course by a long and deep barranca (gorge) which has historically been known as the gateway to Sonora (Sauer 1932:69). This barranca begins near the pueblo of Mazocahui and ends at the fringe of the Lower Sonoran Desert near the pueblo of La Puerta del Sol. From here the river flows across the desert emptying into the Gulf of California (also known as the Sea of Cortez). Pailes (1976, 1978a and b) has referred to the entire area north of the barranca as the upper Río Sonora Valley. This dissertation includes only the southern half of what Pailes referred to as the upper valley and for convenience is referred to as the middle valley.

[24]Throughout the entire serrana the ranges become increasingly higher toward the east. These ranges merge with the Sierra Madre Occidental at Sierra Bacadehuachi east of the Río Bavispe (approximately 100 kilometers east of the Río Sonora).


Rio Sonora
Banamichi
Huepac
Aconchi
Baviacora
Sierra Aconchi
Sierra Sta. Margarita
N
1000
800
600
1500
2000
Figure 11. TOPOGRAPHY
800 Elev. in meters
Modern settlements
d _ d Cross Section (Fig 12) Profile
0
5
10 km

that become less parallel southward in Mexico. The middle Río Sonora Valley is located where the Basin and Range Transition Zone changes strike from north-south to north-west-southeast. Here the range to the east remains north-south trending, but the one to the west conforms generally with the direction of the Gulf of California coastline. The result is that the peripheral ranges are closer together in the southern end than in the north end of the valley, with the river changing direction congruently with the change in strike.

The gradual southward taper to the ranges, and the change in strike have affected the character of the basin structure mainly by altering the stream configuration. In the northern part of the valley the river is much closer to the eastern than to the western range. It is through this section that the bajada (alluvial plain) development is areally greater west of the river (Fig. 11 and 12a). Southward, the river runs very close to the western range in the central part of the valley near the foot of the Sierra Aconchi. Through this stretch the bajada development is extensive to the east and absent to the west (Fig. 12b, c, and d). Throughout the remaining southern portion of the area this configuration remains roughly the same. Some bajada development is noted on the west, but the preponderence of the bajada is to the east. The overall configuration of the valley can

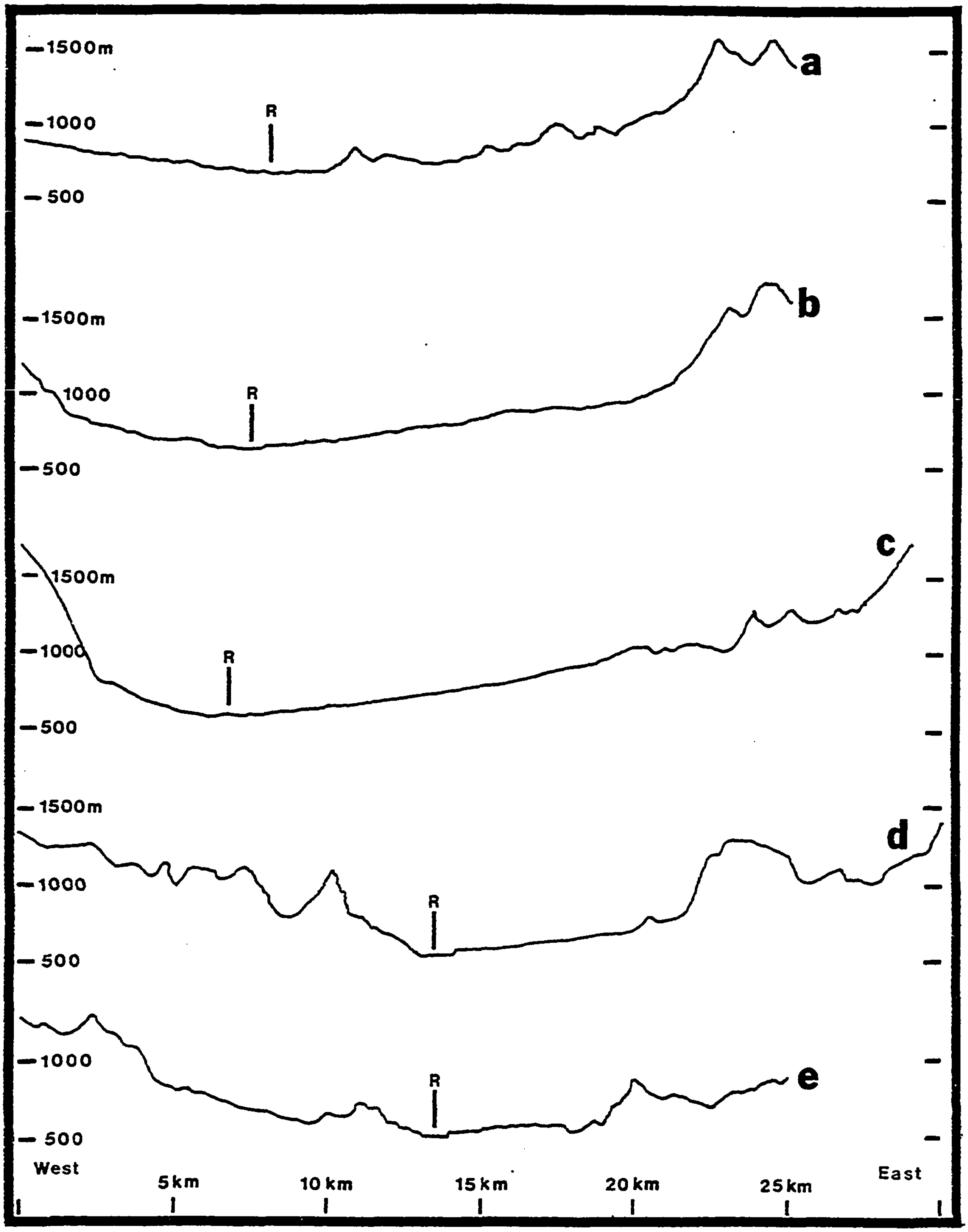



Figure 12 Valley Cross-Sections (see Fig.11.)

then be seen as one in which the river has cut its main channel diagonally between the adjacent mountain ranges. That is, rather than paralleling the ranges, which themselves are not parallel, the river enters the valley in the northeast corner and exists in the southwest corner (Fig. 13).

The Río Sonora is not a perennial stream today. Dunbier (1968:92) notes:

> Its headwaters reach into the . . . area where rainfall exceeds 20 inches [500 mm] per year. However, the Río Sonora, in its middle course, passes through more arid terrain, and by the time it reaches El Oregano [50 km, downstream of the study area], well within the desert, the loss through such factors as evaporation and percolation is so great that the stream flow amounts to a mere 0.3 inch [7.5mm] average over the Sonora River basin (Fig. 14).

Dunbier fails to recognize that much, if not most of the water loss may be the result of extensive modern day irrigation. The evidence suggests that the river might have maintained a constant flow through the middle valley before the arrival of modern (post 1900) cultivation. Hewes (1935:288) noted that:

> . . . during the dry months of autumn and spring the Río Sonora frequently is dry to the north of El Ojo de Agua, whereas southward, due to the welling up of water from below, there is always water in the river and water in the ditches. . . .[25]

The springs found throughout the middle Río Sonora Valley flow rather regularly. Indeed, this dependable ground water may possibly be the greatest single resource

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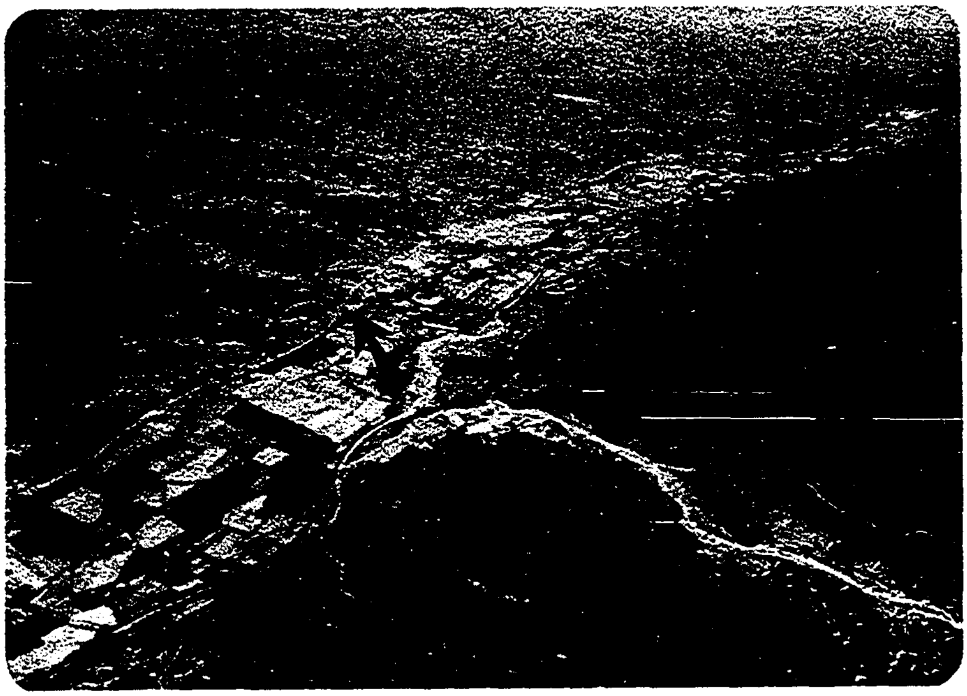
[25]Translated, Ojo de Agua means the eye of the water.



A. Southern end of the valley looking Southeast. Descending arrow indicates the pueblo of Baviácora, ascending arrow indicates site Son K:8:34 OU (see Fig. 4a).

B. Central portion of the valley looking South. Pueblo of Huepac is located in the lower left, Sierra Aconchi is at far right.

Figure 13. Aerial Views of the Middle Río Sonora Valley.

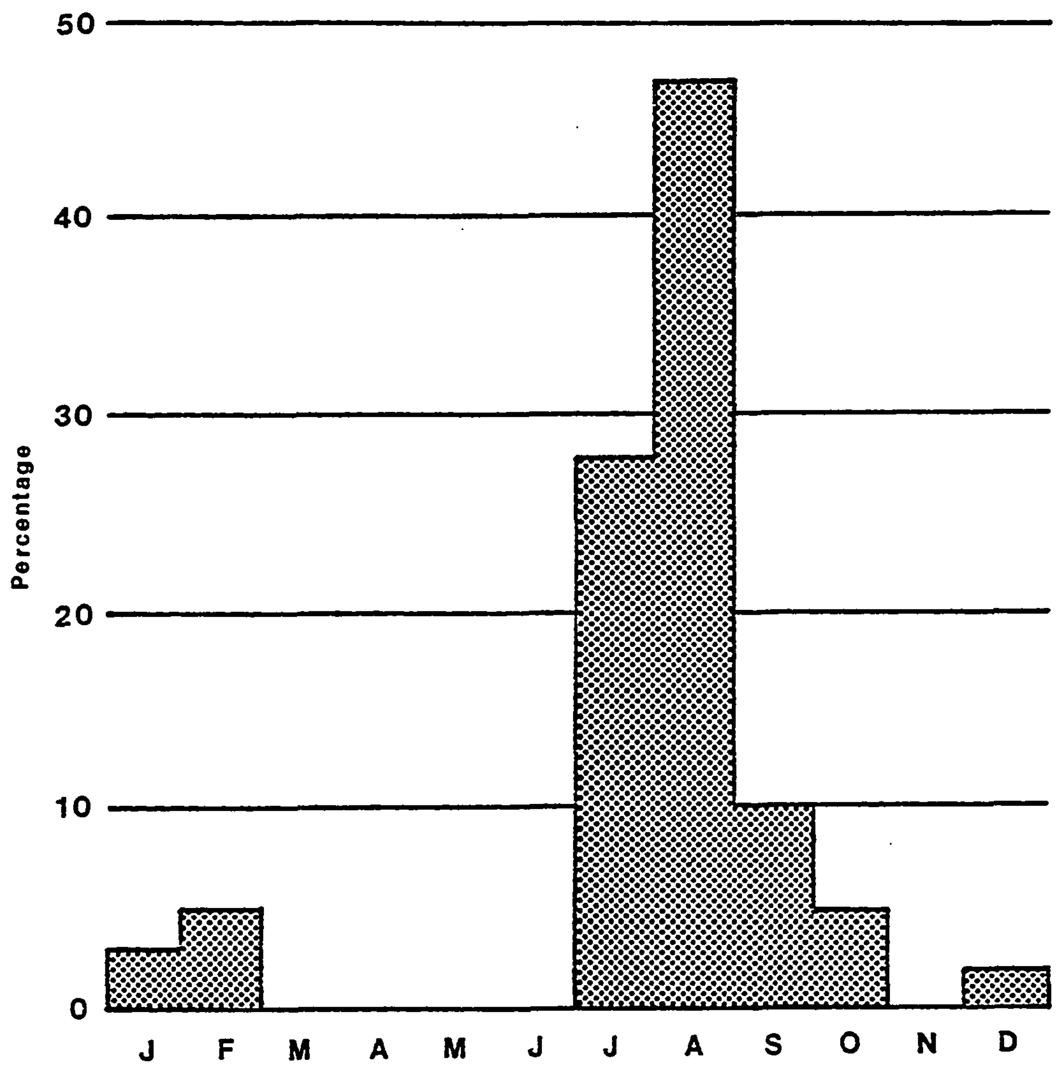



Figure 14. Monthly Percentage of Río Sonora Stream Flow (Dunbier 1968).

available to residents. Schramm (1932:42) notes that in one arroyo near the Sierra Aconchi bedrock is about 2.2 meters below the arroyo floor, and that the basal 10.0 cm is saturated gravel. This bedrock is not a uniform depth throughout the valley as attested by the various well depths. In many places wells for modern irrigation may be as deep as 3 or 4 meters. In other places the water table is very shallow and can be easily tapped by hand-digging small wells (Fig. 15). Such features, which are similar to the 'sipping holes' of the Bushmen are universally known as tamilas (Nir 1974:63).

Basically, the locations where water is found in the channel during the height of the dry season are either at, or a short distance downstream from springs, such as that observed by Hewes at Ojo de Agua (Fig. 16). The largest single stretch of uninterupted flow occurs in the southern half of the middle valley. It is possible that if surface water were not diverted for agriculture that the spring flow would be sufficient to provide a year-round source of surface water throughout the valley, except, perhaps, during the driest of years.

The main river channel is fed with water from three sources. The springs have already been discussed and the downstream flow from the head was cited by Dunbier. The third source is the peripheral mountain ranges flanking both sides of the valley. These ranges, which receive

Figure 15. A Tamila (hand-dug well) to Obtain Drinking Water.

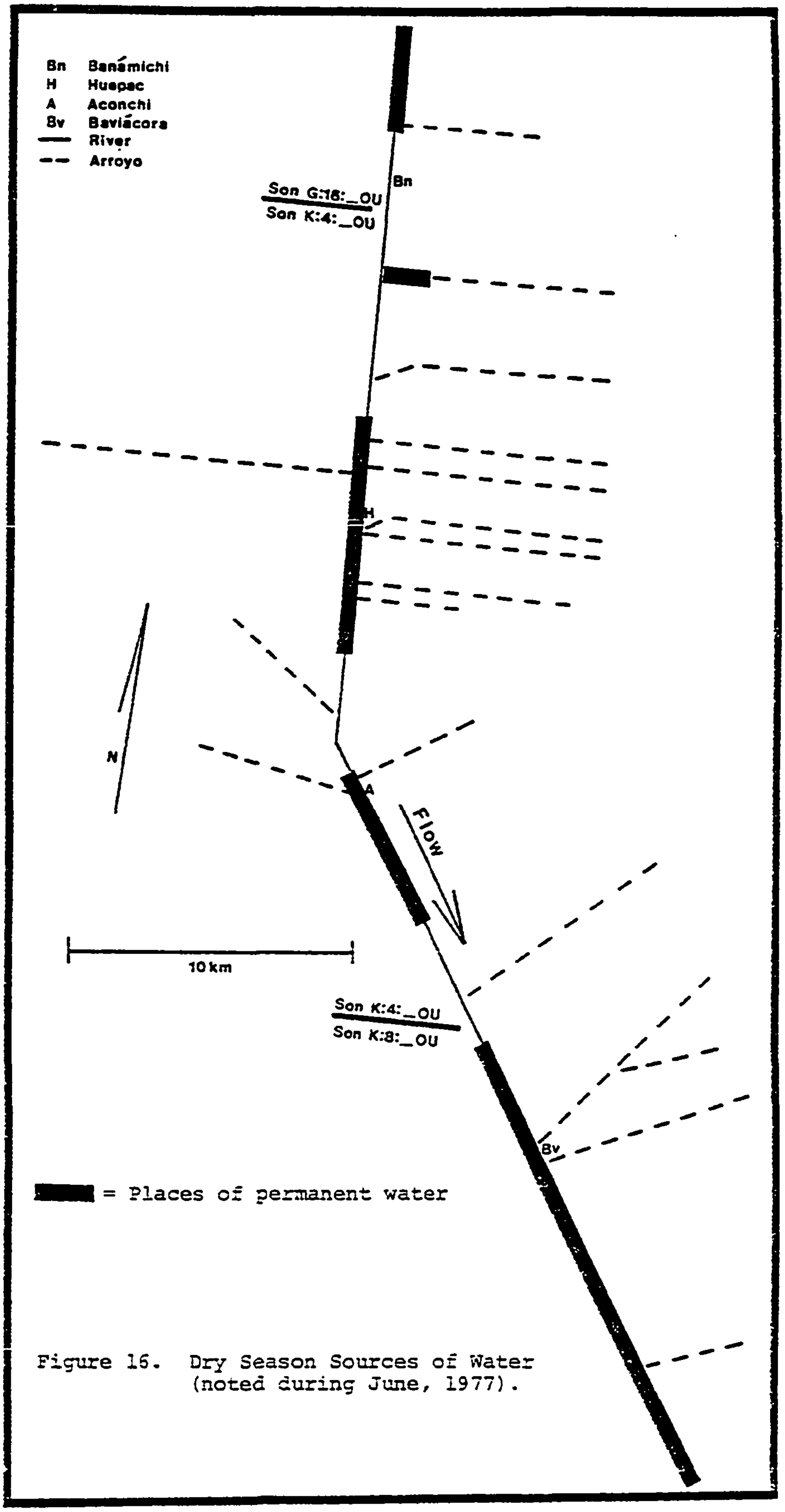



Figure 16. Dry Season Sources of Water (noted during June, 1977).

more rainfall than the valley proper during the summer and winter months, deposit water in the main channel through the numerous arroyos that dissect the bajada. Typically dry, these arroyos can have their floors covered with rapidly flowing water only minutes after the start of a thunderstorm in the mountains.

The overall drainage pattern of the valley is that of a trellis. Large arroyos and the river are most conspicuous water courses. Low order streams are limited solely to the mountains and their immediate foothills.

In summary, the topography and drainage characteristics of the valley are conducive to locating permanent settlements along, or at least proximal to, major water courses. Although the water courses are typified by irregular flow, the discharge is of considerable size and, therefore, suitable for sustaining a large agriculturally based population.

## Climate

In the Río Sonora Valley, as for the whole of the Sonoran Desert, there is a seasonal dichotomy of winter rains and summer rains. Severe drought conditions prevail during the late spring, with a more moderate drought occuring in the fall. A rainy day during the winter season is commonly characterized by moderate but steady precipitation, whereas intensive early evening thunderstorms characterize the summer rainfall regime (Ives 1949). Rainfall in the middle Río Sonora Valley, like most arid and semi-arid regions, is marked by both temporal and spatial variability (Noy-Meir 1973). Temporal variability tends to be greatest when the amount of rain is low, decreasing as rainfall increases. Although the seasonality of the rainfall is predictable, the amount received is not. In Baviácora, for example, the average rainfall in July is 90.9 mm (Table 2, Hastings 1964). The total precipitation received during July was 24.2 mm in 1958 and 130.3 mm in 1959. Likewise, Baviácora received 3.2 mm and 109.6 mm of rainfall during August of 1953 and 1960, respectively. Both figures represent considerable departure from the 53.7 mm average. Probably the greatest temporal deviation in rainfall was the 290.0 mm experienced during November of 1946. Excluding that year, the average November rainfall for Baviácora was only 7.3 mm. It is difficult to discuss precipitation in terms of averages because of the

TABLE 2

PRECIPITATION DATA FROM THE MIDDLE AND UPPER RÍO SONORA VALLEYS (in mm)

| Month | Baviácora | Bacoachi |
|---|---|---|
| January | 24.5 | 34.1 |
| February | 7.5 | 12.5 |
| March | .2 | 10.0 |
| April | .2 | .1 |
| May | .5 | 6.4 |
| June | 14.8 | 18.6 |
| July | 90.9 | 148.4 |
| August | 53.7 | 92.6 |
| September | 24.0 | 17.5 |
| October | 4.2 | 11.4 |
| November | 9.2 | 9.5 |
| December | 19.9 | 20.8 |
| Annual Average Total | 249.6 | 381.9 |

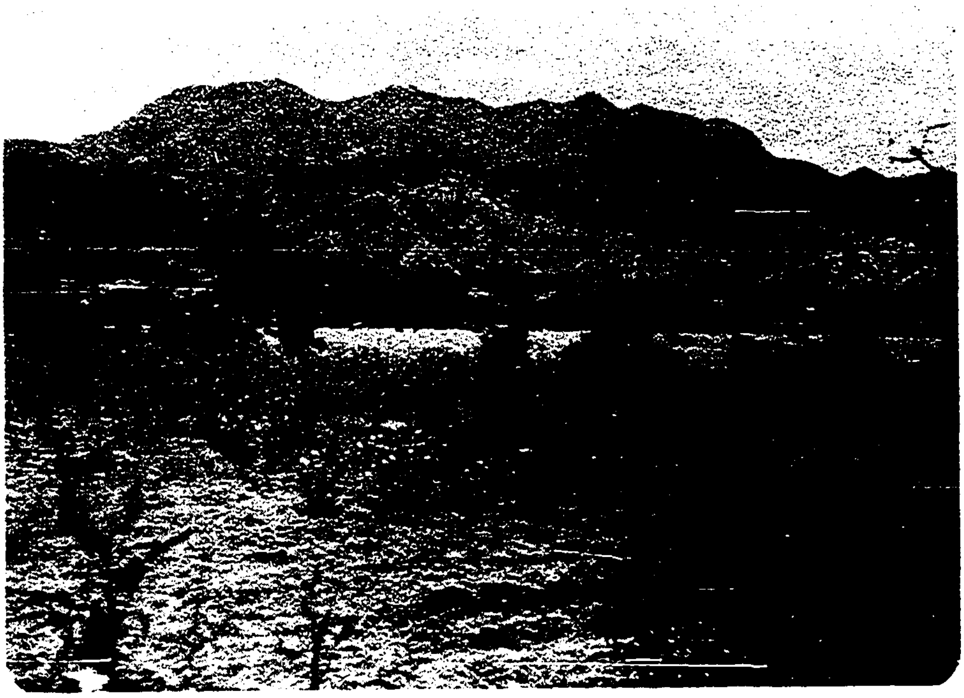
These data are averaged from the years of 1947, 1949, 1950, 1953, 1954, 1955, 1956, 1959, 1960, 1961, 1962. These are the only years in which complete monthly data were available for both stations (Hastings 1964).

extreme variabilities. Perhaps the most conclusive statement that can be made is that the months of July and August experience between 55 to 60 percent of the annual rainfall, and that December and January experience about 20 percent.

The onset of the summer rains, which bring quick and needed relief from the previous month's drought, is especially important for summer crops. The impact of these rains is easily noted by comparing the luxuriousness of vegetation in June and July (Fig. 17). Although the rainfall is greater in the summer, so is evapotranspiration. In contrast, lower evapotranspiration rates during the winter rainy season make the effectiveness of the rainfall greater than that of the summer season (Ives 1949:171). Today, this duality of rainfall seasons permits double cropping; corn in the summer and wheat in the winter. Of course, the variability of precipitation can have disasterous effects on crop yields.

The spatial variability of Sonoran rainfall is as unpredictable as temporal variations. For example, Aconchi received 241.0 mm in August 1951 while Baviácora, only 14 kilometers downstream, received only 87.3 mm (Hastings 1964). This spatial variation is largely the result of the stochastic processes involved in convective situations (Ives 1949).

Although there appears to be a slight increase in rainfall with elevation, there is a definite increase to the north and east (Dunbier 1968:18-19). A comparison of



A. Sierras West of Baviácora, June, 1977.

B. Sierras West of Baviácora, August, 1977.

Figure 17. Comparison of Dry and Rainy Season Vegetation.

rainfall data between Baviácora in the middle Río Sonora Valley and Bacoachi in the upper valley verifies this trend (Table 2).

In contrast to the rainfall figures, temperature data from stations in and near the Sonoran Desert vary little from year to year. During the summer season day-time highs in the middle Río Sonora Valley can be well over 40°C, and sometimes over 45°C. Summer night-time low temperatures rarely go below 25°C resulting in an average summer temperature of approximately 30°C (Table 3). Winters in the valley are cool with a January average of 13.6°C. Frosts are common but of short duration in the valley. Snow, which is rarely experienced in the valley is common in the mountains during the winter season.

Unlike rainfall characteristics, there is a notable correlation between mean temperatures and elevation. A simple correlation and regression analysis for all reporting stations in the serrana indicates that temperatures decline 6.5°C for every 1,000 meter rise in elevation. The elevation-temperature regression explains 93.3% of the variation.

Regional temperature patterns are the reverse of the regional rainfall patterns; mean temperatures decrease northward and eastward. The index of aridity also decreases congruently with the regional increases in precipitation and decreases in temperature (Ives 1949:150-151).

TABLE 3

TEMPERATURE DATA FROM THE MIDDLE RÍO SONORA VALLEY (in °C)

| Month | Baviácora |
|---|---|
| Janurary | 13.6 |
| February | 16.2 |
| March | 19.1 |
| April | 23.1 |
| May | 25.6 |
| June | 29.9 |
| July | 30.4 |
| August | 29.5 |
| September | 29.1 |
| October | 24.8 |
| November | 18.4 |
| December | 14.5 |
| Annual Average Total | 22.8 |

These data are averaged from 1945 through 1962 (Hastings 1964).

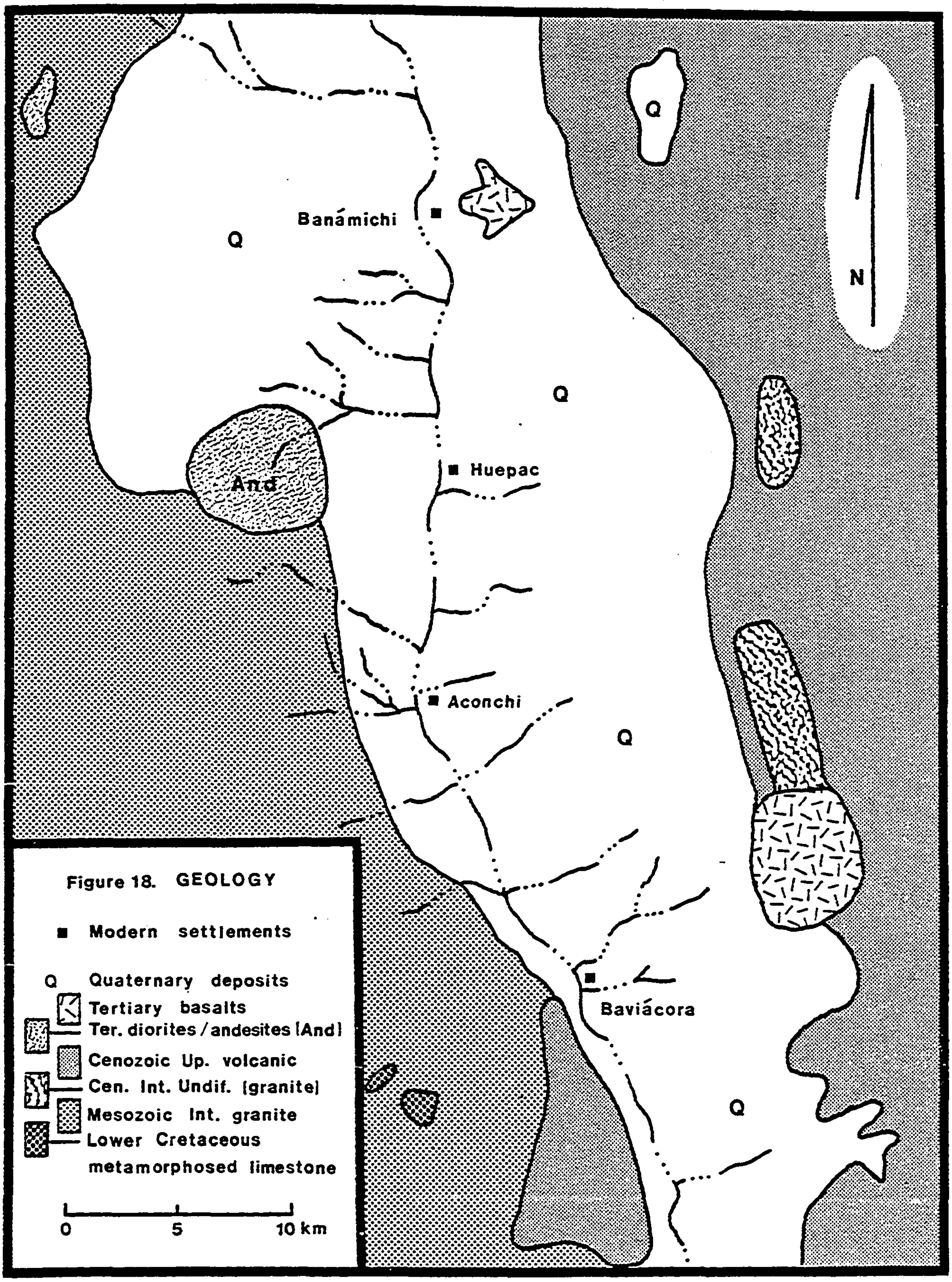
The influence of the sierras is undoubtedly the chief factor affecting the regional climatic pattern.

The rainfall and temperature regimes in the middle Río Sonora Valley have cultural implications in that they are adequate for practicing agriculture. Although rainfall variability is a problem, it is partially offset by the dual rainfall regime which allows for double cropping. In addition, the previously discussed dependability of ground water may be considered complementary crop-loss insurance.

## Geology

Although Precambrian and Paleozoic sedimentary rocks of miogeosynclinal type constitute a base for the southern portion of the Basin and Range province, they are not revealed in the Río Sonora Valley. This valley and its distinguishing geologic features are relatively recent, with only the western mountains dating as early as Mesozoic times. The overall configuration of the valley basin is the result of uplifting and subsequent erosion of the ranges (Fig. 18).

Briefly, the entire geologic history of the valley is noted by violent orogenic forces, erosion, and deposition (Fig. 19; Sillitoe 1976). Deposition of marine sedimentary material during the Cretaceous period was the earliest geologic activity. Eocene vulcanism later resulted in


Banámichi
Q
Q
Q
And
Huepac
Q
Aconchi
Q
Baviácora
Q
N
Figure 18. GEOLOGY
Modern settlements
Q Quaternary deposits
Tertiary basalts
Ter. diorites / andesites (And)
Cenozoic Up. volcanic
Cen. Int. Undif. (granite)
Mesozoic Int. granite
Lower Cretaceous metamorphosed limestone
0 5 10 km

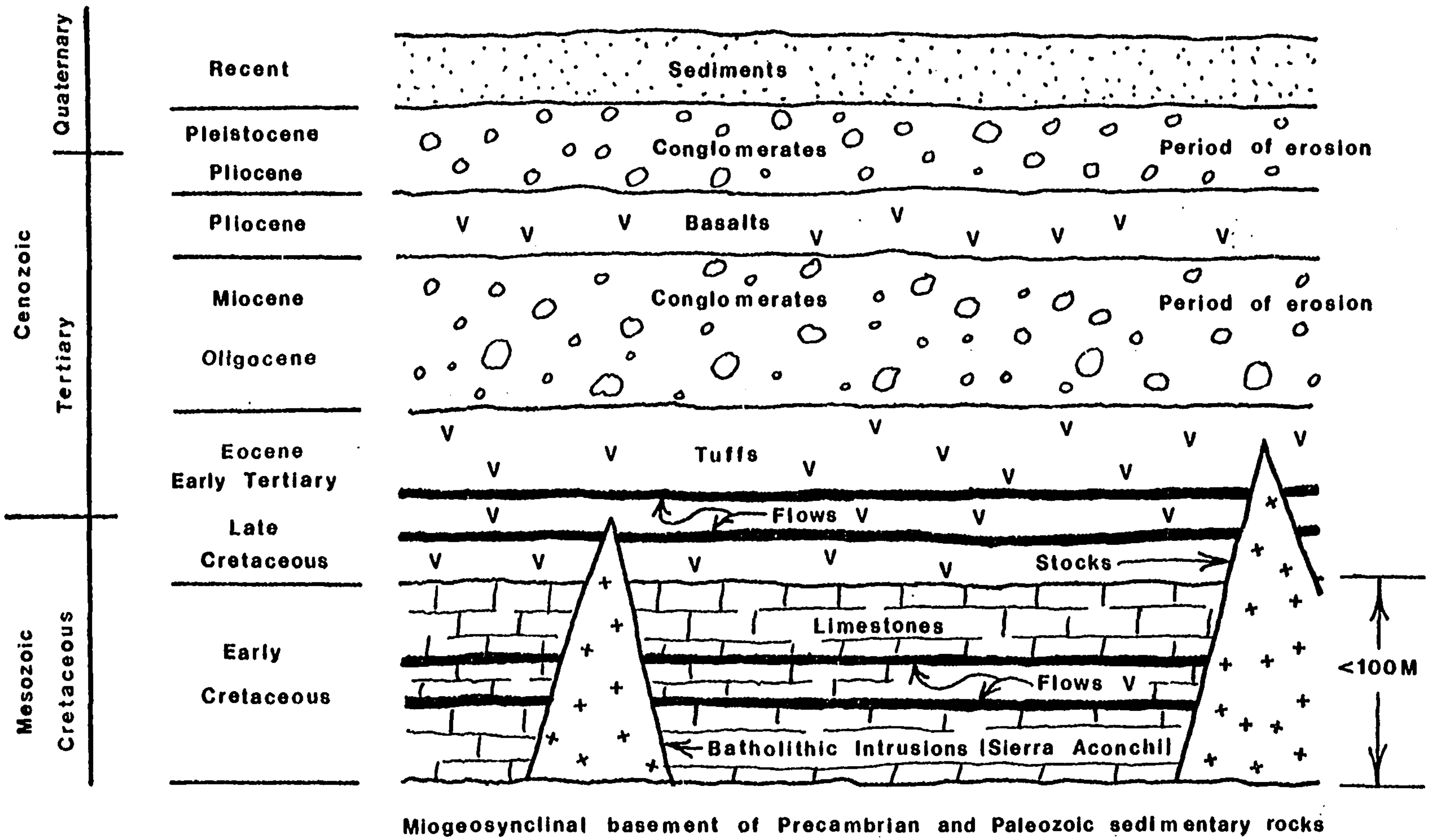



Figure 19. Regional Geological Stratigraphy (generalized)

extensive areas of flows and ash deposition that resulted in the formation of tuffs. Batholithic emplacement took place in a series of discrete pulses during the late Cretaceous period. The granitic intrusions which formed the Sierra Aconchi and the entire western flanking range resulted in the disruption and displacement of the earliest sedimentary rocks (Fig. 13b). It is this brecciation with mineralization along the sedimentary-igneous contact that were of economic concern to the early Spaniards and modern man (e.g. Daco 1976). Early Tertiary (Ecocene) intrusive granites formed the eastern Sierra Santa Margarita range.

Erosional activities were operating on both the western and eastern ranges in the middle Tertiary times. The remnants of erosional activity are noted by the Oligocene and Miocene conglomerates underlying much of the basin and exposed in road and arroyo cuts. Briefly, the materials comprising the base of the bajada originated as alluvium and colluvium from the eroding Mesozoic-age granitic mountains to the west (Fig. 20 a-c). These materials were later covered by deposits that originated from erosion on the Cenozioc-age mountains to the east (Fig. 20 d-3). These later materials are darker in color and quite distinct from the older, lighter colored material (Fig. 21). In places on the west side of the river the Mesozoic-age materials comprise the entire slope

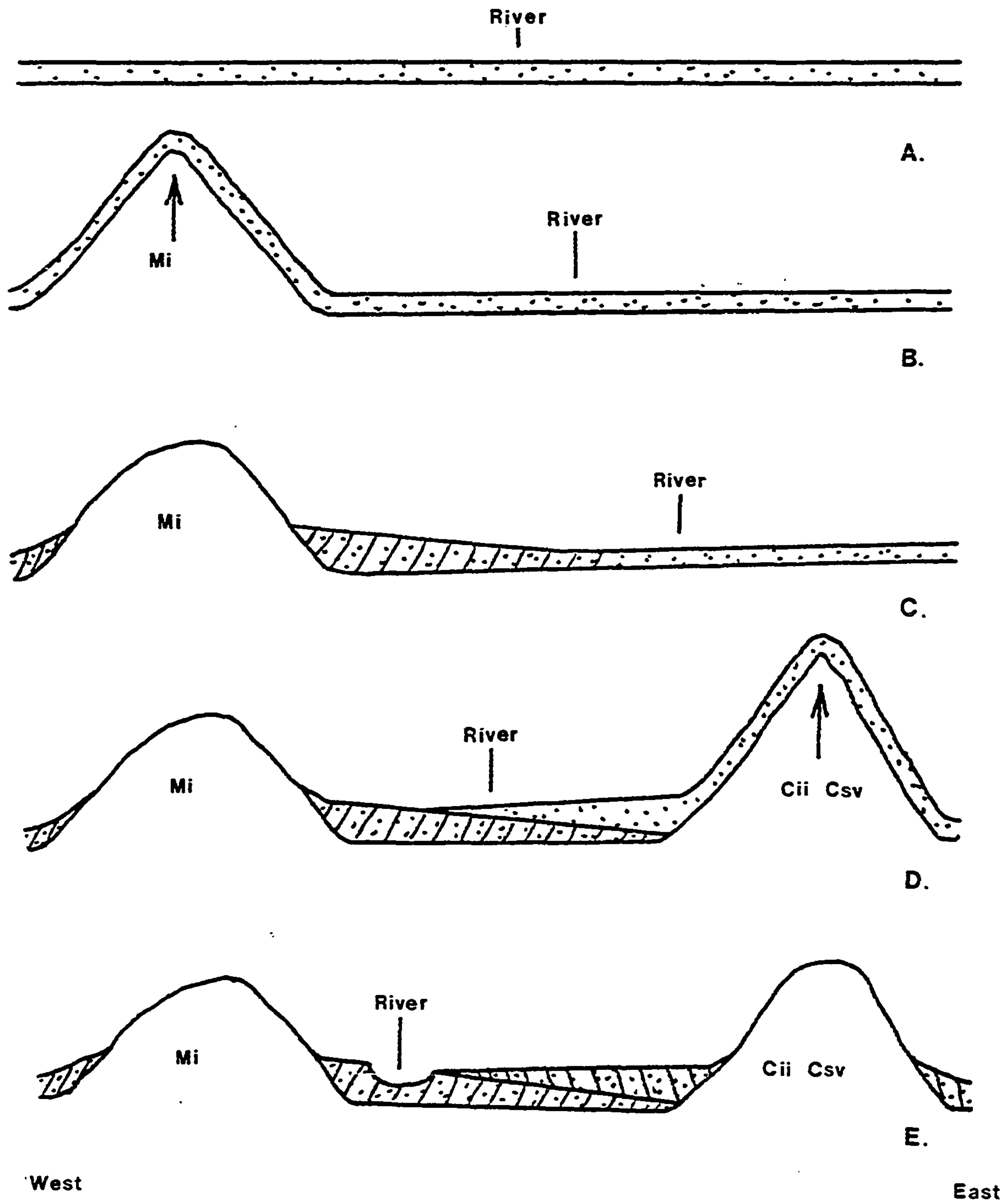



Figure 20. Geologic Sequence of Bajada Evolution

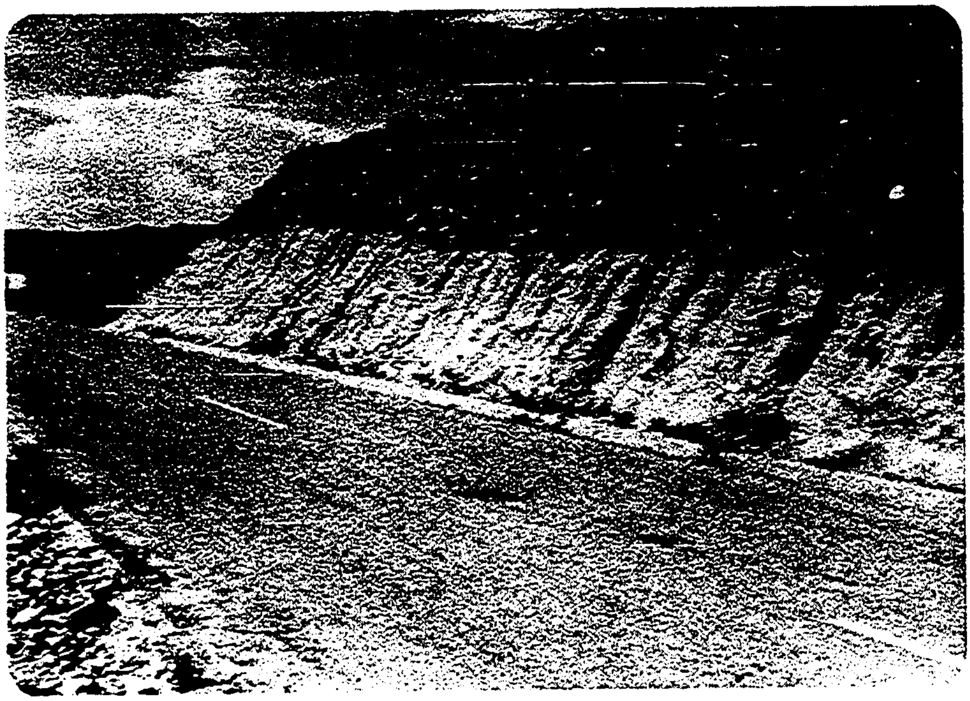


Figure 21. Brown Over White Bajada Materials.

Figure 22. White Slopes on the West Side of the River.

formation (Fig. 22; Fig. 23a). More common, especially on the east side, is the situation in which the older material is apparent on the north-facing slope with the younger material on the south-facing slope (Fig. 23b). This asymmetry of deposition is the result of the gentle southerly dip of the bajada (congruent with river flow) that facilitates sheet wash flowing over the southern edge of the bajada and not the north. That the older materials are granites, and better cemented, accounts for their steep slopes and differences in soil characteristics.

Extensive volcanic activity also occurred periodically during the Tertiary. Cerro El Cobrizo, with its peak 7.0 kilometers west of Huepac, is the largest single intrusive volcanic feature in the northern part of the valley. This peak is totally intrusive, being comprised of diorites and andesites. Two kilometers east of Banámichi is another Tertiary age volcanic feature (Fig. 24b). This low but distinctive hill is covered with lava that once flowed over a small area on the south and west sides of the hill. The largest volcanic feature of Tertiary age in the southern part of the valley is the Serrita de Baviácora, approximately 10 kilometers east of the pueblo with which it shares a name (Fig. 24a). This feature is a weathered volcanic dome surrounded by extrusive flows that eminated from a northeast-southwest trending fissure along the northwest side of the dome. This flow runs

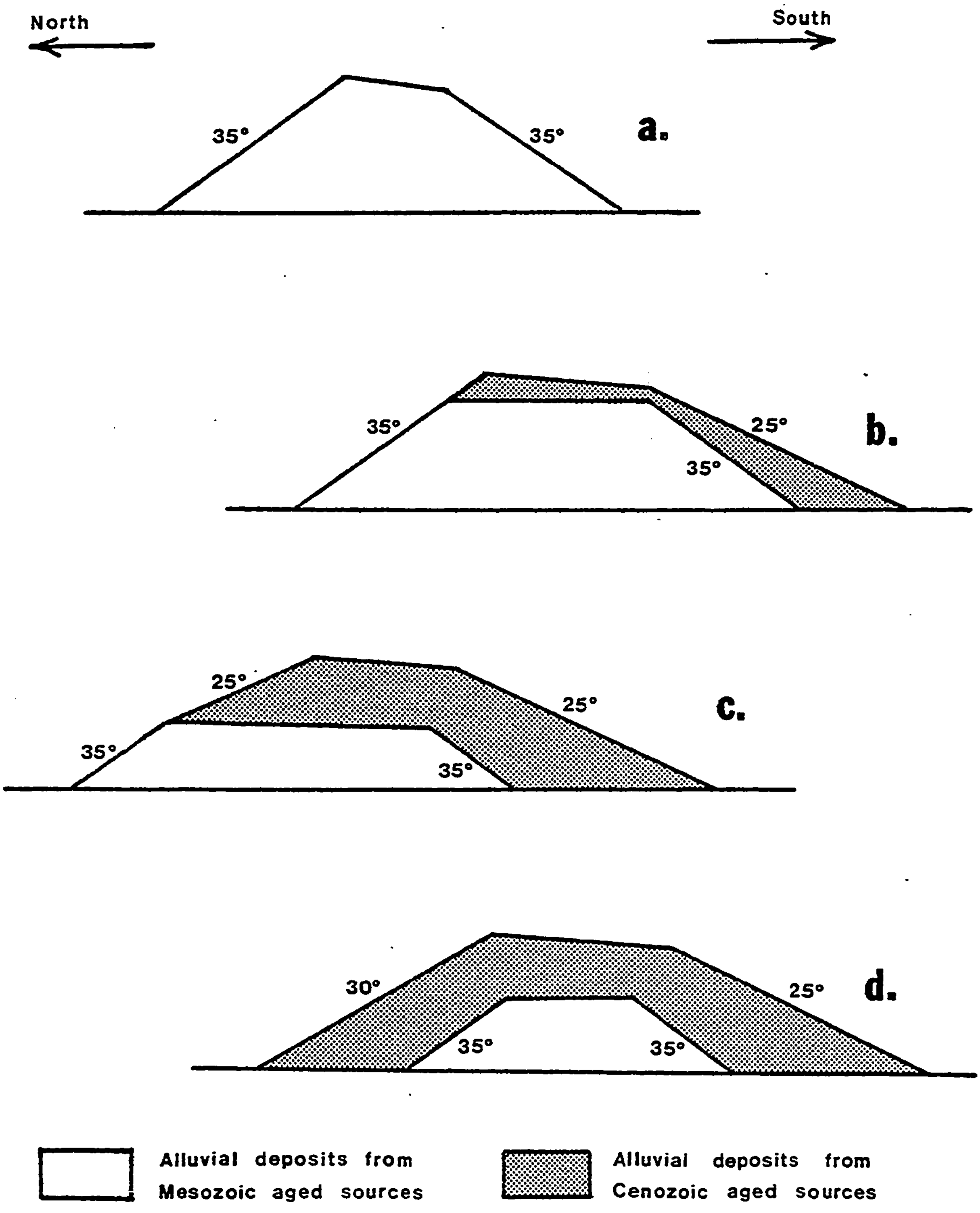
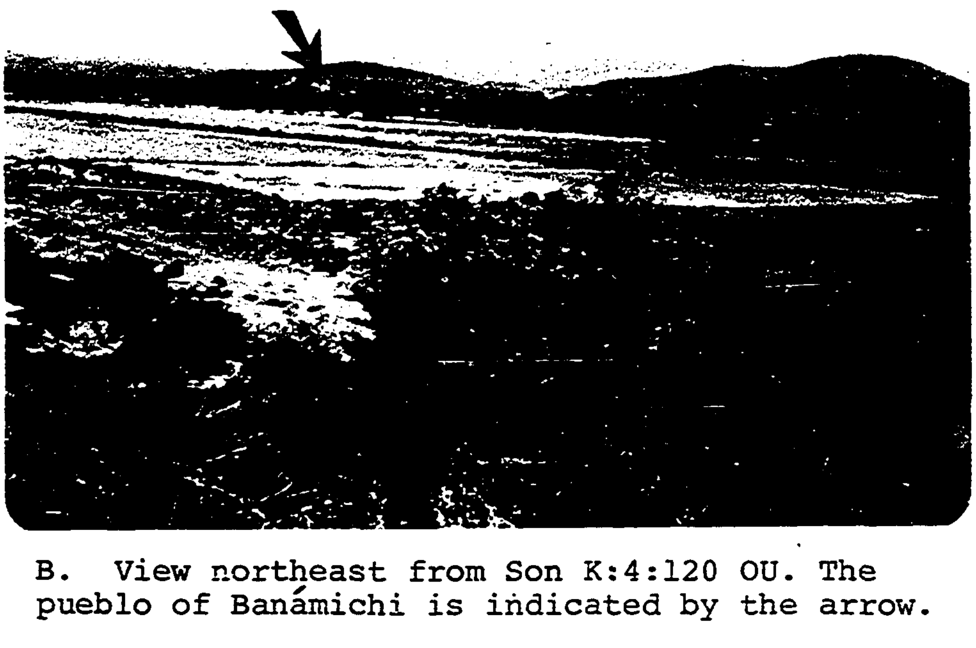



Figure 23. Cross-sections of dissected bajadas of varying ages and composition

A. Serrita de Baviácora viewed from Son K:4:24 OU.



B. View northeast from Son K:4:120 OU. The pueblo of Banámichi is indicated by the arrow.

Figure 24. Volcanic Domes of Tertiary Age.

southwesterly and underlies the pueblo of Baviácora.

Late Cenozoic (Pliocene) volcanism marked the end of violent geologic activity in the Río Sonora Valley. Extensive amounts of extrusive materials cover most of the Sierra Santa Margarita flanking the eastern limit of the valley. Another region marked by extrusive materials of this age is along the west side of the river in the southern portion of the study area. The late Pliocence and entire Pleistocene were periods of erosion resulting in the formation of extensive amounts of conglomerates in the low lying areas. The greatest part of the basin forming conglomerates are today covered by Quaternary deposits. Quaternary features are typically of the greatest archaeological interest (Salas 1976), because it is during this period in which rivers and floodplains, the centers of human activity, developed.

In summary, a diversified geology is characteristic of the middle Río Sonora Valley. The combined effects of late Mesozoic and early Cenozoic geologic activities set the stage whereby a broad valley with an extensive bajada was formed. The overlying Quaternary-age material and the processes which shaped the valley provided an environment conducive to human habitation.

## Ecological Zones -- Land Use

The geological history has resulted in the formation of six distinctive physiographic zones in the middle Río Sonora Valley: the floodplain, bajada, pediment, undifferentiated slope, piedmont, and uplands (Fig. 25). Although the parent materials and soils of these zones vary considerably, they produced a rather uniform macro-level vegetation zone that Shreve and Wiggins (1964) call the Foothills of Sonora. On a micro-scale, however, very distinctive vegetation differences are noted that largely parallel the physiographic zones. The riparian woodland, desert scrub, mixed scrub, and thorn forest zones are associated with the floodplain, bajada and undifferentiated slope, and pediment respectively. The piedmont, the extreme upper portion of the pediment, and the lower part of the upland physiographic zone are marked by the piedmont transition vegetation zone. The upland physiographic zone is vegetated by an oak woodland with a pine-oak woodland covering the highest elevation (Fig. 26).

The ecological zones found in the middle Río Sonora vary not only is size and physical composition but also in the extent to which they have economic and cultural utility.[26] Certain zones contain resources not available

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[26]The number of square kilometers of each zone (Tables 4, 7, 10, 13, 16, 18) includes only those portions of the ecological zones that lie within 15 kilometers of the river. Anything further from permanent settlements

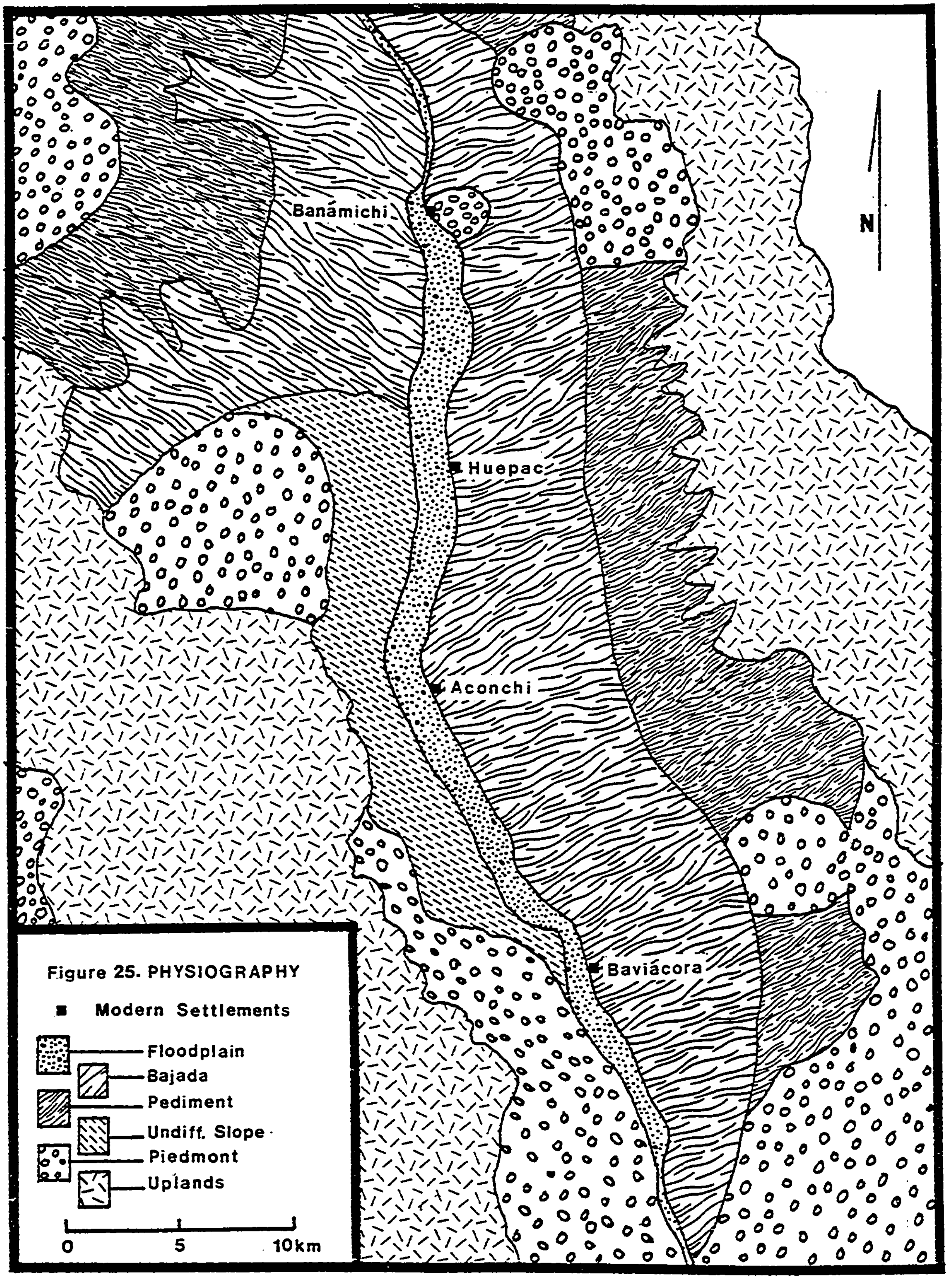
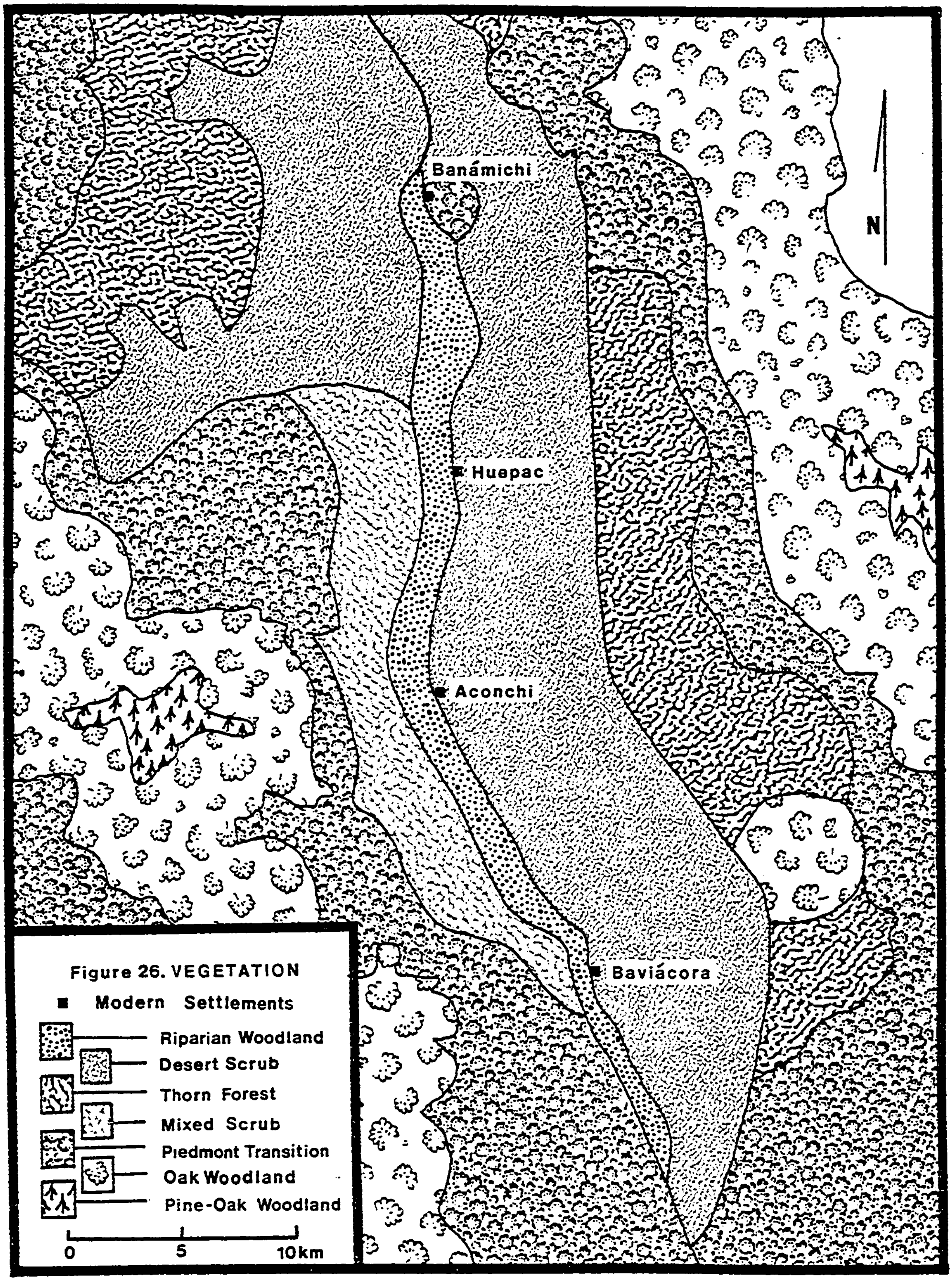


Figure 25. PHYSIOGRAPHY


N
Banámichi
Huepac
Aconchi
Baviácora
Figure 26. VEGETATION
Modern Settlements
Riparian Woodland
Desert Scrub
Thorn Forest
Mixed Scrub
Piedmont Transition
Oak Woodland
Pine-Oak Woodland
0
5
10km

in other zones. In addition some zones have, on the whole, more utilitarian value than other zones. As might be suspected, the area along the main water course is an optimal zone.

The riparian woodland zone, the environmental center of the valley, ranges from only a few hundred meters in width in the extreme northern and southern ends of the valley to more than 2.0 kilometers in width between Banámichi and Aconchi. From Aconchi to approximately 7.0 kilometers south of Baviácora the average width of this zone is roughly 1.0 kilometer. Roughly 25 percent of this region is occupied by the active river channel and abandoned meanders. Like most semi-arid land streams, the Río Sonora maintains a typically low discharge that results in meandering (Butzer 1971, Ch. 11). Periodic flooding tends to aid in altering the stream flow by depositing additional materials. Torrential rains, however, often result in extensive degradation which tends to compensate for any previous aggregation. The physiographic and edaphic characteristics of the floodplain are quite diverse, but can be divided into two sub-regions: the channel and the floodplain area above the channel (Table 4). This physiographic dichotomy has broad cultural implications.

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could not be reached in half a day by foot and was probably not utilized to a large extent by ancient inhabitants. Such an approach excludes those campsites that may be several days travel away (Vita-Finzi and Higgs 1971).

TABLE 4

PHYSICAL AND EDAPHIC CHARACTERISTICS OF THE FLOODPLAIN[1]

| | Channel | Floodplain |
|---|---|---|
| Area ($km^2$) | 17 | 53 |
| Lowest Elevation[2] | 520 | 521 |
| Highest Elevation[2] | 679 | 680 |
| Slope | 1° | 1° |
| Soil Classification | Torrifluvent | Torripsamment |
| Soil Texture | Silt loam | Loamy sand |
| Percent Sand | 18.7 | 80.7 |
| Percent Silt | 69.9 | 13.0 |
| Percent Clay | 11.9 | 6.3 |
| Soil pH | 7.0 | 7.7 |
| Munsell Soil Color | 7.5YR 6/2 Pinkish gray | 10YR 5/3 Brown |
| Soil Organic Matter (%) | - | 1.3 |
| Soil Phosphorus (ppm) | - | 41.7 |
| Soil Potassium (ppm) | - | 100.0 |
| Soil Nitrate Nitrogen (ppm) | - | 13.4 |

[1]These data are extracted and synthesized from Appendices VII and VIII. Explanations of analyses are found in Appendix IX.

[2]Meters above mean sea level.

The channel is agriculturally unusable to human populations. The broad area above the channel, however, is excellent agricultural land. The coarse texture of the soil is more efficient for retaining soil moisture in arid regions than are finer soils (Walter 1973:67, 68, 100). In addition, this permeability facilitates the flow of ground water. The levels of soil moisture, phosphorus, potassium, and nitrate nitrogen are more than sufficient for good crop production (Appendix IX). The level of organic matter in the soil is quite low. This deficiency, however, is more illusionary than real. At certain times of the year the amount of litter is relatively low. This condition is typically the case during the growing season. For short periods during the year, especially when the numerous Prosopis spp. produce and disperse their beans, the level of organic matter is quite high. In turn, the nutrients in organic matter are rapidly assimilated into the plants, resulting in a soil with apparent low levels of organic nutrients. Rapid assimilation of organic material is typical of hot environs whether arid or humid (Richardson 1946; Nye 1961).

The riparian woodland vegetation characteristic of the floodplain is predominantly Prosopis spp. (Fig. 27, Table 5). The principal subordinate plants, Senecio salignus and Jecota (Mex.), are both indicators of a high water table. Statistically the dominance of Prosopis spp.

A. Transect 1, Area 3

B. Near the pueblo of La Labor.

Figure 27. Riparian Woodland Vegetation.

TABLE 5

BIOTIC CHARACTERISTICS OF THE RIPARIAN WOODLAND[1]

| | |
|---|---|
| Area ($km^2$) | 70 |
| Plant Density[2] | 16.0 |
| Percent Trees | 18.7 |
| Percent Shrubs | 83.3 |
| Percent Cacti | 0.0 |
| Avg. Ht. of Dominant Plant (m) | 4.0 |
| Avg. Dia. of Dominant Plant (m) | 4.0 |
| Canopy Cover (%) | 90.0 |
| Dominant Plant | *Prosopis* sp. |
| Principal Subdominant Plant | *Senecio salignus* |
| Grass Cover | Heavy[3] |

[1]These data are extracted and synthesized from Appendix VII. Appendix X contains a list of common plants.

[2]Plants per 10 meter square.

[3]Clusters of grasses and herbs are common with many areas covered by no grass.

is not noted (Table 5). The large scattered stands of the species suggests that <u>Prosopis</u> spp. would be statistically dominant if it were not for the nearly total farming of the woodland today.

The natural vegetation is largely fast-growing and winter deciduous (Appendix X). The phytogeographic affinities of the natural plants are with the north, or temperate North American (Felger, <u>et al</u>. 1976:29). The relatively high degree of shade and shallow water table are conducive to a heavy grass and herbaceous ground cover. Many of the natural plants found along the riparian woodland have documented utilization (Table 6; Castetter and Bell 1942; Pfefferkorn 1949; Felgar, <u>et al</u>. 1976). Indeed, it has been recorded that the neighboring Pimas relied heavily on gathered <u>Prosopis</u> spp. beans even though 50 to 60 percent of their food was agriculturally produced (Castetter and Bell 1942:56-57). The largest proportion of the floodplain is, of course, presently under cultivation with only remnants of the woodland in the peripheral areas. The most luxurious stands of woodland are located in the southern end of the valley. It is highly probable that the shallow water table (Fig. 16) in this segment is conducive to this denser growth. The ecological advantage of the southern segment is reflected in todays cropping patterns. Although wheat is the dominant crop grown throughout the valley, it is most prolific in

TABLE 6

RIPARIAN WOODLAND PLANTS OF CULTURAL UTILITY[1]

| Plants | Usage |
|---|---|
| Amaranthus palmeri | greens |
| Arundo sp. | roofing, thatch |
| Celtis pallida | berrys |
| Chenopodium sp. | seeds |
| Juglans major | walnuts |
| Palmaceae spp. | roofing, thatch, cordage |
| Populus sp. | building, materials, agricultural impliments. |
| Prosopis spp. | roof timbers, firewood, cordage, beans |
| Salix sp. | cordage, building materials, agricultural impliments |

[1]A list of common plants can be found in Appendix X.

the north and intermixed with a wide variety of vegetables in the south.

Floodplain farming is the most common and widespread form of agriculture practiced in the Río Sonora Valley today. The relatively simple techniques involved are certainly not beyond the technical ability of ancient inhabitants. Briefly, fields are irrigated from acequias (canals) leading from diversion weirs constructed across the river course. Short stakes are often driven into the river bed forming a diagonal line across the river flow. Branches are then woven between the poles. Low mounds of earth are usually erected behind the brush. Since gaps are often left in these structures to allow excess water to escape, they must be considered weirs, and not dams. They serve no storage function as water is never impounded. Rather, it is channeled into canals leading from the diversion weir to the milpas (fields) (Fig. 28).

These weirs are obviously temporary structures and have to be replaced after every flood. The canals are more permanent, but still have to be repaired and cleared. Canals are closed by shoveling mounds of dirt across the canal at the appropriate point. Opening merely involves removal of the earthen fill. In some cases, seedlings are cut, trimmed, and planted in a row adjacent to and paralleling the river channel (Nabhan and Sheridan 1976;

A. View upstream, diverted water flows to the right.

B. View downstream, main stream is on the right.

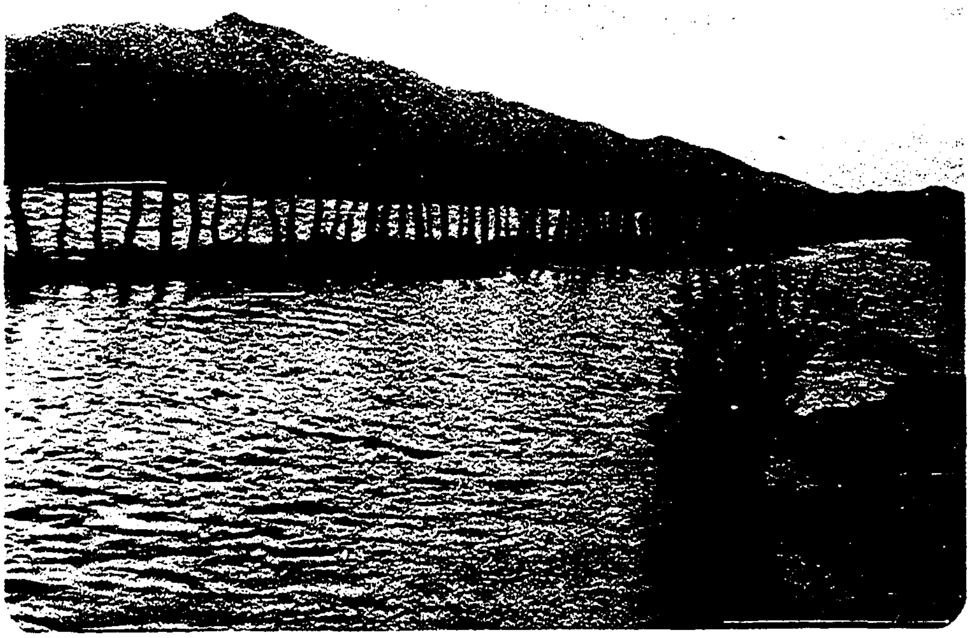
Figure 28. Diversion Weir for Floodplain Irrigation Agriculture (near the pueblo of Arispe).

Fig. 29). These living fence rows promote silt deposition, extending the size of the *milpas*. These fixtures also help retard flood damage.

During the dry season and periods of drought cultivation is dependent on *nacimientos* (permanent springs) that flow from the riverbed. In some places, a spring provides water, but the valley is too constricted to permit farming to take place. In other parts of the floodplain, arable land exists, but the riverbed is dry during most of the year. On the whole, however, *nacimientos* provide a dependable source of water relative to the variability of rainfall and surface water.

In summary, the riparian woodland-floodplain is an environmentally attractive zone for human, animal, and plant populations. A high water table, regularly available water, and porous and fertile soils result in a vegetation growth exceeded in no other zones in the valley. The same conditions that facilitate luxuriant natural plant growth also provide optimal conditions for the growth of domesticated plants. To this end utilization of this environmental zone has made the riparian woodland not only the environmental center but also the cultural center of the valley. This situation was as true in the pre-Hispanic period as it is today.

The *desert scrub-bajada* is the largest environmental zones of the middle Río Sonora Valley. This zone



A. River during flood stage. Main channel is on the left, milpa to the right.

B. River during period of low water. Note that the area right of the fence row is higher than the main channel due to silt deposition.

Figure 29. Living Fence Row (near the pueblo of San Pablo).

is formed by alluvial and colluvial materials that have been poorly indurated into conglomerates and are overlain by Quarternary deposits (Martin 1963). The deposits forming the bajada are the result of extensive erosion in the higher elevations. Were it not for the presence of several arroyos of varying lengths and widths cutting transversely, the bajada would be a gently sloping but relief-free surface (Table 7).

The bajada, like the floodplain, includes two sub-regions: the main bajadas east and west of the river and the bajada edge along the east side of the river. The principal difference between the bajada sub-regions is soil characteristics. Under normal conditions the soils of the bajada edges are finer textured than those soils of higher elevations (Yang and Lowe 1956). In the middle Río Sonora, however, this textural distribution is reversed. Soils along the bajada edge are sandy loams with an average of 4.7 percent more sand and 2.8 percent less clay than the other bajada soils. The soils of the bajada edge are also more alkaline and darker than other bajada soils. These characteristics are probably the result of extensive modern cattle grazing. Indeed, fecal material from range animals is quite common in this sub-region. In addition, the bajada edge was intensively occupied by human populations in pre-Hispanic times. This intensive modification by human action results in classifying soils along the

TABLE 7

PHYSICAL AND EDAPHIC CHARACTERISTICS OF THE BAJADA[1]

| | Main | East Edge |
|---|---|---|
| Area ($km^2$) | 468 | - |
| Lowest Elevation[2] | 600 | 600 |
| Highest Elevation[2] | 800 | 605 |
| Slope | 1.9° | 2.0° |
| Soil Classification | Haplargids to Aridic Haplustolls | Arents |
| Soil Texture | Sandy loam | Sandy loam |
| Percent Sand | 68.2 | 72.9 |
| Percent Silt | 22.0 | 20.1 |
| Percent Clay | 9.8 | 7.0 |
| Soil pH | 6.2 | 7.3 |
| Munsell Soil Color | 7.5YR 5/4 Yellowish red | 7.5YR 5/3 Brown |

[1]These data are extracted and synthesized from Appendices VII and VIII. Explanations of analyses are found in Appendix IX.

[2]Meters above mean sea level.

bajada edge as Arents (Soil Conservation Service 1975).

The desert scrub vegetation of this zone is characterized by a proliferation of small trees and thorny shrubs (Fig. 30, Table 8). The vegetation, which is known locally as the *monté* (Hewes 1935:284), has been referred to as an arborescent desert (Shreve and Wiggins 1964:52). Covering 468 square kilometers, this vegetation zone is dominated by *Mimosa laxiflora*, which accounts for approximately 43.0 percent of all vegetation. Trees, especially *Cercidium* sp. and *Prosopis* spp., are common (Appendix VIII). Grasses, common and lush in the riparian woodland, are thin and nearly non-existent on the bajada. In contrast, cacti, which are largely absent in the riparian woodland, are common in the desert scrub zone. The distribution of cacti, however, is not uniform. Along the bajada edge east of the river cacti account for 17.6 percent of all vegetation. Further east in the central portion of the Desert Scrub zone cacti comprise a mere 6.5 percent of all plants. *Cereus thurberi* is characteristic and common in all parts of the bajada, but *Opuntia fulgida* is most common in all parts of the bajada edge. The formidability of this plant to archaeological research was noted by Amsden (1928:39): "It is the awfullest cactus I ever saw." The proliferation of *Opuntia* spp. along the bajada edge is largely the result of edaphic conditions resulting from extensive human intervention.

A. Transect 3, Area 1.

B. Aerial view north of the pueblo of Baviácora.

Figure 30. Vegetation of the Desert Scrub Zone.

TABLE 8

BIOTIC CHARACTERISTICS OF THE DESERT SCRUB ZONE[1]

| | |
|---|---|
| Area ($km^2$) | 468 |
| Plant Density[2] | 43.3 |
| Percent Trees | 7.8 |
| Percent Shrubs | 83.4 |
| Percent Cacti | 8.8 |
| Avg. Ht. of Dominant Plant (m) | 1.5 |
| Avg. Dia. of Dominant Plant (m) | 1.5 |
| Canopy Cover (%) | 56.8 |
| Dominant Plant | *Mimosa laxiflora* |
| Principal Subdominant Plant | *Franseria* sp., *Jatropha* sp. |
| Grass Cover | Sparse[3] |

[1]These data are extracted and synthesized from Appendix VII. Appendix X contains a list of common plants.

[2]Plants per 10 meter square

[3]A few herbs and grasses are usually found only under other plants.

The vegetation of the desert scrub-bajada zone differs from that of the riparian woodland (Table 9). *Prosopis* spp. is less dense than on the floodplain and probably was not exploited on a major scale in the scrub-bajada zone in the past. Cordage plants increase as do the variety of wild food plants. The tuna fruit of *Cereus thurberi* is probably the most plentiful. *Opuntia* spp. buds are numerous, but are not utilized by the modern inhabitants of the valley.

In summary, the desert scrub-bajada environmental zone has many plants of cultural utility, but is poorly suited to the cultivation of domesticated plants. Soils are rocky and thin. In addition, the availability of water is a problem that further renders this region agriculturally unproductive. Interestingly, however, bajadas steeper than those in the Río Sonora are cultivated using swidden (slash and burn) techniques in southern Sonora (Fish n.d.). Such agriculture relies solely on the extremely variable rainfall and is practiced only by those farmers who are poor, and unable to obtain rights to farm the floodplain. Along the Río Sonora the edge of the bajada overlooking the floodplain is a favored place of settlement location.

The *thorn forest-pediment* zone is named after a similar vegetation zone found along the Río Mayo in southern Sonora and a geologic feature common in the Basin and Range Province. The pediment is an erosional surface formed by

TABLE 9

DESERT SCRUB-BAJADA PLANTS OF CULTURAL UTILITY[1]

| Plants | Usage |
|---|---|
| Agave spp. | cordage, thatch, beverage |
| Celtis pallida | berries |
| Cereus thurberi | fruit |
| Dasylarian spp. | cordage, thatch |
| Olneya tesota | beans, firewood |
| Opuntia spp. | fruits |
| Prosopis spp. | roof timbers, firewood, beans |

[1]A list of common plants can be found in Appendix X.

headward erosion of the mountain slope (Tuan 1959). This feature is markedly distinct from its downslope depositional counterpart, the bajada (Fig. 31, Table 10). Typical of arid and semi-arid lands, these relief-free and gently sloping surfaces have thin deposits overlying planed bedrock. In the middle Río Sonora, unlike typical situations, these pediments are highly dissected by the arroyos and _barrancas_ originating in the mountains. This dissection is so advanced that little true pediment surface remains. Theoretically, the surface slopes should be approximately 3.0° (Fig. 12). Because they are formed on bedrock, these soils are much thinner than the alluvial soils of the bajadas; accordingly, they are not as well developed. The steepness of the slopes is conducive to neither soil maturation or human utilization.

The thorn forest vegetation zone is distinctive (Gentry 1942; Fig. 32), characterized principally by the _Acacia_ with its stiff, boat-shaped silvery thorns and the _Ipomea_ with its smooth light-colored bark. All varieties of cacti are common in the zone, but _Foquieria splendens_ is the most prolific. Grass cover is somewhat denser than that of the desert scrub zone, but it is by no means luxuriant. Other contrasts between this zone and the desert scrub zone are fewer shrubs, but more tree and cacti; less dense vegetation by number but increased plant diversity, and increaded height and canopy (Table 11, Shreve and Wiggins 1964:71.

Figure 31. Distinctive Boundary Between the Bajada and the Pediment. Pediment is on the right (infrared photo).

Figure 32. Vegetation of the Thorn Forest Zone (Transect 10, Area 3).

TABLE 10

PHYSICAL AND EDAPHIC CHARACTERISTICS OF THE PEDIMENT[1]

| | |
|---|---|
| Area ($km^2$) | 254 |
| Lowest Elevation[2] | 800 |
| Highest Elevation[2] | 1,100 |
| Slope | 25.6° |
| Soil Classification | Lithic Torriorthent |
| Soil Texture | Sandy loam |
| Percent Sand | 59.9 |
| Percent Silt | 27.5 |
| Percent Clay | 12.6 |
| Soil pH | 6.1 |
| Munsell Soil Color | 7.5 to 10YR 4/3<br>Brown to dark brown |

[1]These data are extracted and synthesized from Appendices VII and VIII. Explanations of analyses are found in Appendix IX.

[2]Meters above mean sea level.

TABLE 11

BIOTIC CHARACTERISTICS OF THE THORN FOREST[1]

| | |
|---|---|
| Area ($km^2$) | 261 |
| Plant Density[2] | 36.4 |
| Percent Trees | 13.8 |
| Percent Shrubs | 72.5 |
| Percent Cacti | 13.7 |
| Avg. Ht. of Dominant Plant (m) | 2.0-4.0 |
| Avg. Dia. of Dominant Plant (m) | 2.0-4.0 |
| Canopy Cover (%) | 64.3 |
| Dominant Plant | Acacia cymbispina |
| Principal Subdominant Plant | Ipomoea arborescens |
| Grass Cover | Medium[3] |

[1]These data are extracted and synthesized from Appendix VII. Appendix X contains a list of common plants.

[2]Plants per 10 meter square

[3]Grasses and herbs are common, especially under other vegetation.

As distinct as it is, the thorn forest is less productive than the desert scrub-bajada zone in terms of useful vegetation. Carrying out agriculture in this rugged zone certainly would have been impractical if not impossible. Although the number of species found in this zone is more numerous (Appendix X) than in the desert scrub zone, useful plants are not as great (Table 12).

The <u>mixed scrub-slope</u> zone lies along the west side of the river overlooking the floodplain from north of Huepac to south of Baviácora. Physiographically this area has been labled as undifferentiated slope (Fig. 25). Botanically it is a mixed scrub zone (Fig. 26). The amorphous names applied to the physiographic and biotic zones comprising this region are the result of the complex and unmappable elements. Physiographically, this zone is noted by extreme variation in slope angles, and in the composition of the underlying materials. This zone has pediment characteristics in some places, but is similar to the bajada in others (Table 13). The average slope for this zone, 11.6°, is intermediate between that of the pediment and that of the bajada. The short distance from the mountain peaks to the river explains the lack of substantial bajada development. The mountains to the east are younger and higher, determining the westward location of the river. As will be recalled, the river runs asymetrically through the valley and it is this westward offset that results in a mixed sediment-bajada slope.

TABLE 12

THORN FOREST-PEDIMENT PLANTS OF CULTURAL UTILITY[1]

| Plants | Usage |
|---|---|
| *Agave* spp. | thatch, cordage, beverage |
| *Bursera* spp. | medicinal |
| *Cereus thurberi* | fruit |
| *Dasylarion* spp. | baskets, cordage |
| *Opuntia* spp. | fruit |
| *Yucca* spp. | baskets, cordage |

[1]A list of common plants can be found in Appendix X.

TABLE 13

PHYSICAL AND EDAPHIC CHARACTERISTICS
OF THE UNDIFFERENTIATED SLOPE[1]

| | |
|---|---|
| Area ($km^2$) | 7.0 |
| Lowest Elevation[2] | 600 |
| Highest Elevation[2] | 700 |
| Slope | 11.6° |
| Soil Classification | Aridic Haplustolls to Camborthids |
| Soil Texture | Sandy loam |
| Percent Sand | 72.5 |
| Percent Silt | 20.1 |
| Percent Clay | 7.4 |
| Soil pH | 7.4 |
| Munsell Soil Color | 10YR 5/3 Brown |

[1]These data are extracted and synthesized from Appendices VII and VIII. Explanations of analyses are found in Appendix IX.

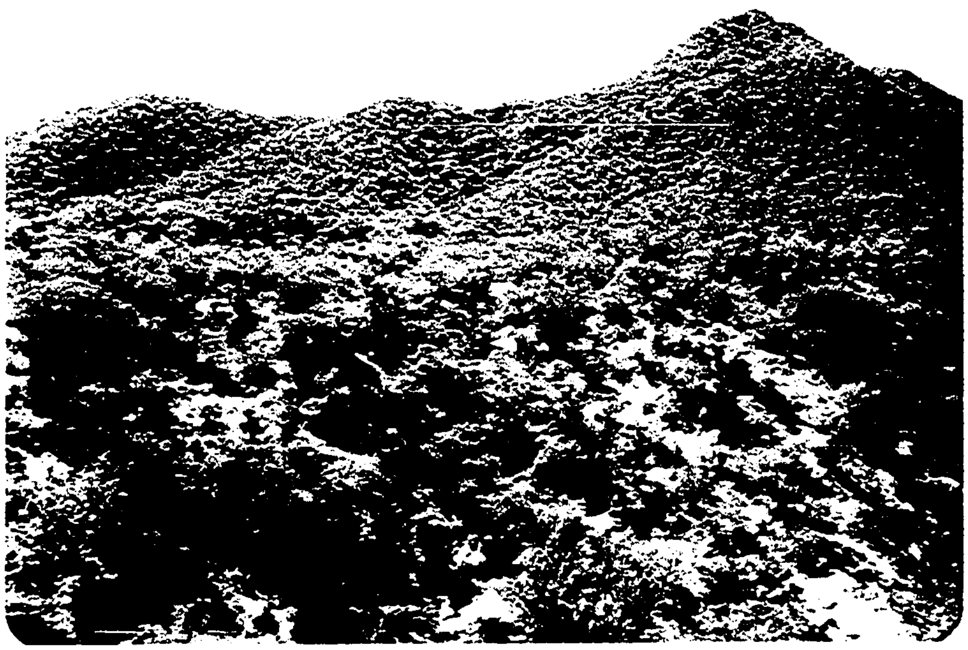
[2]Meters above mean sea level.

Many of the soils in this zone are extensively disturbed by human activity, taking on latent characteristics of Arents. Indeed, the pH value is similar to the bajada edge on the east side of the river. These soils vary enormously in color, ranging from grays to reds. Typically, however, the soil color is brown.

The vegetation of the mixed scrub zone, (Fig. 26) like the soils and geology of the undifferentiated slope zone has affinities to both the desert scrub zone and the thorn forest (Appendix X). Canopy cover is similar to that of the bajada, but the density of plants is more like that of the thorn forest. The frequency of cacti and grass is more like the thorn forest than the desert scrub zone while the frequency of trees is less than in the thorn forest (Fig. 33; Table 14). This situation may possibly be the result of samples being taken close to the edge, often from near archaeological sites. This zone not only has characteristics of the desert scrub-bajada and thorn forest-pediment zones, but also bears a similarity to the bajada edge on the east side. This latter characteristic is due largely to both direct (occupation), and indirect (grazing) human intervention. This zone is quite varied both physiographically and biotically, and is proximal to the river. It has great exploitative potential (Table 15).

While most of the vegetation in the Río Sonora Valley is drought resistent, that of the desert scrub,

A. Transect 10, Area 1.



B. View of Transect 2, Area 9.

Figure 33. Vegetation of the Mixed Scrub Zone.

TABLE 14

BIOTIC CHARACTERISTICS OF THE MIXED SCRUB ZONE[1]

| | |
|---|---|
| Area ($km^2$) | 78.0 |
| Plant Density[2] | 34.9 |
| Percent Trees | 8.3 |
| Percent Shrubs | 78.5 |
| Percent Cacti | 13.2 |
| Avg. Ht. of Dominant Plant (m) | 1.6 |
| Avg. Dia of Dominant Plant (m) | 1.6 |
| Canopy Cover (%) | 57.0 |
| Dominant Plant | *Mimosa laxiflora* |
| Principal Subdominant Plant | *Jatropha* sp. |
| Grass Cover | Sparse[3] |

[1]These data are extracted and synthesized from Appendix VII. Appendix X contains a list of common plants.

[2]Plants per 10 meter square

[3]Grasses and herbs are commin in some places, especially under shrubs.

TABLE 15

MIXED SCRUB-SLOPE PLANTS OF CULTURAL UTILITY[1]

| Plants | Usage |
|---|---|
| *Agave* spp. | thatch, cordage, beverage |
| *Bursera* spp. | medicinal |
| *Celtis pallida* | berries |
| *Cereus thurberi* | fruits |
| *Dasylarion* spp. | cordage, thatch |
| *Olneya tesota* | beans, firewood |
| *Opuntia* spp. | fruit |
| *Prosopis* spp. | roof timbers, firewood, beans |
| *Yucca* spp. | thatch, cordage |

[1]A list of common plants can be found in Appendix X.

thorn forest, and mixed scrub zones is more so than that of the other zones. This vegetation is intimately linked to the summer monsoon precipitation, and is almost totally leafless in late spring and early summer prior to the summer rains. Although vegetation of these zones has a subtropical element they appear not to be vulnerable to temporary freezes (Felgar, et. al. 1976:27).

The piedmont transition (Figs. 25 and 26) is another zone that proved difficult to classify and map. This zone is characterized by the rolling to rugged terrain between the pediment surface and the higher elevations, or by the numerous intrusive stocks (Fig. 24). Cerro El Cobrizo west of Huepac and the area 5.0 to 10.0 kilometers east of Banámichi are typical intrusive stocks common to the area. Elevations in both of these areas range between 800 to 1,200 meters above sea level. Further south and along both sides of the river the piedmont zone is noted by rugged, dissected volcanic deposits, including both flows and intrusions. The Serrita de Baviácora is also included in this zone as it has been characterized as being both a foothill transition and a sizeable volcanic intrusion. Soil characteristics in this zone vary due to the diversity in geology and, hence parent material. On the average these soils are coarser and darker than those downslope on the pediments (Table 16).

The vegetation of the piedmont transition zone may

TABLE 16

PHYSICAL AND EDAPHIC CHARACTERISTICS OF THE PIEDMONT[1]

| | |
|---|---|
| Area ($km^2$) | 468 |
| Lowest Elevation[2] | 800 |
| Highest Elevation[2] | 1,200 |
| Slope | 21.5° |
| Soil Classification | Lithic Torriorthents, Camborthids, Lithic Aridic Haplustolls |
| Soil Texture | Sandy loam |
| Percent Sand | 70.3 |
| Percent Silt | 21.9 |
| Percent Clay | 7.8 |
| Soil pH | 6.3 |
| Munsell Soil Color | 10YR 4/3 Brown |

[1]These data are extracted and synthesized from Appendices VII and VIII. Explanations of analyses are found in Appendix IX.

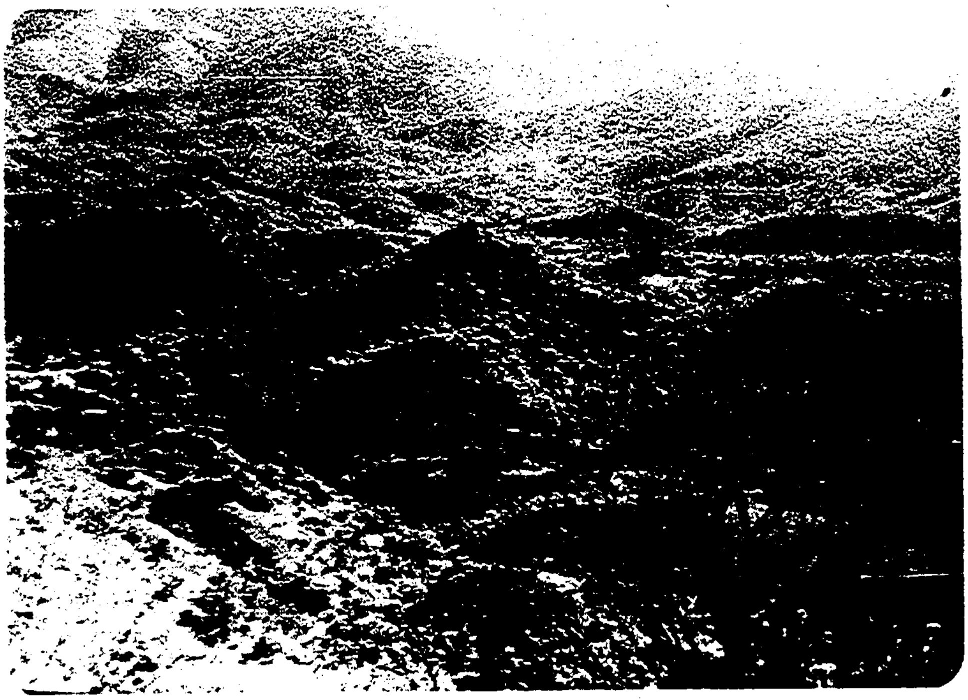
[2]Meters above mean sea level.

be equated to the Desert Woodland Ecotone of Felgar and his colleagues (1976) (Fig. 34, Table 17). The transition zone includes species from other vegetation types, yet also may contain a different array of dominants (Appendix X). Competition between shrub and tree species may be intense, yet there are seldom pure stands of one tree or shrub species. At any zone site, the plant assemblage may be peculiar to itself. This feature makes for difficult mapping. Accordingly, a great expanse of diverse territory and vegetation is included in this zone. Grass cover ranges from light to heavy, the latter being more common. In addition, the relative proportion of trees to shrubs also varies. Although the average height of plants is 2.1 meters, there are several individuals which exceed this height. Indeed, *Ceiba acuminata*, a tree found in the south end of the valley may reach 8.0 meters in height. Toward the north end of the valley *Prosopis* spp. is more typical of the transition zone. *Juniperus monospermia* is found higher in this zone and in the portions of higher zones, especially toward the north end of the valley.

Little evidence was found to indicate that this environmental zone was utilized in pre-Hispanic times. With the exception of cattle little cultural activity is conducted here today. *Capsicum* sp., a spice known locally as Chiltepin, is the only plant gathered seasonally.

The *oak woodland* environmental zone covers the

A. Transect 9, Area 2.



B. Twelve kilometers East of the pueblo of Huepac.

Figure 34. Vegetation of the Piedmont Transition Zone.

TABLE 17

BIOTIC CHARACTERISTICS OF THE PIEDMONT TRANSITION[1]

| | |
|---|---|
| Area ($km^2$) | 550 |
| Plant Density[2] | 24.8 |
| Percent Trees | 18.1 |
| Percent Shrubs | 76.6 |
| Percent Cacti | 5.3 |
| Avg. Ht. of Dominant Plant (m) | 2.7 |
| Avg. Dia. of Dominant Plant (m) | 2.7 |
| Canopy Cover (%) | 70.7 |
| Dominant Plant | Ceiba acuminata (South)<br>Prosopis sp. (North) |
| Grass Cover | Heavy[3] |

[1]These data are extracted and synthesized from Appendix VII. Appendix X contains a list of common plants.

[2]Plants per 10 meter square

[3]Wide variety of grasses and herbs covering nearly all ground area.

majority of the upland physiographic zone. The physiography includes that zone from roughly 1,100 meters above sea level to the mountain peaks (Table 18). Rolling terrain similar to that of the piedmont zone characterizes the upland zone. Soil texture on the average is much finer than any other physiographic zone. These soils are quite thin, however, and are typically lithic.

Vegetation in the oak woodland is, as the name implies, dominated by Quercus spp. (Table 19, Fig. 35). The dominant oaks are often integrated with Pinus spp. in the higher elevations (Fig. 36). The appearance of Quercus spp. is dependent on slope exposure and edaphic conditions (Felgar, et al. 1976), although temperatures and probably moisture are also important. Quercus spp. produces its acorns in early summer. In favorable years acorns, primarily from Q. emoryi are harvested and consumed in nearby pueblos. The distribution and density of trees is not uniform in this zone. In places, the relative paucity of trees produces parkland-like characteristics similar to the Oak Forest described by Gentry (1942). The oaks found within the Río Sonora drainage are largely deciduous, lacking leaves in the late spring and early summer.

Information pertaining to the pine-oak woodland comes largely from the work of Felgar and his colleagues (1976). This zone covers only 15.6 square kilometers and is limited to those elevations over 1,800 meters above sea

TABLE 18

PHYSICAL AND EDAPHIC CHARACTERISTICS OF THE UPLANDS[1]

| | |
|---|---|
| Area ($km^2$) | 445 |
| Lowest Elevation[2] | 1,100 |
| Highest Elevation[2] | 2,185 |
| Slope | 15.6° |
| Soil Classification | Lithic Torriorthents, Camborthids, Lithic Aridic Haplustolls |
| Soil Texture | Loam |
| Percent Sand | 52.8 |
| Percent Silt | 32.9 |
| Percent Clay | 14.3 |
| Soil pH | 5.1 |
| Munsell Soil Color | 10YR 5/4 Yellowish brown |

[1]These data are extracted and synthesized from Appendices VII. and VIII. Explanations of analyses are found in Appendix IX.

[2]Meters above mean sea level.

TABLE 19

BIOTIC CHARACTERISTICS OF THE OAK WOODLAND[1]

| | |
|---|---|
| Area ($km^2$) | 351.0 |
| Plant Density[2] | 8.3 |
| Percent Trees | 79.5 |
| Percent Shrubs | 20.5 |
| Percent Cacti | 0.0 |
| Avg. Ht. of Dominant Plant (m) | 3.7 |
| Avg. Dia. of Dominant Plant (m) | 3.8 |
| Canopy Cover (%) | 46.7 |
| Dominant Plant | *Quercus* spp. |
| Principal Subdominant Plant | - |
| Grass Cover | Medium[3] |

[1]These data are extracted and synthesized from Appendix VII. Appendix X contains a list of common plants.

[2]Plants per 10 meter square

[3]Thin cover of grass with herbs limited to shaded areas.

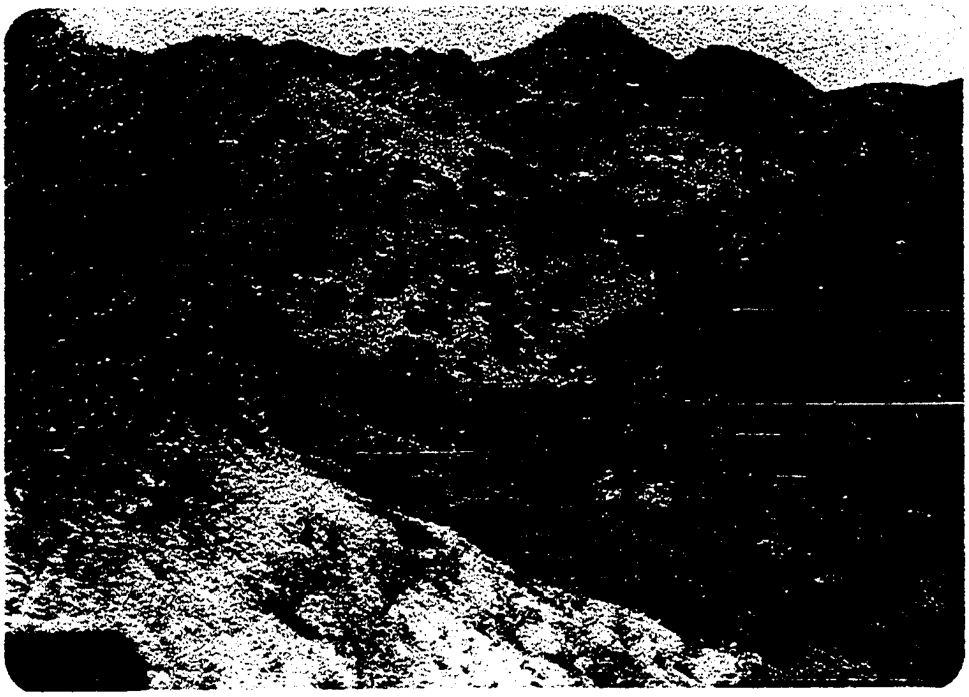


Figure 35. Vegetation of the Oak Woodland.

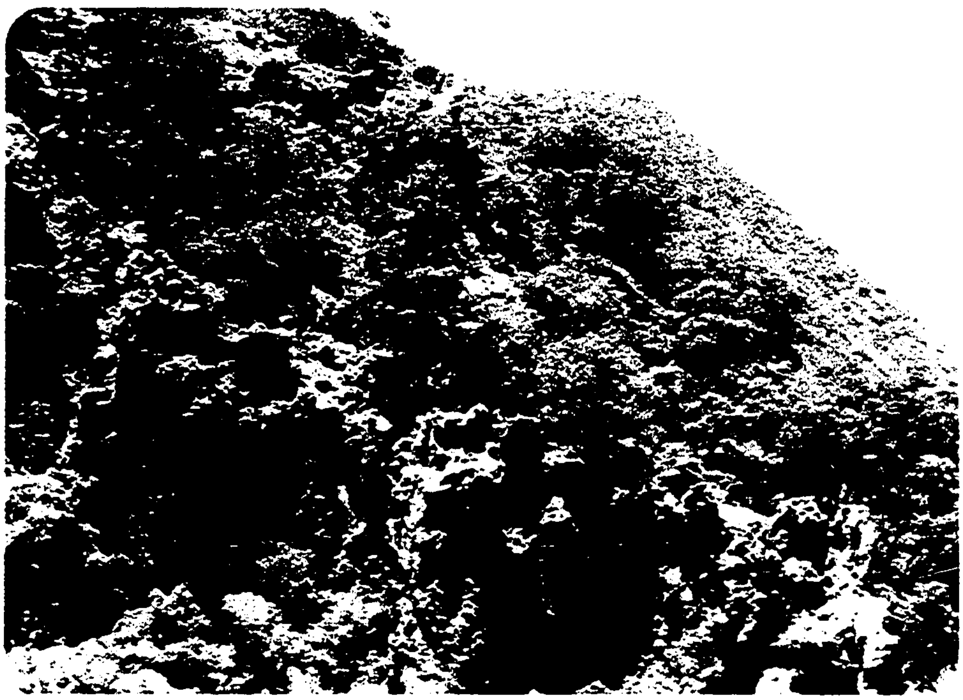


Figure 36. Oak Woodland / Pine-oak Woodland Fringe.

level. Marshall (1957), who provided the first description of the vegetation atop the Sierra Aconchi, noted that *Pinus* spp. had been extensively logged by the 1950s.

The general aspect of the pine-oak woodland is evergreen with maximum renewal of growth occuring in late spring and again with the onset of the summer rains. During drought years, however, the *Quercus* spp. and certain other broadleaf trees and shrubs become deciduous towards the end of the late spring and early summer season. The Sierra Aconchi represents the southwestern limit for montane vegetation in the Basin and Range Province of Sonora.

Although the seven ecological-landuse zones are regionally identifiable, they are not all internally homogenous or areally continuous. With the exception of the floodplain and the uplands, these zones, especially the bajada-desert scrub zone, are dissected by numerous disjunct arroyos that in many respects can be collectively considered as a discrete ecological zone. Though these arroyos are collectively treated here as separate environmental entities, it is realized that they are actually only sub-regions of larger zones. Generalizations can be made about these features, although their discontinuous nature makes them nearly impossible to map on a small scale.

Discriminated according to size, arroyos are classified as being either large, intermediate, or small. It may be argued that this is a genetic classification rooted in the idea that arroyos increase in size with age. This taxonomic scheme, however, is intended to be generic and offered solely for discussion purposes (Table 20).

Typically, soils and vegetation in the arroyos are like those of the riparian woodland. The soils of both the intermediate and small arroyos are most similar to those of the floodplain (Tables 4 and 20). The soils of the large arroyos are somewhat finer in texture and lighter in color. It is unlikely, however, that this condition has much influence on vegetation differences or agricultural productivity. The differences in soil texture are probably a function of arroyo lengths, and hydraulic discharge rates. The flatter slopes would tend to reduce the discharge rate, increasing sedimentation of fine materials. Indeed, the large (long) arroyos have the greatest drainage areas, the flattest slopes and the finest grain materials.

Statistically, the vegetation of the intermediate arroyos is most like that of the riparian woodland (Tables 5 and 21). The vegetation of the large arroyos is dominated by large trees, especially *Prosopis* spp. (Fig. 37). This dominance of trees is probably similar to the riparian woodland prior to extensive agriculture. The density of plants, height of dominants, number of cacti, amount

TABLE 20

EDAPHIC CHARACTERISTICS OF THE ARROYOS[1]

| | Large | Intermediate | Small |
|---|---|---|---|
| Slope | 1.0° | 1.3° | 1.4° |
| Classification | Torripsamment | | |
| Texture | Sandy loam | Loamy sand | Loamy sand |
| Percent Sand | 73.1 | 86.3 | 85.3 |
| Percent Silt | 19.6 | 10.2 | 9.8 |
| Percent Clay | 7.3 | 3.5 | 4.9 |
| Soil pH | 7.6 | 7.5 | 7.5 |
| Munsell Soil Color | 10YR 6/3 Pale brown | 10YR 5/3 Brown | 10YR 5/3 Brown |
| Organic Matter (%) | 1.3 | 1.0 | 1.0 |
| Phosphorus (ppm) | 41.7 | 50.0 | 37.5 |
| Potassium (ppm) | 123.4 | 125.0 | 98.0 |
| Nitrate Nitrogen (ppm) | 11.6 | 11.6 | 12.0 |

[1]These data are extracted and synthesized from Appendices VII and VIII. Explanations of analyses are found in Appendix IX.

TABLE 21

BIOTIC CHARACTERISTICS OF THE ARROYOS[1]

| | Large | Intermediate | Small |
|---|---|---|---|
| Plant Density[2] | 15.7 | 17.7 | 27.0 |
| Percent Trees | 87.3 | 26.6 | 18.5 |
| Percent Shrubs | 12.7 | 63.8 | 79.3 |
| Percent Cacti | 0.0 | 9.6 | 2.2 |
| Avg. Ht. of Dom. Plant (m) | 3.7 | 1.7 | 1.6 |
| Avg. Dia. of Dom. Plant (m) | 4.0 | 1.6 | 1.5 |
| Canopy Cover (%) | 65.0 | 52.5 | 53.8 |
| Dominant Plant | *Prosopis* sp. | | *Jatropha* sp. |
| Grass Cover | Medium | Sparse | Sparse |

[1]These data are extracted and synthesized from Appendices VII. Appendix X contains a list of common plants.

[2]Plants per 10 meter square.

A. Transect 3, Area 3.

B. View of Arroyo del Rancho, east of the pueblo of Baviácora.

Figure 37. Vegetation of the Large Arroyos.

of canopy cover and grass cover also support this suggestion.

There is an apparent correlation between arroyo size and percentage of trees. The size and frequency of trees increases, but the density of plants decreases as arroyos become larger (Figs. 37, 38 and 39). The woodland-like vegetation of the large arroyos is also accompanied by finer textured soils and by a slight increase in soil organic matter. It should be noted also that the increase in *Prosopis* spp. is advantageous for agricultural purposes as the presence of this legume aids in nitrogen fixation (Steila 1976).

The large arroyos, like the riparian woodland, are good agricultural environs. There is, however, a difference in that arroyos do not experience consistent or predictable flows of water. Rainfall dependent agriculture is, and probably was, prehistorically practiced in the large arroyos of the middle Río Sonora Valley (Fig. 40). Necessary soil moisture came from precipitation, especially the summer monsoon rains, rather than from any permanent source of water. Nevertheless, rainfall dependent farming does not necessarily imply the absence of water works. In fact, very few *temporale* (modern rainfall dependent) fields today rely entirely on direct rainfall. Shallow ditches are often constructed from normally dry arroyos to the fields. When rain falls, runoff is collected in the arroyo

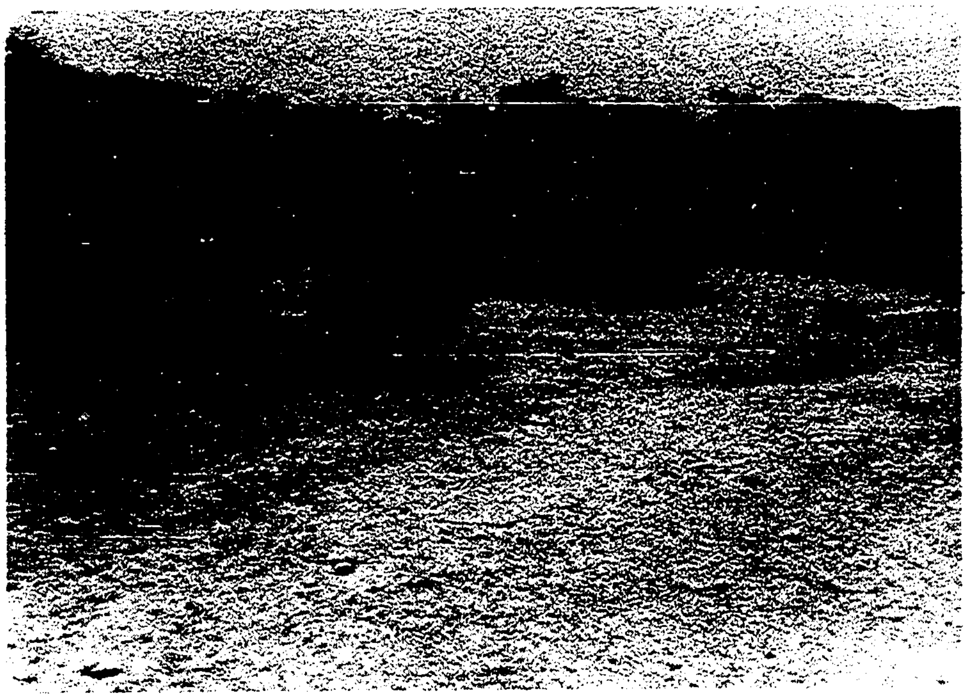


Figure 38. Vegetation of an Intermediate Arroyo (Transect 4, Area 4).

Figure 39. Vegetation of a Small Arroyo.

Figure 40. A *Temporale* Field. Arroyo del Rancho, east of the pueblo of Baviacora.

Figure 41. *Temporale* Diversion Weir and Canal.

and channeled via the ditches onto the fields (Fig. 41). Such fields are large, covering significant portions of the arroyo floors. Temporales are utilized for summer crops because winter rains do not provide sufficient moisture or runoff.

Channel-bottom weir terraces are not used for agricultural purposes in the Río Sonora Valley today.[27] Remnants of several such features, however, are found in some of the large arroyos (Appendix XIV). Fields created by these weirs, like the temporale fields, rely on both rainfall and runoff. Unlike the temporale fields, however, channel bottom weirs slow down runoff to provide soil deposition and moisture to facilitate plant growth (Forde 1934; Stewart 1939; Rohn 1963; 1972). This system may be one of the very simplest forms of terracing (Spencer and Hale 1961; Donkin 1979:32-34). It is produced by a simple wall built normal to a slope (Fig. 42). Such terraces are found across flow lines of slight gradient near the fringes of arroyos. Unlike a channel, these slopes would not normally carry a large discharge of water. These locales result in the utilization of the gently

---

[27]The term channel-bottom weir terrace is used internationally by agronomists, agricultural economists, and scholars in many disciplines (Spencer and Hale 1961). Archaeologists, however, have preferred to refer to such features as check-dams. The international terminology is used herein as it is more specific; the term check-dam can be applied to a variety of agricultural features.

Figure 42. Excavated Channel Bottom Weir Terrace. Site Son K:4:114 OU.

Figure 43. Upstream View of Channel Bottom Weir Terraces. Site Son K:4:114 OU.

flowing sheet wash over the bajada edge and floodwater that occasionally exceeds the channel capacity (Fig. 43). Only a very slight amount of labor is invested in making the fields a planting surface.

In summary, the middle Río Sonora Valley has been categorized in terms of six physiographic and seven vegetation biotic zones. These zones are grouped into seven ecological-land use zones. The floodplain and the large arroyos with their recent alluvial soils have the best agricultural soils of all the ecological-land-use zones. Although some of the other zones have soil nutrient levels adequate for agriculture, steep slopes, rocky soils, and deficient water impede agricultural development.

Three types of agroecosystems are found today in the ecological-land use zones of the middle Río Sonora Valley. Each of these systems represents a different environmental adaptation. The weir terrace fields (arroyos) are typical traditional agrarian features of semi-arid and arid lands. They depend on direct rainfall to supply soil moisture, and runoff to supply both moisture and soil nutrients (via the silt). _Temporale_ fields (arroyos) are largely dependent on rainfall, but also rely on diverted water to supply additional water. These fields lie on more fertile soils than weir terrace fields and require minimal care. Both weir terrace fields and _temporale_ fields are found away from the river channel in large arroyo beds. Floodplain farming involves the utilization of water from the main river channel. This form of agriculture relies on vast amounts of labor inputs and regular flows of surface water.

The availability of water in proximity to arable land is the central geographical factor limiting agriculture in the Río Sonora Valley. Water, however, is largely a function of rainfall and is not always dependable with drought years that occur in a frequent but unpredictable fashion. Drought conditions would probably have their greatest effect on the weir terrace fields rather than on other agrarian practices. Under extensive environmental degradation, neither soils nor moisture would be deposited adequately enough to sustain even marginal crop yields. Temporale fields would also be heavily affected by droughts, but not as severely as would the weir terrace fields. Temporale fields are dependent on water solely for moisture, not on silt deposition. Floodplain agriculture would be the least affected form of farming under drought conditions. Short-term droughts (one to perhaps two or three consecutive years) may be partically alleviated by a dependence on ground water which is readily available on the floodplain. Extended droughts, however, would probably result in a significant lowering of the water table, thereby increasing crop losses.

Flooding is another threat to crop production in certain sections of the valley. Floods are capable of destroying fields along the floodplain and in large arroyos, but usually do not effect both zones simultaneously. In addition, flooding is rarely a threat to both winter and summer crops in the same year. In contrast, a severe long-term drought could prove disasterous to all forms of agriculture in all ecological-land use zones.

Although each of the ecological zones contain some plants of economic utility, the distribution of these plants are by no means uniform. The productivity of such zones can be envisioned as a continuum representing a transect running from the river laterally across the valley to the mountain peaks. An apparent distance decay function to the availability and exploitation of various plants in various zones exists. The riparian woodland is not only the agricultural core of the region but it also has the greatest attraction value to resource procurers. The pine-oak woodland, most distant from the river, is probably the ecological zone of the most limited utility.

The riparian woodland zone offers the best agricultural and resource procurement zone in the valley. As such, it was probably utilized since the first inhabitants entered the valley and has continually served as the economic core for valley subsistence.

## Paleoenvironments

The contemporary environment is often used as a comparative base for determining past environments in archaeological situations (Coe and Flannery 1964; Sanders 1976). Four approaches have been used to assess the similarity between modern and past environmental conditions in the middle Río Sonora Valley. The paleoclimatic conditions have been estimated by reviewing the results of dendrological research and by estimating the extent of aggregation and degradation relative to relic features in the middle Río Sonora Valley.[28] Vegetation differences were estimated by reviewing the results of palynological research and by soil analysis.

The dendrological research conducted in northwest Mexico has been extremely limited as compared to that performed in the western United States. Only recently have researchers gone into northwest Mexico specifically

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[28]Dendrology is the study of tree-rings. Dendrochronology is the technique used in archaeological research to determine dates of materials associated with timbers for which there exists an established tree-ring sequence. Dendroclimatology is the science of reconstructing past climates from tree-ring sequences. Certain trees add growth rings annually. Thick rings usually indicate good growth years (e.g. years of heavy rainfall and/or temperatures). Narrow rings are formed during moisture-deficient years. A series of tree-rings widths can be documented and correlated together such that one can ascertain when a tree grew by identifying the sequence of rings by the relative proportion of ring widths. Theoretically, the last ring was added the year before the timber was felled. It should be noted, however, that many polynologists argue that differences in tree-ring widths are a function of changes in the seasonality rather than changes in the amount of rainfall (Gladwin 1947, Martin 1963:66).

to obtain dendrological data (Stokes, et al. 1976; Wiseman 1976). Unfortunately, this work remains unfinished and results unpublished. This situation necessitates that inferences be drawn largely from the results of that work performed in the U.S. Schulman's (1942) work provided the first tree-ring documentation of prehistoric climatic changes in the Southwest. In a later work Schulman (1956) identified major periods of drought as well as periods of sufficient rainfall. His data indicate the existence of a 200 year period in rainfall and runoff in the Colorado River Basin; the 1200s were extraordinarily dry; the 1300s were extraordinarily wet. Martin (1963:66) later substantiated that this period experienced abnormally low amounts of winter precipitation but reserves his comments not to include a decrease in annual rainfall. The drought of the first interval and the floods of the second appear to have far exceeded in duration and intensity those recorded during the 1940s and '50s (Schulman 1956:69). Recent work has shown that climatic conditions in the Southwest today are drier than in the 1940s (Balling 1979). The combined conclusions of Schulman and Balling tend to suggest that conditions today might be approaching those of the 1200s. Indeed, Schulman even states that precipitation highs in the decades prior to the 1950s broke a drought rivaling that of the 1200s (Schulman 1956:69).

Evidence indicates that the present fluctuation represents, in terms of secular dendroclimatic data, a major disturbance in the general circulation pattern over the western United States (Schulman 1956; Balling 1979). The regionalization of such activity is noted by the decrease in the intensity of the 13th century drought found in dendrological data from the Río Grande Valley (Smiley, Stubbs, and Bannister 1953). Scott (1966) demonstrated that this drought extended south into Mexico, at least as far as Casas Grandes, Chihuahua. That the intensity was as high in Mexico as it was further north is doubtful due to the general circulation pattern in this part of the continent. The climate of the four-corners region is influenced by polar continental upper atmospheric conditions. That factors controlling the climate of Sonora are predominantly tropical and marine (Ives 1949) tends to suggest that the relative effects of the 13th century drought were less severe in this region.

That extended periods of drought did not effect the pre-Hispanic population of the Río Sonora Valley and did not produce an environment much different from that of the today is borne out by the location of relic features in relation to aggredation and degradation evidence. The relative abundance of stone embedded foundations found along the bajada edge and remote floodwater weir terraces found in arroyos suggest that severe entrenchment has not occurred since the time in which such structures were utilized. If such were the case, these features probably would have washed away. Periods of degradation are well documented as occurring simultaneously with drought conditions (Bryan 1928, 1940), or at least with periods of secular rainfall changes (Leopold 1951; Cooke and Reeves 1976). Of course, it could be that moderate degradation has occurred as many of these features are in a delapidated condition. It is suggested, however, that such destruction is more a function of age. That such features may have been buried during a period of aggredation (higher rainfall period?) and later exposed by degradation is possible. Such an elaborate sequence is unlikely to have occurred at each site in the valley simultaneously. It can be concluded, therefore, that pre-Hispanic climatic conditions were probably not too different from those of today. Substantial short-term climatic changes since pre-Hispanic times have not occurred to the extent that vegetation has been permanently affected (Bahre and Bradbury 1978).

Recent comparisons of fossil and modern pollen data from sites along the edge of the bajada indicate that the pre-Hispanic vegetation, although similar to the modern vegetation, was "...of a more open form both during and subsequent to occupation (Rankin 1977)." Two problems exist in this palynological investigation.[29] First, no

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[29]The quality of Rankin's work is not questioned either is substance or technique. She was looking main-

pollen from Mimosa laxiflora was listed from the excavated or surface collections. It is possible that this pollen was collectively listed in the Leguminosae family in which case differences between genera and species are obliterated. That 43.0 percent of all modern vegetation on the bajada is M. laxiflora should be requirement enough for separating Leguminosae pollen by species. It is also possible that M. laxiflora is a very recent introduction on the bajada and would not be found in the fossil pollen. This situation is highly likely since it and Leguminosae spp. species are notorious invaders of overgrazed grasslands (Walter 1973:19). Overgrazing is a common problem in the middle Río Sonora Valley today. The second problem with the pollen data is the lack of emphasis placed on Gramineae spp. pollen. A pollen core from Son K:4:24 OU demonstrated a slow decline in Gramineae spp. pollen through time, with a rapid disappearence near the surface of the core. This decline in grasses is also noted in the morphological characteristics of the bajada soils. As will be recalled, the soils of the bajada are Haplargids and Aridic Haplustolls. Aridisols are quite recent and, by definition, are found in arid and sparsely vegetated regions. Mollisols, typically found in sub-humid and semiarid regions, are associated with grassland and savanna

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ly at pollen spores from plants of economic value. Reconstructing the complete paleoenvironment was to a large extent beyond the scope of her analysis.

vegetation. The modern vegetation of the desert scrub zone in the Río Sonora Valley can hardly be considered grassland (Fig. 30). Nevertheless, evidence tends to indicate that soils in this zone were developed under conditions somewhat more grassier than today. These soils (Fig 44 and Table 22) show the beginning stages of argillic (clay) illuviation (increases in the 20-35 mm horizon), displaying Haplargid characteristics. The epipedon, however, is too dark to be classified as an Aridisol. These features probably indicate that the soil once had a grass cover, albeit not dense, producing organic matter resulting in a dark epipeden characteristic of Mollisols. Drying by increased solar exposure resulted in the loss of organic matter and lightening of the soil color. Removal of the grass promoted clay illuviation.

Under conditions of more dense grass one would expect to find fewer _Leguminosae_ (pollen) and more _Gramineae_ (pollen) than under overgrazed conditions. Indeed, such were the findings of Hastings and Turner (1965:152) and Bahre and Bradbury (1978:158) for other overgrazed grasslands in parts of Sonora and southern Arizona. In the middle Río Sonora Valley _Leguminosae_ pollen shows no continual increases through time. The _Graminea_ pollen, however, shows a noted decline in very recent times. It is therefore, suggested that the pre-Hispanic desert scrub zone vegetation probably included fewer trees and shrubs,


Figure 44. Soil Profile of Aridic Haplustoll/Haplargid.

TABLE 22

SOIL PROFILE OF TYPICAL BAJADA ARIDIC HAPLUSTOLL/HAPLARGID

| Depth | Color | pH | % Sand | % Silt | % Clay | Texture | Structure |
|---|---|---|---|---|---|---|---|
| 0-20 | 5YR 5/4 Reddish brown | 7.0 | 35.2 | 39.6 | 25.2 | Loam | Med. Ang. Blocky |
| 20-35 | 7.5YR 6/4 Light brown | 7.6 | 29.2 | 39.6 | 31.2 | Clay loam | Med. Ang. Blocky |
| 35-50 | 10YR 6/3 Pale brown | 7.7 | 33.2 | 41.6 | 25.2 | Loam | Coarse Ang. Blocky |
| 50-70 | 10YR 7/3 Very pale brown | 7.7 | 43.2 | 45.6 | 11.2 | Loam | Coarse Ang. Blocky |
| 70-100 | 10YR 7/3 Very pale brown | 7.2 | 61.2 | 33.6 | 5.2 | Sandy loam | V. Coarse Ang. Blocky |

and more grass than is found today. Possible grass species may have been Hilaria mutica, Muhlenbergia porteri, and Sporobolus airoides. These species are typically found in natural stands throughout eastern Sonora today (Johnson, and Carillo Michel 1977). Rankin's analysis was limited solely to archaeological sites along the edge of the bajada. As was noted earlier, this zone has vegetation and soil characteristics different from the whole of the bajada. More specifically, there is a proliferation of cacti along the edge that is not found elsewhere. These cacti are the result of vegetation destruction by intensive occupation. Cacti, especially Opuntia fulgida and other species of Opuntia have been well documented as species that not only invade, but also proliferate in heavily distrubed areas.[30]

Environmental change was not limited solely to the bajada, or desert scrub zone. Under virgin conditions the riparian woodland would have covered the entire floodplain except the river channel. Accordingly, Prosopis spp. would not only have been dominant but ubiquitous throughout this zone. The degree to which this woodland area was destroyed can be seen only as a function of the amount of land under irrigation during the period in question. Presently it will

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[30] Personal communication with Dr. Fred Wiseman, Department of Geography and Anthropology, Louisiana State University.

suffice to say that the woodland currently covers somewhat less area than it would have under non-agrarian conditions.

The higher elevations also have been subjected to environmental degradation, especially during th 20th century. Marshall (1957), as mentioned earlier, noted that _Pinus_ spp. had been extensively logged by the early 1950s. Reports from local informants indicate that _Quercus_ spp. were extensively depleted throughout the early and middle decades of the 20th century. These species were not cut for timber but rather for fuel in nearby grain mills. Presently large open areas appear intermixed with groves in the oak woodland (Fig. 35). The extent and the cultural impact of this degradation were not measured for this study, but it is certain that exploitation of acorns would have been greater before the cutting.

In summary, it is doubtful that the climate in the middle Río Sonoran Valley during pre-Hispanic times was much different than it is today. It is probable, however, that minor climatic fluctuations occurred periodically. That these fluctuations affected the vegetation or human occupance to any great extent is doubtful. It is also unlikely that the "Great North American Drought" of the 13th century had much of an effect on the Río Sonora Valley. These findings not withstanding, the evidence for or against major climatic change in the valley during the periods in question is tenuous and all conclusions must be viewed with extreme caution. Unlike climatic conditions, vegetation patterns were quite different in late pre-Hispanic times than they are today. The riparian woodland, the oak woodland, and the pine-oak woodland, are much less wooded today than in the past. Increased agriculture near the river, with wood and timber exploitation in the mountains account for this vegetation decline. The desert-scrub zone was probably more like a desert grassland in the past (Hastings and Turner 1965).

These changes had minimal effects on the pre-Hispanic inhabitants of the valley, although environmental changes are most important for interpreting pre-Hispanic occupance patterns from modern data. Modern conditions are noted by a ubiquitous distribution of leguminous species. Such plants, of course, have utilitarian value in their edible seeds. In pre-Hispanic times such species were limited largely to the riparian woodland and large arroyos. Those found on the bajada or other zones would not have been numerous enough to exploit in substantial quantities. The locating of sites proximal to riparian areas, therefore, facilitates dependable environmental exploitation.

## Environmental Factors and Settlement Location

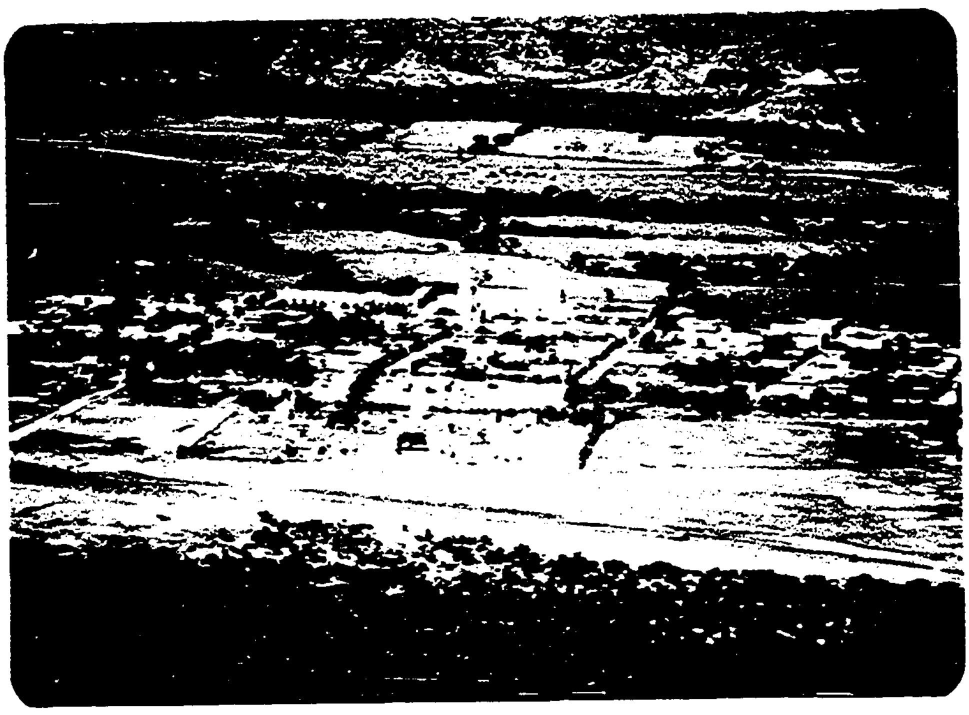
> The first principle of settlement geography is that the group chose its living site where water and shelter were at hand, and about which food, fuel, and other primary needs could be collected within a convenient radius (Sauer 1952:12).

Three of Sauer's environmental factors that influence settlement location--water, food, fuel--are found in the middle Río Sonora Valley. The ecological zone which produces food, fuel, and water most abundantly and with the greatest regularity in the middle Río Sonora Valley is the riparian woodland. As would be expected, the preponderence of permanent habitation sites are located proximal to the river and its immediate environs. That settlements are located on the bajada edge overlooking the river rather than on the floodplain is, however, a curiousity. Safety from flooding and drainage is the most obvious explanation for locating settlements above the floodplain. But as was noted earlier, substantial portions of the floodplain are free from most floods. The modern pueblo of San Felipe occupies such a location. Anyone who spends time during the evenings and nights in the riparian woodland soon appreciates the annoyance created by mesquitos and other insects. The bajada above the lower, wetter areas is a relatively insect-free area probably because of breezes not felt in low-lying areas. These breezes occur throughout the day and have the effect of cooling body temperatures, even during the hottest summer hours. It is also possible that the bajada provided freedom from cold air drainage especially during the cool to cold winters. Indeed, cool drafts from the mountains through the arroyos can be felt even during summer nights. Such drafts are not felt on top of the bajada.

Under homogenous conditions, one would expect to find settlements uniformly distributed along the bajada edge throughout the entire region. The region is not homogeneous, however, and sites are not uniformly spaced. Although sites are located with a high degree of regularity, there are places in which relic settlements are found with great irregularity and infrequency. Three such areas are on the west side of the river from Baviácora to La Labor, from Aconchi to San Felipe, and west of Banámichi. Another area is on the east side of the river between Ojo de Agua and La Mora. These four areas are physiographically different, each with its unique physical qualities that discourage site location. Two of the west side areas do not have extensive bajada development due to proximity of mountains to the floodplain. The area from Baviácora to La Labor is rugged hill lands covered largely by recent volcanic materials. The area from Aconchi to San Felipe shows limited slope (bajada and pediment) development. The type, proximity to point of origin, and amount of formative materials, however, have implications limiting settlement location. The formative materials of this undifferentiated slope are predominantly Cretaceous-age intrusive granites. The pediment portion of the slope is created by erosion on the face of the Sierra Aconchi batholith. The bajada portion of the slope is alluvium and colluvium created by the erosional forces that formed the pediment. The nature of this material and its slope qualities has already been discussed and illustrated (Figs. 20, 21, 22, 23a). The total lateral extent of this slope is not more than a few kilometers, and often less than 1,000 meters. This limited slope development of weakly cemented materials results in the formation of several deeply incised narrow arroyos (Fig. 39). Deep incision has resulted in V-shaped arroyo floors. The high areal density of such arroyos has also resulted in a bajada with numerous narrow ridges with no extensive flat areas suitable to settlement location.

The area west of Banámichi between Ojo de Agua and La Mora has an exactly opposite morphology as the area just discussed. West of Banámichi the bajada is well developed but the underlying material is granitic conglomerates with interbedded tuffs. This relatively hard material results in numerous deeply encised arroyos forming a "badlands" topograph (Fig. 45). Between Ojo de Agua and La Mora the bajada development is quite extensive with some of the longest and widest arroyos found in the Río Sonora Valley. So wide are these arroyos that the ridges between them are very thin with tops too narrow to be suitable for settlements. Sites are found in a rather uniform and predictable fashion in all other bajada edge locales throughout the valley.

A. View North from Site Son K:4:120 OU.



B. View West from volcanic dome east of the pueblo of Banámichi (Fig. 24a).

Figure 45. Badlands Topography West of Banámichi (Arrows indicate common points).

## Settlements

> The character of the ruins along the Sonora River as far as Babiácora may be summed up in a general picture. From ten to fifty small houses, with a substructure of rubble, irregularly scattered, and enclosures, also of rubble but not connected together, formed a village . . . .
>
> Another class of ruins shows low mounds . . . . It is difficult to determine whether the mounds were houses or not (Bandelier 1892:487).

### Structures: Functions and Ages

Without exception the earliest archaeological surveyors who traversed the Río Sonora noted only the presence of embedded rock or rubble foundations and public architecture. As was mentioned earlier, these observations led the investigators to assume a rather brief and late occupation, and suggested immigration rather than internal growth as an explanation for the relatively high level of culture attained by the inhabitants of the region (Amsden 1928:49).

Four types of habitation structures can be identified by their relic foundations or constructional characteristics: (i) surface structures of which there are four variations; (ii) houses-in-pits of which there are two sub-types; (iii) mounds; and (iv) trincheras house remains.

Surface structures are noted by rows of vertical standing rocks embedded in adobe footing (Fig. 46). Typically, such foundations are either square or rectangular in shape and average 23.2 meters in area. The most common surface foundations measure 4 meters by 5 meters. The similar-

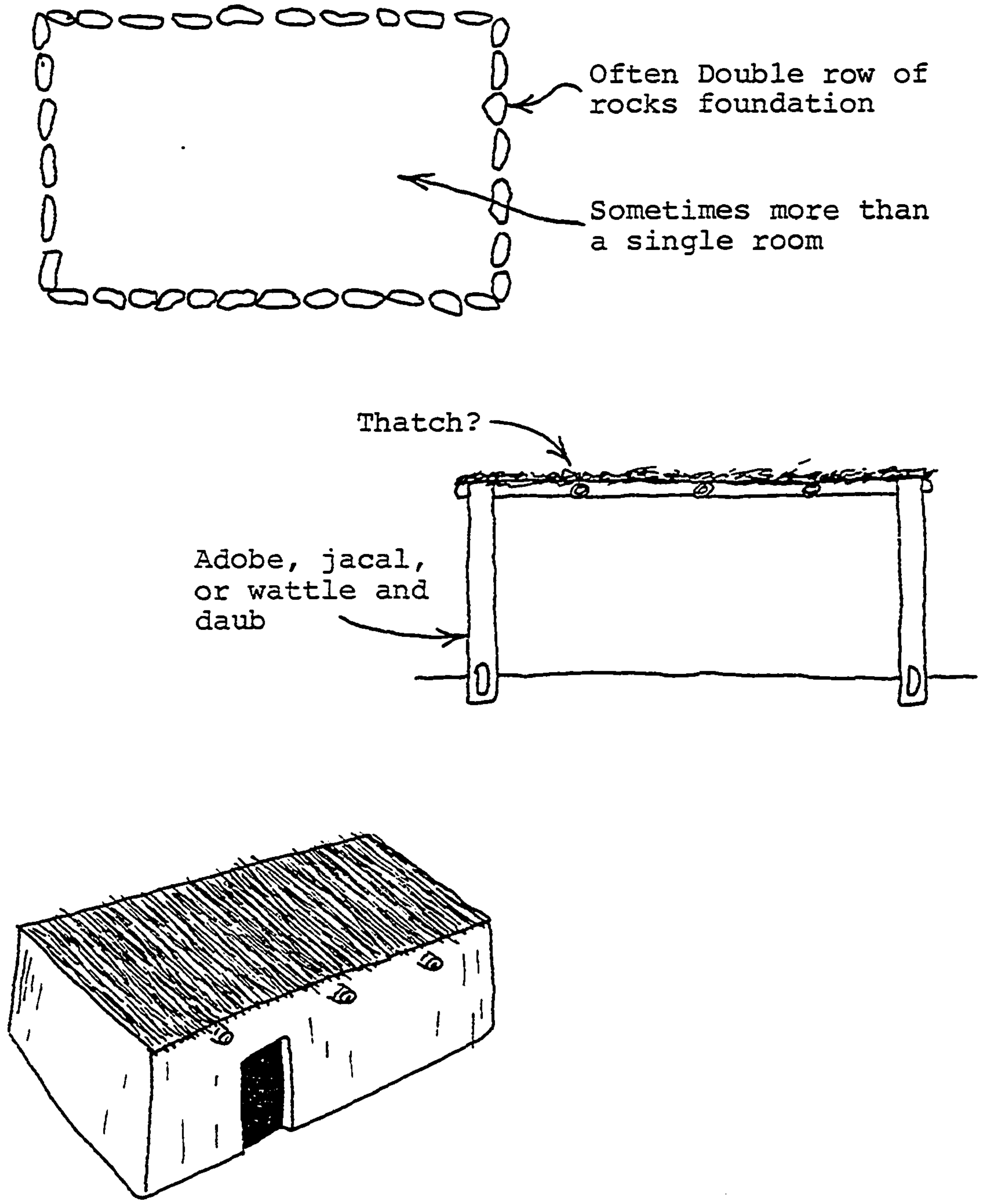



Figure 46. Schematic of a Typical Surface Structure.

ity between currently occupied adobe houses in the Río Sonora Valley and pre-Hispanic houses is not only striking but suitable for making ethnographic comparisons (Figs. 47 and 48). The greatest distinguishing characteristic between ancient and modern structures is the use of brick, a Spanish introduced trait. Pre-Hispanic surface structures were principally of puddled adobe although other materials may have been used. Pfefferkorn (1949:192) notes that *jacal* (stakes and brush) walls were common in the early historic period. DiPeso (1974) has evidence of wattle and daub walls at Casas Grandes, Chihuahua. Adobe, however, was probably the most common material as evidenced by vast amounts of melt found on archaeological sites.

Other architectural features uncovered during recent excavations include adobe floors, and *Prosopis* spp. roof timbers. Although no other roofing materials have been recovered, it is most likely that a thatch of *Arundo* sp. covered with earthern materials was utilized (Fig. 46). All of these architectural features are found in adobe houses occupied today.

Pre-Hispanic surface structures are noted by four subtypes. Most typical are the single room structures with a single row of rocks constituting the foundation. One variation of this design is a single room, double rock-row foundation. The significance of the double row is not completely

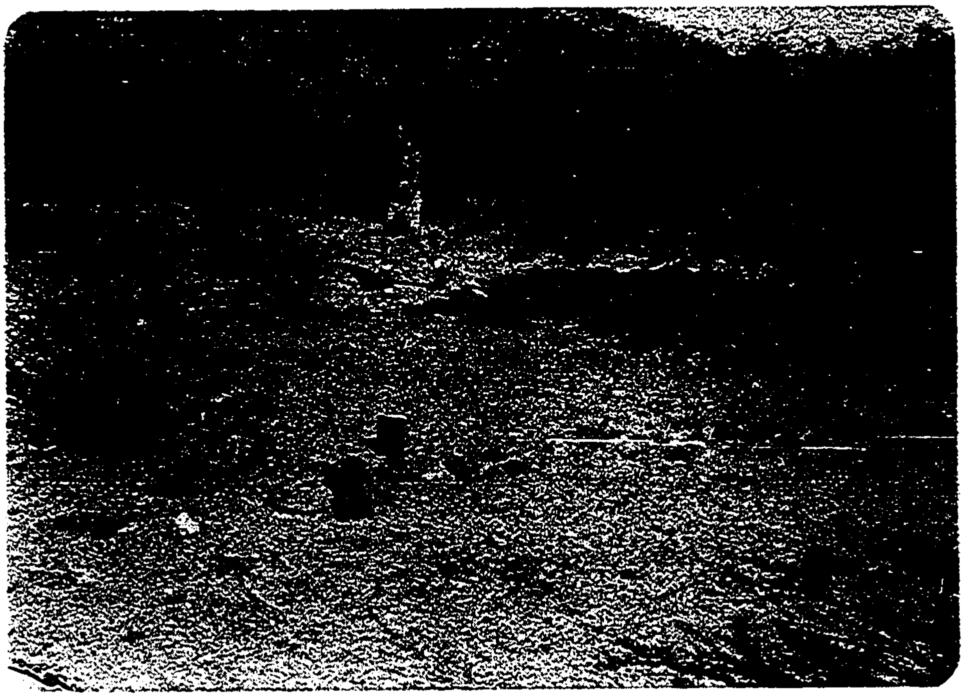


Figure 47. Relic Pre-Hispanic Surface Structure Foundation. Site Son K:4:94 OU.

Figure 48. Foundation of an Historically Occupied Surface Structure.

understood. Amsden (1928:45, 47) postulates that a double row provided a tight joint for walls reinforced with poles. That the two rows are often in contact verifies the tight fit but casts doubt on the reinforcing capabilities of an infinitely thin pole. A modification of the double row foundation is the multiple (3 or 4) row foundations. Such features are probably historic in that such footings are common under modern structures. The purpose of the multiple rows is to provide a flat surface on which to lay adobe bricks and since the ancient inhabitants did not have bricks, an historic age is suggested for these foundations.

In addition to the single room structures are multiple room variations (Fig. 49). Such multiple room features are noted by both single and double row foundations and possibly may be the result of expanded single room structures. Indeed, the size of individual rooms in such features is comparable to the size of single room houses.

Specific anthropological implications concerning the size, style, function, and evolution of house types is beyond the scope of this study. Some preliminary thoughts are, nevertheless, proposed. Single room structures probably reflect occupancy by a single (nuclear?) family. While it is possible for either a nuclear or a single family to occupy a multiple room structure, it is also possible that an extended family or even a second or third family could have shared such a house. It is also possible that

Figure 49. Excavated Multiple Room Surface Structure (Site Son K:4:24 OU).

the larger multiple room houses were occupied by elite members of the society, or served a function other than dwelling. Communal storage, religious, social, or decision-making activities might have been conducted in these larger features. By and large, however, surface structures, especially single room structures, probably served as dwellings. That the multiple room variation is later in age than single room houses is a possibility, but such a suggestion has not been verified.

Surface structures, like many archaeological features, have deteriorated greatly with age. Accordingly, evidence of these features is often fragmentary at best, and sometimes no more than speculative. Many of the surface structures recorded from the Río Sonora Valley are evidenced solely by a few linearly arranged rocks (Fig. 50). In other cases the location of prehistoric structures is suggested by a mere clustering of surficial rocks in an otherwise rock-free area (Fig. 51). Such a condition is most common on sites where a few structures are confirmed and others suspected by neighboring rock clusters.

Pailes (1978a) has evidence of surface structures occurring in the later three phases of cultural occupation. The presence of such structures has been confirmed by $C^{14}$ dates and obsidian hydration analysis (Appendix VI). In addition excavations revealed that polychrome ceramics from the Chihuahuan cultural province, were found to be associated

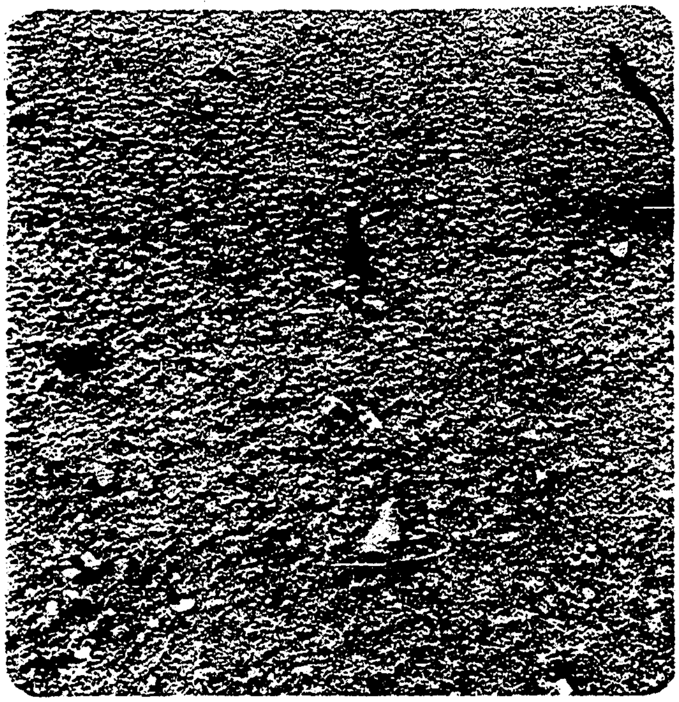
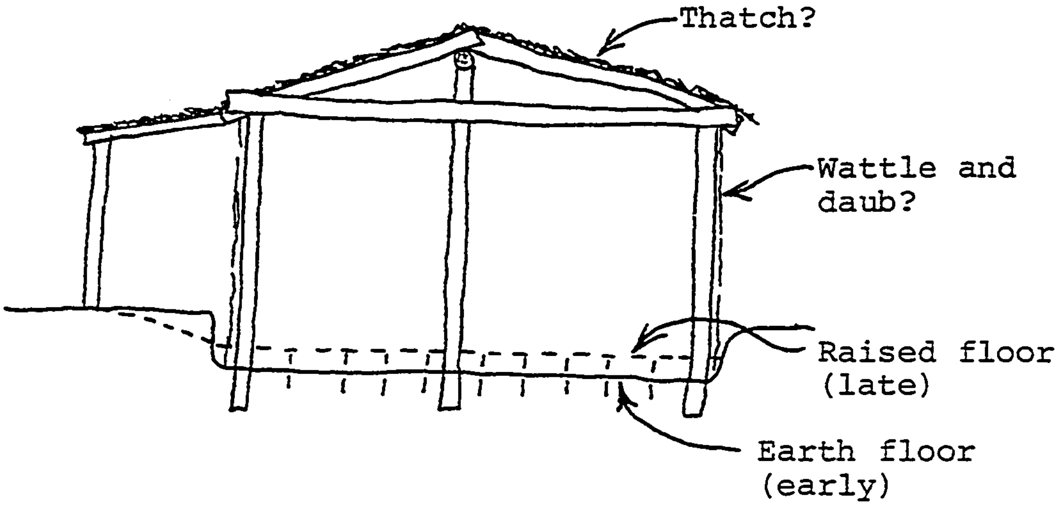


Figure 50. Fragmentary Remains of a Surface Structure. Trowel marks the uppermost of three aligned rocks. Site Son K:4:106 OU.

Figure 51. Rock Cluster Suggestive of a Badly Eroded Surface Structure Foundation. Site Son K:4:16 OU.

with surface structure. Typical polychrome ceramics include Carretas, Huerigas, Ramos, and Babicora types. These ceramic types were produced in greatest quantities during the Paquimé and Diablo phases at Casas Grandes, A.D. 1205 to 1340, thereby verifying the mid to late age of surface structures (Appendix VI).

The two types of houses-in-pits have already been mentioned in regard to the cultural history of the middle Río Sonora Valley. There appears to be a lack of contemporaneity between the two styles, but as of yet this idea has not been fully substantiated. Architecturally, houses-in-pits are semi-subterranean structures of varying depths in which the sides of the pit are not integral parts of the structural wall (Fig. 52). Floors are either adobe or raised *Prosopis* spp. piers and beams. Determining the wall material is more speculative for houses-in-pits than for surface structures. It is most probable, however, that wattle and daub or jacal was utilized. Reports of the earliest Spanish contain descriptions of mat houses further south in Sinoloa and Southern Sonora (Sauer 1932). That such houses were found in the *serrana* has neither been verified nor refuted. Burned structural timbers have been identified as *Prosopis* spp. Like the surface structures it is most probable that roofs were made of dirt covered *Arundo* sp. thatch. No houses-in-pits are currently occupied in the Río Sonora



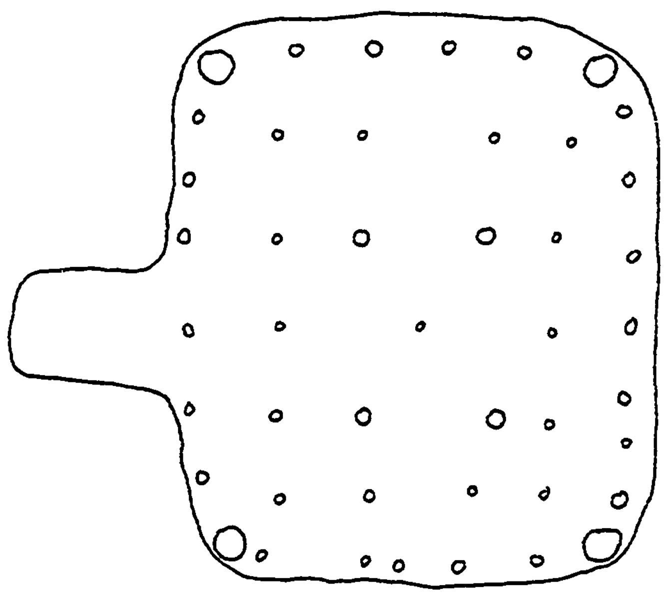
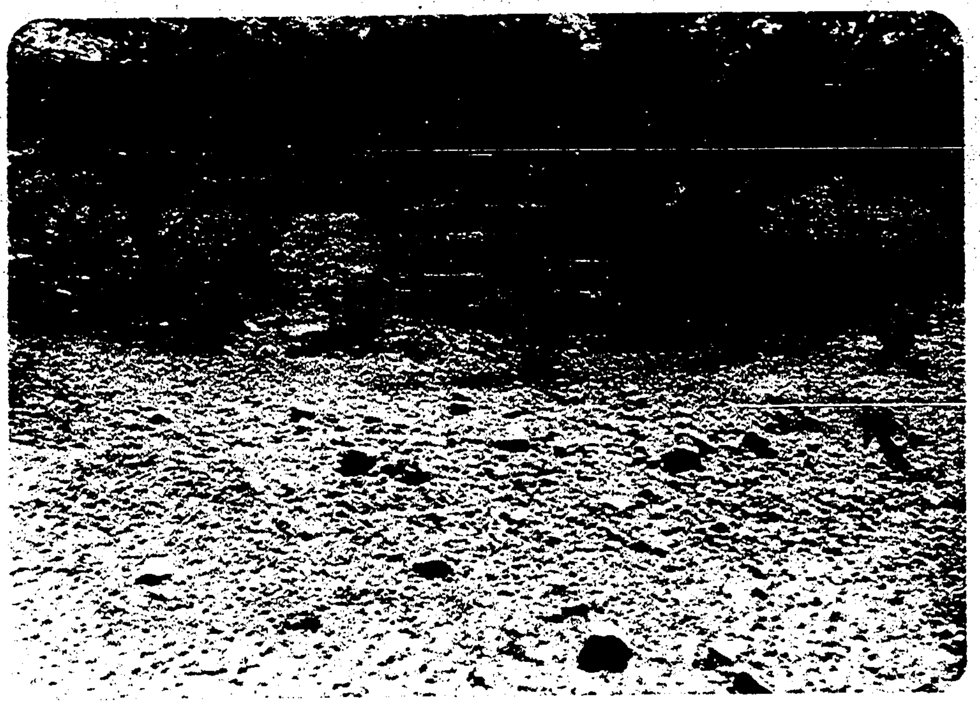



Figure 52. Schematic of a Typical House-in-Pit.

Valley.

Houses-in-pits vary in size, depth, shape, and constructional features. Although the specifics of architecture are beyond the scope of this study it is sufficient to note that such features were generally rectangular with rounded corners and rarely more than 1.0 meter deep. The surficial evidence of houses-in-pits are usually circular depressions. The exact size and shape of the buried features, however, cannot be ascertained from surface evidence. Houses-in-pits are quite often filled in with debris from later occupations or are filled by natural erosion processes. The average surface diameter of filled-in structures is 6.6 meters. Such features are either circular depressions in an otherwise flat landscape (Fig. 53a) or horseshoe-shaped piles of rubble with a slight central depression (Fig. 53b). It is possible that the surfical differences are indicative of subsurface constructional differences. Recent excavations have shown a tendency for the horseshoe variety to have raised floors and adobe block entrances, but too few structures have been excavated to draw firm conclusions. Much of what is known concerning houses-in-pits comes from the work at Snaketown, Arizona (Haury 1976) and San Cayetano del Tumacacori, Arizona (DiPeso 1956).

Without question, houses-in-pits are the earliest form of permanent architecture recorded in the Río Sonora



A. Depression-type structure. Descending arrow marks the central depression, ascending arrow marks the edge of the structure. Site Son K:4:144 OU.

B. Rock ring-type structure. Descending arrow marks the central depression, ascending arrows mark the edge of structure. Site Son K:4:130 OU.

Figure 53. Surficial Remains of Houses-in-Pits.

Valley and throughout the American Southwest. Obsidian hydration and $C^{14}$ analyses provided the basis for ascertaining the early dates of such houses in Sonora (Appendix VI). In addition excavations revealed that polychrome pottery was found to be associated largely with the structural back-fill of many houses-in-pits. That this pottery was relatively late and used as fill supports the early age of the back-filled structures. The relative frequencies with which polychrome pottery was also found in association with surficial remants of all structural types, however, verifies that houses-in-pits were not only early but were utilized throughout the occupance sequence Appendix VI).

Pailes (1978a) has also demonstrated that houses-in-pits were not only early, but that they persisted into later phases. Such occurances are also noted from other areas in the Southwest (DiPeso 1974, Bullard 1960). The work of Bullard (1960) demonstrates that pit houses became smaller and shallower as surface structures transformed from small, temporary structures to larger, permanent structures. Bullard suggests that the earliest surface structures were storage features with pit houses being habitation dwellings. For reasons not yet fully comprehended, the size, characteristics, and functions of structures changed with surface structures being predominantly habitation features while pit houses became storage features.

That such a transformation occurred in the Río Sonora has yet to be substantiated. Nevertheless, it is documented that houses-in-pits were earlier than surface structures. The large size of some houses-in-pits in association with surface structures tends to suggest a temporally late and communal function for such features.

Although the shift from houses-in-pits to surface structures is well documented, arguments persist concerning the contemporaneity between architectural styles. As Pailes (1978a) has demonstrated there are four cultural phases in the middle Río Sonora Valley, a house-in-pit phase, a transition phase, followed by two surface structure phases. The proportional differences in architectural types constructed during the transition phase is currently unresolved. It has been verified from site Son K:4:24 OU that a house-in-pit was occupied quite early and reoccupied in a later phase. That new houses-in-pits were built once surface structures became accepted is doubtful.[31]

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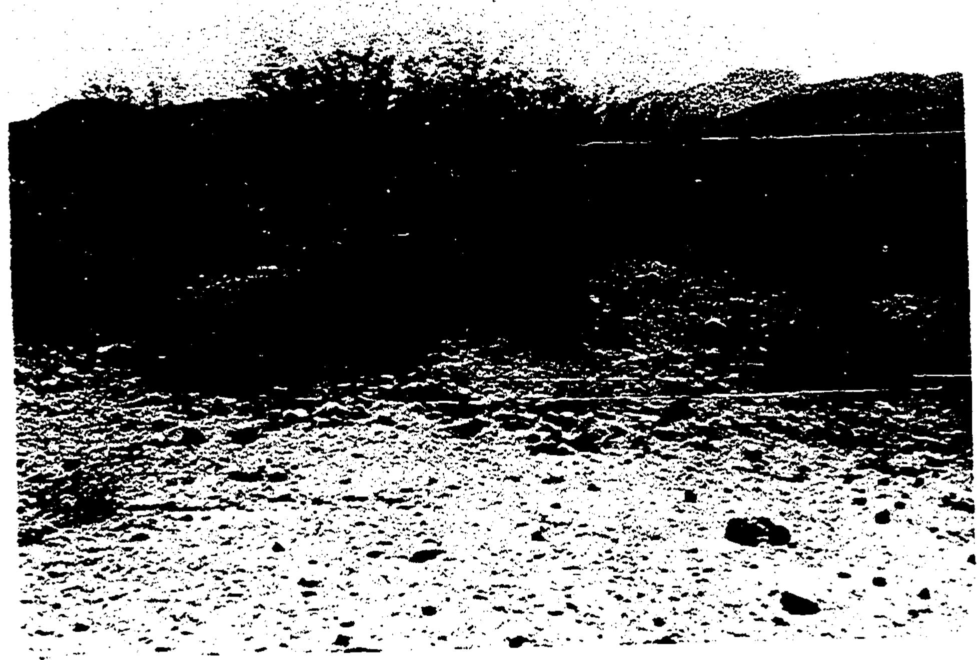
[31] Although confirmation is lacking, an analogy from 20th Century America suggests this to be the case. During the 1940s wood veneer houses were dominant on the urban residential landscape. Throughout the 1950s wood-sided houses continued to be built, but brick veneer increased in popularity. Today nearly all new constructions utilize brick but many families continue to reside in woodsided houses. It is recognized that a shift from wood to brick is largely stylistic while a shift from subterranean to surface structures has broader implications. Nevertheless, it is felt that houses-in-pits that were occupied in later phases were probably constructed during the earlier phases and the more recent occupations were actually reoccupations. The reoccupation contemporaneously with surface structures appears to be borne out by the previously discussed ceramic sequence (Appendix IV).

Two other types of relic structures are also found in the Río Sonora Valley, mounds, and Trincheras foundations. Two types of mounds are noted on archaeological sites in the study area, one is piled rock rubble (Fig. 54a) and the other is clearly adobe melt from surface structure walls (Fig. 54b). The possibility of the former type being a foundation is quite high, the probability of determining superstructure characteristics is quite low. The most likely possibility is that jacal or wattle and daub houses were elevated for some reason, possibly in order to divert runoff from flowing through the structure. Such construction techniques are noted among the Tepehuan in extreme southwestern Chihuahua (Riley 1969:817).

Trincheras foundations are so named because of their similarity and perhaps origin with the Trincheras culture to the northwest of the middle Río Sonora Valley. These foundations, vary considerably in size but average 20.6 meters in surface area. Constructed of low and narrowly piled rubble, these features may have been filled with debris that has since washed away (Fig. 55). It is possible that such fill would, like the mounds, have created a platform upon which a structure might have been built. Although little is known about these features, they are probably relic structures, most likely houses, and appear to be relatively late in pre-Hispanic terms.

In addition to the numerous dwelling structures there

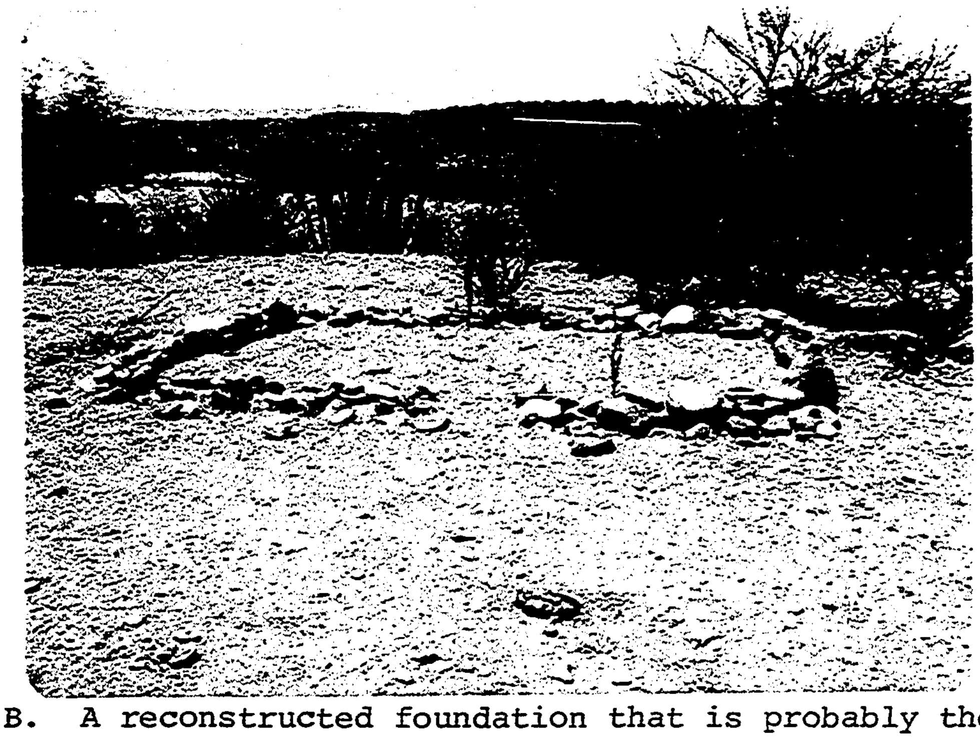
A. Rock mound at site Son K:4:72 OU.



B. Adobe mound at site Son G:12:10 OU.

Figure 54. Surficial Remains of Pre-Hispanic Mounds.

A. Disturbed remnant foundation with arrows marking adjacent walls (edges of structure). Site Son K:4:73 OU.



B. A reconstructed foundation that is probably the work of local amateurs. Site Son G:16:22 OU.

Figure 55. Surficial Remains of Trincheras House Foundations.

exists several other structural relics that served various functional purposes. Some of these features, because of their size, must have involved communal labor during construction and probably served the entire community and often the entire valley population. Other features, although they cannot be associated with specific houses, probably served individual family and perhaps community needs.

The most publicized and known of all pre-Hispanic structures in northwest Mexico are the "Cerros de Trincheras" (Sauer and Brand 1932 and Hinton 1955). These terrace-sided conical hills of presumably defensive nature and pre-Hispanic age (Harlem 1964) are most common northwest of the study area, in the Sonoran Desert near Altar (Johnson 1963). Fortified hills are also found in regions peripheral to the Trincheras culture. These hills are a variation of the true Cerro de Trincheras. According to Sauer and Brand (1932:69)

> Dissected, lava-capped terraces in the valleys were also utilized prehistorically in similar manner. The characteristic differences in rock work appear to be due to differences in the problem of using such sites. The talus slopes of lava mesas have trincheras, or lack them, according to the character of the summit. Where a smooth summit exists, partly surrounded by cliffs, the prehistoric occupation may have been restricted to such a buttressed flat mesa, its weakest points reenforced by rock walls or corrals . . . . Otherwise rock corrals (forts?) may occur on top and at exposed flanks, with numerous trincheras stretching along the slopes of the valley-facing scarp . . . .

Such fortified hills are found at four and possibly five places along the middle course of the Río Sonora. The largest and best known of these hills is Cerro Batonapa (Son K:4:22 OU) 2.0 kilometers southeast of Banámichi (Appendix V). In addition to Batonapa, confirmed Trincheras hills are found at Son K:4:70 OU, Son K:4:127 OU, and Son K:4:132 OU (Fig. 56). A possible fifth hill site, Son K:4: 105 OU, 1.0 kilometer south of Huepac has been heavily disturbed by the location of a historic mining mill. At places along the sides and near the top of this hill are remnants of crude walls that may have been part of a fortified hill. Indeed, Bandelier noted a fortified hill near Huepac (Bandelier 1892:493). That the mill was constructed in the early 1900s and destroyed by fire in 1943 may explain why Bandelier knew of the site which local residents have no knowledge of today.

All of the Cerros de Trincheras in the middle Río Sonora Valley are located on the highest mesas (bajada edge) overlooking the floodplain (Fig 57). The enclosures (Sauer and Brand's forts) vary in size from a 15 meter square to a 60 meter by 28 meter rectangle. The walls of the enclosures are about 1.0 meter high and 2.0 meters thick. They are dry work consisting of boulders of vasicular basalt averaging 20 centimeters in diameter and neatly piled (Fig. 58).

Polychrome intrusive ceramics (purple-on-reddish brown) found on Cerro Batonapa suggest a late period of util-

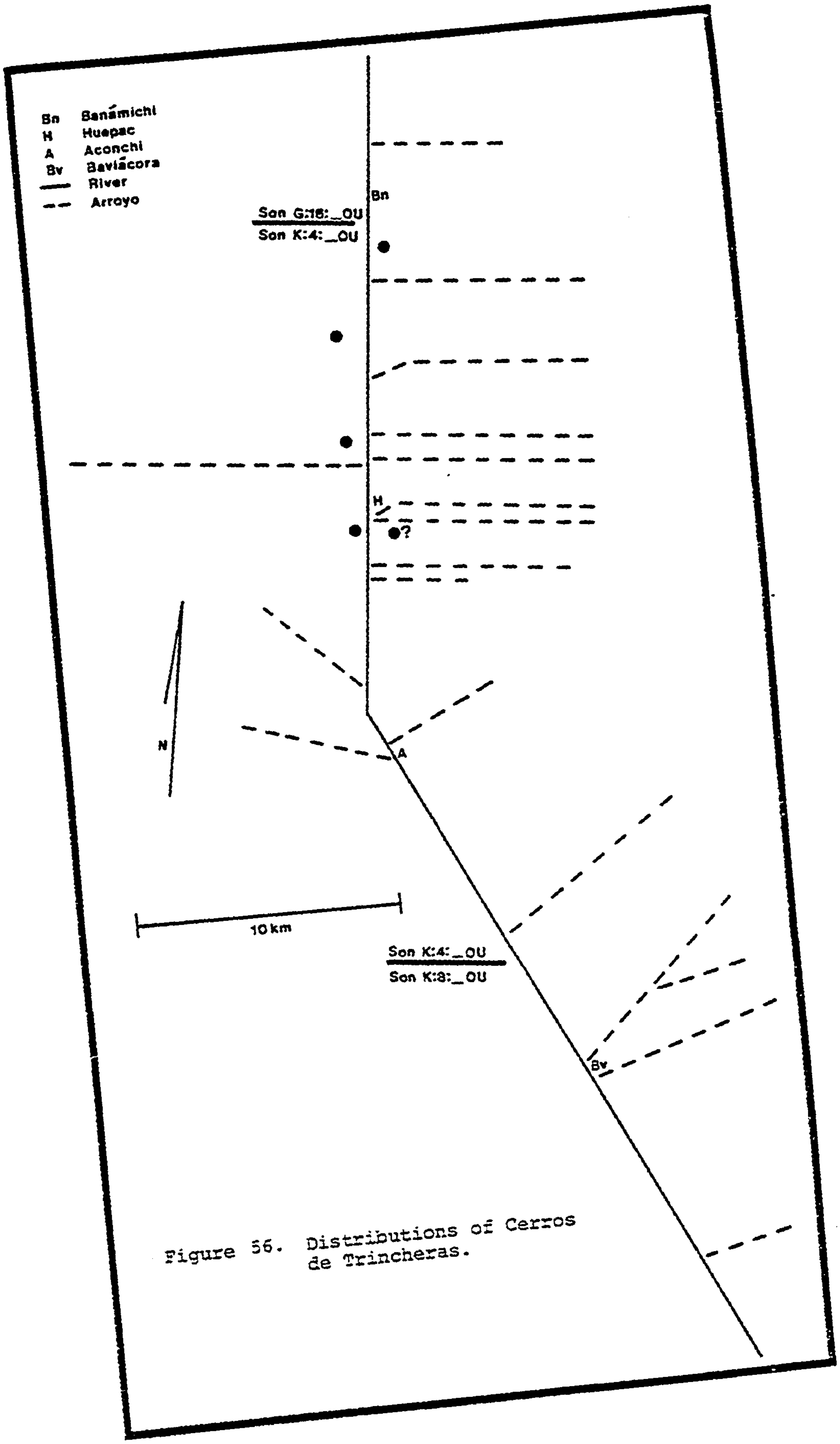
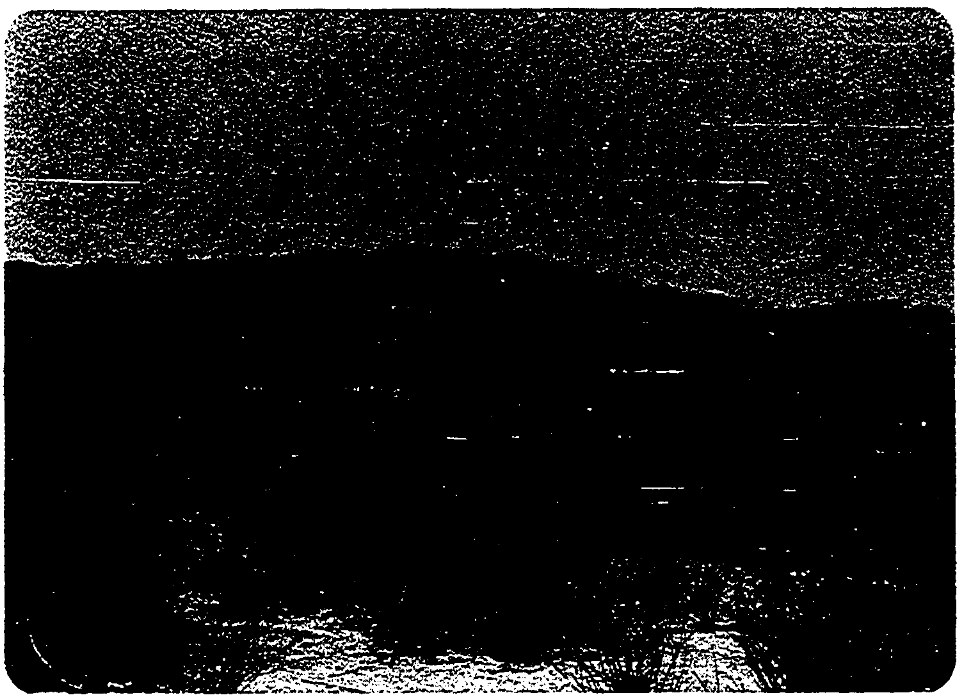



Figure 56. Distributions of Cerros de Trincheras.

A. Cerro Batonapa, site Son K:4:22 OU.



B. Site Son K:4:132 OU viewed from site Son K:4:94 OU.

Figure 57. Cerros de Trincheras.

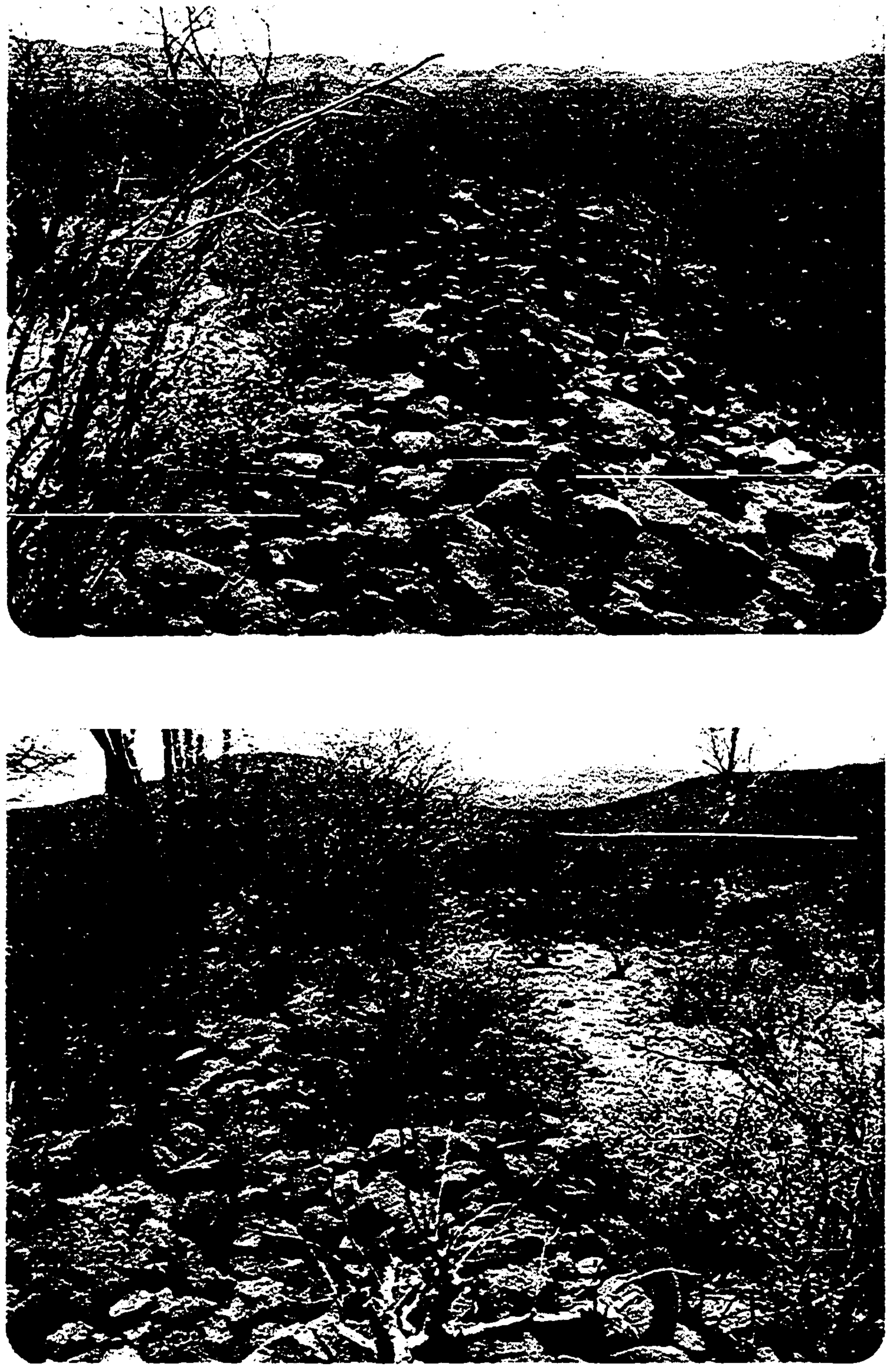


Figure 58. Enclosure Walls of a Cerro de Trinchera. Cerro Batonapa, site Son K:4:22 OU.

ization.[32] Bandelier suggests too that this hill was utilized into the historic period as a refuge from raiding Apaches. Although no houses could be confirmed either on the terraces surrounding the enclosure or within the enclosure atop Batonapa, it is suspected that pre-Hispanic peoples resided here. Relic houses were noted on this hill by Bandelier during his visit in March 1884 (Lange and Riley 1970). It is possible that these features were obliterated during the past 90 years. Permanent structures were noted at Son K:4:127 OU, suggesting permanent occupation at least for that Trincheras hill. It is most probable that all the Cerros de Trincheras served as gathering places for the entire valley's population at least during times of warfare (Sandomingo 1953:169-172).

At sites Son K:4:24 OU and Son K:4:72 OU are found large features not found at other sites in the middle Río Sonora Valley. These structures, because of their size, most probably involved communal and possibly societal labor during construction. Briefly, these features are two parallel mounds of rubble approximately 2.0 meters wide and 0.5 meters high, 45.0 meters long and 28.0 meters apart (Figs. 59 and 60). Although these structures are crude by Meso-

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[32] Some disagreement exists on the exact dates of Cerros de Trincheras Hinton (1955) argues that mesa-top sites date between A.D. 700 and A.D. 1200. Johnson (1963) claims that mesa-top sites are older (A.D. 800-1100) than corical hill sites (A.D. 100-1550). Sauer and Brand (1932) distinguish mesa-top sites from conical hill-sites on the basis of topography rather than age.

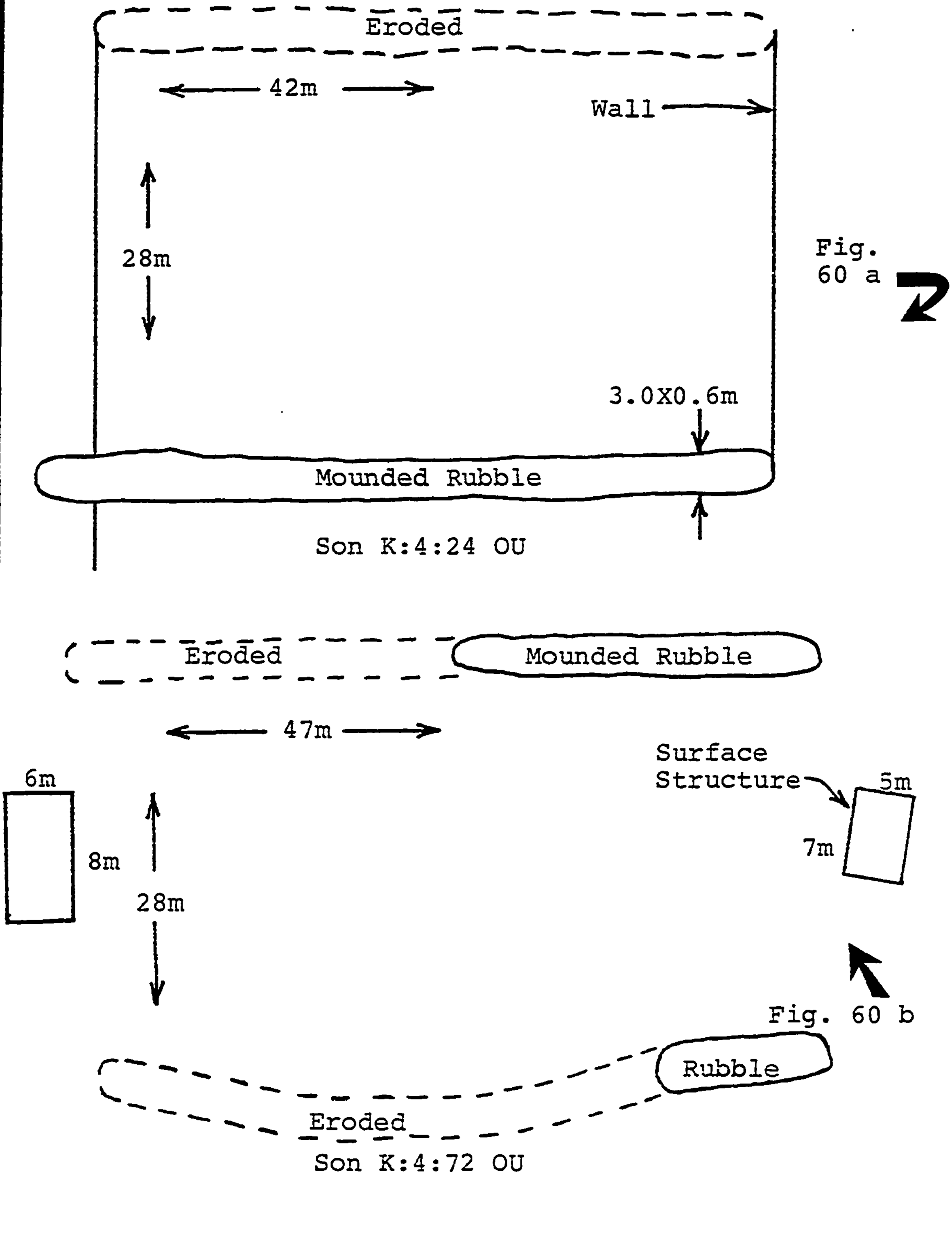


Figure 59. Schematic of Possible Postclassic Ballcourts.

A. Site Son K:4:24 OU.

B. Site Son K:4:72 OU. Note the remnant surface structure in foreground.

Figure 60. Possible Postclassic Ballcourts. Arrows indicate the locations of the mounded rubble. See Fig. 59 for orientation of photographs.

american standards they are elaborate when compared to similar features found in other parts of the Southwest (e.g. Wasley and Johnson 1965; DiPeso 1974; Smith 1961). Their similarities with both Southwestern and Mesoamerican ballcourts tends to suggest that their function was probably of a ballcourt nature.[33] Polychrome trade ceramics are quite often found in the rubble fill utilized for construction of the mounds. Accordingly, these structures appear to be relatively late cultural features. The selectivity of sites located rather centrally, one in the southern portion of the valley, the other in the northern section, suggests that the activities conducted at these features were for the benefit of the respective surrounding populations (Fig. 61).

Two sites Son K:4:16 OU and Son K:4:127 OU have enclosure features that in many ways resemble the ballcourts. These features, however, are much smaller averaging 18.0 meters by 31.0 meters (Fig. 62). In addition, the walls themselves are somewhat smaller, being approximately 0.25 meters high and slightly more than 1.0 meter thick (Fig. 63). Both of these structures have breaks in one longitudinal wall, but it has not been determined if these gaps are deliberately planned openings (doors?) or a function of erosion. The wall construction, although smaller,

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[33] Personal communication with Dr. Arturo Oliveras M. INAH, Hermosillo, Sonora.

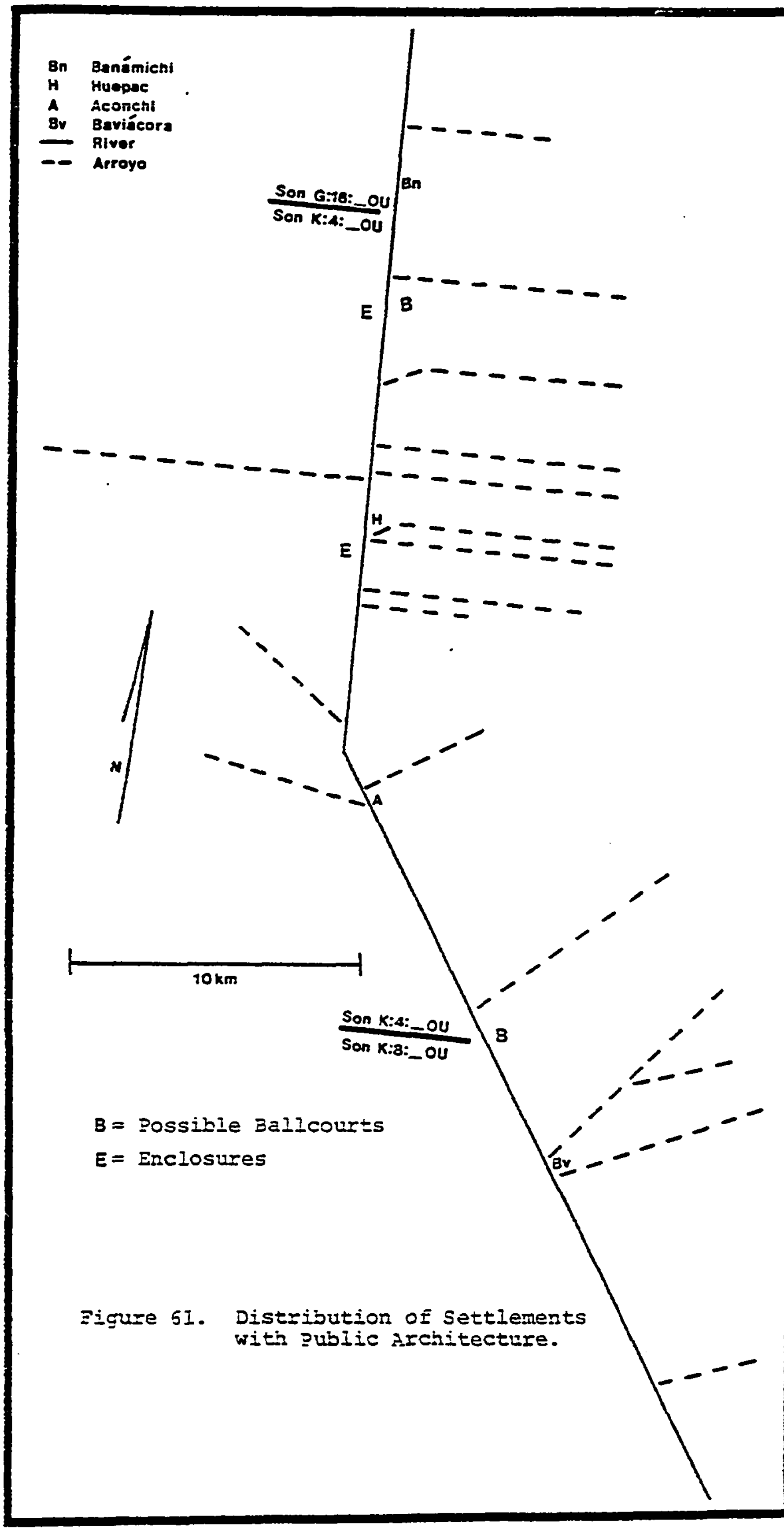


Figure 61. Distribution of Settlements with Public Architecture.

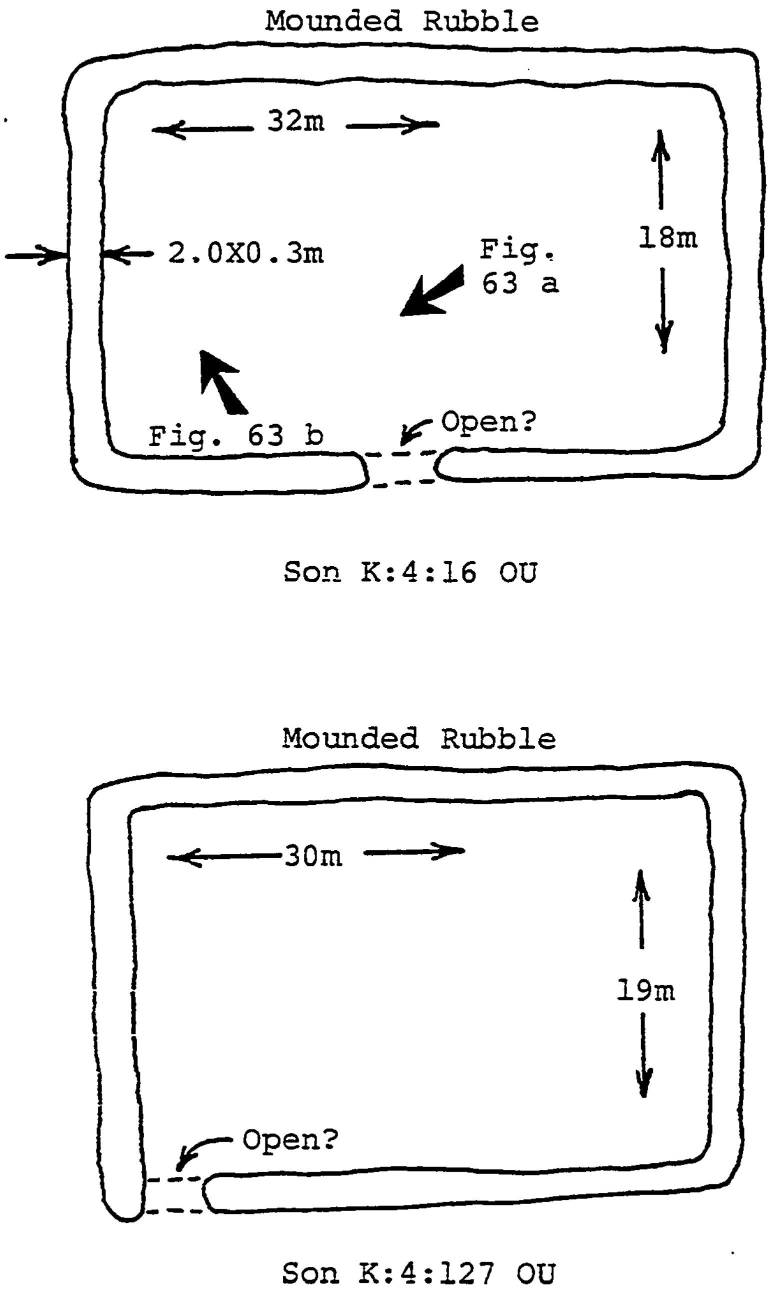


Figure 62. Schematic of Pre-Hispanic Enclosures.

A. Arrow indicates wall, pack is approximately in the center of the enclosure.

B. Man is standing atop one wall.

Figure 63. Surficial Remains of a Pre-Hispanic Enclosure. Site Son K:4:16 OU.

is similar to that of the ballcourts. Unlike ballcourts, however, these enclosures have mounded rubble along all four sides. The exact function of these enclosures is yet determined. It is not likely that these features were roofed as no post holes were found. Indeed, a roofed structure of such dimensions would surely have required numerous supports. These structures at the very least served a communal function and may have served significant portions of the valley's population.

Several pre-Hispanic settlements along the middle Río Sonora are distinguished by walls similar in construction to those of the Cerro de Trincheras. Unlike the enclosed summits (forts?), however, these features are discontinuous linear walls (Fig. 64). The exact function of these walls can only be surmised as defensive. Several situations exist, however, where the walls are either too short or oriented the wrong direction to defend anything. In other cases the entire site is not only defensible but is dominated by such walls. Sites Son K:4:62 OU and Son K:4:125 OU are probably the best examples of such a site (Appendix V). The exact age of such walls is difficult to ascertain because they are associated with all types of structures. Five of the seven sites with these walls are located away from the river (Fig. 65) along large arroyos. The only conclusive statement that can be made about these walls is that a significant amount of labor was expended in their con-

Figure 64. Trincheras-type Wall. Site Son K:4:125 OU.

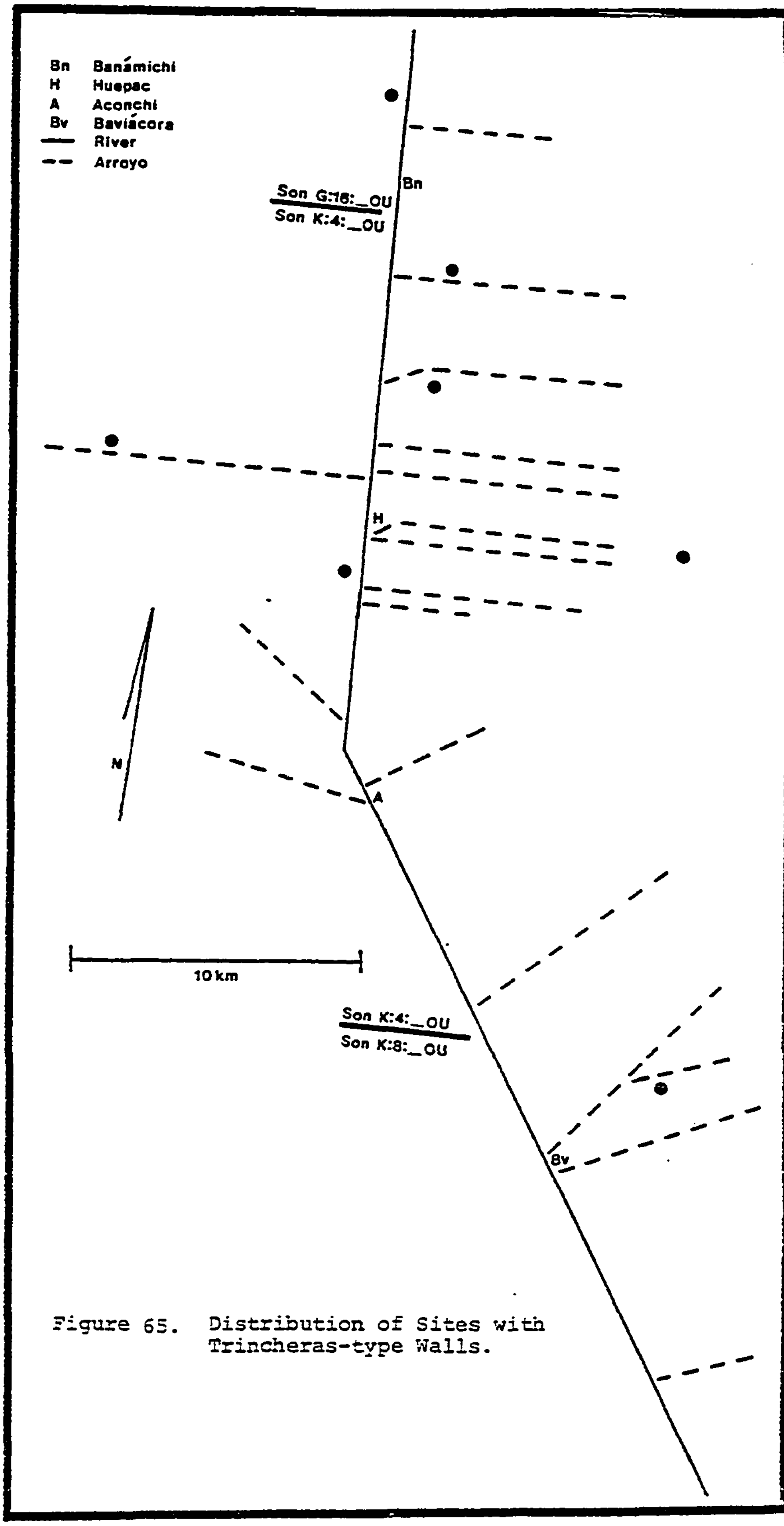


Figure 65. Distribution of Sites with Trincheras-type Walls.

struction.

On the family and community level are archaeological features of great curiousity. Typically found on many sites are remnants of roasting pits (Fig. 66) and possible storage structures (Fig. 67). The roasting pits were dug in the earth and back-filled with coals and rocks. Meat and other items to be cooked were then placed in the pits. Such pits range considerably in both diameter and depth. Because of their badly eroded condition no measurements were taken for this work. It will suffice to say that these pits, which are identifiable by a dense clustering of fire-cracked rocks encased in burned earth, were obviously food preparation features. Erosion of the surrounding landscape facilitated the identification of roasting pits. Burned wood is often found in such pits. Dates from $C^{14}$ analyses demonstrate that ages of such antiquities extended throughout the entire occupational sequence (Appendix VI).

The functional classification of the small circularly embedded stone foundations as storage is purely speculation. Excavations of such features uncovered no evidence of crop storage. Of course, personal equipment may have been kept in these structures leaving no trace of their past presence. One such feature on site Son K:4:120 OU had a rock floor within 20 centimeters of the surface. More commonly, however, sterile soil was found at such a depth. The superstructure materials as well as the dates of

Figure 66. Surficial Remains of a Roasting Pit. Site Son K:4:35 OU.

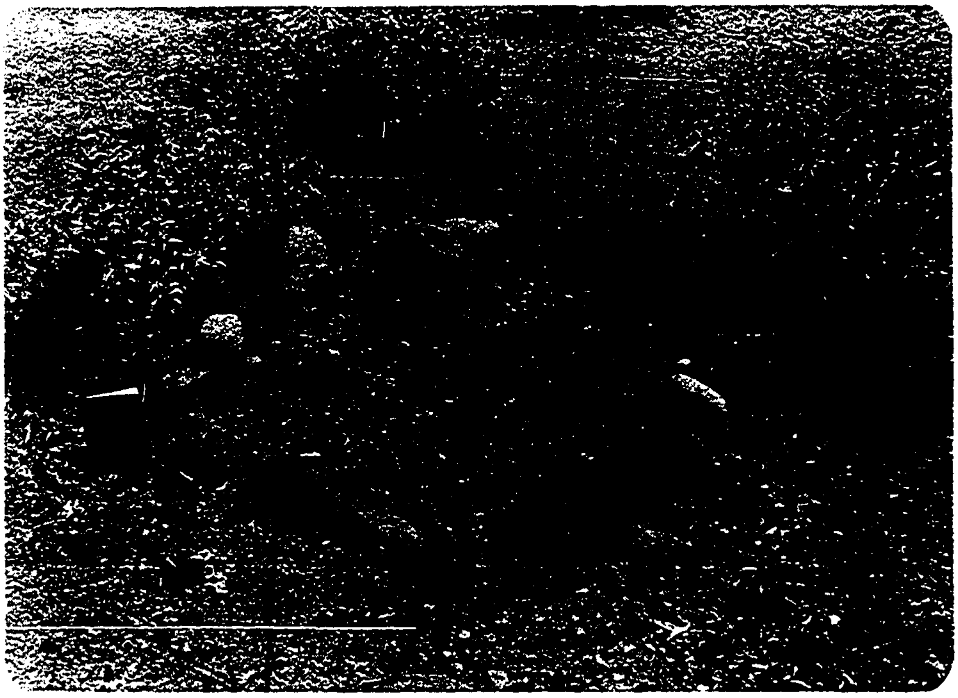

Figure 67. Surficial Remains of a Possible Storage Structure. Site Son K: 4:120 OU.

these rock rings is indeterminable. They exist solely in association with other structures, most often surface structures.

## Communities and Hierarchies

An analysis of settlement patterns necessitates the development of a site typology, a classification that reflects the differences in size, function, features, and other attributes of sites dating to the same period. By far the greatest concern with producing objective site typologies has come from workers in the Valley of Mexico (Sanders 1956, Parsons 1971, Blanton 1972b), and Peru (Lanning 1967). The typology used for Río Sonora settlements follows the example set by these previous works. This hierarchy is based largely on size (numbers of houses). The majority of sites are small and only a few sites have public architecture. This situation suggests that no hierarchy based on functional differentiation (Berry and Garrison 1958c) existed in pre-Hispanic times. Indeed, primacy of a few centers over all other sites is a much more accurate settlement description. In community terms, however, there may be significant differences between settlements with two houses and those with seven houses (assuming one family per house). Single house sites probably differ in their social organization from sites with multiple houses (Flannery 1976; Ch. 3). The settlement hierarchy outlined here is a combination of geographical city-system and archaeological community hierarchies. The highest levels have importance concerning intravalley and inter-site sociopolitical interactions. The lowest levels are more community-subsistence oriented. This dichotomy is especially true for the later phases.

The evolution of Río Sonora settlement systems is the principal concern of this study. It is important, therefore, to note the changes in the entire system, especially the changes in the structure of the settlement hierarchy. The undeveloped ceramic sequence makes it necessary to use architectural differences to note chronological changes in settlement. The most pronounced temporal differences in architecture is the relatively early date of houses-in-pits and late dates of surface structures (Appendix VI). The temporal dichotomy between house-in-pit architecture and surface structure architecture facilitates the delination of two occupation phases. Where this approach may not be desireable from an archaeological point of view it actually simplifies the problem of noting settlement changes along the ecological-social continuum. In effect, we can compare the ecological-spatial orientation proportions in one phase with those of the other.

For the period of concern in this study the structures and, hence, settlements are classified as early or late. House-in-pit sites are classified as being "early"

(A.D. 1000-1200). All sites with habitational evidence are classified "late" because houses-in-pits also occur simultaneously with the later phase surface structures. A three-tiered community hierarchy is evident during the early phase (Fig. 68).

(1) Nucleated Villages. Defined by Parsons (1971) and Blanton (1972b), nucleated villages are sites comprised of clustered houses (agglutination) that lack large scale ceremonial-civic architecture. Blanton uses 100-1,000 persons as an average population for such sites, while Parsons uses 100-1,500 with villages over 500 persons classified as "large". Lanning (1967:35) employed similar taxonomic criteria. Of the 65 early sites in the middle Río Sonora Valley, only Son K:4:24 OU, the San Jose site with its 60+ houses-in-pits, falls into this category.

(2) Hamlets. Parsons defined a hamlet as any community of under 100 persons, and Blanton placed sites with populations between 10 and 100 in the hamlet category. Both concur that such sites lack ceremonial-civic architecture and are solely residential sites. MacNeish (1969) distinguished hamlets from villages by the latter's arrangement of houses around a plaza with hamlets composed solely of small house groups. Two sites (3.0 percent) with 10 and 12 houses respectively from the early phase can be identified as hamlets in the middle Río Sonora Valley, Son K:4:32 OU, and Son K:4:110 OU.

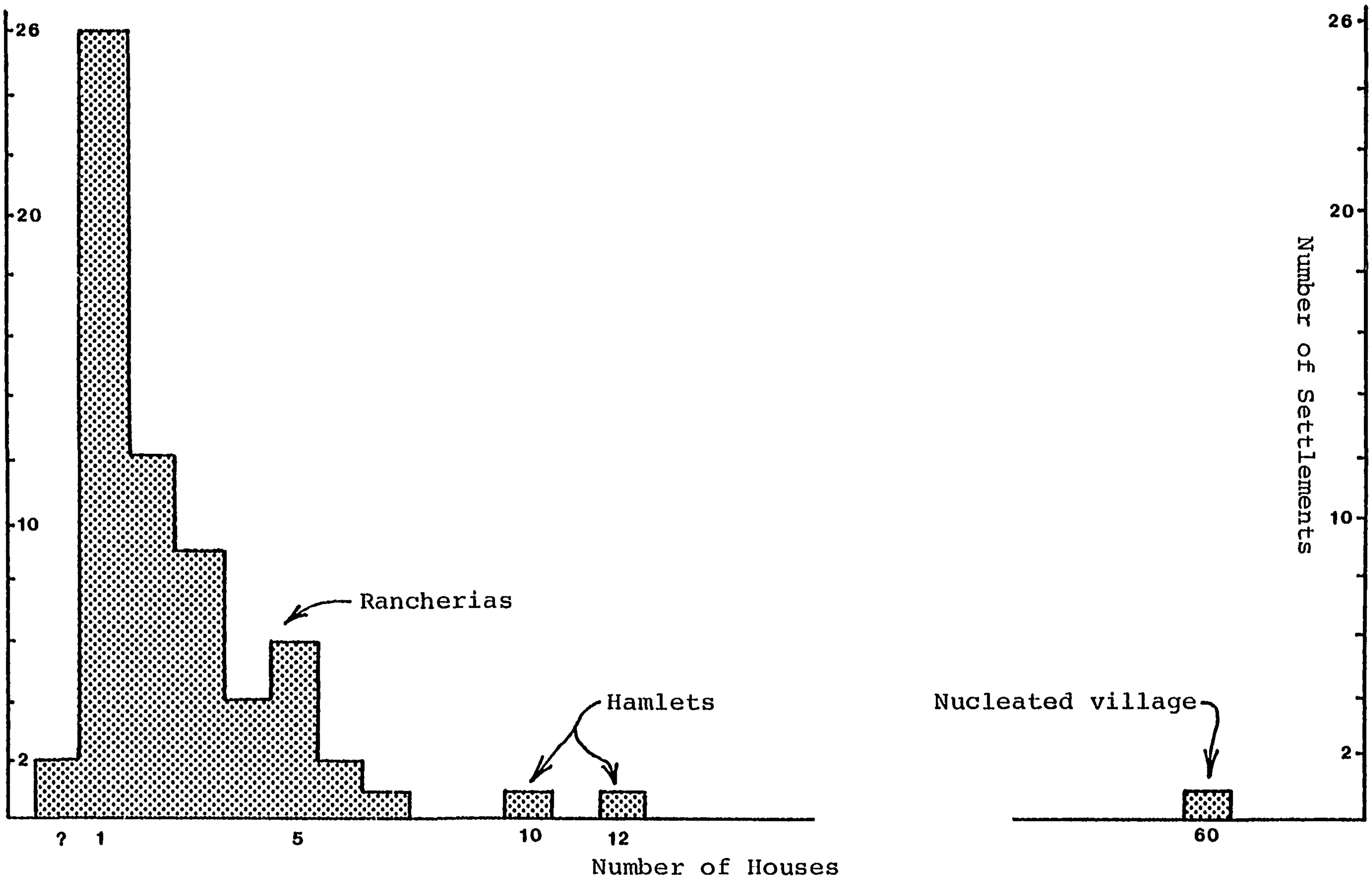


Figure 68. Early Phase Settlement Sizes.

(3) Rancherias. The term rancheria is common among Southwestern archaeologists. It refers specifically to small, scattered, and riverine oriented habitation sites. The dispersed nature of these desert sites is often noted as a contrast to the densely populated pueblos of the Colorado Plateau. Typically, such sites have only a few houses. The category here includes all sites with between one and eight houses. Sixty-two (95.5 percent) of all early Río Sonora sites are rancherias. Of these, 26 (40.0 percent of all sites) were isolated residences. Blanton (1972) considers such sites distinct from sites with 2 or more houses, but for our purposes the inclusive term "rancheria" is used in reference to all small sites.

During the late phase (A.D. 1200-1550?) a four-tiered community hierarchy existed (Fig. 69).

(1) Regional Centers. Large, nucleated, architectural complexity and large-scale ceremonial-civic architecture are criteria for classification of a site as a regional center. Regional centers in the Río Sonora Valley are similar to the "secondary" sub-category defined by Parsons, and Blanton for highland Mexico. Parsons' scheme requires a population of several hundred to a few thousand. Blanton puts the population level between 1,000 and 2,000 inhabitants. The regional center, by definition, is similar to Lannings (1967) "Town". Two (1.2 percent) of the 162 late Río Sonora sites are classified as regional centers--Son K:4:24 OU has well over 100

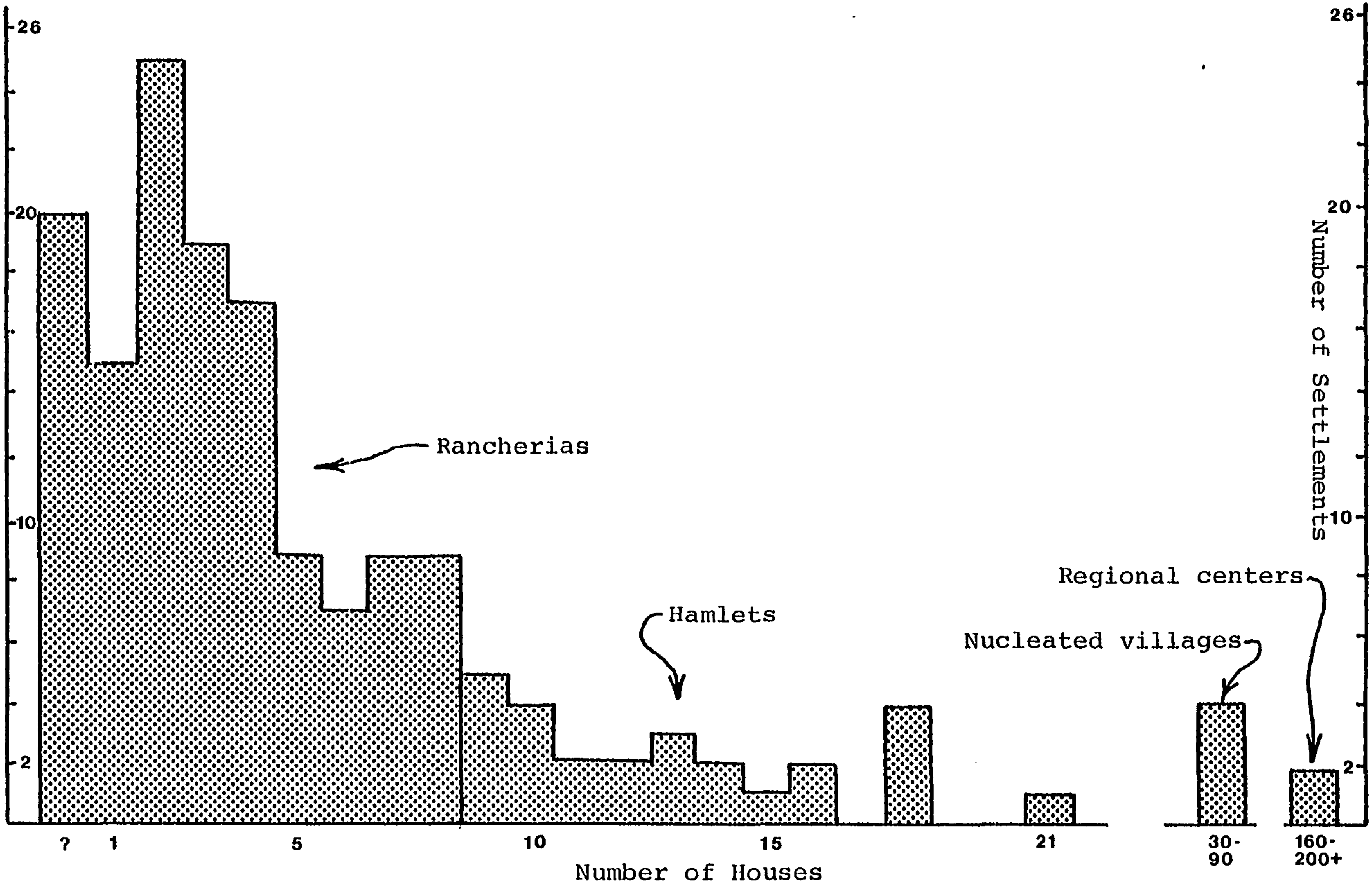


Figure 69. Late Phase Settlement Sizes.

houses and Son K:4:16 OU has possibly 200 houses. Both sites are large and contain public architecture. The former site has a possible ballcourt, the latter an enclosure. These features tend to confirm that these sites served as focal points for some intravalley interaction.

(2) Nucleated Villages. Criteria for this classification group is the same as for the earlier phase. Four (2.5 percent) of the settlements from this late phase are nucleated villages, Son K:4:20 OU, Son K:4:72 OU, Son K:4:120 OU, and Son G:16:27 OU. The only early phase nucleated village grew into a regional center in the late phase. Nucleated villages probably had some extra-community (intersite) functions. Indeed, Son K:4:72 OU contains a possible ballcourt that suggests considerable intersite linkages.

(3) Hamlets. Like villages, the criteria is the same for late phase hamlets as early phase hamlets. During the late phase 26 (16.0 percent) sites were of this category. The smallest hamlet had nine structures, the largest had twenty-one. The two early phase hamlets did not grow into villages. Their architecture was predominantly houses-in-pits. Little growth was noted.

(4) Rancherias. There were 130 (80.2 percent) sites during the late phase that had between one and eight houses. Rancherias are the only site category to show a percentage decrease, in the later phase. Although the actual number of rancherias increased by two-fold, the percentage of sites decreased. The greatest decrease was in isolated resi-

dences. Only 15 (11.5 percent) of such sites existed in this late phase. This drop in number, but increase in site size, suggests population agglomeration and a trend toward nucleation because of increased competition. Like all rancherias, these 130 sites were probably oriented toward subsistence agriculture.

## Patterns and Distribution

Of all the pre-Hispanic settlements in the middle Río Sonora Valley, 65 were inhabited during the early phase of occupation. Fifty-eight of these settlements are located on the bajada edge and were probably riverine oriented (Fig. 70). A nearest neighbor analysis reveals that the distribution of these settlements throughout the entire length of the valley is functionally random (R=1.277). This statistic of distributions, however, may not yield an accurate picture of settlement location in this case. A count of riverine settlements by bank-side and valley segment reveals that 34.5 percent of the sites are located along the west bank in the north half of the valley (Table 23). The majority of sites in the southern half of the valley are located between the modern pueblos of Baviácora and Aconchi, especially along the west bank. This distribution, which appears to be associated with those places where permanent water is found on the floodplain (Table 24; also see Figs. 16 and 70 for comparative pur-

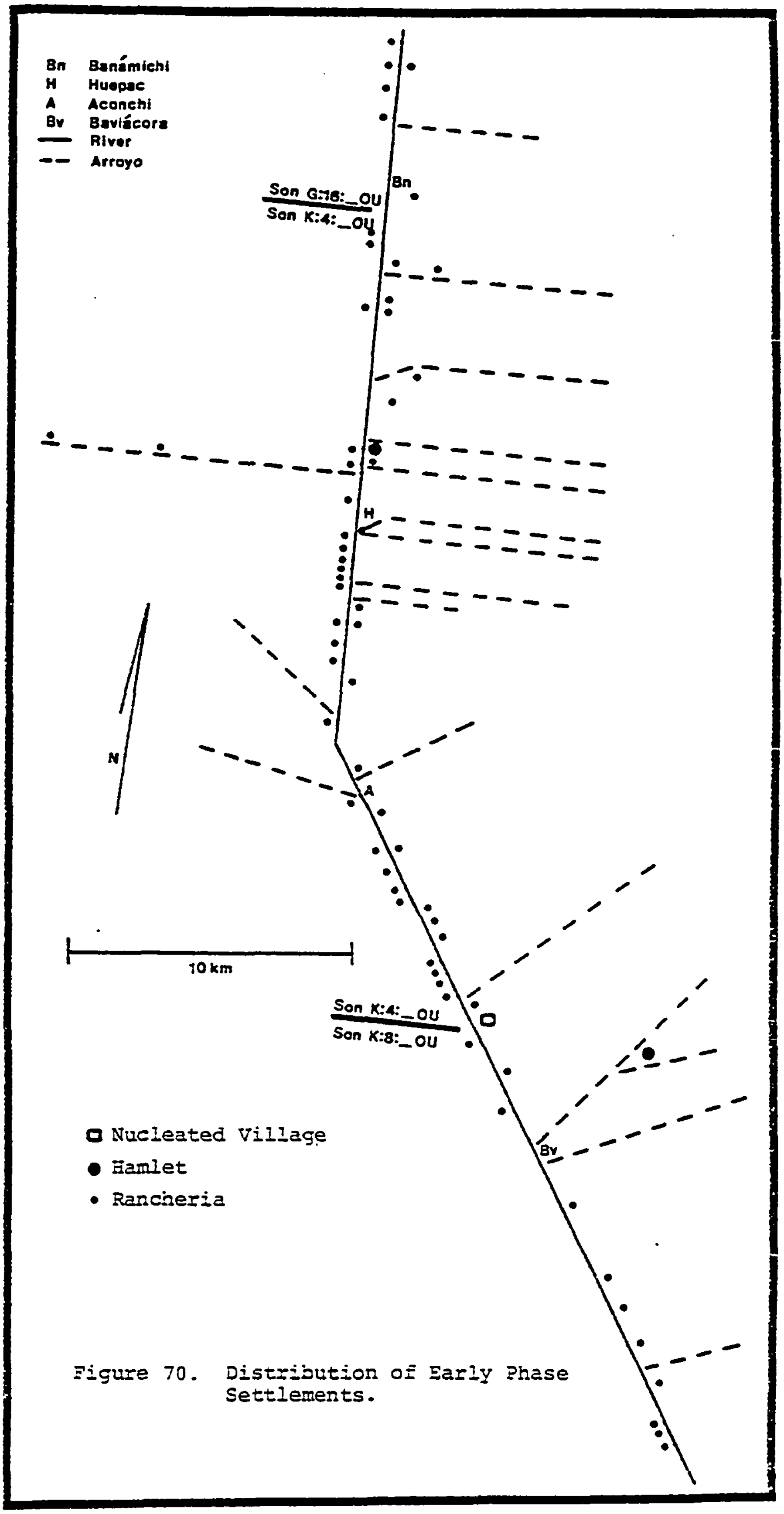


Figure 70. Distribution of Early Phase Settlements.

TABLE 23. Riverine Settlement Distribution[1]

| | West Bank | East Bank | Total |
|---|---|---|---|
| North Segment | | | |
| Early Phase | 20 (34.5) | 10 (17.3) | 30 (51.8) |
| Late Phase | 35 (24.7) | 31 (22.5) | 66 (46.5) |
| South Segment | | | |
| Early Phase | 14 (24.1) | 14 (24.1) | 28 (48.2) |
| Late Phase | 31 (21.1) | 45 (31.7) | 76 (53.5) |
| Total Valley | | | |
| Early Phase | 34 (58.6) | 24 (41.4) | 58 (100) |
| Late Phase | 36 (45.8) | 76 (54.2) | 142 (100) |

[1]Data is extracted and synthesized from Appendix III. Percentages, by phase are indicated by parentheses ( ).

TABLE 24. Distribution of Riverine Settlements to Permanent Water.

| Sites | Water | No Water |
|---|---|---|
| Early Phase (N=58) | 39(67.2) | 19(32.8) |
| Late Phase (N=142) | 100(70.4) | 42(29.6) |

( ) indicates percentages by phase.

poses) is also an essentially random pattern. It is to be expected that roughly two-thirds of the settlements (67.2%; Table 24) would be located near water if two-thirds (approximately 65%; Table 25) of the floodplain contained water.

The distribution of higher order settlements during the early phase, however, were not so random. The highest order site, Son K:4:24 OU (San Jose) is centrally located in the southern half of the valley. This nucleation of houses is located quite near the head of a permanent riverine water source (spring?). That the water is rather high and foodplain somewhat more restricted in the south than in the north would appear to be conducive to a clustering of residences. Indeed, nearly half of the 136 houses-in-pits in the southern segment of the valley are at the San Jose site. One of the two second level settlements, Son K:4:32 OU, is located at the juncture of two large arroyos 3.0 kilometers from the floodplain. The other intermediate settlement is located along the river, but its proximity to a large arroyo suggests that the residents were oriented for both riverine and arroyo exploitation.

The overall distribution of settlement along the middle Río Sonora Valley suggests that the population during early phases of occupation had a largely environmental focus. The location of settlements in proximity to dependable water and other natural resources confirms this

TABLE 25. Distribution of Permanent Water and Riverine Settlement Locations.

N=51[1]

| | Sites | No Sites |
|---|---|---|
| Water (n=33) | | |
| Early Phase | 25(75.8) | 8(24.2) |
| Late Phase | 29(87.9) | 4(12.1) |
| No Water (n=18) | | |
| Early Phase | 12(66.7) | 6(33.3) |
| Late Phase | 17(94.4) | 1 (5.6) |

[1]For analytical purposes the river was graphically divided into fifty-one one-kilometer segments. Thirty three of these segments have permanent water while eighteen are seasonally dry. ( ) indicates percentages.

notion. A considerable portion, 58.6 percent, of the early settlements are located in the mixed scrub-slope ecological zone. As was noted earlier, this zone shows the most promise for natural resource utilization because of the dense and diverse vegetation within a relatively restricted area. That 65.8 percent of the population (assuming houses are surrogates for population) resided in the environmentally favorable southern half of the valley solidifies the environmental focus argument.

Of the 162 sites occupied during the late phase of occupation, 142 were located overlooking the river (Fig. 71). A nearest neighbor analysis reveals that the locations of settlements were less random in this phase than they were earlier (R=.953). Again, the statistic used to assess this distribution is somewhat misleading in that it does not account for bimodal distributions. During the early phase, 16 (27.6 percent) of the settlements had nearest neighbors on opposite sides of the river. In the late phase, six (4.2 percent) of the settlements had opposite bank nearest neighbors. These six sites were located in the extreme northern and southern ends of the valley where floodplain development is minimal. The floodplain width has characteristics of a barrier thereby creating a bimodal distribution that statistically appears as a clustered distribution for late phase settlements. Employing a one-dimensional nearest neighbor statistic indicates that

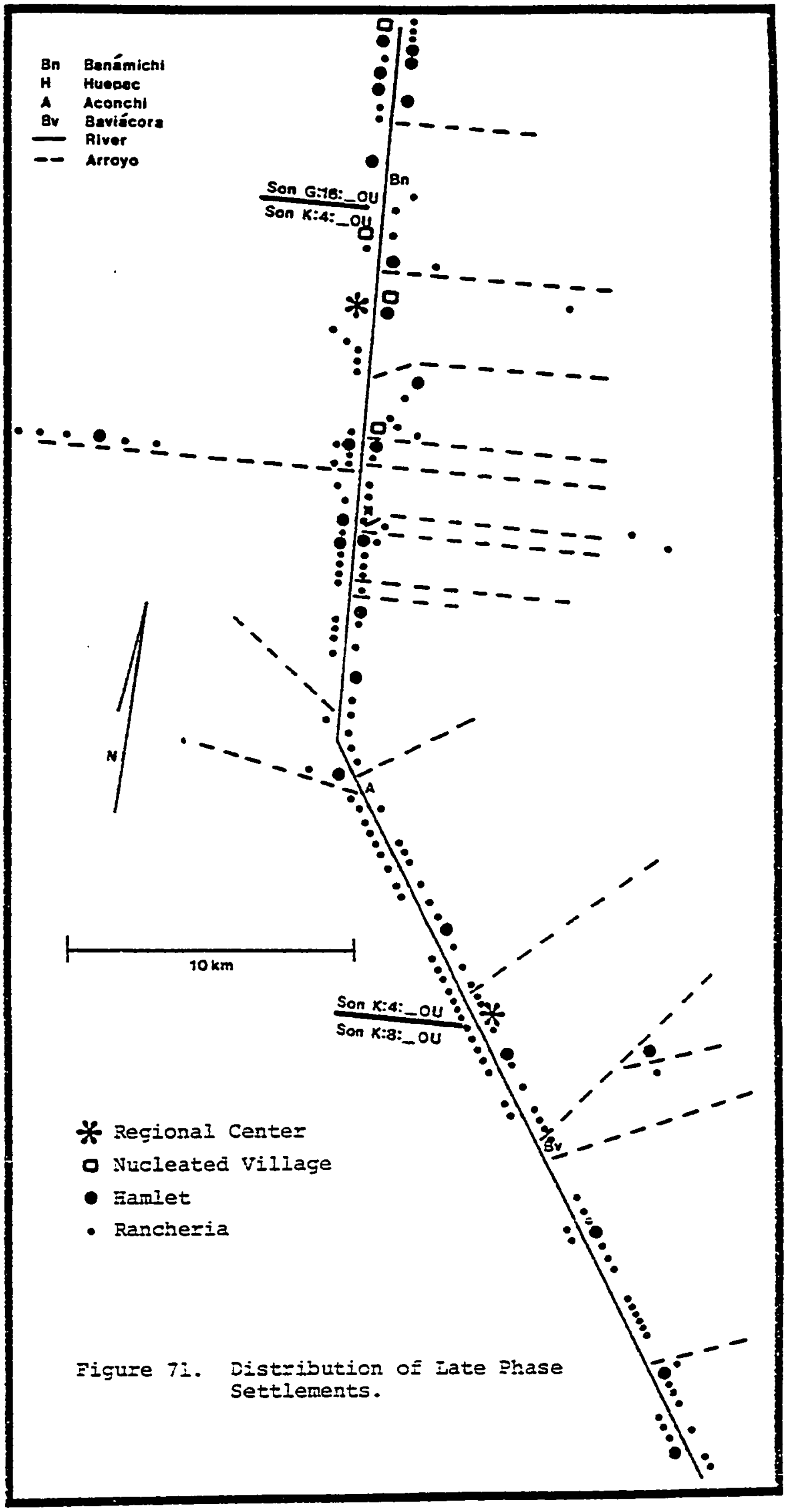


Figure 71. Distribution of Late Phase Settlements.

sites along the west side of the river are clustered (R=.579) while sites along the east side are more randomly distributed (R=.615) (Dacey 1960). Although a marked increase in settlements occurs between early and late phases, occupation along the extreme southern end of the valley along the west bank was only minimally increased.

The habitation preference for the west bank along the north half of the valley seems to have been reduced in the later phase. A more uniform bank-side-valley segment settlement distribution is noted for this phase (Table 23). A marked growth in settlement numbers, however, is noted for the physiographically more uniform east bank, especially in the southern end of the valley. Both those areas with and those areas without permanent water experienced growth in the late phase. The tendency for settlements to be located near areas of permanent water increased slightly during the late phase (Table 24). The necessity of water for intensifying irrigation agriculture to feed a growing population is offered as explanation for this trend. More significantly, however, is the settlement expansion into areas with no permanent water. Where the one-third of the floodplain length without permanent water had 33.3 percent of the early phase settlements, only 5.6 percent of the floodplain length remained unsettled during the late phase (Table 25). In effect, the settlement growth noted in the late phase was sufficiently stressful not only to intensify in those areas with permanent water but also included areas where permanent water is scarce.

The distribution of higher order settlements during the late phase shows signs of more regular spacing than high order settlements of the early phase. Indeed, the development of a hierarchy itself is an indicator of more uniformity of settlement spacing. The appearance of site Son K:4:16 OU, a regional center in the center of the northern valley segment, creates a dual-center dominance of the valley. The second order settlements in the hierarchy are all located in the northern half of the valley. These four sites have a mean interstitial distance of 5.75 kilometers with a standard deviation of 2.54. Half of these sites are reflexive nearest neighbors indicating a clustered to random distribution (Dacey 1960).

The size of these sites is most likely a function of both environmental and sociopolitical interaction influence. Three of these sites, Son K:4:120 OU, Son K:4:20 OU, and Son K:4:72 OU, are situated on the only inhabitable mesas overlooking vast expanses of arable land. For example, site Son K:4:120 OU is situated on the nearest inhabitable mesa to the broad floodplain near Banámichi. The heavily dissected terrain west of the river does not facilitate the locating of settlements. The mesa on which sites Son K:4:20 OU and Son K:4:72 OU are located have similar characteristics. That the spacing and development of second order sites in the hierarchy are at least partially the result of increased sociopolitical organization is suggested by the public architecture at site Son K:4:72 OU.

The sites comprising the third order of the hierarchical system do not appear to be significant in any respect other than size and number. In terms of intersite sociopolitical interaction, these sites show no tendencies toward uniformity of spacing. This condition is especially true in the northern half of the valley. Third order sites on the west side (north segment) of the river have a mean spacing of 2.88 kilometers with a standard deviation of 2.63. The reflexive nearest neighbor index is 0.57 confirming the clustering to randomness in spacing (Dacey 1960). The east bank counterparts of these sites have a mean spacing of 2.09 kilometers with a standard deviation of 1.05. Their spacing index of .45 indicates clustering. Third order sites in the southern half of the valley show a marked tendency toward dispersion. The mean interstitial distance of these sites is 4.14 kilometers with a standard deviation of 1.95. The reflexive nearest neighbor index of 0.667 verifies the random to uniform spacing.

Although the number of arroyo oriented sites increased since the eraly phase, the percent of arroyo to river sites remained nearly the same. Significant, however, is that arroyo sites are small and overall show a decrease through time in sociopolitical importance. Indeed, site Son K:4:32 OU, a hierarchically important arroyo site during the early phase, became a less significant third order site in the later phase.

In summary, a three-tiered community hierarchy existed in the early phase and a four-tiered community hierarchy existed in the late phase of occupance. The development of an extra tier in the hierarchy may be considered an indication of increased cultural complexity of the Río Sonora population. The early sites showed a distinct locational propensity toward gatherable resources--the floodplain-riparian woodland. The increase in number of late phase sites created a more uniform settlement distribution in the early phase by expanding into areas of the floodplain without permanent water. This uniformity of spacing plus the appearance of public architecture at large sites during this phase might be indicative of an increase in inter-settlement economic activity. The two regional centers, one in the north and one in the southern half of the valley, suggest that these sites were the cultural hubs of their respective valley segments.

## Agriculture

Pre-Hispanic agricultural data from the middle Río Sonora Valleys are few but varied. Three types of data--(i) archaeological evidence, (ii) ethnographic comparisons, and (iii) ethnohistorical accounts are pieced together.

## Agrotechonology

Pre-Hispanic channel-bottom weir terraces have been noted at six sites within tributary arroyos of the Río Sonora drainage (Appendix IV; Spencer and Hale 1961). Such features are rather crudely constructed rock walls (Fig. 72), generally found in series (Hack 1942; Woodbury 1961; Bryan 1929). In the Río Sonora, however, such structures are often badly eroded and in many cases only one or two terraces are identifiable (Appendix XIV). These features slowed down runoff, facilitating silt depostion and providing soil moisture (Stewart 1940a, 1940b; Stewart and Donnelly 1943a, 1943b).

Labor input into the activities associated with such agricultural features was relatively low. Initial construction may have involved considerable labor, but once the terraces were built they may have needed little maintainance. Ground preparation was probably limited to shallow tillage. Holes made with a digging stick were surrounded by small mounds of earth. Castetter and Bell (1942) note that channel-bottom weir agriculture carried out by the Pimas included occassional weeding.

Archaeological evidence of other forms of agriculture is lacking. Ethnohistorical reports by the early Spanish explorers and missionaries noted that floodplain agriculture was most prevalent in the early historic and presumably late pre-Hispanic times. The technology involved in carrying out this rather intensive form of agri-

A. Site Son K:8:63 OU.

B. Site Son K:4:34 OU.

Figure 72. Remnant Channel-Bottom Weir Terraces.

culture would have included deep tillage (plowing), permanent canals, large-channel bottom weirs, and constant weeding. Castetter and Bell (1942) and Pfefferkorn (1949) claim that manuring was not practiced prehistorically in Sonora. Intercropping and multiple cropping, however, could have been employed. Many of these practices involve considerable amounts of labor input.

Evidence of labor intensive floodplain irrigation agriculture is provided largely by the ethnohistoric literature (Sauer 1932; Pfefferkorn 1949). It is possible, however, that a large carved rock (site Son G:16:24 OU) found at the edge of the floodplain north of Banámichi might be a map of such an agricultural system (Fig. 73). The similarity between the designs on the rock and the modern irrigation landscape as seen on aerial photography is striking (Fig. 74). Although it was not archaeologically excavated a remnant irrigation ditch was observed paralleling the modern concrete-lined ditch. Whether this relic ditch is prehistoric or not is undetermined. An elderly informant, however, commented that it had not been utilized during his lifetime.

The idea that the glyph rock might be a map of the floodplain was partially verified by the locational characteristics of pre-Hispanic settlements and their noted respective locations on the rock. The locations of sites Son G:16:22 OU and Son G:16:25 OU correspond to the two sets of concentric circles found on the glyph (Fig. 74).

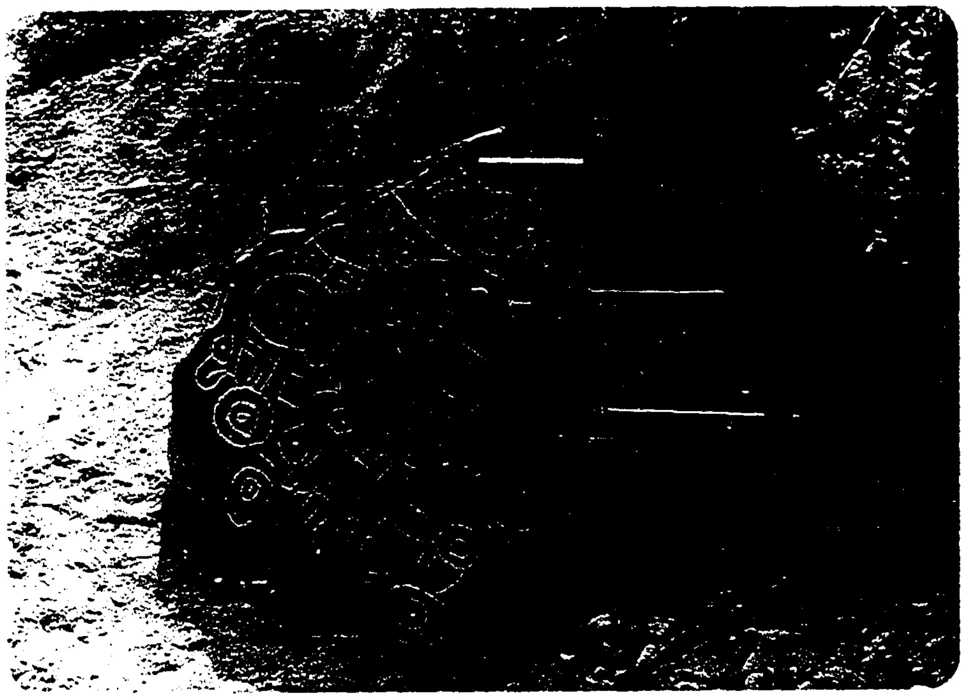

Figure 73. Possible Pre-Hispanic Map of Floodplain Agriculture. Site Son G:16:24 OU. Scale atop rock is .3 meters long.

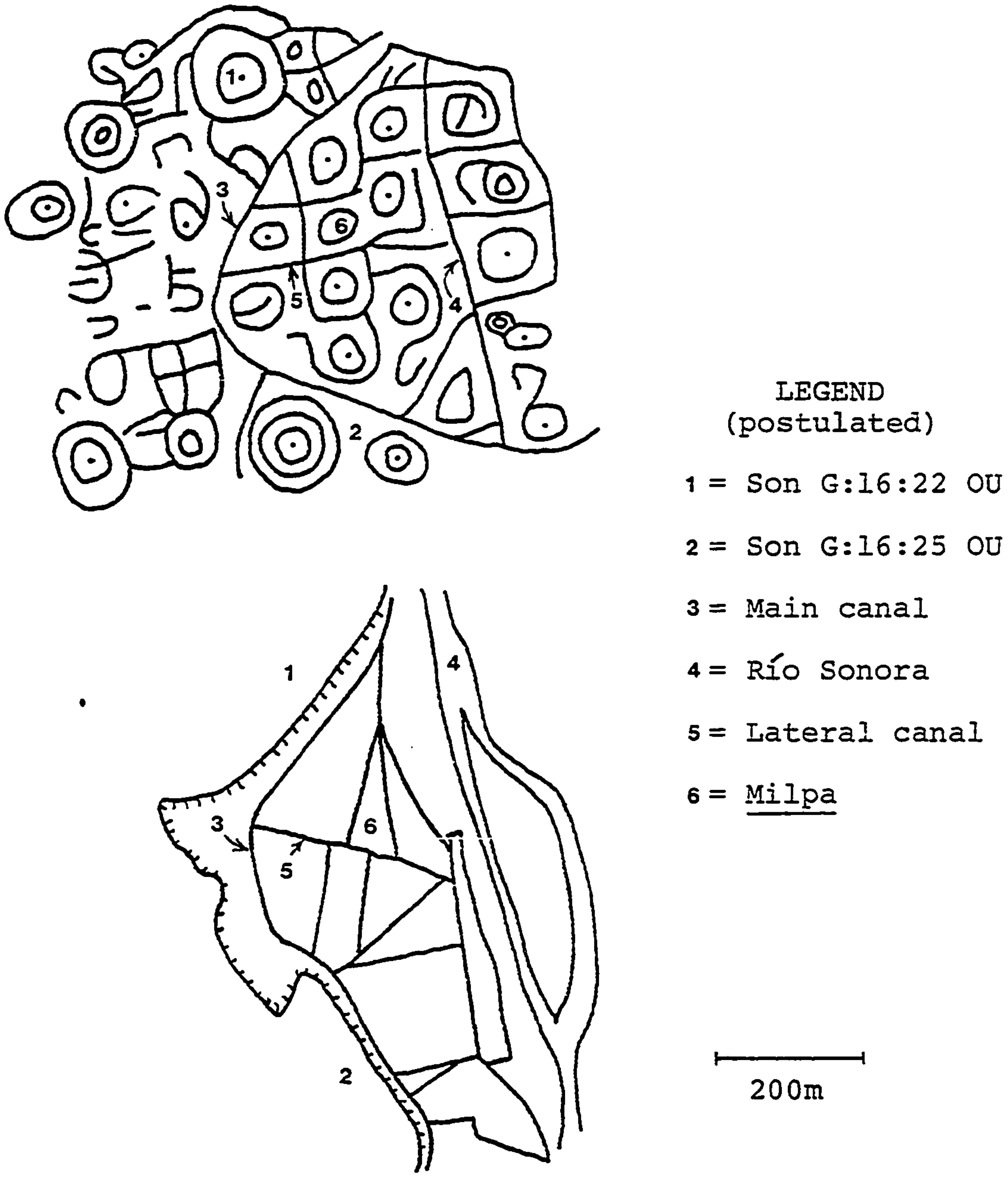


Figure 74. Comparison of Glyph Map with Actual Floodplain.

It is recognized that certain arguments could be made against the similarity of the glyph rock to the modern floodplain conditions. That the river might have changed course is one possible argument. Under constant control by man, however, meandering could have been minimized. That a similarity exists between the location of modern and suspected prehistoric ditches is not without accident. Irrigation ditches are located so as to tap water sources in the most efficient manner. The conditions promoting efficiency were the same in prehistoric times as they are today. In addition, constant utilization and maintenance of ditches is favorable to building totally new ditches.

Weir terrace farming and floodplain farming lie at opposite ends of the agricultural intensity continuum. Today, arroyo-located _temporale_ fields are an intermediate form of agricultural activity. These fields have characteristics of floodwater fields, in that they are rainfall-runoff dependent, and floodplain fields, in their use of canals. The technologies employed in utilizing _temporale_ fields are shallow tillage (small mounding), use of the digging stick, small canals, small-channel weirs, weeding and hoeing. That the pre-Hispanic occupants utilized a form of _temporale_ agriculture is both surmised and highly probable because more intensive and more extensive forms of agriculture were utilized.

## Crops and Cropping

Maize (Zea mays), beans (Phasedus spp.) and squash (Curcubita spp.) were the most common cultivars in all parts of the American Southwest, including the Río Sonora Valley (Carter 1945). Other plants included sweet potatoes (Ipomoea batatas) (Beals 1932), peppers (Capsicum spp.), sugar cane (Saccharum sp.) and melons (?) (Pfefferkorn 1949). Non-edible cultivated plants included gourds (Lagenaria spp.), tobacco (Nicotinana sp.), and cotton (?) (Pfefferkorn 1949). Historically, wheat (Tripsicum sp.), and rye (Hordeum sp.) have been important, but these crops are unquestionably Spanish introductions (Felgar, et al. 1976). Recent investigations in the neighboring Río San Miguel Valley (Felgar, et al. 1976) and in the Río Sonora Valley (Doolittle 1978a) have found that all the crops identified here are grown today on the floodplain using irrigation agriculture. Temporale and weir terrace farming fields would have been suitable only for growing corn and beans during the late summer.

Double cropping is quite important in the Río Sonora Valley today (Doolittle 1978a). This modern market oriented agricultural system involves spring grown wheat and late summer grown corn. That pre-Hispanic residents double-cropped corn is not beyond question. Recent evidence suggests that four varieties of spring grown corn may have been grown in the neighboring Río Sahuaripa Valley in pre-

Hispanic times.[34] During the mid 18th century (when the population level was lower than in late pre-Hispanic times), however, Pfefferkorn (1949) noted that "the earth is plowed only once."

Fertilization of the soil was not practiced aboriginally by the neighboring Pima yet soil depletion was rare (Castetter and Bell 1942:172). The natural fertility of Sonoran river lands is continually replenished with mineral and organic materials deposited by the river during times of overflow. That fields were allowed to lie fallow is possible. Castetter and Bell (1942:172) have noted, however, that fallowing was unknown to the Pimas. To maintain soil fertility, or rather to compensate for depletion, the Pimas planted in mounds rather than rows. According to Castetter and Bell (1942:153)

> All crops were planted with the hills in adjacent rows alternating, and in no case was the soil between the hills worked at planting time. Since no attempt was made to locate hills in the same spots year after year, this was conducive to maintaining soil fertility.[35]

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[34] Personal communication with Dr. Campbell W. Pennington, Department of Geography, Texas A & M University.

[35] They note that maize hills were 80 cm (30 inches) apart.

## Agricultural Intensity

Measuring agricultural intensity has been a task of considerable controversy among scholars concerned with agricultural development. Boserup (1965) considers the frequency of cultivation against constant land and time period. Brookfield (1972) uses the concept of intensity in the traditional economic view, as inputs of capital, labor, and skills against constant land. Turner and Doolittle (1978) recently combined the two schemes into a surrogate measure of agricultural intensity which they consider to be yield per unit area per given time period. In this scheme percentage of time in cultivation is added to weighted values of agrarian technology. Values for cultivation frequencies are developed by comparing time in cultivation with time in fallow. A 1/2:8 crop-fallow cycle (one crop in each of two years followed by eight years of fallow) may be expressed as a 1/1:4 cycle because the standard cultivation unit occurs once every four years of fallow. This cycle is given a value of 0.20 because one crop is cultivated during a five year period. An annual crop cycle, 1/1:0 (one crop per year with no years of fallow) has a value of 1.00 because the standard cultivation unit is repeated each year. A multi-cropping cycle of 2/1:0 (two crops per year with no fallow years) has a value of 2.00 because the standard cultivation unit is doubled each year. The weightings for various techniques are cumulative and range from 0.10 for partial clearance to 0.40 for deep tillage, and 0.20 for temporary slope control to 0.50 for field flooding.

This method of measuring agricultural intensity produces a weir terrace farming value of 1.90; _temporale_ farming, 2.20; and floodplain irrigation agriculture, 3.20 or 4.20, depending on whether one or two crops were planted annually. The implications of these relative indices are quite simple. Accepting the concept of labor efficiency and agricultural production it is reasonable to assume that weir terrace farming later followed by _temporale_ farming, were the earliest forms of agriculture practiced in the middle Río Sonora Valley. As Castetter and Bell (1942) have shown, people relying on weir terrace farming also rely heavily on gathered food resources. In the case of the Pima, this was 50 to 60 percent, primarily _Prosopis_ spp. beans. Settlements, therefore, should theoretically be located proximal to both agricultural lands (Chisholm 1968) (the large arroyos) and _Prosopis_ spp. sources (the riparian woodland). Indeed, this is exactly where house-in-pit sites are found. The largest house-in-pit sites are also proximal to the largest relic floodwater farming sites and the densest _Prosopis_ spp. groves.

Floodplain agriculture involves greater work than weir terrace farming, but provides increased crop regularity, less chances of crop failure, and more total production, especially if double cropping is employed. Following the efficiency hypothesis, utilization of the floodplain would come about only under stress (e.g. population growth, environmental degradation, or coercion). Increased use of the floodplain land for agriculture results in a decline in the supply and demand for *Prosopis* spp. beans. Deterioration of gathered food resources is neatly compensated by the increased dependability and dependence on cultivated foods. The majority of late sites are floodplain oriented.

## Special Sites

Relic settlements and agricultural features are not the only archaeological sites found in the Río Sonora Valley. In many locales lithic and ceramic scatters mark an area where ancient occupants worked or carried out various activities (Appendix IV). The specific functions of these sites is beyond speculation. It will suffice to say that they were either temporary camps or workshop sites. Several sites were noted by broken metates indicating that grinding of food resources must have been conducted at the respective locales. At one weir terrace farming site, Son K:4:42 OU, a one-hand metate was found (Fig. 75). This item was identified as a possible Cochise-type metate used primarily by preagricultural societies for grinding gathered seeds.[36] Interestingly, the modern

[36] Personal communication with Dr. Richard A. Pailes, NSF Project Director.

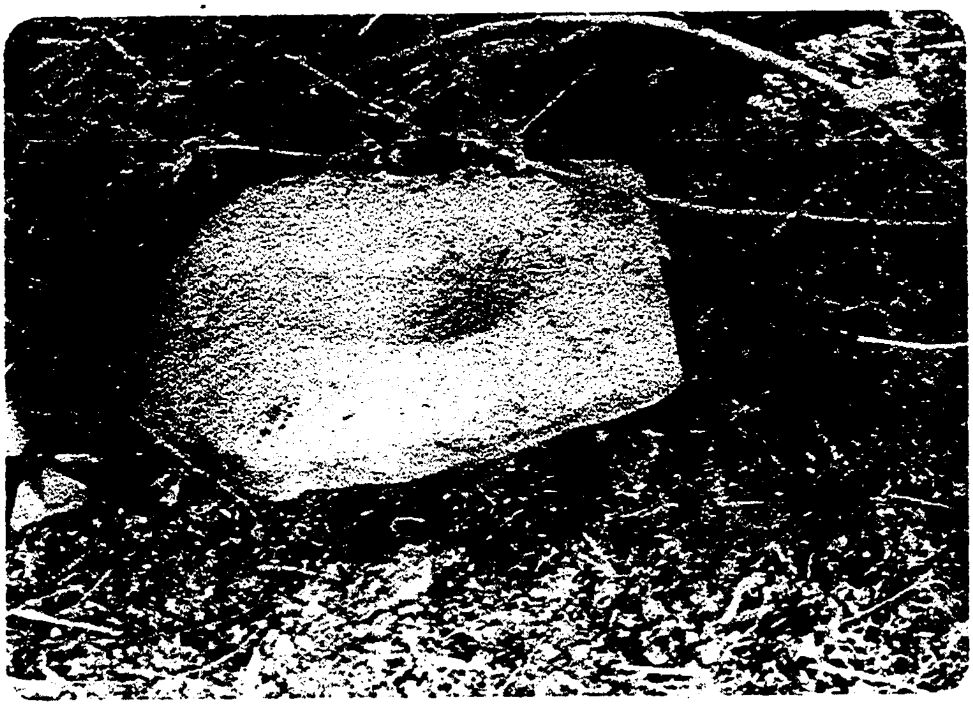
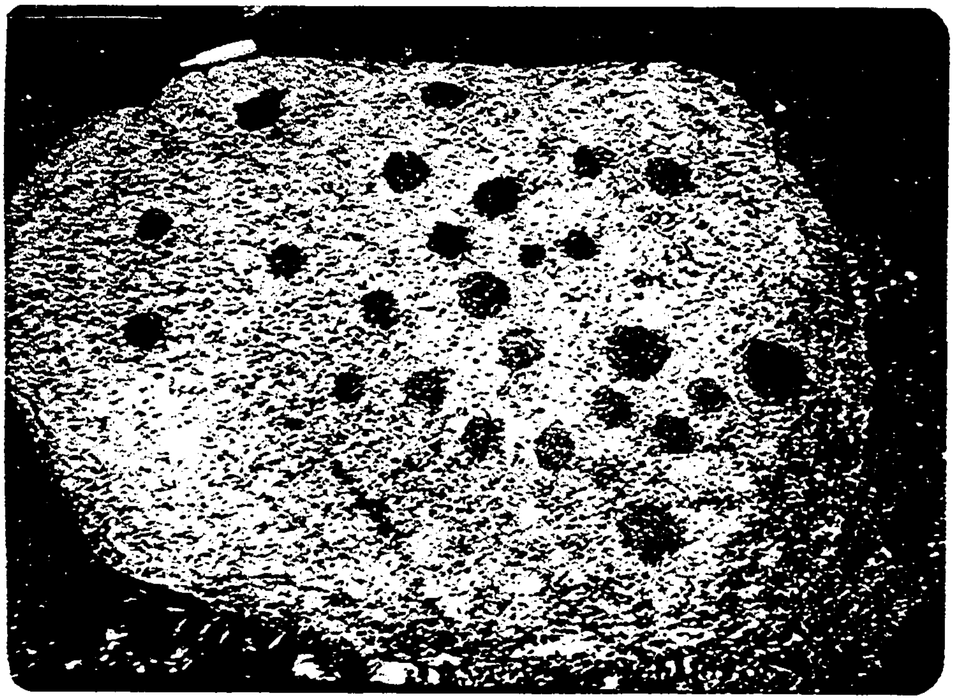


Figure 75. One-hand Cochise-type Metate.

ranch on which the site is located is named "El Bellota", meaning "the acorn". A few sites were marked only by roasting pits. The purpose of these sites is obviously food preparation.

Glyphs are not commonly found in the middle Río Sonora Valley. A few sites, however, have petroglyphs. The possible map at site Son G:16:24 OU has already been discussed. The concentric circle motif found on the rock was also found on a glyph at site Son K:8:60 OU (Fig. 76a). Rocks with several small man-made depressions were found at sites Son K:4:82 OU and Son K:4:53 OU (Fig. 76b). No pictographs were found in the middle Río Sonora Valley. Several are noted from three tributary barranca sites in the upper Valley near Arispe and north of Chinapa (Fig. 77). The meanings of the petroglyphs and pictographs are certainly beyond the scope of this study. Nevertheless, these sites are noted here as cultural evidence of pre-Hispanic occupance. The petropglyphs which obviously involved a great deal of labor, are typically cut in basalt or granitic material. The pictographs were found high on the undercut walls and ceiling of entrenched meanders cut through conglomerates and tuffs. The height of these paintings above the modern arroyo floor (approximately 6 meters) and the configuration of the cut-bank suggests the pictographs are of a very early age (e.g. Butzer, et al. 1979:1207-1210). Indeed, the "Hocker" motif (squared human

A. Concentric Circle Motif. Site Son K:8:60 OU. Outside diameter is approximately 25cm.



B. Circular Depressions. Site Son K:4:53 OU. Depressions are filled with soil for delineation purposes.

Figure 76. Petroglyphs.

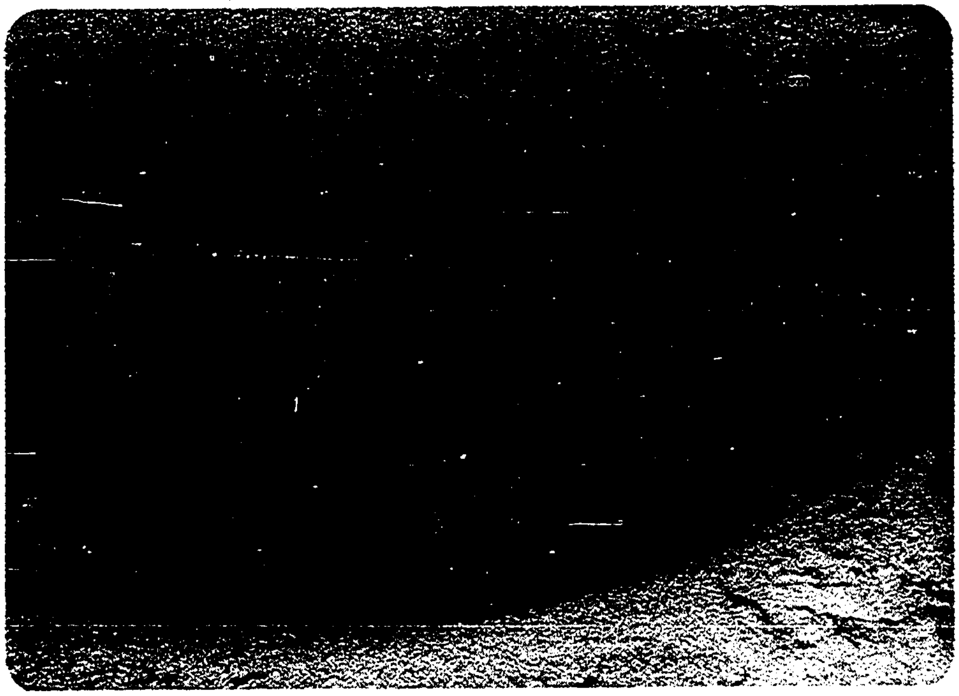


Figure 77. Pictographs. Site Son G:12:13 OU. Ledge where boy is seated is approximately six meters above the barranca floor. Arrow indicates a concentric circle motif.

figure typical of Southwestern pictographs), observed at Son G:12:13 OU, dates earlier than the period of concern for this study. Further downstream from site Son G:16:13 OU is another pictograph. These pictographs at site Son G:16:14 OU are painted only 4 meters above the current arroyo floor. This low height plus the depiction of a man on horseback suggests that this work of art dates into the historic era (Fig. 78).

Probably the most intriguing of all pre-Hispanic non-residential sites in the middle Río Sonora Valley are the hill-top sites marked by small, circular, rock rubble features (Fig. 79). The promotory position of these sites with panoramic views of the valley, each site visible from the next site, suggests that these may have served as a warning system employing fire or smoke signals (Fig. 80).[37] Such a system has been noted at Casas Grandes (DiPeso 1974) and was suggested by Sandomingo (1953) for parts of Sonora, especially in the Opateria.

In summary, settlements throughout the middle Río Sonora Valley are located in relation to agricultural lands, especially the riparian woodland near sources of permanent water. Settlements have been dated as either

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[37]No charcoal was found during the excavation of several of these features. All were eroded to some extent and the downslope side was usually the most heavily eroded part. Burned earth, however, was evident in a few of these features.

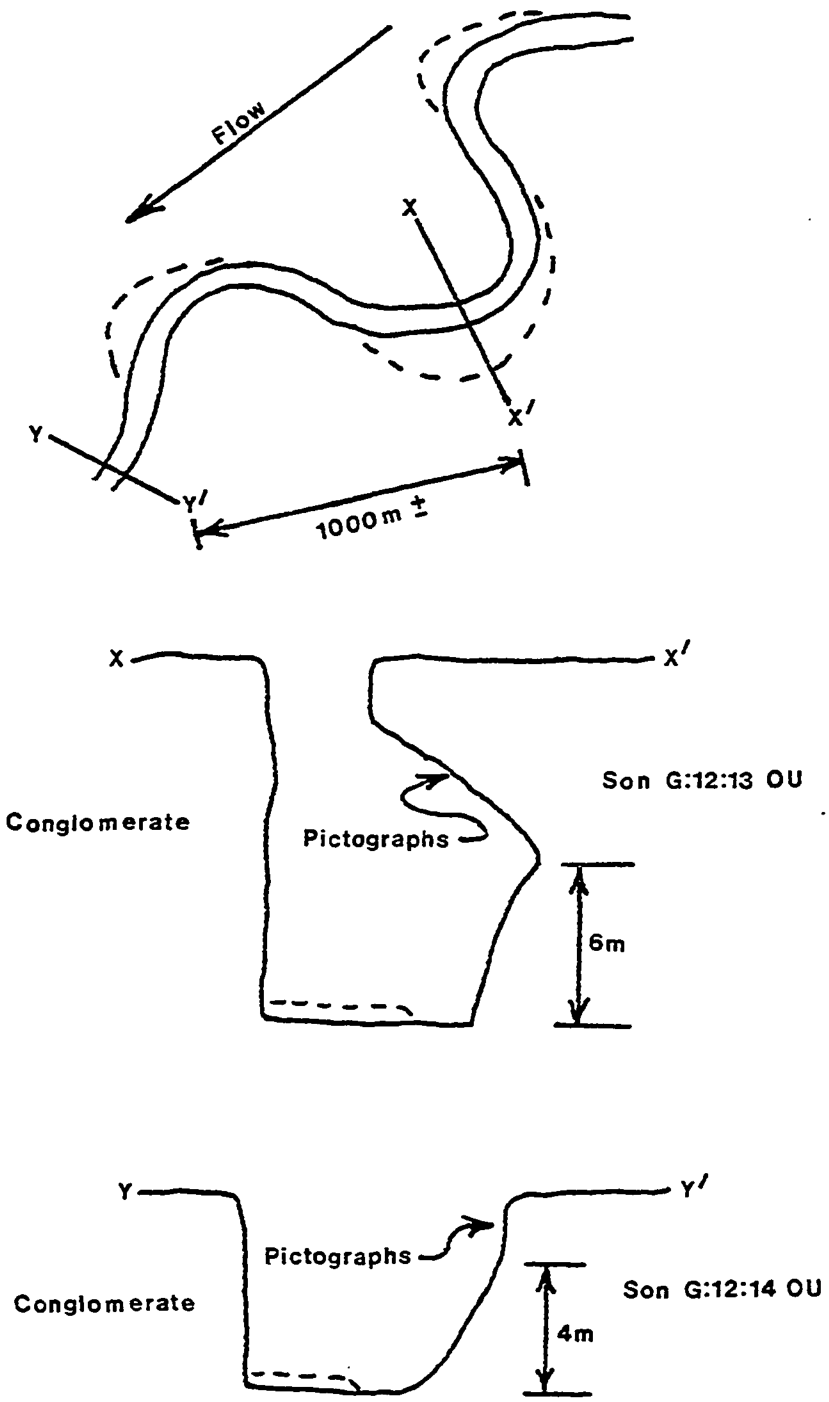
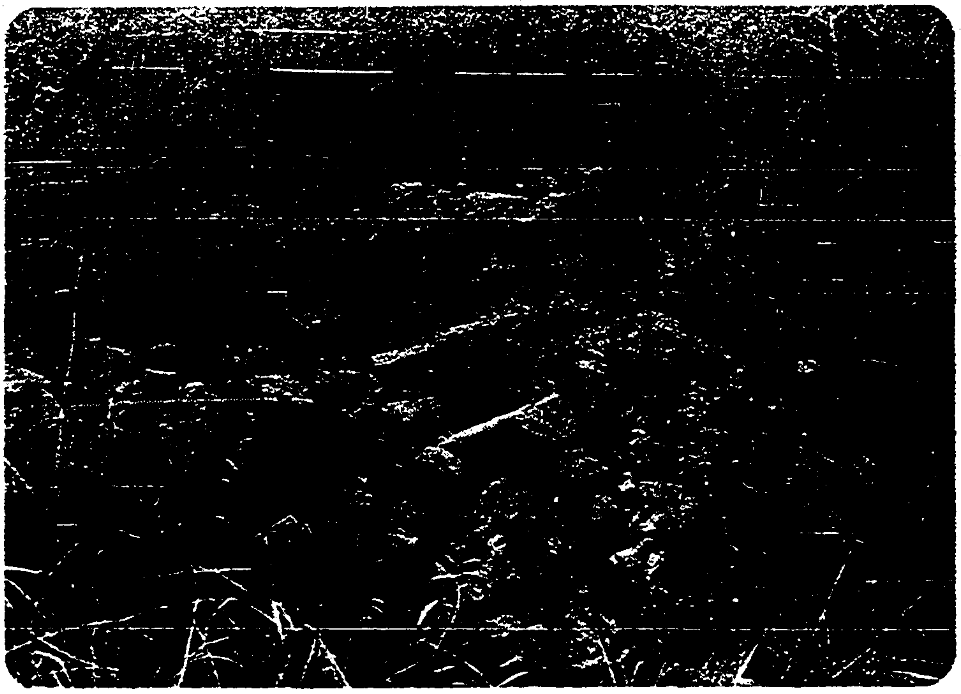


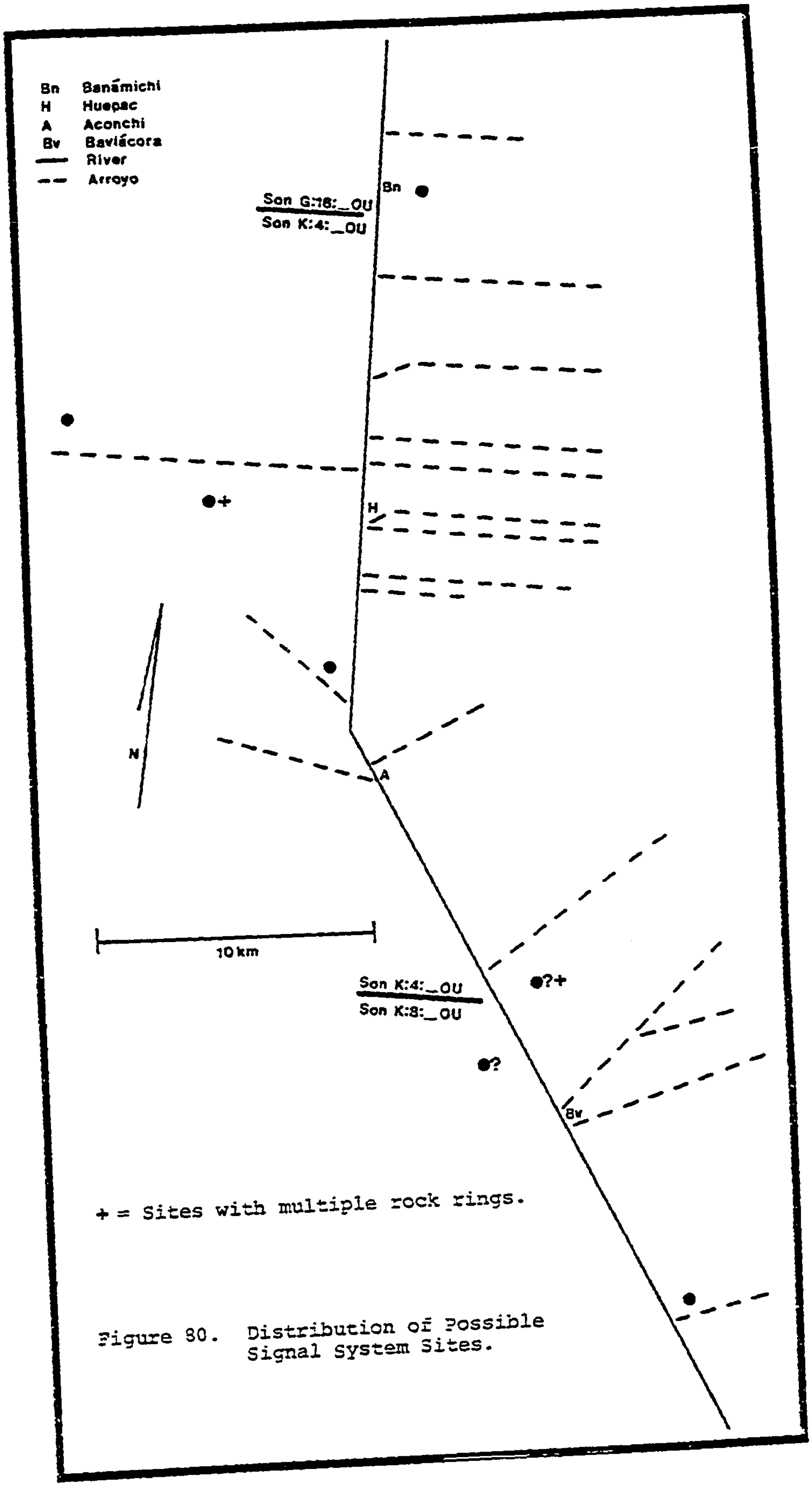

Figure 78. Barranca Entrenchment and Pictographs



A. Site Son K:4:139 OU.

B. Site Son K:4:141 OU.

Figure 79. Possible Pre-Hispanic Signal Sites.




+ = Sites with multiple rock rings.

Figure 80. Distribution of Possible Signal System Sites.

early or late based on architectural characteristics. The distribution, number, and sizes of these sites varied between the early and late phases with indications of a substantially larger population in the late phase. The early phase settlements were fewer in number, with a clustered to random spacing. Late phase settlements were more numerous and more uniformly spaced. A three-tiered and a four-tiered community hierarchy were noted from the early and late phases, respectively. Public architecture also appeared in the late phase. The agricultural practices also appear to have changed through time. The earliest agriculture was extensive and practiced in the arroyos with later more intensive agriculture being carried out on the floodplain.

# PART III

# OCCUPANCE IMPLICATIONS

## DEMOGRAPHY

> It would not be an overstatement to hold that almost every major investigation of pre-Columbian cultural evolution and ecology . . . must ultimately raise the question of Indian numbers (Denevan 1976:1).

### Population Size

Determining prehistoric population sizes or densities is one of the most perplexing and controversial issues concerning archaeologists. Two basic approaches have been used to estimate the size and density of populations in various situations: (i) estimates of specific or actual populations based on settlement data; and (ii) estimates of potential populations based on agricultural assessments. Unfortunately, discrepancies between the estimates obtained from the two approaches usually exist. At best, hypothetical maximum populations can be calculated using the agricultural assessment technique, given that the types of agriculture that were practiced and the amount of lands utilized are known. Alternatively, situations in which agrarian practices are disputed and arable land is not easily determined can lead to estimation difficulties (Turner 1976).

Settlement approach. Several archaeologists have compared modern house numbers and sizes in attempts to estimate prehistoric populations (Naroll 1962, LeBlanc 1971, Haviland 1972). That any one measure is applicable to all places at all times, including Sonora, is doubtful and local or individual measures might be superior. Accordingly, a floorspace per person index was calculated for the middle Río Sonora Valley. A limited survey of contemporary traditional-type adobe houses revealed that the average house in the valley has 28.3 square meters of floor space, and is occupied by 6.3 persons, or 4.5 square meters of floor space per person. A simple regression analysis revealed that the habitant-house size relationship has an $r^2$ of .96 (Appendix XII). The accuracy and importance of these figures should not be taken lightly. Sauer (1935), using baptismal records, found that 6 persons comprised the average prehistoric Sonoran household, some 0.3 persons less than the modern count. Using his index, the average floor space per person would have been 3.9 square meters based on the pre-Hispanic surface structures average size of 23.2 square meters. It is highly likely that the modern houses are somewhat larger than their prehistoric counterparts because they contain material goods not possessed by ancient residents. If this assumption is correct and the modern house floor space is decreased by an arbitrary 15 percent, then the average floor space per person is 3.8 meters. Accounting for material goods, floor space per person in both late pre-Hispanic and modern times are comparable and the average prehistoric household size would have been approximately 6.1 persons.

A total of 224+ houses from 65 settlements were identified with the early phase of occupance.[38] Using 6.1 persons per house, a figure of 1,366+ people is estimated for the valley during this phase. Relic house foundations from the late phase totaled 1,289+ from 162 settlements. Again, applying the 6.1 persons per house figure renders a population of 7,862+ people during the late occupance phase. Accounting for the unknown (+), this figure is not too different from the estimate of 9,000 persons for the valley calculated by Sauer (1935) based on baptismal records. Of course, Sauer's figures are for the historic Opata at a time nearly 100 years after Spanish contact. Given that there is a well documented indigenous population

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[38]The integer indicates the actual number of relic houses identified. The plus sign (+) following the figure is used to indicate that certain sites were heavily damaged and the absolute number of houses was undeterminable. It is highly probable that this number is lower than the actual number of houses occupied during the respective pre-Hispanic phases. Historic destruction and modern development probably obscure many sites. It is also probable that many pre-Hispanic houses are buried under later houses or have been eroded away. The relative proportion of early to late phase houses, regardless of absolute numbers are, however, reasonably accurate.

decline throughout the New World in early post-contact times suggests that the late pre-Hispanic population in the middle Río Sonora Valley was not only at least 9,000, but could have been well over this figure. The highly eroded condition of many of the pre-Hispanic settlements surveyed in this study also suggests that these population estimates might be quite conservative.

Agricultural Approach. Agriculturally based estimations of potential population size or density must be viewed with caution as they are contingent upon numerous assumptions and interpretations. Such estimates, commonly referred to as carrying capacity estimates, rely on formulas which purport to measure, given a particular model of cultivation, the maximum (or actual) population size or density beyond which the process of land degradation will begin (Brush 1977). Specific data required to compute the maximum potential population size or density generally includes the intensity and productivity of the agricultural system in question and the amount of cultivatable land available to the system. Such information pertaining to the early occupance phase in the Río Sonora is sparse because of inferential evidence. Estimates pertaining to the late phase can be better assessed because the type of agriculture that was practiced, intensive irrigation, is known.

Of the 53.0 square kilometers of floodplain that lie above the channel, approximately 75.0 percent or 3,975 hectares (39.75km$^2$) is available for agriculture.[39] Castetter and Bell (1942) demonstrated that 0.4 hectares (1.0 acre) will produce enough maize to feed one person (2.4 hectares per household) using irrigation agriculture on Pima lands. Assuming the Pima figure to be appropriate for other river valleys in the Southwest, including the Río Sonora, then 9,938 people could have been supported by producing one crop per year. Double-cropping half the land (leaving the other half fallow for one year) would also be an alternative maintaining nearly the same population level. This 9,938 figure could almost be doubled if all the land were double cropped annually (assuming that the second crop produces slightly less than the first). Practicing weir terrace and temporale farming simultaneously with floodplain farming and relying partially on gathered food resources would also increase the estimate. In either case a late pre-Hispanic population of around 10,000 is not beyond question. Indeed, Sauer (1935) estimated the pre-Hispanic population to be greater than 9,000.

Despite their shortcomings, the settlement and the

[39] Twenty-five percent is an approximate reduction to account for those lands that are unusable due to lateral channels from arroyos, distance from the water course, and thin or unusable soils. This reduction is based on the approximate amount of floodplain land not under cultivation today (Appendix XI).

agricultural approaches produce similar results for the late phase of occupance. It is accepted here, because a great deal of agreement between the two approaches exists for the late phase, that the settlement approach used for the early phase is also accurate. Of course, a great deal of room for error exists in that any estimates can be reduced to mere exercises by manipulating the variables. Sauer's (1935) estimate based on baptimal records, however, tends to negate discrepancies and add credibility to a maximum population of between 8,000 and 10,000 persons.

## Population Growth

The difference between 65 early sites and 162 late sites, 224+ early houses and 1,289+ late houses, and 1,366+ early people and 7,862+ late people (using the house count figures) suggest a significant population growth in pre-Hispanic times. An accurate estimate of the annual population growth rate, however, is confounded by assigning absolute dates to occupance phases. The earliest data assigned to the early phase is A.D. 1000, while the latest date assigned to the late phase is A.D. 1550. The resultant annual growth rate, assuming a constant exponential growth, would be 0.33 percent (Curve A, Fig. 81).[40] The

[40] It is recognized that the population probably did not grow at a constant rate. Such an assumption, however, is utilized solely for constructing a theoretical argument. Smoothing out short-term fluctuations to construct long-term exponential curves was a practice utilized in recent population work (Meadows, et al. 1972). The growth curve was constructed by the exponential equation, $P_t=(1+r)^t$ where: $P_t$ is the number of houses at time t, and r is the rate of change (Shryock and Siegel 1973:381).

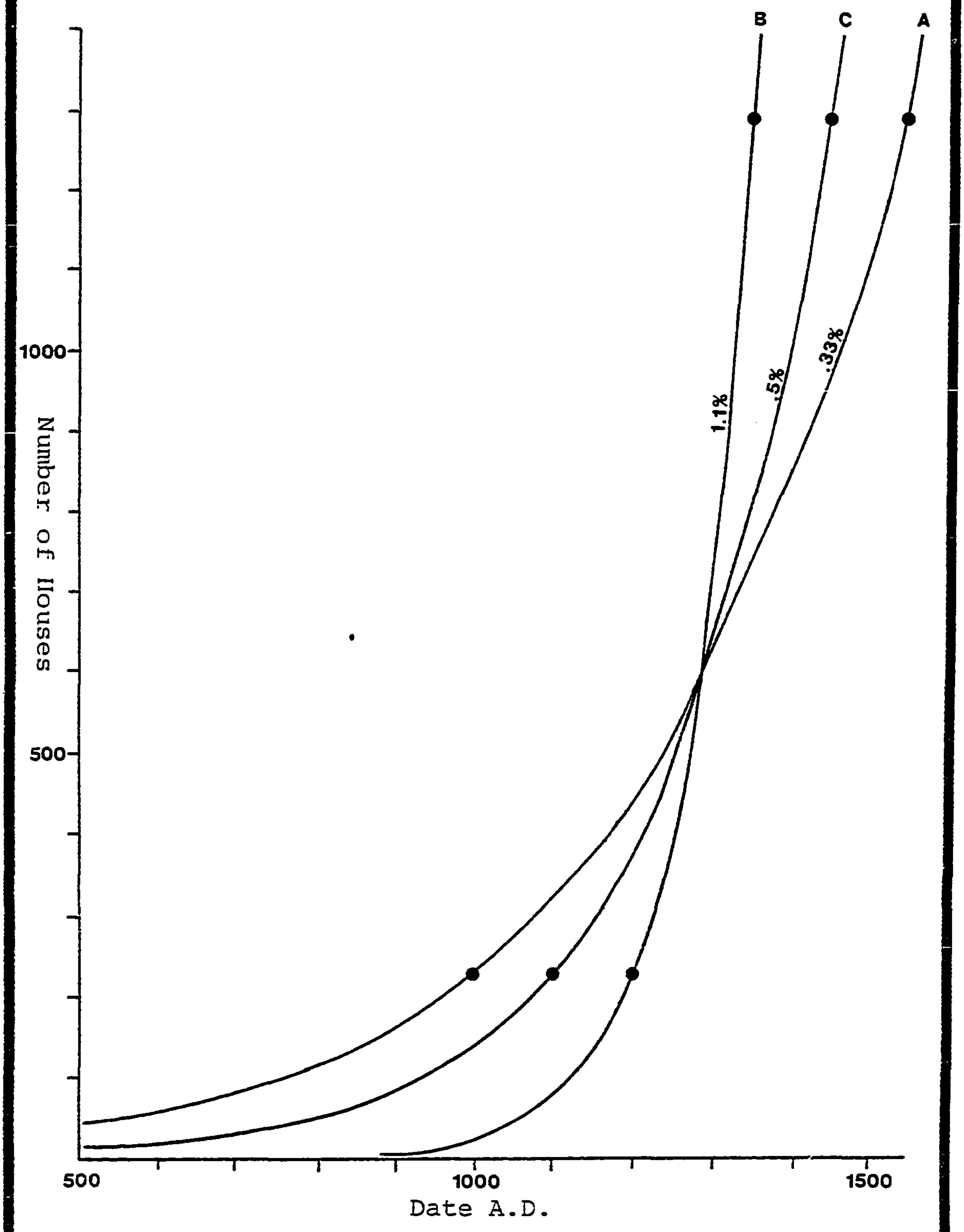


Figure 81. Population Growth as Estimated from Extrapolated House Counts.

latest date assigned to the early phase and the earliest date assigned to the late phase are A.D. 1200 and A.D. 1350, respectively. The estimated annual growth rate using these figures would be approximately 1.1 percent (Curve B, Fig. 81).

Perhaps a somewhat more realistic (at least less extreme) approach is to calculate the rate of change between an intermediate early date, ca. A.D. 1100, and an intermediate late date, ca. A.D. 1450. As would be expected the annual rate of growth between these phases is greater than .33 percent and less than 1.1 percent (Curve C, Fig. 81). The rate calculated for growth between intermediate dates is 0.5 percent.[41]

As is characteristic of all exponential curves, there is a point following an extended period of little incremental increase where a dramatic increase occurs, creating the illusion of a population "explosion." This point can be determined graphically by noting where along the curve the slope becomes more vertical than horizontal.[42]

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[41]The previously recognized house count discrepancies are especially crucial when estimating population growth rates. A calculated curve based on 448 early phase houses (the actual house count doubled) and 1,289 actual late phase houses resulted in a .33 percent annual growth rate. A second calculated curve in which both the early and the late phase actual house counts were doubled resulted in a .6 percent annual growth rate.

[42]The change in slope is an arbitrary measure. Using this approach is not always applicable because of the incremental differences that may occur between the ordinate and the abscissa. The 45° change in slope is acceptable, however, for graphics which are basically square.

Interestingly, the curves for the highest and lowest growth rates both have take-off points ca. A.D. 1100.

In summary, the population of the middle Río Sonora Valley in pre-Hispanic times grew at a theoretical rate of somewhere between .3 percent and 1.1 percent annually, with a probable rate of approximately .5 percent. The assumed exponential growth also resulted in an apparent population explosion sometime around A.D. 1100. In addition, the population level known to have existed in early historic times could have developed from the internal growth of a few households in less than 1000 years. Immigration, although a possible occurrence, need not be interjected as an agent of growth to understand such a rapid growth rate.

## Population Distribution

Thirty-six (55.4 percent) of all early phase sites are located in the northern half of the middle Río Sonora Valley while only 85 (37.9 percent) of the houses from this phase are located there (Table 26). Of the 139 (62.1 percent) southern houses, 60 (26.8 percent) are located on the San Jose Site (Son K:4:24 OU). In other words, excluding the one nucleated village, the population was uniformly distributed between the northern and southern halves of the valley during the early phase. We cannot, however, simply exclude the one major site. The dates stand as they are and the population in the southern segment was

TABLE 26. Early Phase Settlement and Population Distribution.[1]

| | | Riverine | Arroyo | Total |
|---|---|---|---|---|
| North Segment | | | | |
| | Settlements | 30 (46.2) | 6 (9.2) | 36 (55.4) |
| | Population | 66+ (29.5) | 19+ (8.4) | 85+ (37.9) |
| South Segment | | | | |
| | Settlements | 28 (43.1) | 1 (1.5) | 29 (44.6) |
| | Population | 127+ (56.7) | 12+ (5.4) | 139+ (62.1) |
| Total Valley | | | | |
| | Settlements | 58 (89.3) | 7 (10.7) | 65 (100.0) |
| | Population | 193+ (86.2) | 31+ (13.8) | 224+ (100.0) |

[1]Relic houses are used as a surrogate for households, and hence, population. ( ) indicates percentages by phase.

nearly twice that of its northern counterpart. Paradoxically, the floodplain development is twice as great in the northern half, increasing the population per land discrepancy from a factor of 2 to 4+. In other words, of the 3,975 hectares in the valley, approximately 2,645 are in the north and only 1,324 are in the south. The resulting land per household ratio (calculating only arable land) would be 40.1 hectares per northern household and 10.4 hectares per southern household. As both of these figures still are considerably above the minimum requirement of 2.4 hectares per household it can be concluded that despite the differences in population density, minimal stress was placed on the environment. In fact, it is highly doubtful that all the arable land was used during this phase. That the population and settlement density is not uniform is probably a function of the availability and dependability of water and other gatherable resources. That most of the southern section has permanent available water probably promoted early occupance in this section. It is the proximity of the western mountain range that results in a high bedrock surface allowing for shallow ground water flow and, hence, numerous springs and permanent water in the southern section.

During the late phase the distribution of settlements became more uniform. Eighty-two (50.6 percent) were located in the north and 80 (49.4 percent) were located in the southern segment (Table 27). The disparity in population between

TABLE 27. Late Phase Settlement and Population Distribution.[1]

| | Riverine | | Arroyo | | Total | |
|---|---|---|---|---|---|---|
| North Segment | | | | | | |
| Settlements | 66 | (40.7) | 16 | (9.9) | 82 | (50.6) |
| Population | 763+ | (59.2) | 68+ | (5.3) | 831+ | (64.5) |
| South Segment | | | | | | |
| Settlements | 76 | (46.9) | 4 | (2.5) | 80 | (49.4) |
| Population | 437+ | (33.9) | 21+ | (1.6) | 458+ | (35.5) |
| Total Valley | | | | | | |
| Settlements | 142 | (87.6) | 20 | (12.4) | 162 | (100.0) |
| Population | 1,200+ | (93.1) | 89+ | (6.9) | 1,289+ | (100.0) |

[1]Relic houses are used as a surrogate for households, and hence, population. ( ) indicates percentages by phase.

the north and the south shifted drastically. In fact, the proportional shift exactly reversed itself (Table 28). Where 37.9 percent of the population lived in the north during the early phase, 64.5 percent inhabitated the area in the late phase. This shift had the effect of equalizing the ratio of hectares per household throughout the valley. The resultant proprieties (calculating only arable land) would be 3.5 hectares per household in the north and 3.0 hectares per household in the southern segment. These figures are still greater than the minimum requirement of 2.4 hectares per family. If, however, (and there is every reason to believe that) the house count is a conservative figure then we see that the land during this phase is either incurring stress or is somewhat past the stress point. It is reasonable to assume that floodplain irrigation agriculture was at, or approaching, its zenith at this time.

Both arroyo settlements and population comprised less than 15.0 percent of the total valley counts during both phases (Tables 26 and 27). There are some significant aspects to these figures nevertheless. The southern segment had, during both phases, substantially fewer settlements and arroyo inhabitants than did the northern segment. Perhaps this circumstance was a function of fewer arroyos in the south. Although the arroyo settlements did not decline in percentage (they actually increased in number) during the late phase, the arroyo-oriented population

TABLE 28. Relative Percent Changes Between Early and Late Phase Settlement and Population Distributions.

| | Riverine | Arroyo | Total |
|---|---|---|---|
| **North Segment** | | | |
| Settlements | -5.5 | +0.7 | -4.8 |
| Population | +29.7 | -3.1 | +26.6 |
| **South Segment** | | | |
| Settlements | +3.8 | +1.0 | +4.8 |
| Population | -22.8 | -3.8 | -26.6 |
| **Total Valley** | | | |
| Settlements | -1.7 | +1.7 | 0 |
| Population | +6.9 | -6.9 | 0 |

did decline (Table 28). Only 1.6 percent of the late phase southern population resided in arroyo settlements. No conclusive statement can be made concerning arroyo population, although it is safe to say that an almost insignificant number of persons continued to live in arroyo settlements and presumably practice extensive weir terrace farming and wild food resource gathering.

The population shift from the south to the north is not a casual occurrance. This shift had a definite and demonstrable cause and carried within it significant implications. The primary cause was the rapid growth that took place in the valley (Fig. 81). Such growth implemented sufficient stress that agriculture expanded into previously little used territories especially in the northern section.

## Agricultural Sequence

It is reasonable to assume, although no evidence exists, that the earliest inhabitants of the middle Río Sonora Valley were largely foragers and their decendents foragers and incipient agriculturalists. Those later ancients who practiced both gathering and seasonal agriculture relied on an extensive form of agriculture. The most extensive form of agriculture for which there is evidence is weir terrace farming. Only one crop per year can be produced from such fields and in all likelihood, the crop would not be large enough to free one from a reliance on wild food resources. Accordingly, the earliest agriculturalists probably had an arroyo orientation. Although the evidence is tentative, there was a denser arroyo oriented population during the earlier phase than in the late phase (Tables 27, 28, and 29). If the predictive value of the theoretical exponential curve (Fig. 81) is at all accurate then it may be reasonable to assume that such an incipient agricultural population occupied the valley prior to A.D. 700 and certainly before A.D. 1000.

The early phase, noted by house-in-pit architecture probably marked a period of subsistence change. With the population located predominantly along the river, but with a surplus of arable land. The abundance of land suggests that simple irrigation agriculture was beginning to be practiced only close to the river channel or where water was available (springs?). The part of the valley where such conditions were best available is in the southern section (Fig. 16). <u>Temporale</u> farming was also probably practiced at this time.

The population shift to the northern half of the valley was probably the result of increased stress placed on arable lands in the south. In effect, the 10.4 hectare per household in the southern segment was reduced to, but not less than, 3.0 hectares because the population expanded northward bringing newer lands under tillage. During the late phase the entire arable portion of the floodplain was

TABLE 29. Possible Populations, Crops per Year, and Carrying Capacities (Late Phase)

| | A | B | C | D |
|---|---|---|---|---|
| Population | 7,862 | 7,862 | 15,724 | 15,724 |
| Households | 1,289 | 1,289 | 2,578 | 2,578 |
| Crops/Year | 1 | 2 | 1 | 2 |
| Total Land in Crops | 3,975 | 7,950 | 3,975 | 7,950 |
| Hectares/Household | 3.1 | 6.2 | 1.5 | 3.1 |

Note: 2.4 crop-hectares are needed for one household (6.1 persons) to sustain itself for one year.

probably being used.

This sequence relies entirely on the notion of subsistence agriculture and the concept of labor efficiency. It is also based on the idea that the level of population attained during the period of maximum occupation could have been supported by one crop per year (Table 29, A). The example from the Pima, however, indicates that two crops are possible. As Castetter and Bell (1942) and Pfefferkorn (1949) have demonstrated, the Pima double cropped cotton and drought resistent strains of maize. Crop failures are compensated by reliance on gathered foods, predominantly Prosopis spp. beans. Evidence of a similar double cropping system might be emerging for the Río Sonora Valley.[43] It is possible that the Río Sonoran population was twice as large as originally estimated, supported by double cropping (Table 29, D), or agriculture was devoted to both food crops and cotton. In the latter case the 7,862+ population figure would be close to accurate and the ancients could have possibly produced more cotton than they required to satisfy their cultural need (Table 29, B). That a surplus of cotton was exported to Mesoamerica has been suggested by Pailes (1978a). It is, of course, possible that a

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[43]Flotation analysis by personnel on the larger project have recently uncovered traces of cotton fiber found during excavations. Rumex sp. pollen was also found in excavations. Rumex sp. is a dye-producing plant often used by prehistoric Amerinds. Spindle whorls were also found in both excavations and surface surveys. Spindle whorls were used prehistorically for spinning cotton fibers.

population between the minimum 7,862 and the two-fold maximum could have existed with the ancients producing only enough cotton as needed for local use (Table 29, Variation of A). That a population twice as large as the original estimate could have existed on a single crop is out of the question. A population of this size, would have exceeded the carrying capacity and the biological requirement would not have been satisfied unless the land was multi-cropped (Table 29, C).

## Settlement Systems

Concomitant with the population increase and agricultural intensification came a shift in settlement patterns. The change in patterns is the result of changes in social organization, probably resulting from changes in food procurement and cultural complexity. The late phase appearance of public architecture not existant in the early phase is evidence of the increased sociopolitical importance of some sites. Most notable is the evolution of two regional centers, one centrally located in the northern section, and one centrally located in the southern section of the valley. The location of these sites relative to surrounding sites and the physical environs (valley segments) is noted by the construction of hinterland breaking points between regional centers.[44] The hinterland breaking point is 14.0 kilometers

[44] The breaking-point formulation used in this anaylsis was that modification of Reilly's (1929, L931) equation noted in footnote 14.

south of the Las Delicias site, Son K:4:16 OU and 11.5 kilometers north of the San Jose site, Son K:4:24 OU. This boundary is approximately half way between the modern pueblos of Aconchi and San Felipe and corresponds to the change in direction of river flow. Demographically, over 5,000 persons resided in the north segment, and nearly 2,800 in the south. Ethnohistoric evidence of the regionalization of settlements in the Las Delicas interaction field is found in the notes of Bandelier. According to a local resident, Pedro Calistro:

> Previous to the (Spanish) Conquest, the pueblos of Banámichi, Huepaca, Aconchi, Sinoquipe, formed one [dialect], which was [centered?] at Badeuachi, near Las Delicias, where the ruins are still visible. After the conquest, they divided into the four pueblos mentioned (Lange and Riley 1970:242).

The sociopolitical division of southern and northern halves of the valley has anthopological and historical implications that may exceed settlement evolution alone. Although these implications are largely beyond the scope of this work, they are noted to demonstrate that an intra-valley division developed in the late phase, and that such a division is evident in the settlement pattern and surficial data. In effect, population growth and all its related changes are evidenced by various occurrences. The frequency with which obsidian artifacts are found is greater in the southern segment than in the north (Fig. 82). The locations of Cerro de Trincheras, (Fig. 56), sites with enclosures

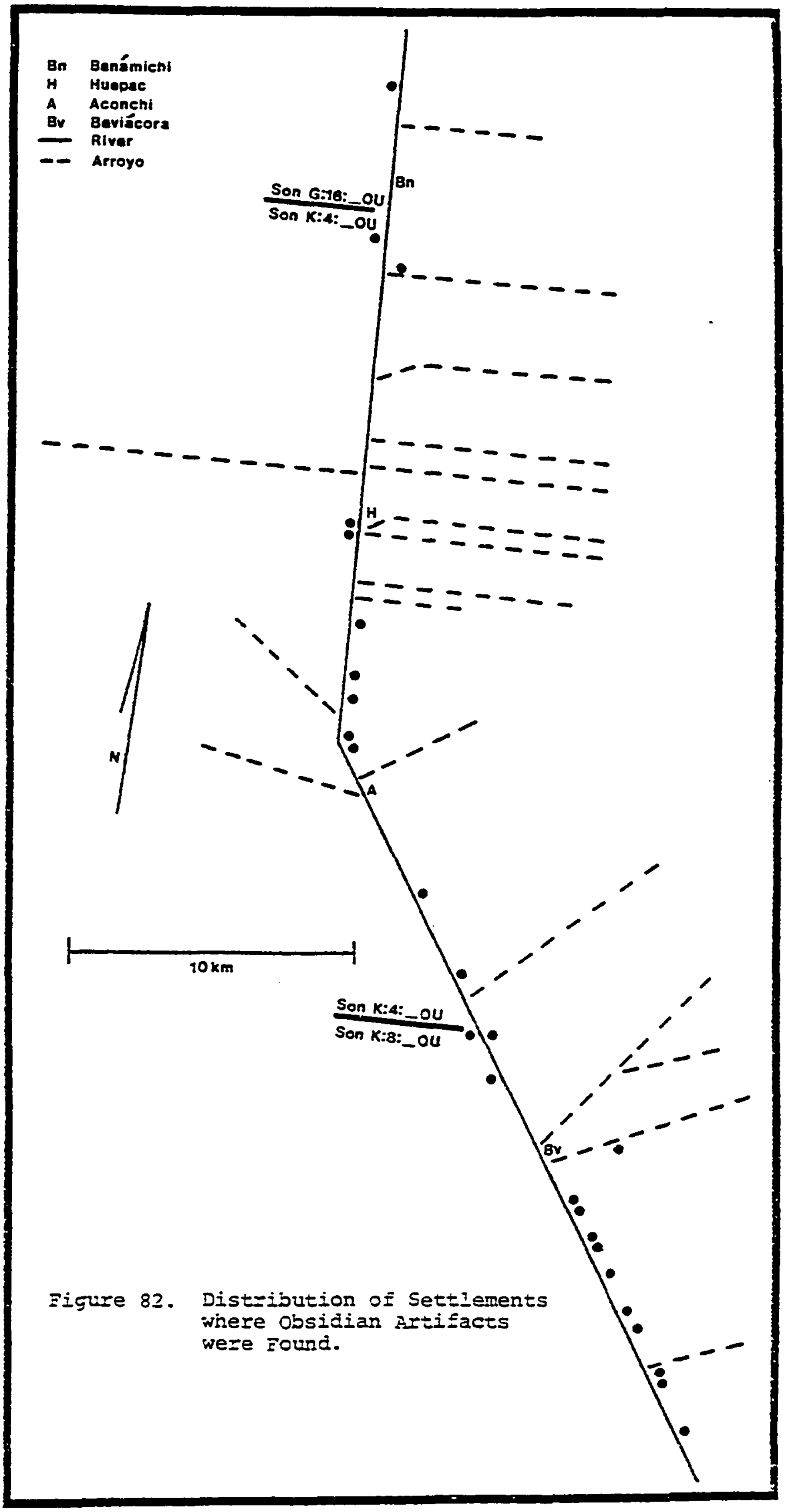


Figure 82. Distribution of Settlements where Obsidian Artifacts were Found.

(Figs. 61, and 62), sites with Trincheras-type walls (Fig. 65), and sites with house mounds and Trincheras houses (Fig. 83) are all found predominantly in the northern half of the valley. Although the distribution is not mapped, Trincheras purple-on-red ceramics were found with greater frequency in the northern segment. The high frequency of Trincheras foundations along the large arroyo west of the modern pueblo of Huepac may indicate the route of Trincheras cultural intrusion. This large arroyo provides one of only two routes of access across the western mountains into the Río San Miguel drainage. The other pass is just north of the study area, south of the modern pueblo of Sinoquipe. At sites along this arroyo Trincheras foundations were also noted. This evidence tends to suggest that the northern segment of the valley was influenced during the late phase by peoples of the Trincheras culture.[45] The link between the northern half of the valley, the San Miguel and points west was verified by informants at Banámichi who relayed to Bandelier in 1884 that:

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[45] Pailes (1972:389) originally stated that interaction between the Río Sonora and Trincheres cultures must have been post A.D. 1100. In a recent communication however, Pailes suggests an alternative hypothesis in which Trincheras peoples occupied the valley during early times but were later pushed out (westward) by intrusion from Chihuahuan cultures. The Cerros de Trincheras were constructed during the intrusion for which a late date is not only speculative but logical.

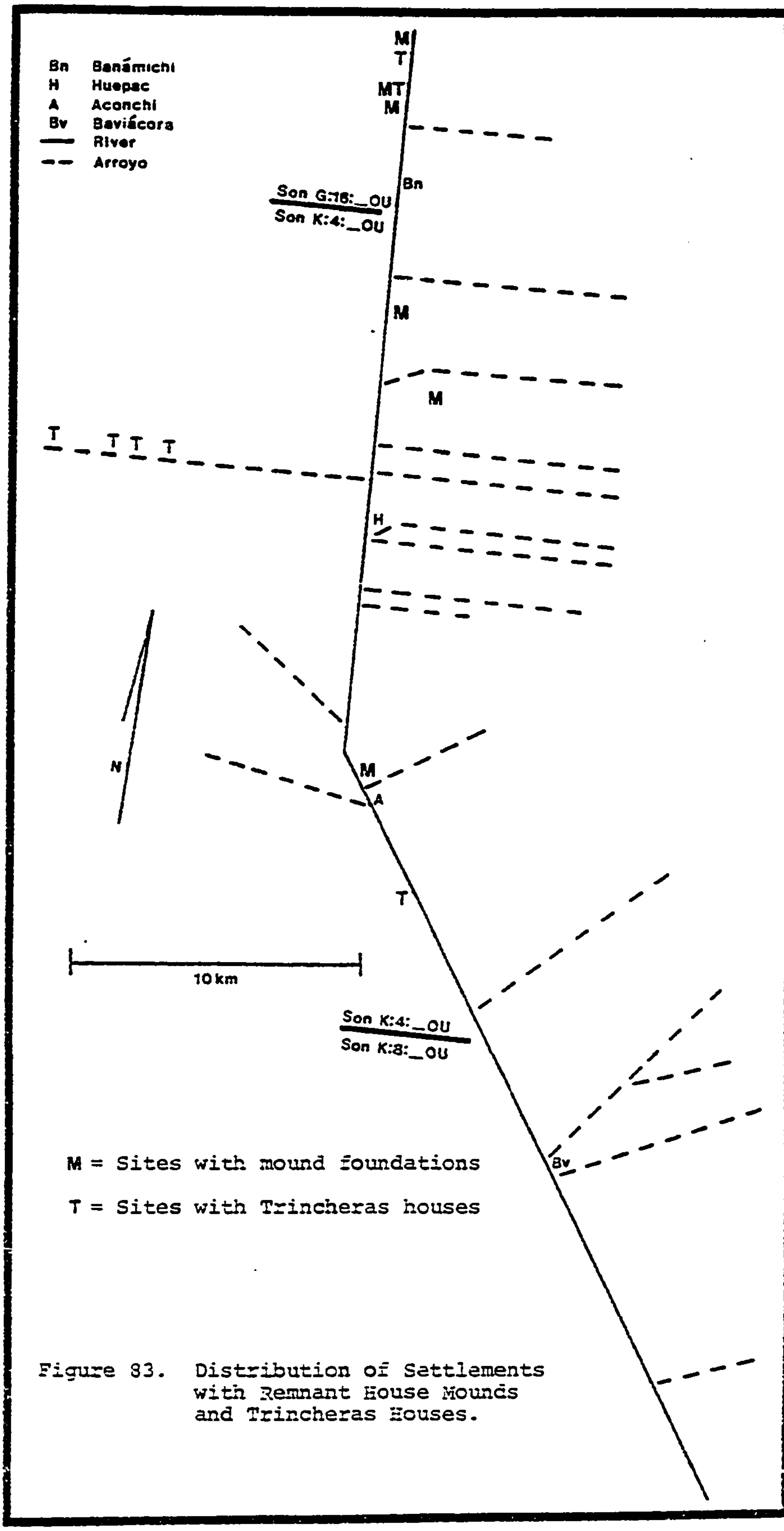


Figure 83. Distribution of Settlements with Remnant House Mounds and Trincheras Houses.

> The Opata are divided into two dialects: those of Bacuachi, Arispe, Chinapa, Huepaca, Aconchi, and Babiácora being one; Banámichi, Sinoquipe, Opodepe, Toapa, Cucurpe, Soyapa, Tres Alamos, etc., forming the other (Lange and Riley 1970:242).[46]

The sphere of influence of the San Jose site, Son K:4:24 OU, cannot be documented by ethnohistorical records as can its northern counterpart. Nevertheless, the limitations imposed by the physical environment impeded settlement to the south, thereby creating a "natural" boundary.

## Spanish Resettlement

That many modern pueblos were originally built as Jesuit mission towns poses some perplexing questions concerning the surficial evidence of pre-Hispanic settlements. It is most apparent that historic and recent activities have damaged many archaeological sites (Fig. 84). Indeed, road cuts often dissect, and orchards often overlie, ancient settlements (Appendix XI). Determining the extent of site destruction may be best achieved by investigating the historical preconditions of modern settlement location.

The archaeological evidence and the accounts of the early explorers suggest that the Jesuits should have found the Opata living in large nucleated settlements, practicing

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[46]The six pueblos in the first group plus Banámichi and Sinoquipe are located along the Río Sonora. Opodepe and Cucurpe are located in the Río Son Miguel Valley. The other settlements are various places in the Sonoran Desert.

Figure 84. A Heavily Disturbed Pre-Hispanic Settlement. Site Son K:4:108 OU.

irrigation agriculture, and presumably having some complex form of sociopolitical organization. Curiously, when the Jesuits arrived in the early 17th century they found the Opata living in dispersed rather than nucleated settlements (Bannon 1955; Spicer 1962). The large towns that the explorers reported in the mid 16th century, and which, on the basis of archaeological evidence, existed in the 13th century, were gone.

Writing in 1644, Perez de Ribas noted that the dispersed Opata of the Río Sonora Valley were brought together (reduced-reduccion) by the Jesuits into pueblos for Christianization and "this change from rancherias to pueblos they undertook with singular promptness and good nature" (Robertson 1968:147). If it is true that between the time of the explorers and that of the Jesuits Opata population had become significantly dispersed, it is apparent that important changes preceded the arrival of the Jesuits. Sauer (1935:11-12) notes that the spread of small pox and measles devastated the population of northern Sinoloa and Southern Sonora. Because of the known contacts and trade routes between Mesoamerica and American Southwest, it seems reasonable to assume that these diseases may have spread further north into the Río Sonora Valley. Their impact on large nucleated settlements would have been particularly severe and may account for the shift toward population dispersion prior to the arrival of the Jesuits. That these peoples readily accepted the Jesuits and their nucleated settlement system has been hypothesized by Reff (1978) as a result of their preconditions toward a nucleated and centrally controlled society.

As was noted by Bandelier, the peoples of the northern half of the valley as far as Sinoquipe were one, with a center near Las Delicias (Lange and Riley 1970:242). Reff (1978) is probably correct in assuming that Spanish-introduced disease severly reduced the population, especially at the large settlement (presumably Las Delicias). This disaggregation of population probably resulted in a disintensification of agricultural practices (see e.g. Brookfield 1972) and a scattered settlement pattern. Evidence of such was found by the Jesuits (Pfefferkorn 1949; Nentvig 1971). That the Jesuits agglomerated the population into four settlements (Banámichi, Huepac, Aconchi, and Baviácora) rather than the original two, Las Delicias and San Jose, is an intriguing question. It is possible that the peoples resisted returning to their disease-destroyed centers in fear of falling victim to the same factors that resulted in the site's decline. Although such a case is possible, and evidence for some minor resistence exists, it is not demonstrable. Choosing new locations, however, does not explain the increase in the number of uniformly space sites. It is most probable that the settlements that were later to become <u>reduccion</u> pueblos were occupied prehistorically. That these settlements were anything more than hamlets is unlikely for as Bandelier's informant noted in one post-Conquest case:

> Ba-na-michi (not Banámichi) stood formerly in the river bottom in the fields of Figueroa, but an inundation of the river compelled them to seek the bluff, which was formerly called San Nicolas (Lange and Riley 1970:242).[47]

It seems logical then to assume that if the bluff contained a substantial pre-mission population that the mission would have originally been located there. That factors other than nucleated populations were the impetus for missions locations seems a more plausible explanation. It is suggested and accepted here that modern pueblos are known to have mission origins, and are not located atop major pre-Hispanic sites. Accordingly, a population approaching twice the original estimate of 7,863+ is rejected, as is a prehistoric settlement hierarchy that differs from what has been outlined here.

In summary, the pre-Hispanic population of the middle Río Sonora Valley during the early phase of occupance was probably around 1,500, and a late phase population probably approximated 8,000 to 10,000. This difference in population can be equated to an approximate .5 percent annual

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[47]The difference between Ba-na-michi and Banámichi is interpreted to be solely as a pronunciation distinction of the pueblo name between the time it was located on the floodplain and later when it was relocated atop the bajada. The quote was extracted from that portion of Bandelier's field notes in which he recorded information pertaining to settlements near the modern-day pueblo of Banámichi.

growth rate marked by an "explosion" *ca*. A.D. 1100. During and between the early phase and late phase the population distribution was neither spatially uniform nor temporally stable. The early phase had a population distribution that was oriented more toward the southern half of the valley. Although two-thirds of the late phase residents lived in the north, the overall population density (based on stable lands) was uniform throughout the valley. During the early phase, agriculture was arroyo oriented in the north, and both arroyo and floodplain oriented in the south. During the late phase the entire arable portion of the floodplain (both north and south) was under cultivation. At this time the land was at a maximum carrying capacity, given the constant of one crop per year. Intensive double cropping would have produced a surplus that would have necessitated outlets other than local consumption or utilization, perhaps export.

Concommitant with the population growth and agricultural intensification came nucleation of settlements and a noted increase in the complexity of social organization. The two regional centers dominated the late phase settlement landscape and equally divided the valley into their respective hinterlands or spheres of influence. In the early historic period the population was apparently reduced by disease with the large agglomerations (regional centers) being hardest hit and, hence, reduced in size and importance. The later arrival of the Jesuits reduced the scattered population into a few pueblos which were antecedents of the modern settlement system.

PART IV

THEORETICAL RAMIFICATIONS

> Theory may be compared with reality for various ends . . . comparison now has to be drawn not to test theory, but to test reality. Now it must be determined whether reality is rational (Lösch 1954).

Resolution of the Evolutionary Dilemmas

A literature review dealing with settlement systems reveals four dilemmas concerning the modeling of settlement evolution (see Part I, Evolutionary Dilemmas). These dilemmas involve dichotomous interpretations concerning (i) initial occupance, (ii) population-settlement growth, (iii) market development, and (iv) the development of settlement hierarchies. Interpretation of the limited occupance data from the middle Río Sonora Valley, provides some insight into resolving these dilemmas as they apply to the development of pre-Hispanic settlements in the region.

Dilemma 1 deals with modeling initial population distribution as either agglomerated or dispersed. The data indicate that the easliest documented population in the Río Sonora Valley conformed to neither of these dichotomous cases. Rather, the early phase population was generally dispersed in several small settlements but with one large settlement, the San Jose site, containing a significant proportion of the valley's residents. The occurrance of this large site amongst many smaller sites may necessitate a merger of the dispersion/agglomeration models. Data problems, especially the weak chronological control, also might be confounding the issue. More data with stronger controls might reveal that the early population actually conformed to the forms required by either of the models. Hudson's (1969) dispersion model might apply in this case, because the Bylund (1960) and Morrill (1962) nucleation schemes require that all settlements to be equal in size until the landscape is settled or that they conform to a rank-size distribution. During the early phase there was neither a complete settlement of the landscape nor a clear rank-size distribution of settlements. The primacy of one site over all others suggests that external market factors may more appropriately explain San Jose's disproportionate size. This idea will be discussed later.

Dilemma 2 involves the nature of settlement growth as one in which settlements increase in number before they increase in size (Hudson 1969), or in which settlement size increases prior to splintering and increasing in number (Bylund 1960; Morrill 1962). The pre-Hispanic situation in the middle Río Sonora Valley is not like either model. Population as attested by numbers of houses, grew substantially between the early and late phases of occupance while the number of settlements little more than doubled. Indeed, where the estimated population grew at an approximate average of 0.5 percent annually, the settlements grew at an annual average of only 0.25 percent (Fig. 85). The growth of site sizes is best seen in the differences between the number of settlements with single and multiple houses in the respective phases (Figs. 68 and 69). Of the 65 early sites, 26 (40.0 percent) had single houses and 12 (18.5 percent) had 2 houses. During the late phase, the number of single house sites dropped to 15 (9.3 percent) of the total 162 settlements. Although the actual number of sites with 2 houses doubled to 25 (15.4 percent) in the late phase, the percentage remained about the same as earlier. Estimated population figures further illuminated the increase in site size. During the early phase, 18.8 percent of the population resided in single or double house sites. In the late phase, only 4.9 percent lived in such diminutive settlements. The largest increase was in both the regional centers and the larger rancherias. The growth in site numbers is, of course, most easily noted as the increase from 65 to 162 between the early and late phases.

The simultaneous growth of settlements in terms of size and numbers suggests that another merger of models may be necessitated. This conclusion, however, could re-

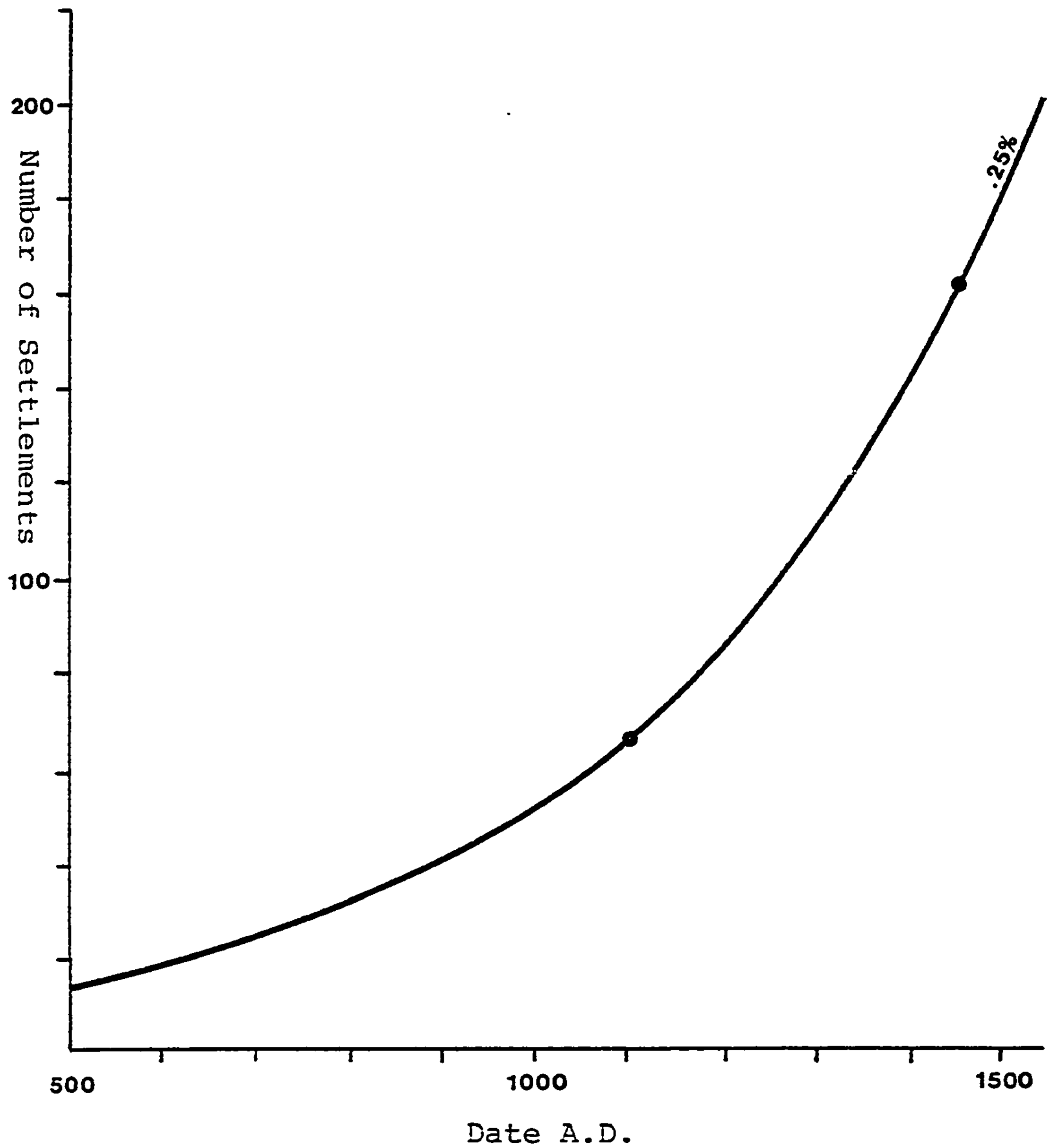


Figure 85 . Settlement growth.

sult from data problems. Superior chronological control, for example, might indicate that one of the two models is correct. Also, the failure to clearly establish the occurrence of either alternative may reflect the inability of both models to consider forces external to the evolving settlement systems.

Including both internal and external factors to explain settlement growth begs the resolution of Dilemma 3, concerning market development (center growth).[48] Blanton (1978), Fisch (1978), and Belshaw (1965) argue that centers (markets) grow as a result of internal processes resulting from a society becoming increasingly more stratified.[49] There is ample documentation in their works to support the notion of a growing population which places stress on the environment, resulting in the emergence of one dominant center (e.g. Carneiro's circumscription argument). The data from the Río Sonora Valley, however, do not fit the conditions of this argument. Stress was apparently nonexistent during the early phase, when the dominance of one site over all others was first evidenced. The 9.0 hectares

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[48]It must be remembered that the concept of market development in this study refers to marketing principles. It is not intended to be taken in the literal sense of places where goods are physically exchanged although such is one possible explanation.

[49]Belshaw was looking specifically at market structures whereas both Blanton and Fisch were investigating a site's growth. Both approaches are similar because markets and settlements are often synonomous and evolve similarly.

of agricultural land available to each household in the middle Río Sonora Valley in no way approaches the calculated stress minimum of 2.4 hectares. The stress argument based on internal processes is discounted here as it is not a sufficient explanation for emergence of the San Jose site. On the other hand, the Río Sonora settlement data are comparable to situations in which external processes and interregional contacts, such as those explanations offered by Polanyi and his colleagues (1957) and Kohl (1978), are the causes of market development of one center's dominant growth.

Only inferences can be made about pre-A.D. 1000 populations, settlements, subsistence, and cultural levels in the middle Río Sonora Valley because of the quality and quantity of data. It is apparent, however, that the early phase was one of emerging development. This phase is noted by a rapid population growth (explosion) which was associated with cultural changes. As has been demonstrated, primate cities typically are phenomenon occurring with developing states (Mehta 1964; Linsky 1965; El-Shahks 1972). The San Jose site (Son K:4:24 OU) during the early phase could be considered a form of primate settlement. This point seems rather obvious, but its implications necessitate further consideration, particularly in response to Vapnarsky's (1968) concepts of interdependence and closure. Vapnarsky found in developing Argentina that the dominance of one center over all others is characteristic of conditions where previously experienced closure (in this case, regional isolation) breaks down and where interdependence (intersite interactions) remain rather low. External relationships become important, reminiscent of Polyanyi's (1957) "necessary trade" argument. The works of Wood (1974) and Kohl (1978) also suggest that a correlation between growth of centers (markets) and the development of interregional contacts exists. Although it is not possible to confirm such contacts as the cause of San Jose's growth, nevertheless it is an interesting hypothesis. The ethnohistoric documentation of an Amerind trade route (Bishop 1933), the existence of Mesoamerican trade goods further north in the Southwest (Lister 1978; Reyman 1978), the hypothesized influence of Mesoamerica on Southwestern cultures _ca_. A.D. 700-900 (Kelley and Kelley 1975), and the historic presence of the Black Christ of Esquipulas, an early historic Guatemalan phenomenon, in New Mexico and in the pueblo of Aconchi all suggest pre-Hispanic contacts with the south (de Borhegyi 1954). Kelley and Kelley (1975) also make some strong arguments that Southwestern cultures may even be extensions of Mesoamerican cultures.

The possibility of a Mesoamerican orientation is enhanced when the specific location of the San Jose site is viewed relative to the entire middle and especially the middle and upper reaches of the Río Sonora Valley. Burghardt (1971) introduced the concept of gateway cities to settlement studies concerned with extra-regional contacts. As Hirth (1978) has pointed out, in prehistoric situations, gateway communities may develop as a response to increased trade or to the settling of sparsely populated frontier areas.[50] They are generally located along natural corridors and at critical passages between areas of high productivity, dense population, and at the interface of different technologies or levels of sociopolitical complexity. The function of these settlements is to satisfy demand for commodities through trade. Hinterlands of gateway cities are elongated with the principal stttlement being located toward the export side of the region. The early phase San Jose site fits all the criteria of being a site whose major function may have been that of a gateway city with contacts to points south (Mesoamerica?). This condition, however, may not have been so strong during the later phase as further internal growth probably resulted in a more intraregional focus of the settlement system.

Resolving dilemma 3 for the case of the Río Sonora now allows for some further discussion on Dilemma 2--settlement growth. Hudson-type models hold that the initial population is randomly distributed; with internal growth

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[50]In the frontier situation, the gateway community could be similar to the "mother" community in the Bylund and Morrill models. The two concepts are not merged here because the settlement patterns during the late phase was characterized by systematic growth and fission.

the region becomes more densely populated. Immigration is allowed in such models, but the behavior of all new participants is the same whether they are products of internal growth or products of immigration. Bylund-type models hold that the initial population is nucleated at one site and that as the site grows new sites emerge. Like Hudson-type models, immigration is allowed. Also, new participants follow the system as it has previously operated. In effect, once a settlement evolution scheme is initiated it progresses through with no functional alterations other than intensification (White 1977). The early stages of settlement evolution in the Río Sonora probably were influenced by foreign intruders. Prior to A.D. 700 and certainly before A.D. 1000, the evolution scheme was probably most like the initial stages in the Hudson scheme, a dispersed population. The presence of intruders from places unknown (Casas Grandes?, Mesoamerica?) later (but still prior to A.D. 1000) resulted in the emergence of one nucleated site amongst the many smaller sites. Such a change cannot be accomodated by either Hudson-type, or Bylund-type models in their purest form. Once the new settlement system was established, however, it more than likely grew or evolved in a predictable fashion according to the newly established preconditions. In effect, the initial settlement scheme, be it dispersed or nucleated, intensifies with growth; dispersed becomes nucleated and nucleated becomes dispersed. Once something happens to alter the scheme a new evolution-intensification scheme begins. The resultant scheme is then based on the new modifications and their manifestations.[51]

White's (1977) nodality-centrality-primacy argument has merit here. Primacy is associated with societies having low-technology transportation. For two-dimensional surfaces, centrality is the primary determinant for settlement size and growth. For one-dimensional surfaces, nodality is the dominant determinant. The keystone of White's explanation is centrality or nodality. The more intensive the settlement system, the more central the principal center. The late phase settlement pattern in the middle Río Sonora Valley appears to be a manifestation of an intensified early phase settlement system. The early phase nucleated village, San Jose (site Son K:4:24 OU), was not centrally nor nodally located in the valley. It was, however, located centrally and nodally in the southern segment of the valley. In the late phase a second regional center emerged centrally in the northern segment.

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[51]Mees (1975) noted this occurrance in the emergence of cities in Medieval Europe. Using catastrophe theory, he found that even a slow improvement in communications could result in a sudden change in the nature of the settlement system within a region that had previously been unspecialized and self-contained becoming more active in manufacturing, farming, and commerce. He noted that growth patterns are different between those regions that are isolated and those that are parts of interregional networks.

Accordingly, there were two regional centers during the late phase each centrally and nodally located within their respective sections of the valley. That these sites emerged is most likely a combination of internal growth and external contacts. The late phase system is much like a gateway city-system that evolved into a more intensive intraregional system.

The intensification of gateway city-systems into central place city-systems was considered by both Burghardt (1971) and Hirth (1978). Although we do not have a central place hierarchy in any stage of Río Sonoran settlement evolution, regional centers (central places) do emerge. Internal population growth of a magnitude necessary to accomodate such order was theoretically possible. This growth may have created competition with the gateway community whose hinterland extended over a large area. According to Hirth, increased competition between emergent central places can generate some predictable changes in settlement evolution. In the case of the Río Sonora, the gateway community probably: (i) lost a portion of its hinterland but maintained control over a representative portion of the area; (ii) shifted its major emphasis from control of inter-regional trade to tighter integration of economic activity within its own physiographic region; and (iii) evoked a more complex form of sociopolitical authority to combat increased economic competition. This last change, which was seen to be the most important to Hirth, is crucial in the case of Sonora because the newly arisen regional center is in the northern half of the valley and is surrounded by Cerros de Trinceras. As Hirth noted:

> It is this last response that carries the greatest potential stimulus for cultural evolution. An increase in political authority and militarism on the part of the gateway community could lead to an elimination of competition through hinterland conquest.

Although it is beyond the scope of this work it is interesting to hypothesize an intensification of militarism on the part of the southern valley residents against their new northern competitors. As an addendum, Kelley (n.d.) has evidence of an intensive Pochteca-type Mesoamerican trade network operating as far north as the modern state of Durango, and suggests equally strong networks operating as far north as northern Arizona (Kelley and Kelley 1975). That the San Jose site and Las Delicias (site Son K:4:16 OU) served as stopping points along such a trade route is possible. Indeed, such a through-the-valley-trade has ethnohistoric documentation (Bishop 1933) and the features tentatively identified as Postclassic ballcourts at San Jose and La Mora (site Son K:4:72 OU) directly across the river from Las Delicias tend to support such a conclusion.

In summary, dilemmas 2 and 3 can be explained in terms of a dispersed population that prior to its evolution into any hierarchical system was modified by outside forces (possibly external markets) that provided the impetus necessary for one center's dominance. Further, internal growth and increased external contacts resulted in a settlement pattern which was a modification of an intensification of the early phase pattern. The one large site surrounded by numerous smaller sites grew into two centers surrounded by many smaller sites. The centrality and nodality of each center is evidence of the previous gateway city-type system with one center located peripheral to the region evolving into a more intra-regional system.

Dilemma 4, whether hierarchies develop with rank-size regularity (Beckmann 1958; Nordbeck 1974), or with a progression from uniformity through primacy to a rank-size distribution (Vapnarsky 1968; El-Shakhs 1972), is perplexing in the case study here because the evidence suggests simultaneous population and settlement growth. The creation of this dilemma may be possibly a function of the respective researchers orientation. Beckmann and Nordbeck employ the law of allometric growth to modern time-static settlement patterns and statistically derive inferences about evolutionary trends that produced the pattern. As has been recently demonstrated, however, applying the allometric formula to synchronic situations (the rank-size rule is a description of a static state) and assuming the results to be indicative of a diachronic evolving process is erroneous (Vining and Louw 1978). In effect, the allometric parameters are shown not to be stable but are subject to considerable fluctuation. The allometry formula, therefore, is not an indication of differential growth so much as it is an empirical formula of limited value for analyzing underlying factors controlling proportions (Reeve and Huxley 1945:132). In addition, the rank-size distribution seems to be a condition which applies particularly well to 20th century levels of cultural development.

Vapnarsky and El-Shakhs investigated developing situations, noting the differences in settlement patterns through time. The object of these works was to understand evolutionary processes by measuring changes in settlement patterns, whereas Beckmann and Nordbeck attempted to understand processes by looking solely at the final pattern. Accordingly, the evolution of hierarchies can be understood more accurately by looking at developing, rather than developed situations. The most successful approach is to investigate development from a bottom to top Lösch perspective, rather than from a top to bottom Christaller perspective. Following this latter approach it is not surprising that the results of this study support the work of Vapnarsky and El-Shakhs. In the middle Río Sonora Valley there was probably an early (pre-A.D. 1000) uniformity in settlement size. In the early phase a primate city-type system evolved, albeit under the influence of external contacts. It is only in the late phase that the settlement hierarchy begins to show signs of elaboration. A primate city-type system remained operative at this time, but a community hierarchy began to develop.

Presuming that the data are relatively accurate, this case study suggests that the various models of settlement evolution may be too simplistic when applied to the middle Río Sonora Valley. This criticism is by no means unique to this work. It is recognized that most explanations are initially rather simplistic and only after considerable testing are modified to include more complex situations. What is needed is the recognition that several factors often operate simultaneously to create a specific situation and that a model considering only one factor while holding others constant will not fit all situations. Improvement on such models will most likely come through continued geographic studies of contemporary situations because of the data difficulties inherent in prehistoric situations. The archaeological contribution will probably be to emphasize the apparent ramifications of long-term evolution, one of which is the changing influences of environmental and socioeconomic factors that can be portrayed in terms of the ecological-social continuum. The recognition and application of geographic models to prehistoric data may also help to clarify specific anthropological arguments. A large amount of information can be extracted from settlement data, especially when viewed in relation to existing models.

## The Ecological-Social Continuum

Two propositions have been proferred in this study: (i) less complex cultures maintain strong ecological relationships while more complex cultures have more tenacious socioeconomic relationships; and, (ii) differences between the respective foci of less complex and more complex cultures are manifested in settlement patterns. Although these points were not structured in a hypothesis-testing format, they were investigated in an empirical form which resulted in conclusions formulated in a generalized theoretical manner. This study indicates that a shift in occupance patterns from an environmental to a socially dominated dominion took place in the Río Sonora Valley during pre-Hispanic times. The thrust has been directed to the explanation of the causes, consequences, and implications of cultural development through changes in settlement systems. The approach undertaken is interdisciplinary between archaeology and geography. Practitioners in the former discipline have a tradition of emphasizing the cultural-ecological relationships of less complex cultures in a diachronic framework, while the practitioners of the latter discipline have had a propensity toward formulating theories of socioeconomic interactions of more complex cultures. The differences between the disciplinary approaches have been bridged here by applying theories of settlement system evolution as developed by geographers to a prehistoric situation. This combination of approaches has been accomplished by the construction of a hueristic concept called the ecological-social continuum. This device facilitates understanding occupance development by emphasizing relative shifts from the cultural ecological relationships to the socioeconomic relationships that are manifested in settlements.

While the holistic nature of the continuum has advantages for transcending interdisciplinary lines of research and for studies concerned with occupance development, it is not without shortcomings. A fundamental problem encountered is the application of detailed, 20th century to a situation in which the data base is meager. The second problem is the attempt to combine stringently controlled chronological models with the loosely structured occupance phases of the ancient situation. These two problems resulted in the abandonment of rigid statistical and physical models commonly used in geographical settlement studies. A second shortcoming involves the weak chronological control for occupance phases in the Río Sonora Valley and the resulting tenuous nature of the inferences that were made. In effect, specificity has been relaxed. These problems, however, have not been ignored nor have their implications been treated lightly. Their presence was recognized and efforts were made to minimize spurious results. Throughout this study the perspectives of both the geographer and the archaeologist have been taken in order to articulate problems differently and to search for fresh and, wherever possible, more broadly based explanations. Furthermore, this work has been presented in a discursive approach to overcome the sometimes limited documentation necessary for a more limited but tightly argued case. Many of the inferences are deliberately speculative in the hope that they may provoke more painstaking research in the future. With these qualifications in mind, the major conclusions are summarized.

1. The Río Sonora floodplain (riparian woodland zone) is a free-draining alluvial surface that has been the focus of human settlement since pre-Hispanic times. Permanent water in many places (even through the dry season), especially in the southern half of the valley, an abundance of wild food resources, and presumably an abundance of native animals were found in this zone. The earliest foragers would have found the area proximal to the river most favorable for occupance. Although no permanent settlements have been dated pre-A.D. 1000, it is possible that such sites were located either on the floodplain or on the bajada edge overlooking the riparian woodland zone. The zone away from the floodplain that is most productive in terms of plant diversity is the undifferentiated slope-mixed scrub zone. An added benefit of habitating this zone is not only proximity to a variety of wild resources, but

proximity to the riparian woodland zone, proximity to permanent water, and proximity to the oak woodland zone noted for its abundance of acorns. Locating on this elevated slope would also have defensive advantages as well as having advantages in utilizing cool breezes and avoiding cold-air drainage. The west side of the river, with its diversity and proximity to numerous zones is the most likely locale in which ecologically oriented foraging groups might focus their occupance attention. Indeed, it is in this zone that a possible Cochise-type metate used principally for grinding gathered seeds was found, as was the earliest $C^{14}$ date of 450 B.C. (Appendix VI).

2. Following the labor efficiency thesis, the earliest agriculture conducted in the middle Río Sonora Valley was, in all probability, arroyo oriented. Although the permanent water found on the floodplain would have been attractive it is unlikely that the earliest farmers would have exerted the energy to clear the dense growth of <u>Prosopis</u> spp. when planting in cleared zones (arroyos) was possible.[52] Evidence of such extensive agriculture is found in the form of remnant channel-bottom weir terraces in several of the large tributary arroyos.[53] Utilizing

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[52]Sauer (1952) also states that flooding would have prevented usage of floodplains, and that constructing flood prevention dams would involve technology too advanced for early cultivators. This latter idea also conforms to the labor efficiency hypothesis.

[53]There probably existed a phase where prior to con-

seasonal run-off, these fields could not have supported an occupance unit (family?) entirely and a partial dependence on gathered resources would have been essential. Adjusting to these circumstances, settlements were situated so that access (distance) to the arroyos, the main river channel, and the riparian woodland was facilitated. That most of the large and agriculturally suitable arroyos are on the east side of the river probably accounts for intensification of permanent settlements along this side of the river. That arroyos are a major factor in subsistence is evidenced by the location of several arroyo oriented settlements. Approximately 88 percent of the early phase settlements and accompanying population was located along the river, 12 percent were arroyo oriented.

3. The earliest phase for which permanent settlements are identifiable is ca. A.D. 1000 to A.D. 1250. During this phase, 65 settlements were inhabited by approximately 1,400 people. Presumably, egalitarian, 62 of these settlements had 7 or fewer houses; with a mean of 2.3 houses, a median of 4 houses and, most importantly, a mode of one house. Two of the three remaining settlements had 10 and 12 houses, respectively. One of these was completely arroyo-oriented while the other had a bi-zonal focus. During the early phase the distribution of settlements was equally

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structing weirs, seeds were planted in favorable places with no other labor inputs (Ak-chin fields? Hack 1942).

distributed between the southern and northern halves of the valley. Two-thirds of the riverine oriented population, however, was located in the environmentally advantageous southern section. Nearly half of the southern population was located at the one large site identified with this phase.

4. During the late phase, *ca*. A.D. 1250 to A.D. 1550, population and settlement focus was nearly 91 percent riverine oriented, though some settlements maintained an arroyo focus. It was during this phase that the total number of settlements reached 162 with a population of 8,000-10,000. Significantly, a differentiation in settlement sizes is most apparent during this phase. Two major centers, one in the northern section and one in the southern section dominated the valley. Also in association with this phase is the appearance of public architecture indicating an increase in social stratification, as well as the centralization of authority or at least exchanges (economic, political, religious, or otherwise). The late phase settlement distribution remained equally divided between the southern half and the northern half of the valley. Significant however, was the population shift. Nearly two-thirds of this phase's population was located in the northern segment.

5. That the northern segment of the valley has roughly two-thirds of the arable land along the middle course

of the Río Sonora has some significant implications concerning man-land ratios. Although the early phase population was centered on the most areally restricted portion of the flood-plain, major stress apparently was not placed on the environment. There was still an abundance of arable land even given the relatively circumscribed area. During the late phase, however, the population was significantly greater than in earlier times. The population diffused throughout the valley, probably to minimize stress in any one locale. Similar occurrances have been suggested by Carneiro (1972) and verified for predynastic Egypt by Butzer (1976). It was during this late phase that the population reached a point in which stress was becoming evident. Indeed, the production capacity was either beginning to be, or possibly already was exceeded. This increased demand for agricultural produce not only resulted in an expansion of activities into previously little used lands but also resulted in an intensification of agricultural practices to include irrigation cultivation and possibly double cropping.

6. Whether or not intensive double cropping was practiced is an intriguing question. Given the maximum estimated population (roughly 8,000-10,000) double cropping would not have been necessary. Yet there is not only evidence of double cropping, but of double cropping food with non-food items, specifically cotton. The Opata were known

as the only cotton cultivators in pre-Hispanic times in this part of Mexico. Is it possible then that these pre-Hispanic occupants of the middle Río Sonora Valley were producing more than their normal surplus and exporting this surplus? The settlement evidence suggest this might have been the case.

7. The settlement pattern during the early phase, with its one large center located assymetrically toward the southern end of the valley, is suggestive of a gateway community with an export focus to the south (Mesoamerica?). The dominance of one site over all others on the settlement landscape also has theoretical affinities to primate city-systems, a form of settlement scheme associated with developing societies involved with external contacts.

8. The intensification of the settlement system from a primate-gateway system into a dual centered regional system, each with a proportional share of the hinterland, is documented in other areas of pre-Hispanic Mexico (Hirth 1978). Its occurrence in the Río Sonora, therefore, is not totally unexplained. The settlement evolution scheme noted in Sonora differs from the general models proffered by geographers, as such models are limited by their sole consideration of internal growth. The settlement pattern during the late phase in the middle Río Sonora Valley is, at least, partially indicative of internal growth. There are not only more settlements, but proportionally fewer

small settlements and more large settlements. The emergence of the second regional center in the north would also come about under internal growth and population expansions as a mechanism by which to reduce travel time to the central places.

9. The population growth between the early phase and the late phase is apparent in the settlement patterns of the respective phases. Although the rate of growth was approximately 0.5 percent annually the implications on occupance were astonishing. It is theoretically possible at this rather low rate of growth that the population could have grown from a few households to over 10,000 people achieving considerable development in less than a millenia. Whether or not the late phase population was completely the result of indigenous growth is unknown. It is, however, highly probable that the northern section of the valley was heavily influenced by peoples from outside the valley. Determining whether there was immigration or only diffusion of cultural traits is beyond the scope of this work. What is known is that the population grew substantially. That this growth was predominantly in the north also has been demonstrated.

10. The shift in occupance focus toward the north half of the valley during the late phase has two pertinent ramifications both of which are political in nature. First, the division of the valley according to the respective hin-

terlands of the two regional centers is reminiscent of the late Predynastic nomes in the Nile Valley. As Butzer (1976) noted for Egypt and might well have parallels in Sonora:

> These nomes, as basic territorial entities, originally had socio-economic as well as ecological overtones, but then became increasing administrative in nature. (Butzer 1976:105).

Second, the appearance of defensive structures in the north half of the valley during the late phase shows a political response to factors from places other than this segment of the valley. Two possible explanations are offered, neither is tested, however, because they exceed the scope of this work. First, the emergence of the regional center could have met with opposition from peoples in the southern half of the valley. Defending the new market from those whose hinterland had been truncated has a measure of credibility. Hirth (1978) speculates just such an occurrence to be most important in cultural development. Second, the large population of the north might have been the result of immigration. If so, these intruders (?) might have had need for personal and societal protection. Whatever the case, a distinct valley division resulted in the late phase.

As has been explicitly stated in the Introduction, and implicitly considered throughout this work, the shift from a purely ecological to a more socioeconomic focus can not occur in a short period of time. Rather, the shift occurs slowly but inexorably, often in a discontinuous and erratic manner, in stages or steps and in varying degrees.[54] The differences between the early and late phases in the pre-Hispanic case from the middle Río Sonora Valley illuminates only one such step, but one of a significant magnitude. Not only was there a spectacular rise in the population but there was a major shift in agricultural practices. Seasonal extensive agriculturalists-foragers became intensive agriculturalists. Concomitant with change in production came probable changes in the disposal of produced goods. Subsistence production remained essential, but it is highly probable that new activities (double-cropping) were ventured into for export reasons. This new orientation

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[54]Catastrophe theory, a relatively recent topic of academic debate (especially in Great Britian and France) might have some applicability in understanding such occurrences (Thom 1975; Zeeman 1976). Although mentioned twice, catastrophe theory was not considered as a methodology for this study, nor were the studies employing it referred to extensively. Further research is needed before its applicability, either as a methodology or as a substantive research topic, is verified. The early proponents of catastrophe theory argue that its structure allows for answering questions that were previously beyond the scope of topology, the branch of mathematics from which it evolved. (Topology is the study of those properties of geometric forms that remain invariant under certain transformations such as bending and stretching.) These proponents also argue that catastrophe theory can be applied to any situation in which discontinuous events, be they biological, natural, or cultural, are discernable. A problem, however, is that equations defining the seven elementary catastrophes are so complex that they can be little more than generalized. In many ways the arguments in favor of the theory as a general explanation, and the inherent problems of measurement, render the pros and cons of catastrophe theory to be vaguely reminiscent of those of general systems theory. While some thoeries such as graph theory were tested and adopted in their relative youth, others, like general systems theory, remain unverified. Catastrophe theory was not used here in order to avoid subscribing to any one approach prematurely.

in all likelihood gave rise to the regional centers and more elaborate intersite settlement system than noted in the earlier phase.

In summary, the early occupance was oriented toward small, scattered settlements associated with ecological factors. Later occupance developed with an increased density in the packing of settlements dominated by two regional centers. These settlements showed less association with environmental features and greater association with sociopolitical interaction, suggesting that cultural factors, especially those resulting from the intensive agriculture, were becoming more of an influence than ecological factors. The recognition of this shift is important to studies of occupance and should steer archaeologists and geographers away from their monodirectional schemes in which either sociopolitical or ecological factors are held constant.

On Growth and Development

The progression away from environmental influences toward spatial influences concomitant with increasing cultural complexity has been demonstrated for the Río Sonora primarily by noting the changes, especially growth, in the settlement system. That growth, as measured by changes in one of more variables, is a surrogate for development of the entire system has been implicitly assumed in most, if not all, cultural studies.[55] Refutal of the Beckmann-Nordbeck approach of understanding settlement evolution, however, casts yet another shadow of doubt on the assumption of allometry as applied to cultural studies (Naroll and von Bertalanffy 1956). More specifically, the conceptual difference between sectoral growth and total development must be clarified in respect to the ecolgical-social continuum.

Magnitude is the level or degree of a phenomenon as represented by a number; it is scalar. The change of magnitude in reference to variation in successive intervals of time is growth. Although growth is typically positive, it also can be negative. In a two-dimensional diagram, magnitude in relation to time is represented by a kind of

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[55]Development is a word used in many different contexts such as cultural development (civilization) and economic development. In all cases, however, it cannotes some type of improvement. For purposes of discussion here, the term development is used in reference to increases in cultural complexity. An increase in complexity seems to follow from all types of development, even though an increase in complexity often appears not to be an improvement.

vector known as a growth curve, the velocity of which is the rate of growth. Form is determined by the rate of growth in various directions of $n$ vectors in an $n$-dimensional space. When the ratios of the curves relative to each other tend to alter, steady and persistent alteration of form or the phenomenon of morphological development is achieved (Thompson 1945:78-82).

In cultural studies, growth and development are all too often considered synonomous, perhaps because with little difficulty, graphics can be reduced from $n$-dimensions and $n/2$ (in some cases $n-1$) vectors to two-dimensions with only one vector.[56] Most typically, whole population figures are plotted against time (e.g. Fig. 81). Error is interjected by assuming that population growth is some indicator of development, a concept which is reduced in status to a type of "intangible".[57] Often attempts are made to quantify

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[56] In an econometric framework, Georgescu-Roegen (1978) states that the difference between growth and development is quantification in the case of the former concept and qualification in the case of the latter concept. Growth is measured by movement (typically positive) along a differential equation line. Development is the movement from one equation line to another (presumably higher) line in a family of curves. A parallel perspective for cultural studies is offered by Price (1977) who uses the concepts of intensification and shift much as Georgescu-Roegen uses the concepts of growth and development.

[57] Calculating the growth of numerous variables in terms of a multiple regression analysis and considering the total explained variation to be a closer approximation of development is also erroneous. Such a procedure is unacceptable as the whole (development) may be something other than the sum of the parts (growing variables) that have been chosen for analysis.

development by constructing illusionary development levels across the growth curve parallel to the abscissa. The argument then tends to follow the notion that a population of a certain number is correlated with a specific level of cultural complexity (e.g. Service 1962).

The concept of increasing population pressure as an explanation for cultural complexity, such as Carniero's thesis (1972), is rooted in anthropological concepts combined with the works of agricultural economists such as Boserup (1965). Childe (1951) and Adams (1962) suggest the existence of an association between agriculture and sociopolitical development. Turner and his colleagues (1977), following the work of Boserup, found a positive correlation between levels of agriculture and population density given various environmental conditions. The overly simplistic explanation of population growth resulting in more intensive forms of agriculture, increased cultural complexity, and greater sociopolitical development, however, does not always hold, but can be better understood in terms of the ecological-social continuum.

Growth, including population growth, involves geometric progression (Malthus 1830, Cipolla 1970). Biologically, however, growth cannot progress indefinitely (Forrester 1973). Evidence suggests that populations eventually reach their limits (Meadows, _et al_. 1972). As Thompson (1945:144-145) noted:

> A typical population grows slowly from an asymptotic minimum; it multiplies quickly; it draws slowly to an ill-defined and asymptotic maximum. The two ends of the population curve define, in a general way, the whole curve between; for so beginning and so ending the curve must pass through a point of infection, it <u>must</u> be an S-shaped curve.

Theoretically, population growth must level off, but the tapering-off of development is a concept previously given little consideration. In effect, a positive correlation between population and cultural complexity is most likely limited solely to societies with low levels of complexity, that is societies oriented toward the environmental end of the ecological-social continuum.

A loose but interesting analogy can be made between the vector derived between cultural complexity and population growth of societies with environmental foci the early stages of economic growth as proffered by Rostow (1960, 1971) (Fig. 86). Rostow's five-stage scheme has evolutionary characteristics implicitly requiring a shift from an environmental to a socioeconomic orientation (subsistence functions to service functions) if applied to prehistoric or less complex cultures.[58] Rostow identifies all societies by their economic dimensions in a scheme including the traditional society, the preconditions for take-off, the take-off, the drive to maturity, and the age of high mass-

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[58]Rostow's scheme is principally cross-sectional (synchronic) but is based on time-series (diachronic) occurrances.

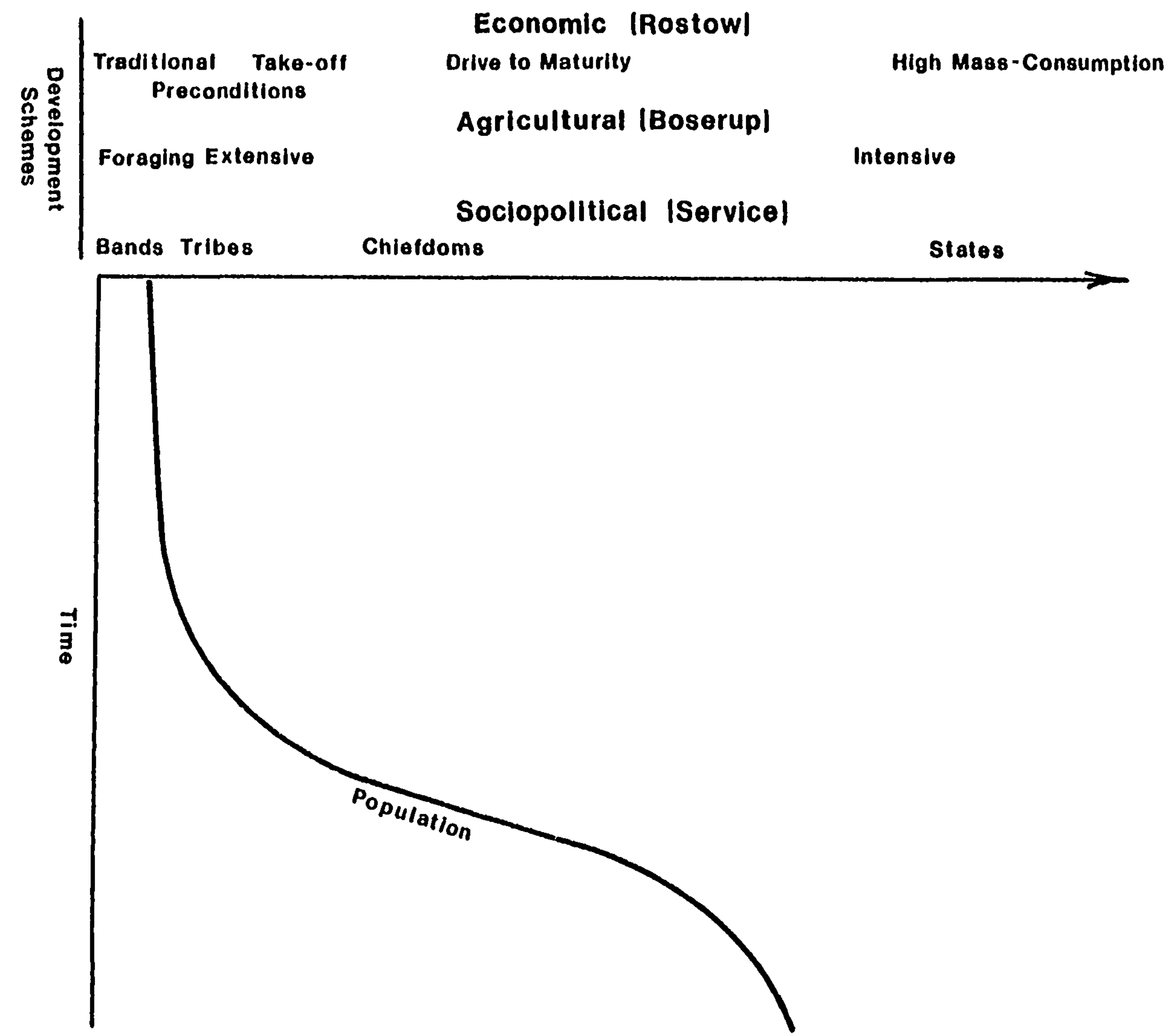


Figure 86. Cultural Development

consumption. The following discussion centers on a Rostow-type model of growth and the evidence for such from the Río Sonora Valley illuminate the strong parallels during the first two stages. The final stage of high mass-consumption is applicable to only a few modern societies and, therefore, is omitted from the following dimension.[59]

Four features distinguish Rostow's traditional society: (i) limited production functions; (ii) a surplus of agricultural land on which production can be expanded; (iii) a high proportion of agriculturally oriented resources; and, (iv) a social structure which is relatively narrow in scope with family connections being the major form or organization. The analogous level of development to this stage in the middle Río Sonora Valley was probably apparent pre-A.D. 1000 and certainly pre-A.D. 700. During this time foraging and incipient, extensive arroyo agriculture was probably the main activity. Accordingly, a surplus of land was available for future, more intensive agriculture. Practicing such simplistic food procurement required little social organization, probably little more than the family and certainly no centralized regional control.

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[59]Rostow originally proposed his scheme in reference to historic and modern data. He did not include foraging societies or even incipient extensive cultivators. For purposes of discussion, however, his relative scheme of development is adopted solely for hueristic purposes. It is no way intended to equate prehistoric Sonoran societies with modern nation states.

Societies experiencing Rostow-type preconditions for take-off are noted by five characteristics (i) low-level production functions, (ii) new technologies which are being translated into new production functions, (iii) an internally and externally widening scope of commerce, (iv) a loose social organization but one in which a regionally based political institution is beginning to arise, and (v) contacts with more advanced external societies. The analogous level of development to this stage is most likely the ca. A.D. 1000-1200 era in the Río Sonora Valley. During this time extensive cultivation was probably the principal activity with an increasing emphasis on cultivated as opposed to gathered foods. Certainly, the development of agriculture required the employment of previously little-used technologies. The increasing emphasis on emerging regional political control is noted by the growth of a nucleated village which apparently had contacts with outside cultures. Indeed, the possibility of such a function conforms to Rostow-type criteria of widening scope of commerce, and the prerequisites for such commerce to be oriented toward a more advanced society (Mesoamerica?).

The take-off stage is the interval when the old blocks of resistence to steady growth are finally overcome. The forces making for economic progress expand and come to dominate the society, and growth becomes the normal condition. Four characteristics mark societies at their take-off stage: (i) revolutionary changes in technology, including agricultural technology, (ii) new resources and methods of production are exploited, (iii) the emergence of a political power group, and (iv) production functions which include services and manufacturing activities as well as agriculture. All of these factors were evident in the Río Sonora Valley _ca_. A.D. 1200-1550. Shifts in technology were noted by intensive floodplain irrigation. Maximum use of previously little used land produced large yields that could have more than satisfied the local resident's cultural need. Accordingly, an export orientation is highly likely, especially if the second crop was a non-food item. The emergence of two regional centers and public architecture confirms the presence of a political structure not previously experienced. In turn, the services produced by the regional centers and the power group were more than likely not agricultural in nature, thereby satisfying the last criteria for delimiting a society at its take-off stage.

The take-off stage is transitional in that it demarcates the significant changes of a society's focus from the ecological to the social pole of the continuum. It is during this stage that the greatest theoretical implications pertaining to agricultural production occur, the shift from subsistence to market.

Revolutionary changes in agricultural productivity are an essential condition for successful take-off, for now a society radically increases its bill for agricultural production. As Leibenstein (1963) has demonstrated, the take-off can only occur if the rate of growth of per capita income exceeds the rate of population growth. Implicit in the argument is the production of a surplus. A surplus in premarket or subsistence economics is, of course, contradictory to the increased production only under population stress argument adhered to so tenaciously by many (Harris 1959; Spooner 1972). It does, however, conform to a larger scale stress picture if one considers the possibility of external contacts via markets, coercion, or taxation. Indeed, if the residents of the Río Sonora Valley were influenced by outsiders (Mesoamericans?) then it is highly likely that such influence was stressful and exploitative.

A long interval of sustained progress, the drive to maturity follows the take-off stage. Two factors characterize societies experiencing this "drive", (i) continued development with widening of technology to all activities, and (ii) the equalizing of the society in an international economy. The key here is that profit abounds, and economic development exceeds population growth. This stage is not evidenced from the Río Sonora data. Technology was never widened to include the manufacturing and service sectors, and overall level of cultural complexity certainly was not equivalent to that of the Mesoamerican cultures. Theoretically, however, the peoples of the Río Sonora Valley could have eventually reached such a cultural level had the Spanish not entered the New World. Indeed, the evidence does suggest that they were emerging at a remarkable rate.

In conclusion, a Rostow-type scheme provides an economic parallel to the ecological-social continuum, the keystone of which is clarification of the differences between the influences on growth (especially population growth) and development (especially sociopolitical development). During the first two stages population and development experience similar trends. The take-off stage, however, delineates the point at which returns from labor inputs begin to exceed population growth such that development can advance rather than just keep pace. The period of concern in this study, A.D. 1000 to A.D. 1550, can be considered a period in which a Rostow-type of take-off with a preceding preconditions stage is noted in the middle Río Sonora Valley. A shift from production to market was transpiring at this time with the settlement system adjusting itself accordingly. It was during this period that the occupance was losing its previous environmental focus and becoming more oriented toward social and economic spatial interaction.

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# APPENDIX I

# GLOSSARY

Problems of esoteric terminology and scholastic jargon are magnified in this work because of its interdisciplinary approach. The following definitions are offered as a partial remedy to this problem.

Biological requirements. The minimum amount of subsistence and related items necessary to sustain the bodily functions of the society.

Community. A group of persons whose normal activities bind them together into a self-conscious, corporate unit, which is economically self-sufficient and politically independent (Beardsley, et al. 1956:133).

Cultural need. The amount of materials desired by a society.

Culture. The learned patterns of thought and behavior characteristic of a society (Harris 1971).

Normal surplus (risk hedge). The amount of food and materials above the biological requirements and cultural needs that are produced for use in resource deficient times.

Occupance. The combined efforts or inhabiting, utilizing, and controlling a region. A metaphorical term derived from the definitions of (i) occupation, an activity that serves as one's regular source of livlihood; and (ii) occupy, to seize possession and maintain control over, or to dwell or reside in a region (American Heritage Dictionary 1978; also see James 1934:81).

Production pressure (stress). A situation where the amount of production begins to exceed the capabilities of the resource base given the level of technology.

Resource base. The physical elements of the environment that not only have utility to the society but are also perceived by the society to have utility.

Settlement. A place of habitation (occupance) either permanently, or for an extended period of time.

Settlement pattern. The temporally static spatial distribution of settlements over the landscape. Such patterns are manifestations of other variables and, therefore, are consequences rather than causes.

Settlement system. A set of settlements which operate and function through the interactions between all of the individual settlements comprising the system. Settlement systems are often manifested in particular patterns and, therefore, are both causes and consequences. Some archaeologists have used the term community pattern when discussing this type of phenomena (Chang 1958).

Site. (i) A geographical site is the metric location (longitudinal and latitudinal coordinates) of an object or activity. (ii) An archaeological site is any place where there are to be found traces of ancient occupation or activity (Hole and Heizer, 1973:111).

Society. A population sharing distinctive and common economic and political relationships.

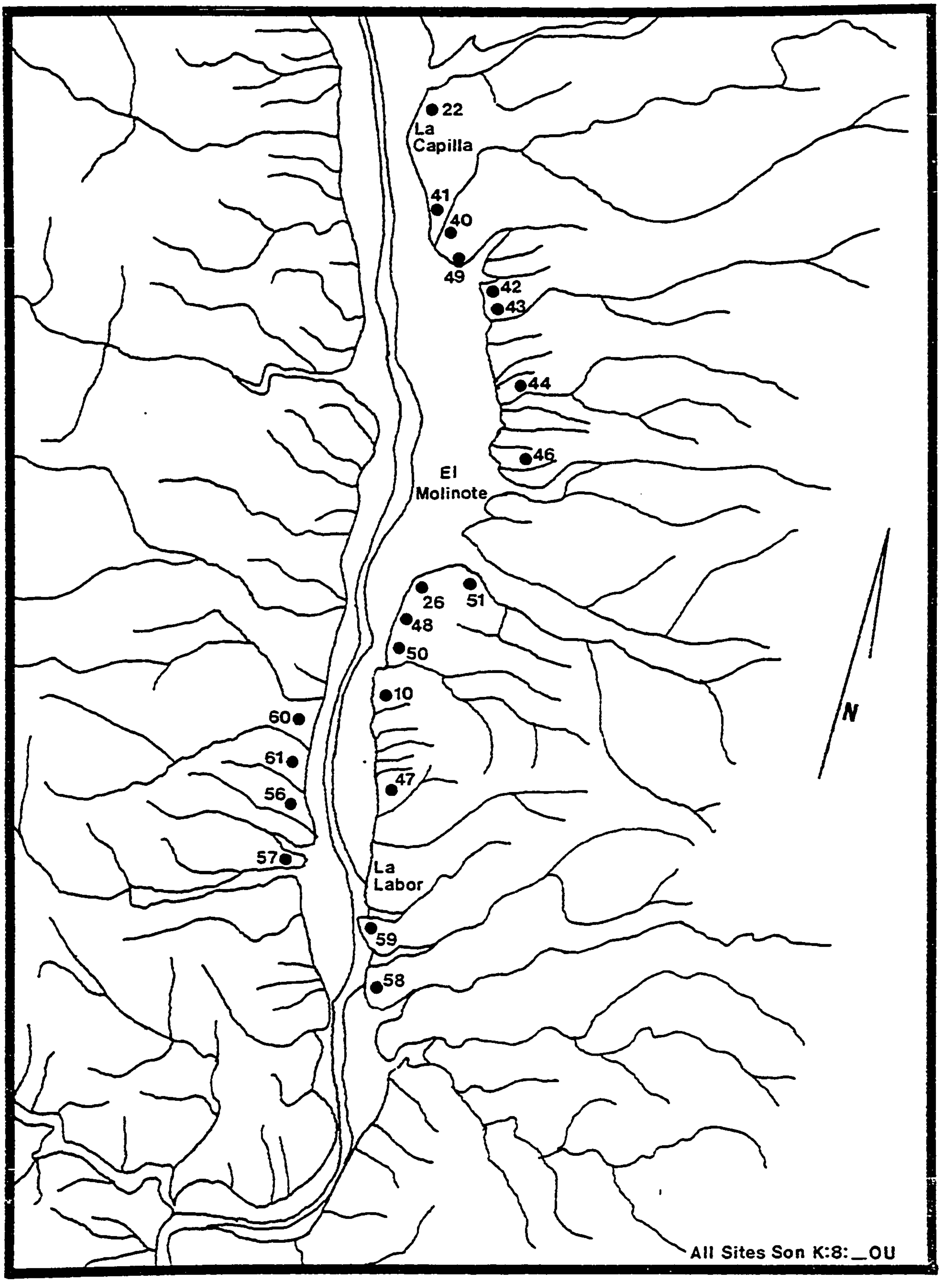
Subsistence production. The self-production of food and materials necessary to satisfy the unit's biological requirements, cultural needs, and normal surplus, without intermediaries or exchange.

Subsistence system. The manner in which foods and materials necessary to satisfy subsistence requirements are produced.

Surplus. Purposeful production above that associated with subsistence production.

# APPENDIX II

# DISTRIBUTION OF ARCHAEOLOGICAL SITES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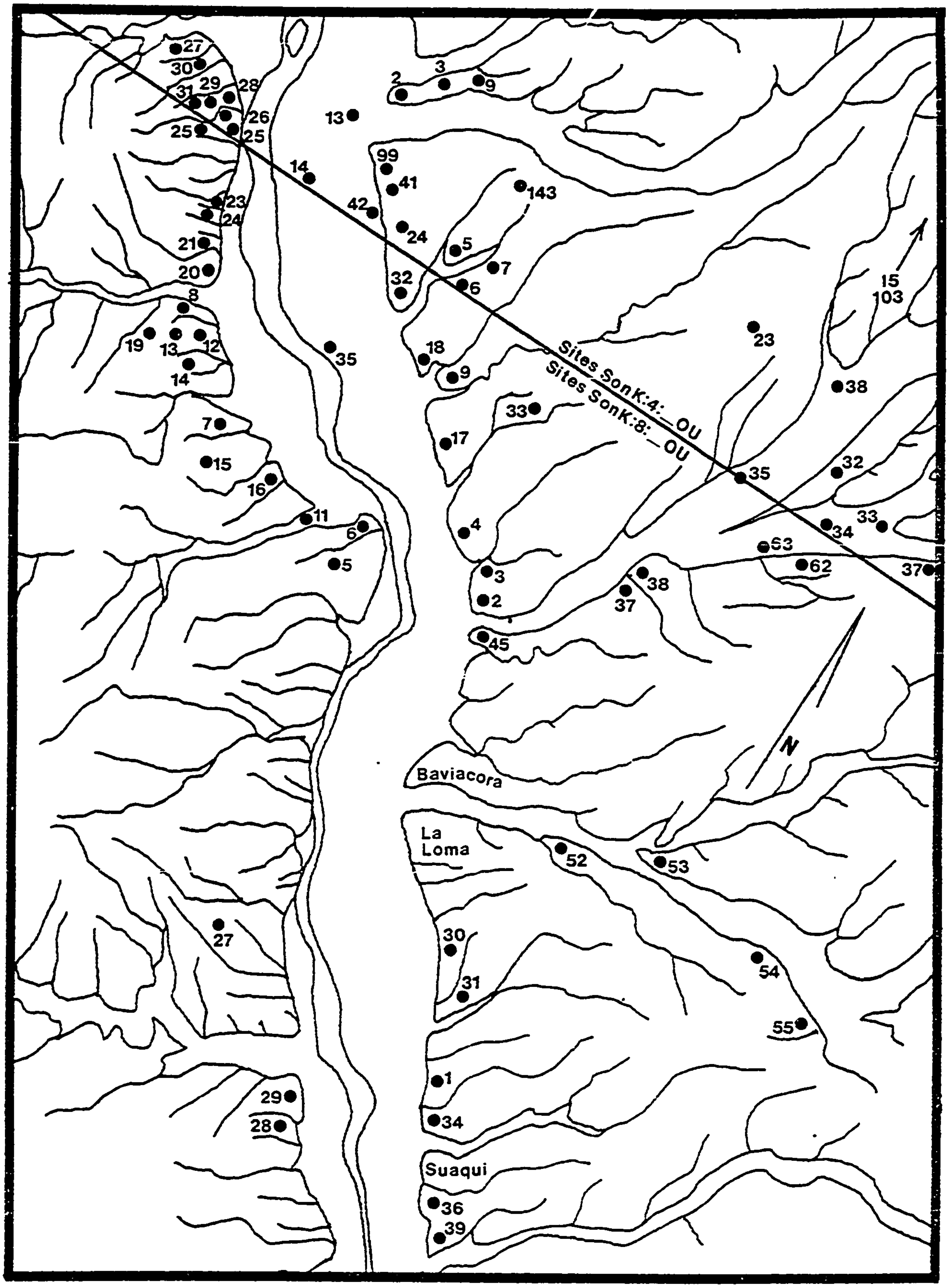

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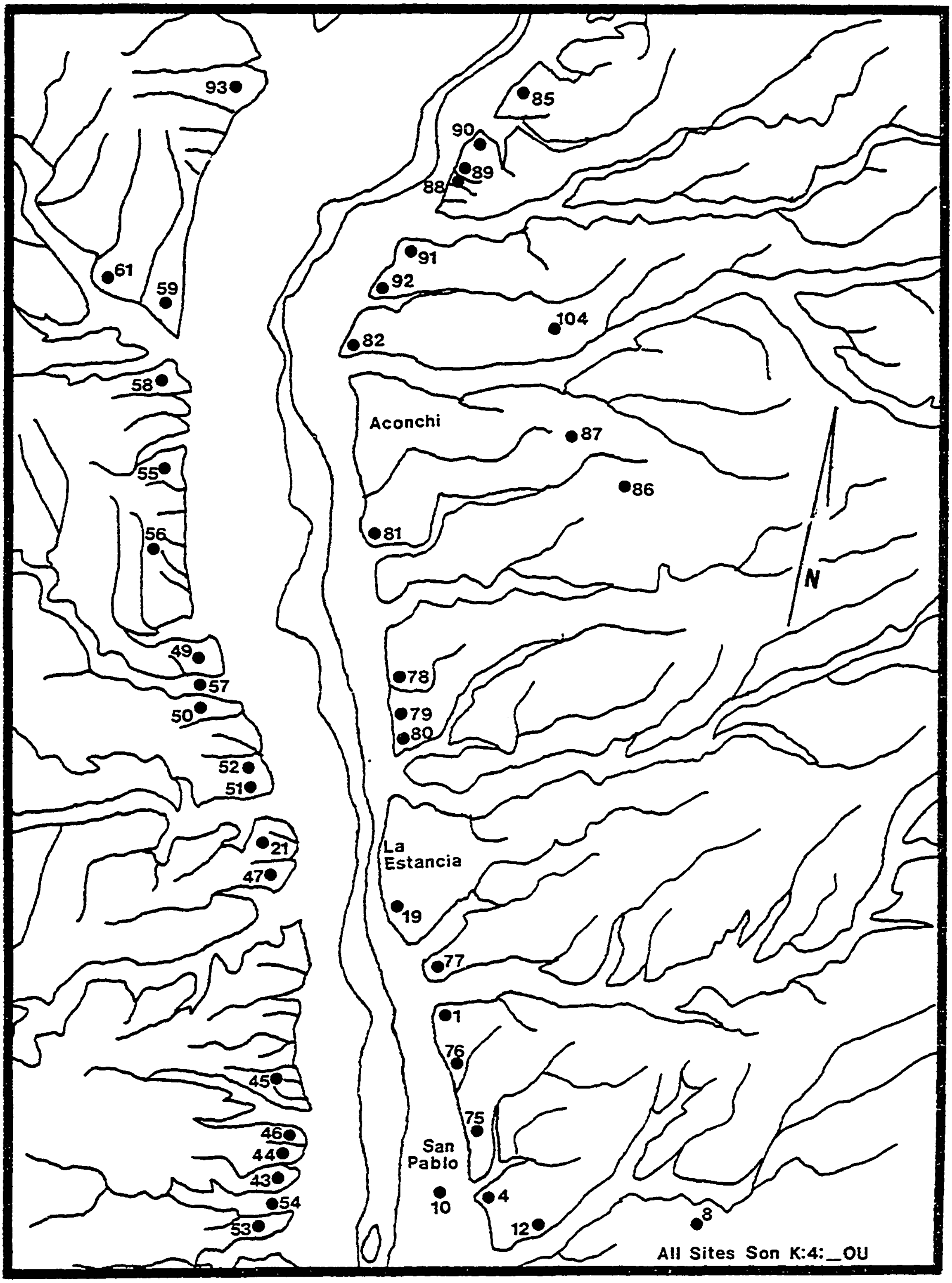
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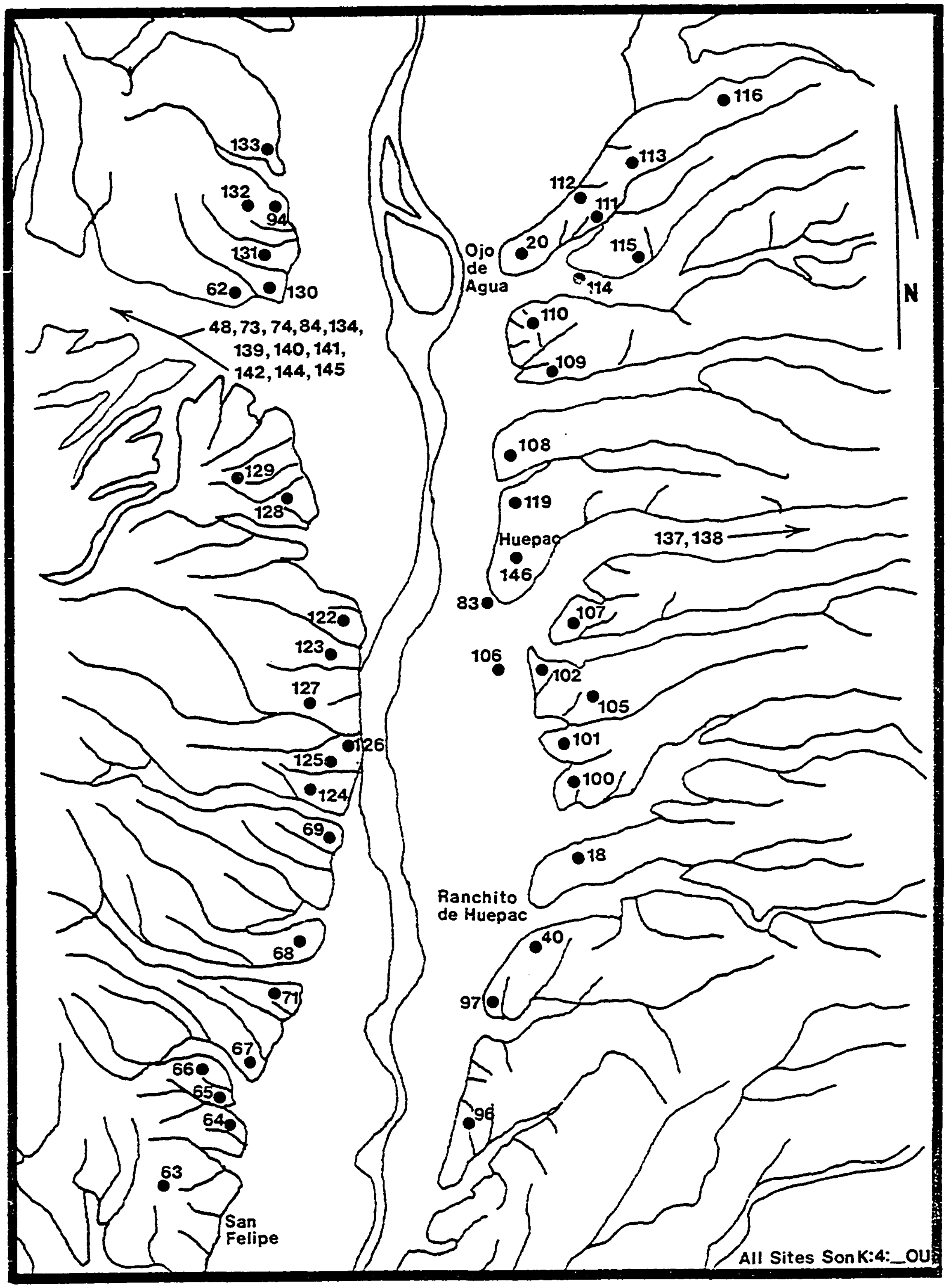

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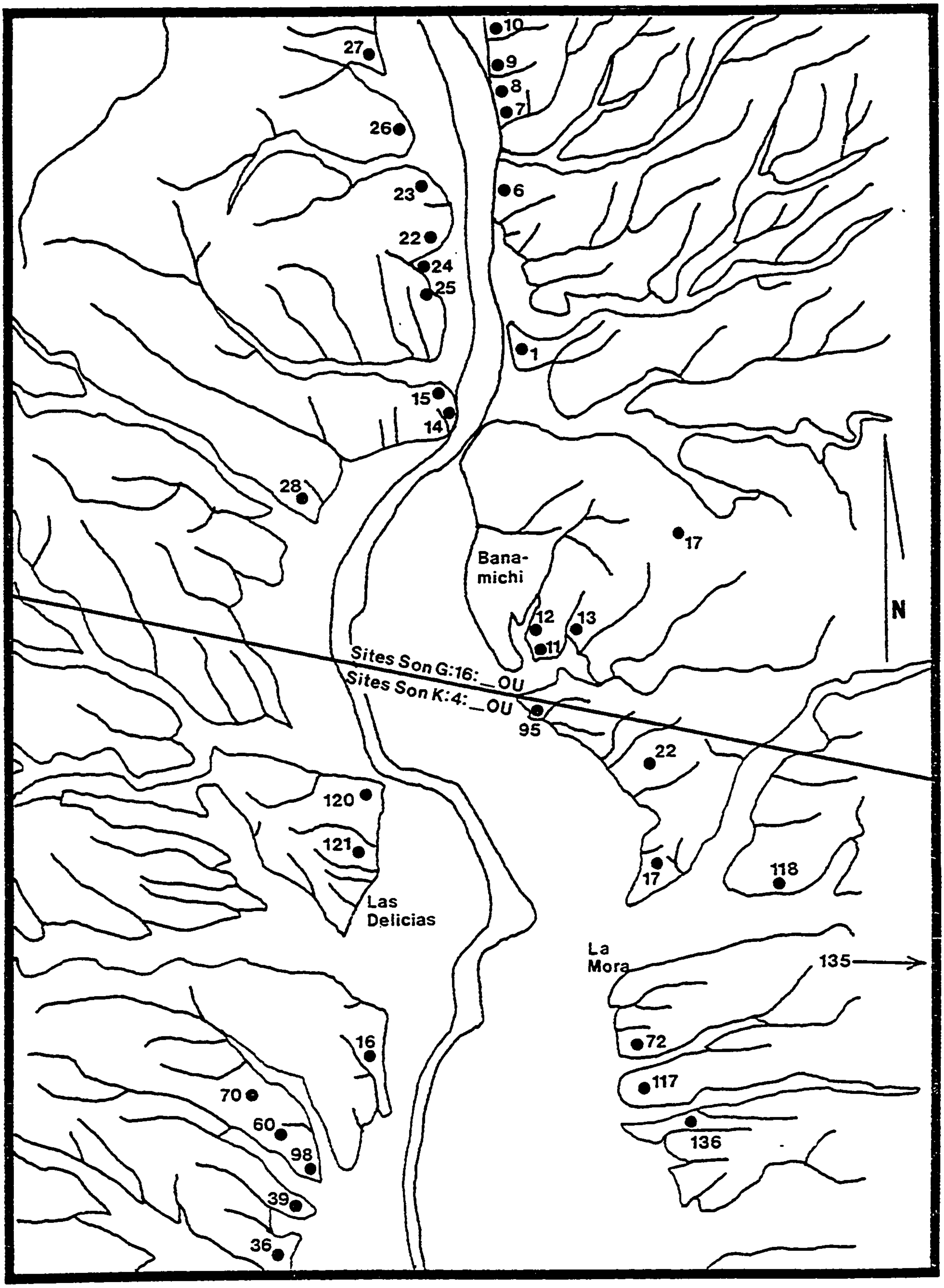
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# APPENDIX III

# ARCHAEOLOGICAL SETTLEMENT DATA

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son K:8:1 OU | W110°09'05" | N29°40'40" | Bajada edge | 1.2 | River | South | East |
| Son K:8:2 OU | W110°09'55" | N29°43'40" | Bajada edge | 0.4 | River | South | East |
| Son K:8:3 OU | W110°10'00" | N29°43'50" | Bajada edge | 0.4 | River | South | East |
| Son K:8:4 OU | W110°10'10" | N29°44'05" | Bajada edge | 0.2 | River | South | East |
| Son K:8:5 OU | W110°10'55" | N29°43'35" | Bajada edge | 1.0 | River | South | West |
| Son K:8:6 OU | W110°10'35" | N29°43'45" | Bajada edge | 0.6 | River | South | West |
| Son K:8:7 OU | W110°11'45" | N29°44'50" | Bajada edge | 0.2 | River | South | West |
| Son K:8:8 OU | W110°12'10" | N29°44'25" | Bajada edge | 0.1 | River | South | West |
| Son K:8:9 OU | W110°10'40" | N29°44'35" | Bajada edge | 0.3 | River | South | East |
| Son K:8:10 OU | W110°08'15" | N29°38'00" | Bajada edge | 0.1 | River | South | East |
| Son K:8:12 OU | W110°12'00" | N29°44'20" | Bajada edge | 0.3 | River | South | West |
| Son K:8:14 OU | W110°11'55" | N29°44'10" | Bajada edge | 0.1 | River | South | West |
| Son K:8:17 OU | W110°10'35" | N29°44'20" | Bajada edge | 0.7 | River | South | East |
| Son K:8:18 OU | W110°10'50" | N29°44'30" | Bajada edge | 0.6 | River | South | East |
| Son K:8:20 OU | W110°12'15 | N29°44'30" | Bajada edge | 0.1 | River | South | West |
| Son K:8:22 OU | W110°08'45" | N29°40'45" | Bajada edge | 1.0 | River | South | East |
| Son K:8:25 OU | W110°12'30" | N29°45'00" | Bajada edge | 0.2 | River | South | West |

| Site Number | Houses -in- Pits | Surface Structures Single Room | Multi Room | Undiff. | Other Features | Chronology |
|---|---|---|---|---|---|---|
| Son K:8:1 OU | | 4 | | | Roasting pit | Late |
| Son K:8:2 OU | | | | 6 | | Late |
| Son K:8:3 OU | 2 | | | 1 | Disturbed | Late |
| Son K:8:4 OU | | 1 | | 2 | | Late |
| Son K:8:5 OU | | | | 1 | | Late |
| Son K:8:6 OU | 2 | 1 | | 1 | | Early/Late |
| Son K:8:7 OU | | | | + | Historic foundations | Late |
| Son K:8:8 OU | 1 | | | | Rock ring | Early/Late |
| Son K:8:9 OU | 1 | 2 | | | | Early/Late |
| Son K:8:10 OU | | | | 1 | Historic house | Late |
| Son K:8:12 OU | | 1 | | 1 | Rock rings | Late |
| Son K:8:14 OU | | 2 | | | | Late |
| Son K:8:17 OU | | 6 | 1 | 1 | | Late |
| Son K:8:18 OU | | 3 | | 8 | Historic houses | Late |
| Son K:8:20 OU | | | | 2 | | Late |
| Son K:8:22 OU | + | + | + | + | Disturbed | Early/Late |
| Son K:8:25 OU | | 5 | 1 | 1 | | Late |

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son K:8:26 OU | W110°07'55" | N29°38'30" | Bajada edge | 0.5 | River | South | East |
| Son K:8:28 OU | W110°09'40" | N29°41'05" | Volcanic Terrace | 0.1 | River | South | West |
| Son K:8:29 OU | W110°09'50" | N29°41'20" | Volcanic Terrace | 0.3 | River | South | West |
| Son K:8:30 OU | W110°09'25" | N29°42'05" | Bajada edge | 0.2 | River | South | East |
| Son K:8:31 OU | W110°09'10" | N29°41'55" | Bajada edge | 0.1 | River | South | East |
| Son K:8:32 OU | W110°11'05" | N29°44'55" | Bajada edge | 0.2 | River | South | East |
| Son K:8:34 OU | W110°09'00" | N29°41'25" | Bajada edge | 0.8 | River | South | East |
| Son K:8:36 OU | W110°08'45" | N29°41'05" | Bajada edge | 0.5 | River | South | East |
| Son K:8:39 OU | W110°08'45" | N29°40'55" | Bajada edge | 0.1 | River | South | East |
| Son K:8:40 OU | W110°08'20" | N29°40'15" | Bajada edge | 0.1 | River | South | East |
| Son K:8:41 OU | W110°08'30" | N29°40'15" | Bajada edge | 0.2 | River | South | East |
| Son K:8:42 OU | W110°08'10" | N29°40'00" | Bajada edge | 0.1 | River | South | East |
| Son K:8:43 OU | W110°08'05" | N29°39'50" | Bajada edge | 0.1 | River | South | East |
| Son K:8:44 OU | W110°07'50" | N29°39'35" | Bajada edge | 0.1 | River | South | East |
| Son K:8:45 OU | W110°09'50" | N29°43'30" | Bajada edge | 0.2 | River | South | East |
| Son K:8:47 OU | W110°07'50" | N29°37'45" | Bajada edge | 0.2 | River | South | East |
| Son K:8:48 OU | W110°08'05" | N29°38'30" | Bajada edge | 0.1 | River | South | East |

| Site Number | Houses -in- Pits | Surface Structures Single Room | Multi Room | Undiff. | Other Features | Chronology |
|---|---|---|---|---|---|---|
| Son K:8:26 OU | 6 | | 1 | 2 | | Early/Late |
| Son K:8:28 OU | | 3 | | | | Late |
| Son K:8:29 OU | | | | 2 | | Late |
| Son K:8:30 OU | 1 | 3 | | | Borrow pit | Early/Late |
| Son K:8:31 OU | | | | 1 | Historic foundations | Late |
| Son K:8:32 OU | | 3 | | | Historic houses | Late |
| Son K:8:34 OU | | 10 | 4 | | Rock ring | Late |
| Son K:8:36 OU | | | | 3 | Historic house | Late |
| Son K:8:39 OU | | 2 | | | Out foundations | Late |
| Son K:8:40 OU | | 2 | | 2 | Roasting pit | Late |
| Son K:8:41 OU | 1 | | | 1 | Disturbed | Early/Late |
| Son K:8:42 OU | | | | 3 | Roasting pit | Late |
| Son K:8:43 OU | | 2 | | 1 | | Late |
| Son K:8:44 OU | 1 | 1 | | | | Early/Late |
| Son K:8:45 OU | | 1 | | 4 | Historic houses | Late |
| Son K:8:47 OU | | | | + | Disturbed | Late |
| Son K:8:48 OU | | 2 | | | Roasting pit | Late |

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son K:8:49 OU | W110°08'20" | N29°40'05" | Bajada edge | 0.1 | River | South | East |
| Son K:8:50 OU | W110°08'05" | N29°38'20" | Bajada edge | 0.1 | River | South | East |
| Son K:8:51 OU | W110°07'45" | N29°38'40" | Bajada-Arroyo | 0.1 | Arroyo | South | East |
| Son K:8:56 OU | W110°08'10" | N29°37'15" | Volcanic Terrace | 0.2 | River | South | West |
| Son K:8:57 OU | W110°08'10" | N29°37'07" | Volcanic Terrace | 0.3 | River | South | West |
| Son K:8:58 OU | W110°07'30" | N29°36'40" | Bajada edge | 0.1 | River | South | East |
| Son K:8:59 OU | W110°07'35" | N29°36'50" | Bajada edge | 0.2 | River | South | East |
| Son K:8:60 OU | W110°08'20" | N29°37'40" | Bajada edge | 0.1 | River | South | West |
| Son K:8:61 OU | W110°08'20" | N29°37'30" | Bajada edge | 0.1 | River | South | West |
| Son K:8:62 OU | W110°08'30" | N29°44'30" | Arroyo edge | 0.2 | Arroyo | South | East |
| Son K:4:1 OU | W110°12'15" | N29°46'50" | Bajada edge | 0.4 | River | South | East |
| Son K:4:2 OU | W110°11'30" | N29°45'45" | Bajada edge | 0.5 | River | South | East |
| Son K:4:4 OU | W110°11'45" | N29°46'10" | Bajada edge | 0.4 | River | South | East |
| Son K:4:16 OU | W110°13'35" | N29°57'20" | Bajada edge | 16.0 | River | North | West |
| Son K:4:17 OU | W110°11'50" | N29°59'15" | Bajada edge | 0.5 | River | North | East |
| Son K:4:18 OU | W110°12'40" | N29°53'15" | Bajada edge | 0.5 | River | North | East |

| Site Number | Houses -in- Pits | Surface Structures Single Room | Multi Room | Undiff. | Other Features | Chronology |
|---|---|---|---|---|---|---|
| Son K:8:49 OU | | 3 | | 2 | Historic houses | Late |
| Son K:8:50 OU | | | | 2 | Historic houses | Late |
| Son K:8:51 OU | | 1 | | 1 | | Late |
| Son K:8:56 OU | 2 | | | 2 | Historic house | Early/Late |
| Son K:8:57 OU | | 7 | | 4 | Historic house | Late |
| Son K:8:58 OU | | 1 | | | | Late |
| Son K:8:59 OU | | 4 | | 4 | Roasting pit | Late |
| Son K:8:60 OU | 1 | | | | Glyph rock | Early/Late |
| Son K:8:61 OU | 2 | | | | 1 Mound | Early/Late |
| Son K:8:62 OU | | | | | Trincheras walls | Late |
| Son K:4:1 OU | | 1 | 2 | | | Late |
| Son K:4:2 OU | | | | + | Walls | Late |
| Son K:4:4 OU | 1 | 1 | | | Roasting pit | Early/late |
| Son K:4:16 OU | + | + | + | 200+ | Public Architecture | Early/Late |
| Son K:4:17 OU | 1 | 7 | | 2 | Historic house | Early/Late |
| Son K:4:18 OU | | 3 | | 1 | | Late |

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son K:4:19 OU | W110°12'35" | N29°47'20" | Bajada edge | 0.6 | River | South | East |
| Son K:4:20 OU | W110°12'45" | N29°56'10" | Bajada edge | 8.0 | River | North | East |
| Son K:4:21 OU | W110°13'30" | N29°47'30" | Bajada edge | 0.4 | River | South | West |
| Son K:4:22 OU | W110°12'00" | N29°59'40" | Bajada edge | 4.5 | River | North | East |
| Son K:4:24 OU | W110°11'15" | N29°45'10" | Bajada edge | 10.0 | River | South | East |
| Son K:4:26 OU | W110°12'30" | N29°45'07" | Bajada edge | 0.2 | River | South | West |
| Son K:4:30 OU | W110°12'40" | N29°45'30" | Bajada edge | 0.1 | River | South | West |
| Son K:4:31 OU | W110°12'45" | N29°45'15" | Bajada edge | 1.4 | River | South | West |
| Son K:4:32 OU | W110°08'25" | N29°45'00" | Bajada edge | 8.0 | Arroyo | South | East |
| Son K:4:36 OU | W110°14'15" | N29°57'15" | Bajada edge | 0.1 | River | North | West |
| Son K:4:39 OU | W110°14'05" | N29°57'30" | Bajada edge | 0.2 | River | North | West |
| Son K:4:40 OU | W110°12'55" | N29°52'50" | Bajada edge | 2.0 | River | North | East |
| Son K:4:41 OU | W110°11'30" | N29°45'20" | Bajada edge | 0.4 | River | South | East |
| Son K:4:43 OU | W110°12'50" | N29°46'00" | Bajada edge | 0.4 | River | South | West |
| Son K:4:44 OU | W110°12'50" | N29°46'10" | Bajada edge | 0.5 | River | South | West |
| Son K:4:46 OU | W110°12'50" | N29°46'20" | Bajada edge | 0.5 | River | South | West |

| Site Number | Houses -in- Pits | Surface Structures Single Room | Multi Room | Undiff. | Other Features | Chronology |
|---|---|---|---|---|---|---|
| Son K:4:19 OU | | | | + | Disturbed | Late |
| Son K:4:20 OU | | 75 | 10 | + | | Late |
| Son K:4:21 OU | 6 | | | | 1 Trincheras foundation | Early/Late |
| Son K:4:22 OU | | | | + | Cerro de Trinchera | Late |
| Son K:4:24 OU | 60 | 65+ | 20+ | + | Public Architecture | Early/Late |
| Son K:4:26 OU | | 1 | | | | Late |
| Son K:4:30 OU | | 1 | | | | Late |
| Son K:4:31 OU | | 3 | | 4 | | Late |
| Son K:4:32 OU | 12 | 6 | | | | Early/Late |
| Son K:4:36 OU | | | | 5 | | Late |
| Son K:4:39 OU | | | | 2 | | Late |
| Son K:4:40 OU | 2 | 6 | | 7 | | Early/Late |
| Son K:4:41 OU | 7 | | | | | Early/Late |
| Son K:4:43 OU | 1 | 2 | | | | Early/Late |
| Son K:4:44 OU | 1 | 2 | | | | Early/Late |
| Son K:4:46 OU | 5 | 2 | | | | Early/Late |

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son K:4:47 OU | W110°13'30" | N29°47'20" | Bajada edge | 0.5 | River | South | West |
| Son K:4:48 OU | W110°17'30" | N29°56'45" | Arroyo edge | 0.2 | Arroyo | North | West |
| Son K:4:49 OU | W110°14'10" | N29°48'15" | Bajada edge | 0.4 | River | South | West |
| Son K:4:50 OU | W110°13'55" | N29°48'00" | Bajada edge | 0.4 | River | South | West |
| Son K:4:51 OU | W110°13'35" | N29°47'45" | Bajada edge | 0.5 | River | South | West |
| Son K:4:52 OU | W110°13'35" | N29°47'55" | Bajada edge | 0.2 | River | South | West |
| Son K:4:53 OU | W110°12'50" | N29°45'45" | Bajada edge | 0.1 | River | South | West |
| Son K:4:55 OU | W110°14'40" | N29°49'05" | Bajada edge | 0.2 | River | South | West |
| Son K:4:56 OU | W110°14'35" | N29°48'40" | Bajada ridge | 0.1 | River | South | West |
| Son K:4:58 OU | W110°14'50" | N29°49'30" | Bajada edge | 0.6 | River | South | West |
| Son K:4:59 OU | W110°14'55" | N29°49'45" | Bajada edge | 0.8 | River | South | West |
| Son K:4:60 OU | W110°14'00" | N29°57'50" | Bajada edge | 0.4 | River | North | West |
| Son K:4:61 OU | W110°15'15" | N29°49'45" | Bajada arroyo | 0.2 | Arroyo | South | West |
| Son K:4:62 OU | W110°14'20" | N29°56'00" | Bajada edge | 0.2 | Arroyo | North | West |
| Son K:4:64 OU | W110°14'30" | N29°52'10" | Bajada edge | 0.2 | River | North | West |
| Son K:4:67 OU | W110°14'25" | N29°52'20 | Bajada edge | 0.2 | River | North | West |

| Site Number | Houses -in- Pits | Surface Structures Single Room | Multi Room | Undiff. | Other Features | Chronology |
|---|---|---|---|---|---|---|
| Son K:4:47 OU | 5 | | | | | Early/Late |
| Son K:4:48 OU | | | | 3 | 4 Trincheras foundations | Late |
| Son K:4:49 OU | 3 | 1 | 1 | | | Early/Late |
| Son K:4:50 OU | | 1 | 2 | | | Late |
| Son K:4:51 OU | | 2 | 2 | | | Late |
| Son K:4:52 OU | 1 | 1 | | | | Early/Late |
| Son K:4:53 OU | 3 | | | | | Early/Late |
| Son K:4:55 OU | | 1 | | | | Late |
| Son K:4:56 OU | | 1 | | | | Late |
| Son K:4:58 OU | 2 | 2 | | | | Early/Late |
| Son K:4:59 OU | | 8 | 4 | | | Late |
| Son K:4:60 OU | | | | + | | Late |
| Son K:4:61 OU | | 1 | | | | Late |
| Son K:4:62 OU | | | | 4 | | Late |
| Son K:4:64 OU | 3 | | | | | Early/Late |
| Son K:4:67 OU | 4 | | | | | Early/Late |

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son K:4:68 OU | W110°14'20" | N29°52'50" | Bajada edge | 0.8 | River | North | West |
| Son K:4:69 OU | W110°13'55" | N29°53'20" | Bajada edge | 0.3 | River | North | West |
| Son K:4:70 OU | W110°14'00" | N29°58'00" | Hill top | 0.1 | River | North | West |
| Son K:4:71 OU | W110°14'20" | N29°52'40" | Bajada edge | 0.2 | River | North | West |
| Son K:4:72 OU | W110°12'00" | N29°58'20" | Bajada edge | 2.0 | River | North | East |
| Son K:4:73 OU | W110°17'15" | N29°56'55" | Arroyo edge | 0.1 | Arroyo | North | West |
| Son K:4:75 OU | W110°11'55" | N29°46'30" | Bajada edge | 3.0 | River | South | East |
| Son K:4:76 OU | W110°12'05" | N29°46'45" | Bajada edge | 0.6 | River | South | East |
| Son K:4:77 OU | W110°12'20" | N29°47'10" | Bajada edge | 1.0 | River | South | East |
| Son K:4:78 OU | W110°13'10" | N29°48'20" | Bajada edge | 0.5 | River | South | East |
| Son K:4:79 OU | W110°13'00" | N29°48'20" | Bajada edge | 0.2 | River | South | East |
| Son K:4:80 OU | W110°12'55" | N29°48'05" | Bajada edge | 0.2 | River | South | East |
| Son K:4:81 OU | W110°13'15" | N29°48'45" | Bajada edge | 0.2 | River | South | East |
| Son K:4:82 OU | W110°13'55" | N29°49'50" | Bajada edge | 1.2 | River | South | East |
| Son K:4:83 OU | W110°13'00" | N29°54'30" | Bajada edge | 1.5 | River | North | East |
| Son K:4:84 OU | W110°18'50" | N29°56'30" | Arroyo edge | 0.1 | Arroyo | North | West |

| Site Number | Houses -in- Pits | Surface Structures Single Room | Multi Room | Undiff. | Other Features | Chronology |
|---|---|---|---|---|---|---|
| Son K:4:68 OU | 2 | 5 | | | | Early/Late |
| Son K:4:69 OU | 4 | 4 | | 5 | | Early/Late |
| Son K:4:70 OU | | | | | Cerro de Trincheras | Late |
| Son K:4:71 OU | | 3 | | 1 | | Late |
| Son K:4:72 OU | 5 | 4 | | + | 20+Mound foundations | Early/Late |
| Son K:4:73 OU | 4 | | | 3 | 1 Trincheras foundations | Early/Late |
| Son K:4:75 OU | | + | | Several | Disturbed | Late |
| Son K:4:76 OU | 3 | 9 | | | | Early/Late |
| Son K:4:77 OU | 3 | 2 | | | | Early/Late |
| Son K:4:78 OU | 5 | | | + | Disturbed | Early/Late |
| Son K:4:79 OU | | | | 5 | | Late |
| Son K:4:80 OU | | 2 | | + | Roasting pit,disturbed | Late |
| Son K:4:81 OU | 2 | 1 | | | Roasting pit | Early/Late |
| Son K:4:82 OU | 1 | 2 | | | 5 Mound foundations, historic house | |
| Son K:4:83 OU | | | | + | Disturbed | Late |
| Son K:4:84 OU | | | | + | Historic house | Late |

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son K:4:85 OU | W110°13'35" | N29°51'15" | Bajada edge | 3.0 | River | North | East |
| Son K:4:89 OU | W110°13'45" | N29°50'55" | Bajada edge | 0.5 | River | North | East |
| Son K:4:90 OU | W110°13'45" | N29°51'00" | Bajada edge | 0.4 | River | North | East |
| Son K:4:91 OU | W110°13'50 | N29°50'25" | Bajada edge | 1.5 | River | South | East |
| Son K:4:92 OU | W110°13'55" | N29°50'10" | Bajada edge | 0.5 | River | South | East |
| Son K:4:93 OU | W110°15'00" | N29°50'50" | Arroyo edge | 1.0 | River | North | West |
| Son K:4:94 OU | W110°14'00" | N29°56'20" | Bajada edge | 0.4 | River | North | West |
| Son K:4:95 OU | W110°12'40" | N29°59'55" | Bajada edge | 0.4 | River | North | East |
| Son K:4:96 OU | W110°13'00" | N29°52'15" | Bajada edge | 0.1 | River | North | East |
| Son K:4:97 OU | W110°13'00" | N29°52'40" | Bajada edge | 0.3 | River | North | East |
| Son K:4:98 OU | W110°14'00" | N29°57'45" | Bajada edge | 0.3 | River | North | West |
| Son K:4:99 OU | W110°11'30" | N29°45'35" | Bajada edge | 0.2 | River | South | East |
| Son K:4:101 OU | W110°12'30" | N29°53'50" | Bajada edge | 2.0 | River | North | East |
| Son K:4:102 OU | W110°12'50" | N29°54'00" | Bajada edge | 0.3 | River | North | East |
| Son K:4:105 OU | W110°12'15" | N29°54'00" | Bajada edge | 0.2 | River | North | East |
| Son K:4:106 OU | W110°12'55" | N29°54'00" | Bajada edge | 3.0 | River | North | East |

| Site Number | Houses -in- Pits | Surface Structures Single Room | Multi Room | Undiff | Other Features | Chronology |
|---|---|---|---|---|---|---|
| Son K:4:85 OU | 1 | 12 | 1 | 4 | Rock rings, Disturbed | Early/Late |
| Son K:4:89 OU | | 3 | | | | Late |
| Son K:4:90 OU | | 2 | | | | Late |
| Son K:4:91 OU | | 4 | 2 | | Out buildings | Late |
| Son K:4:92 OU | | 3 | 1 | | | Late |
| Son K:4:93 OU | 3 | 2 | | 2 | Mill, disturbed | Early/Late |
| Son K:4:94 OU | | 3 | 1 | 5 | | Late |
| Son K:4:95 OU | | | | + | Disturbed, historic house | Late |
| Son K:4:96 OU | | 1 | | 1 | | Late |
| Son K:4:97 OU | 1 | 1 | | 1 | | Early/Late |
| Son K:4:98 OU | | | | 5 | | Late |
| Son K:4:99 OU | | 6 | | | | Late |
| Son K:4:101 OU | | 5 | 2 | | | Late |
| Son K:4:102 OU | | 1 | | | | Late |
| Son K:4:105 OU | | | | | Possible Cerro de Trinchera | Late |
| Son K:4:106 OU | 1 | 14 | | 1 | | Early/Late |

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son K:4:107 OU | W110°12'30" | N29°54'15" | Arroyo edge | 1.5 | River/ Arroyo | North | East |
| Son K:4:108 OU | W110°12'55" | N29°55'10" | Bajada edge | 1.0 | River | North | East |
| Son K:4:109 OU | W110°12'40" | N29°55'30" | Bajada edge | 0.4 | River | North | East |
| Son K:4:110 OU | W110°12'40" | N29°55'45" | Bajada edge | 2.3 | River | North | East |
| Son K:4:111 OU | W110°12'25" | N29°56'15" | Arroyo Edge | 0.3 | Arroyo | North | East |
| Son K:4:112 OU | W110°12'25" | N29°56'25" | Arroyo edge | 0.3 | River | North | East |
| Son K:4:113 OU | W110°12'00" | N29°56'30" | Arroyo edge | 1.2 | Arroyo | North | East |
| Son K:4:115 OU | W110°12'05" | N29°56'10" | Arroyo edge | 0.8 | Arroyo | North | East |
| Son K:4:116 OU | W110°11'30" | N29°56'50" | Arroyo edge | 5.0 | Arroyo | North | East |
| Son K:4:117 OU | W110°12'00" | N29°58'05" | Bajada edge | 0.6 | River | North | East |
| Son K:4:118 OU | W110°11'25" | N29°59'05" | Arroyo edge | 0.6 | Arroyo | North | East |
| Son K:4:119 OU | W110°12'55" | N29°54'55" | Bajada edge | 0.9 | River | North | East |
| Son K:4:120 OU | W110°13'40" | N29°59'30" | Bajada edge | 5.0 | River | North | West |
| Son K:4:121 OU | W110°13'40" | N29°59'20" | Bajada edge | 0.2 | River | North | West |
| Son K:4:122 OU | W110°13'55" | N29°54'30" | Bajada edge | 0.4 | River | North | West |
| Son K:4:123 OU | W110°13'50" | N29°54'15" | Bajada edge | 0.3 | River | North | West |

| Site Number | Houses -in- Pits | Surface Structures Single Room | Multi Room | Undiff. | Other Features | Chronology |
|---|---|---|---|---|---|---|
| Son K:4:107 OU | | 1 | | 3 | Roasting pit | Late |
| Son K:4:108 OU | | | | + | Disturbed | Late |
| Son K:4:109 OU | 1 | 3 | | | | Early/Late |
| Son K:4:110 OU | 10 | 6 | | | | Early/Late |
| Son K:4:111 OU | | 2 | | | | Late |
| Son K:4:112 OU | | 2 | | | | Late |
| Son K:4:113 OU | 5 | 1 | | | | Early/Late |
| Son K:4:115 OU | | | | 3 | | Late |
| Son K:4:116 OU | 5 | 1 | | | 8 Possible mound foundation | Early/Late |
| Son K:4:117 OU | 3 | 2 | | 4 | | Early/Late |
| Son K:4:118 OU | 3 | | | 1 | Trincheras wall | Early/Late |
| Son K:4:119 OU | | | | + | Disturbed, historic house | Late |
| Son K:4:120 OU | 2 | 22 | 3 | 18 | Roasting pits, Rock rings | Early/Late |
| Son K:4:121 OU | 1 | | | 7 | | Early/Late |
| Son K:4:122 OU | | 8 | 3 | 7 | Rock rings | Late |
| Son K:4:123 OU | 1 | 4 | 1 | 2 | Historic foundation | Early/Late |

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son K:4:124 OU | W110°13'55" | N29°53'40" | Bajada edge | 0.3 | River | North | West |
| Son K:4:125 OU | W110°13'50" | N29°53'50" | Bajada edge | 0.3 | River | North | West |
| Son K:4:126 OU | W110°13'45" | N29°53'55" | Bajada edge | 0.4 | River | North | West |
| Son K:4:127 OU | W110°14'00" | N29°54'00" | Bajada edge | 1.5 | River | North | West |
| Son K:4:128 OU | W110°14'00" | N29°55'00" | Bajada edge | 0.4 | River | North | West |
| Son K:4:129 OU | W110°14'10" | N29°55'10" | Bajada edge | 0.5 | River | North | West |
| Son K:4:130 OU | W110°14'15" | N29°56'00" | Bajada edge | 0.2 | River | North | West |
| Son K:4:131 OU | W110°14'15" | N29°56'05" | Bajada edge | 0.4 | River | North | West |
| Son K:4:132 OU | W110°14'25" | N29°56'20" | Bajada edge | 1.5 | River | North | West |
| Son K:4:133 OU | W110°14'25" | N29°56'45" | Bajada edge | 0.2 | River | North | West |
| Son K:4:135 OU | W110°08'30" | N29°58'05" | Pediment | 0.1 | Arroyo | North | East |
| Son K:4:137 OU | W110°07'00" | N29°55'15" | Arroyo edge | 0.1 | Arroyo | North | East |
| Son K:4:138 OU | W110°05'45" | N29°55'00" | Arroyo edge | 0.1 | Arroyo | North | East |
| Son K:4:139 OU | W110°20'20" | N29°56'00" | Arroyo edge | 0.2 | Arroyo | North | West |
| Son K:4:144 OU | W110°20'05" | N29°56'20" | Arroyo edge | 0.7 | Arroyo | North | West |

| Site Number | Houses -in- Pits | Surface Structures Single Room | Multi Room | Undiff. | Other Features | Chronology |
|---|---|---|---|---|---|---|
| Son K:4:124 OU | 2 | 1 | | | | Early/Late |
| Son K:4:125 OU | 1 | 5 | 1 | 1 | Trincheras wall | Early/Late |
| Son K:4:126 OU | 1 | 2 | | 3 | Historic houses, Roasting pit | Early/Late |
| Son K:4:127 OU | 4 | 6 | 2 | | Trincheras enclosure, Public architecture, 1 Mound foundation, historic foundation | Early/Late |
| Son K:4:128 OU | 2 | 3 | | | Roasting pit | Early/Late |
| Son K:4:129 OU | | | | 4 | | Late |
| Son K:4:130 OU | 3 | 2 | | 3 | | Early/Late |
| Son K:4:131 OU | | | | 3 | | Late |
| Son K:4:132 OU | 1 | 1 | | 7 | Cerro de Trinchera | Early/Late |
| Son K:4:133 OU | | 2 | | | Roasting pit | Late |
| Son K:4:135 OU | | | | 2 | | Late |
| Son K:4:137 OU | | | | 2 | | Late |
| Son K:4:138 OU | | | | | Trincheras walls | Late |
| Son K:4:139 OU | | | | + | Historic house | Late |
| Son K:4:144 OU | 1 | 3 | 1 | | 1 Trincheras foundation | Early/Late |

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son K:4:145 OU | W110°18'30" | N29°56'20" | Arroyo edge | 0.4 | Arroyo | North | West |
| Son K:4:146 OU | W110°13'50" | N29°54'35" | Arroyo edge | 3.0 | River | North | East |
| Son G:16:1 OU | W110°12'45" | N30°01'30" | Bajada edge | 1.2 | River | North | East |
| Son G:16:6 OU | W110°12'50" | N30°02'15" | Bajada edge | 0.8 | River | North | East |
| Son G:16:7 OU | W110°12'55" | N30°02'45" | Bajada edge | 0.3 | River | North | East |
| Son G:16:8 OU | W110°12'55" | N30°02'50" | Bajada edge | 0.1 | River | North | East |
| Son G:16:9 OU | W110°12'55" | N30°02'55" | Bajada edge | 0.1 | River | North | East |
| Son G:16:10 OU | W110°13'00" | N30°03'05" | Bajada edge | 0.1 | River | North | East |
| Son G:16:13 OU | W110°12'25" | N30°00'15" | Arroyo edge | 0.1 | Arroyo | North | East |
| Son G:16:14 OU | W110°13'10" | N30°01'10" | Volcanic terrace | 0.1 | River | North | West |
| Son G:16:15 OU | W110°13'10" | N30°01'20" | Volcanic terrace | 0.2 | River | North | West |
| Son G:16:22 OU | W110°13'15" | N30°02'05" | Bajada edge | 3.0 | River | North | West |
| Son G:16:23 OU | W110°13'15" | N30°02'15" | Bajada edge | 0.2 | River | North | West |
| Son G:16:25 OU | W110°13'15" | N30°01'45" | Bajada edge | 0.8 | River | North | West |

| Site Number | Houses -in- Pits | Surface Structures Single Room | Multi Room | Undiff. | Other Features | Chronology |
|---|---|---|---|---|---|---|
| Son K:4:145 OU | | 3 | | 5 | 1 Trincheras foundation, Trincheras enclosure | Late |
| Son K:4:146 OU | | + | | + | Disturbed | Late |
| Son G:16:1 OU | | 6 | 1 | 3 | Historic foundation | Late |
| Son G:16:6 OU | | 8 | 1 | | Historic foundations and houses | Late |
| Son G:16:7 OU | | 7 | 3 | | Wall | Late |
| Son G:16:8 OU | 1 | 1 | | | | Early/Late |
| Son G:16:9 OU | | | 2 | | Historic foundation | Late |
| Son G:16:10 OU | | 5 | 2 | | | Late |
| Son G:16:13 OU | 1 | | | | | Early/Late |
| Son G:16:14 OU | 1 | | | | | Early/Late |
| Son G:16:15 OU | | | 2 | | | Late |
| Son G:16:22 OU | | 5 | 1 | 6 | 2 Trincheras foundations 7 Mound foundations | Late |
| Son G:16:23 OU | | 2 | | | | Late |
| Son G:16:25 OU | 2 | 3 | 1 | 4 | 8 Mound foundations, Roasting pits, Trincheras wall | Early/Late |

| Site Number | Longitude | Latitude | Locale | Area (ha) | Site Orientation | Valley Segment | Bank Side |
|---|---|---|---|---|---|---|---|
| Son G:16:26 OU | W110°13'30" | N30°02'30" | Bajada edge | 0.5 | River | North | West |
| Son G:16:27 OU | W110°13'45" | N30°03'00" | Bajada edge | 1.0 | River | North | West |
| Son G:16:28 OU | W110°14'00" | N30°00'55" | Bajada edge | 0.2 | River | North | West |

| Site Number | Houses -in- Pits | Surface Structures | | | Other Features | Chronology |
|---|---|---|---|---|---|---|
| | | Single Room | Multi Room | Undiff. | | |
| Son G:16:26 OU | 1 | 1 | 1 | 5 | 2 Trincheras foundations | Early/Late |
| Son G:16:27 OU | 2 | 6 | 4 | 11 | 7 Mound foundations | Early/Late |
| Son G:16:28 OU | | 3 | 1 | 7 | 2 Mound foundations | Late |

APPENDIX IV

SPECIAL SITE DATA

| Site No. | Type/Features | Longitude | Latitude | Ground Lithics | Flaked Lithics | Ceramics |
|---|---|---|---|---|---|---|
| Son K:8:11 OU | Scatter | W110°11'10" | N29°43'40" | | X | |
| Son K:8:13 OU | Scatter | W110°12'05" | N29°44'20" | X | X | X |
| Son K:8:15 OU | Signal | W110°11'40" | N29°43'45" | | | |
| Son K:8:15 OU | Scatter | W110°11'20" | N29°43'45" | | X | X |
| Son K:8:19 OU | Scatter | W110°12'15" | N29°44'00" | | X | |
| Son K:8:21 OU | Scatter | W110°12'15" | N29°44'40" | X | X | X |
| Son K:8:23 OU | Scatter | W110°12'20" | N29°44'50" | | | X |
| Son K:8:24 OU | Scatter | W110°12'20" | N29°44'45" | | X | X |
| Son K:8:27 OU | Scatter | W110°10'30" | N29°41'45" | | | X |
| Son K:8:33 OU | Scatter | W110°10'00" | N29°44'50" | X | | |
| Son K:8:35 OU | Scatter | W110°11'15" | N29°44'20" | | X | X |
| Son K:8:37 OU | Scatter | W110°09'20" | N29°44'15" | | X | |
| Son K:8:38 OU | Scatter | W110°09'10" | N29°44'15" | | X | |
| Son K:8:46 OU | Signal | W110°07'40" | N29°39'10" | | | |
| Son K:8:52 OU | Scatter | W110°09'00" | N29°42'55" | | X | |
| Son K:8:53 OU | Scatter | W110°08'20" | N29°43'00" | | X | |

| Site No. | Type/Features | Longitude | Latitude | Ground Lithics | Flaked Lithics | Ceramics |
|---|---|---|---|---|---|---|
| Son K:8:54 OU | Scatter/ Roasting Pit | W110°07'45" | N29°42'50" | | X | |
| Son K:8:55 OU | Scatter | W110°07'30" | N29°42'45" | | X | |
| Son K:8:63 OU | Weir terraces | W110°08'30" | N29°44'40" | | | |
| Son K:4:3 OU | Scatter/ Roasting Pit | W110°11'20" | N29°45'55" | | X | X |
| Son K:4:5 OU | Scatter | W110°10'55" | N29°45'10" | | X | |
| Son K:4:6 OU | Scatter | W110°10'55" | N29°45'00" | | X | |
| Son K:4:7 OU | Scatter | W110°10'50" | N29°45'00" | | X | |
| Son K:4:8 OU | Scatter | W110°10'30" | N29°46'20" | | X | |
| Son K:4:9 OU | Scatter | W110°11'25" | N29°46'00" | | X | |
| Son K:4:10 OU | Scatter | W110°12'00" | N29°46'15" | | | X |
| Son K:4:11 OU | Historic (deleted from analysis) | | | | | |
| Son K:4:12 OU | Scatter | W110°11'25" | N29°46'05" | | X | X |
| Son K:4:13 OU | Scatter | W110°11'50" | N29°45'45" | | | X |
| Son K:4:14 OU | Scatter | W110°12'00" | N29°45'20" | | X | X |
| Son K:4:15 OU | Scatter | W110°07'38" | N29°46'50" | X | X | X |
| Son K:4:23 OU | Scatter | W110°09'20" | N29°45'40" | | X | |

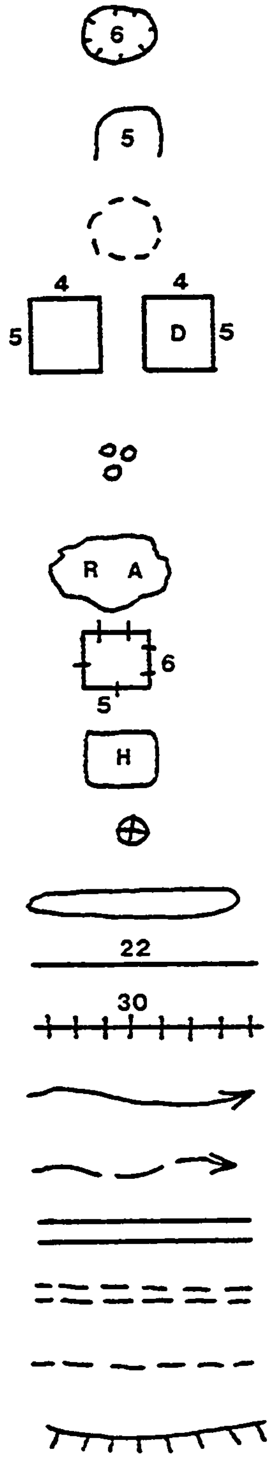
| Site No. | Type/Features | Longitude | Latitude | Ground Lithics | Flaked Lithics | Ceramics |
|---|---|---|---|---|---|---|
| Son K:4:25 OU | Scatter | W110°12'25" | N29°45'02" | X | X | X |
| Son K:4:27 OU | Scatter | W110°12'50" | N29°45'30" | | X | X |
| Son K:4:28 OU | Scatter | W110°12'20" | N29°45'20" | | X | X |
| Son K:4:29 OU | Scatter | W110°12'35" | N29°45'02" | X | X | |
| Son K:4:33 OU | Scatter | W110°08'05" | N29°44'50" | | X | X |
| Son K:4:34 OU | Weir terrace/ Roasting pit | W110°08'30" | N29°44'45" | X | X | X |
| Son K:4:35 OU | Scatter/ Roasting pit | W110°09'00" | N29°44'45" | | X | X |
| Son K:4:37 OU | Scatter | W110°07'50" | N29°44'35" | | X | X |
| Son K:4:38 OU | Weir terrace | W110°08'45" | N29°45'25" | X | X | X |
| Son K:4:42 OU | Roasting pits | W110°11'30" | N29°45'15" | | | |
| Son K:4:45 OU | Scatter | W110°12'55" | N29°46'30" | | X | |
| Son K:4:54 OU | Scatter | W110°12'50" | N29°45'50" | | X | X |
| Son K:4:57 OU | Scatter | W110°14'00" | N29°48'05" | | | X |
| Son K:4:63 OU | Signal | W110°14'55" | N29°51'40" | | | |
| Son K:4:65 OU | Scatter | W110°14'30" | N29°52'15" | | X | |
| Son K:4:66 OU | Scatter | W110°14'35" | N29°52'25" | | X | |

| Site No. | Type/Features | Longitude | Latitude | Ground Lithics | Flaked Lithics | Ceramics |
|---|---|---|---|---|---|---|
| Son K:4:74 OU | Scatter | W110°19'15" | N29°56'30" | | X | |
| Son K:4:86 OU | Scatter | W110°12'15" | N29°49'40" | | X | |
| Son K:4:87 OU | Scatter | W110°12'40" | N29°49'45" | | X | |
| Son K:4:88 OU | Scatter | W110°13'45" | N29°50'45" | | X | X |
| Son K:4:100 OU | Scatter | W110°12'30" | N39°53'40" | | X | X |
| Son K:4:103 OU | Scatter | W110°07'15" | N29°47'07" | | X | |
| Son K:4:104 OU | Roasting pit | W110°12'55" | N29°50'05" | | | |
| Son K:4:114 OU | Weir terraces | W110°12'25" | N29°56'05" | | | |
| Son K:4:134 OU | Signal | W110°17'45" | N29°55'20" | | | |
| Son K:4:136 OU | Scatter | W110°11'50" | N29°57'50" | | X | |
| Son K:4:140 OU | Weir terraces | W110°21'30" | N29°55'15" | | | |
| Son K:4:141 OU | Signal | W110°22'15" | N29°55'30" | | | |
| Son K:4:142 OU | Weir terraces | W110°22'15" | N29°54'50" | | | |
| Son K:4:143 | Signal | W110°10'35" | N29°45'10" | | | |
| Son G:16:11 OU | Scatter | W110°12'35" | N30°00'15" | | X | |
| Son G:16:12 OU | Scatter | W110°12'35" | N30°00'20" | | X | |
| Son G:16:17 OU | Signal | W110°12'00" | N30°00'45" | | | |
| Son G:16:24 OU | Glyph | W110°13'20" | N30°02'00" | | | |

APPENDIX V

MAPS OF PRE-HISPANIC SETTLEMENTS

<u>Legend</u>




Depression-type house-in-pit (#=dia. in meters)

Circular rock-type house-in-pit

Possible house-in-pit

Surface structure (#=length in meters, D=double row foundation)

Undifferentiated relic structure

House mound (R=rock, A=adobe melt)

Trincheras foundation

Historic foundation or modern house

Roasting pit

Mounded rubble

Linear embedded rock wall (#=length in meters)

Trincheras rock wall (#=length in meters)

Floodplain with direction of river flow

Arroyo with direction of stream flow

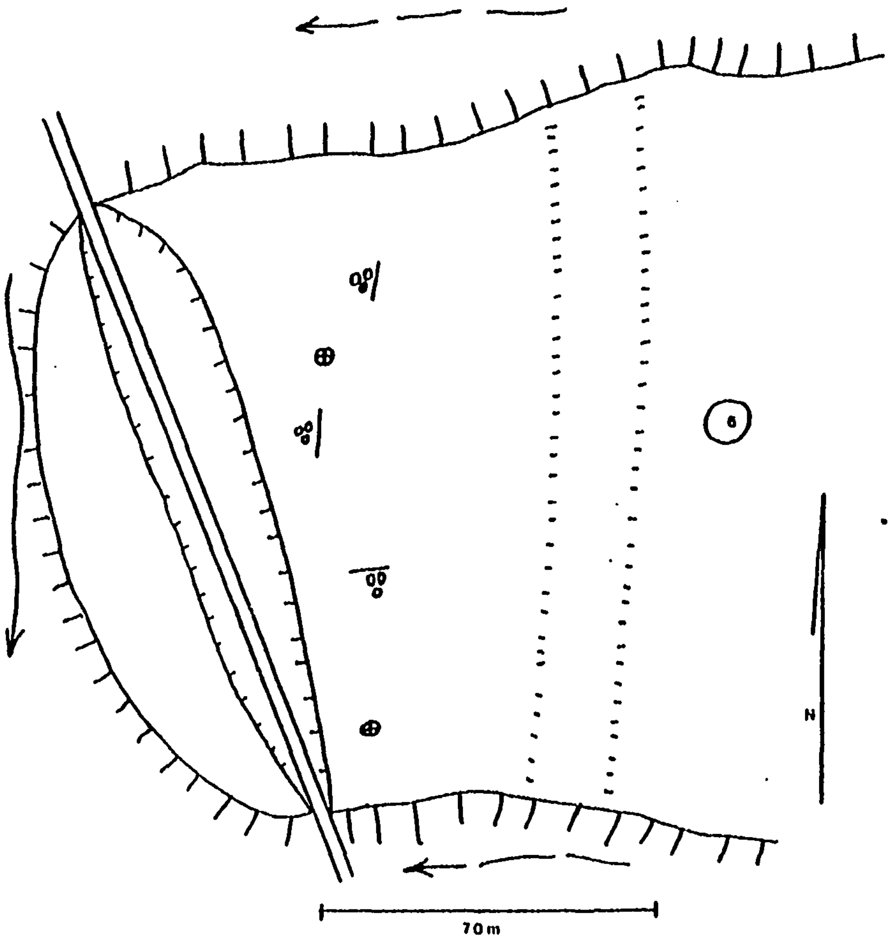
Paved road, Sonora 118

Dirt road, public

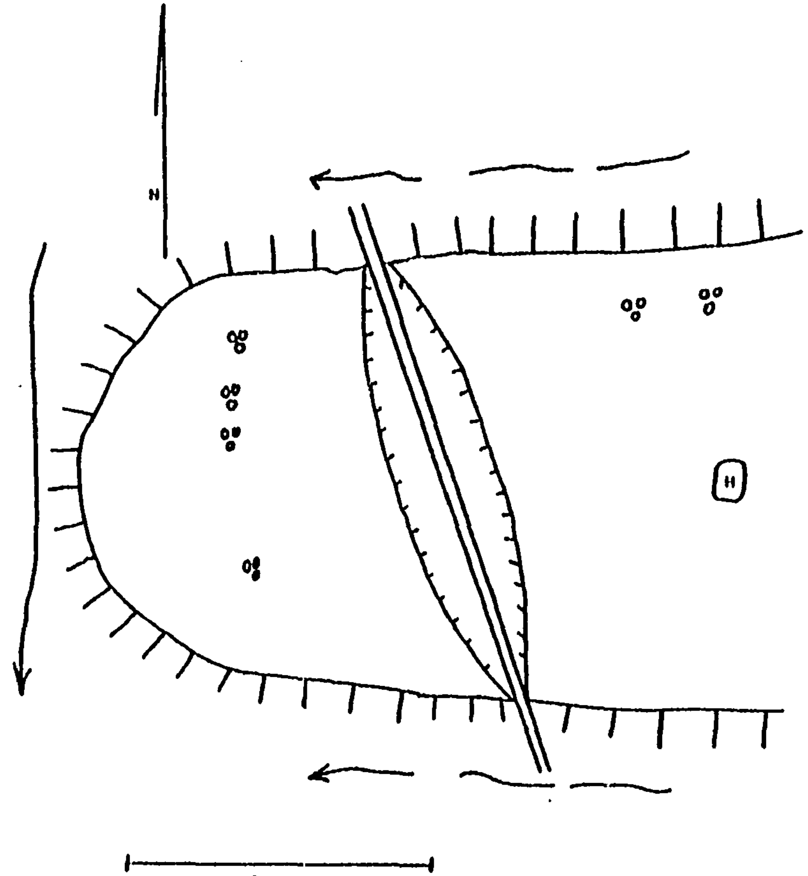
Dirt road, private

Slope face

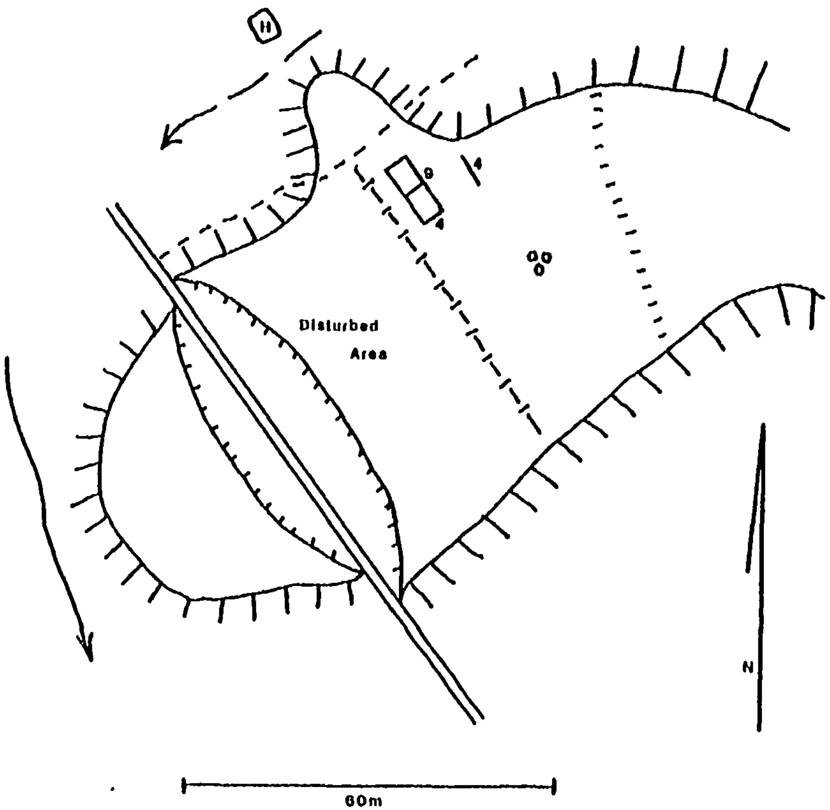
Scale is approximate and applies only to site proper.



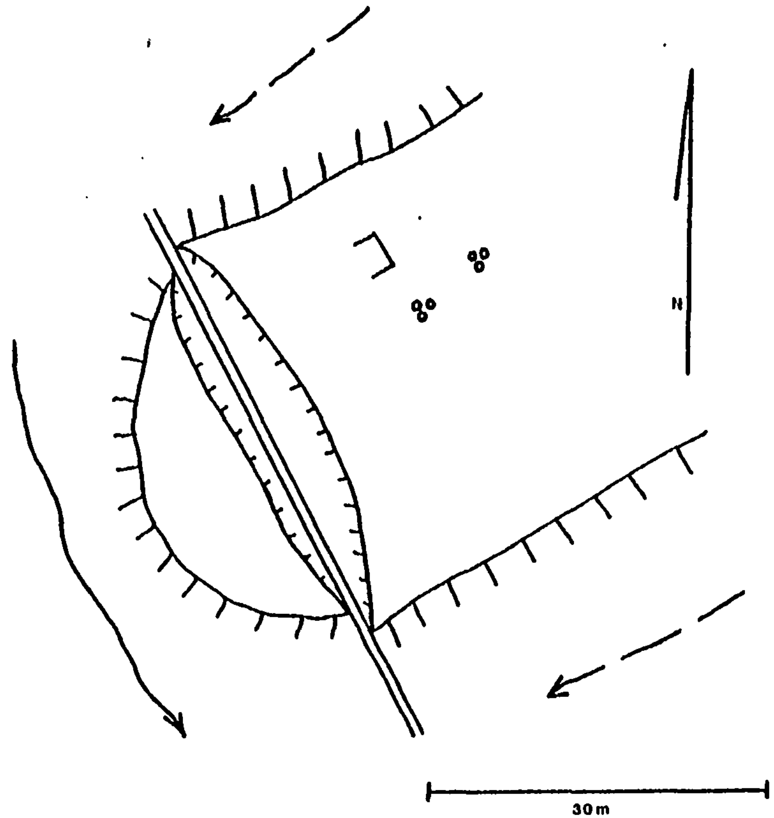

Son K:8:1 OU



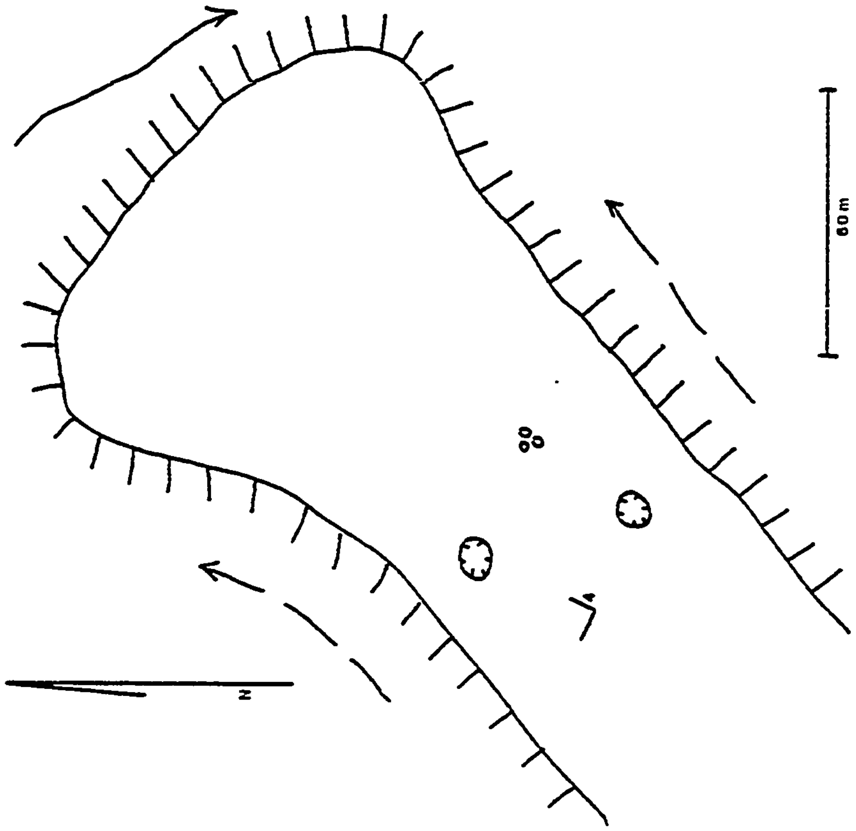

Son K:8:2 OU



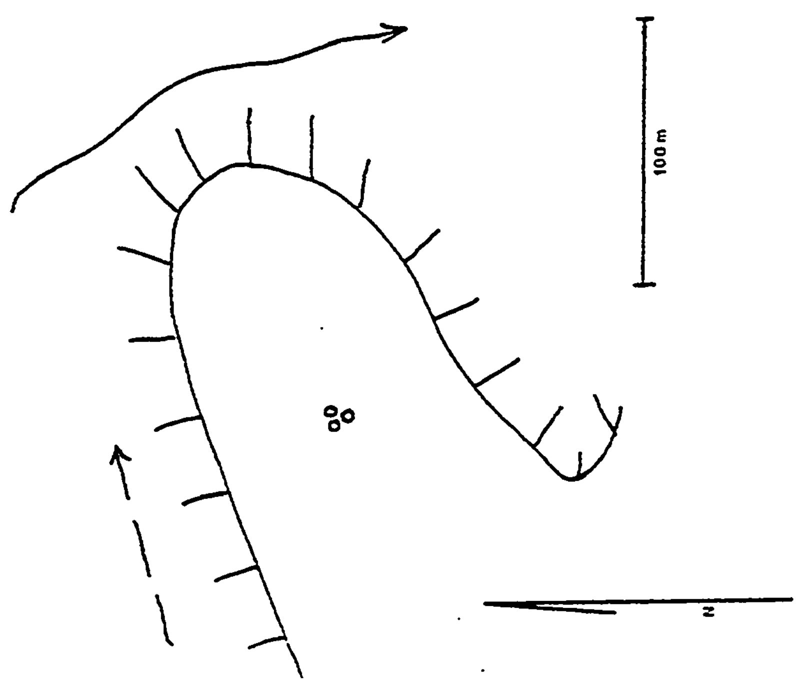

Son K:8:3 OU



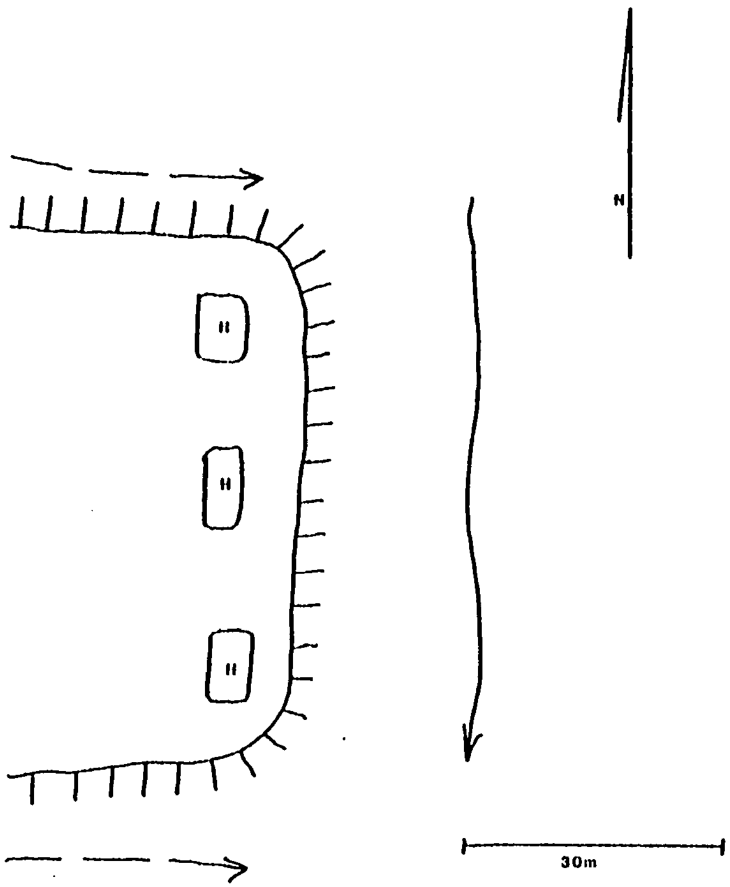

Son K:8:4 OU



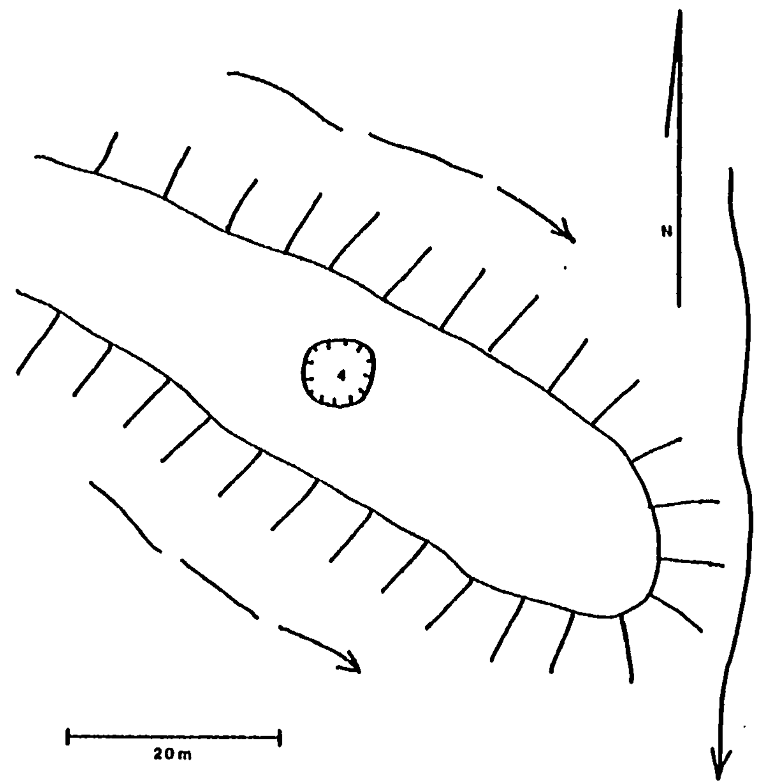

Son K:8:6 OU



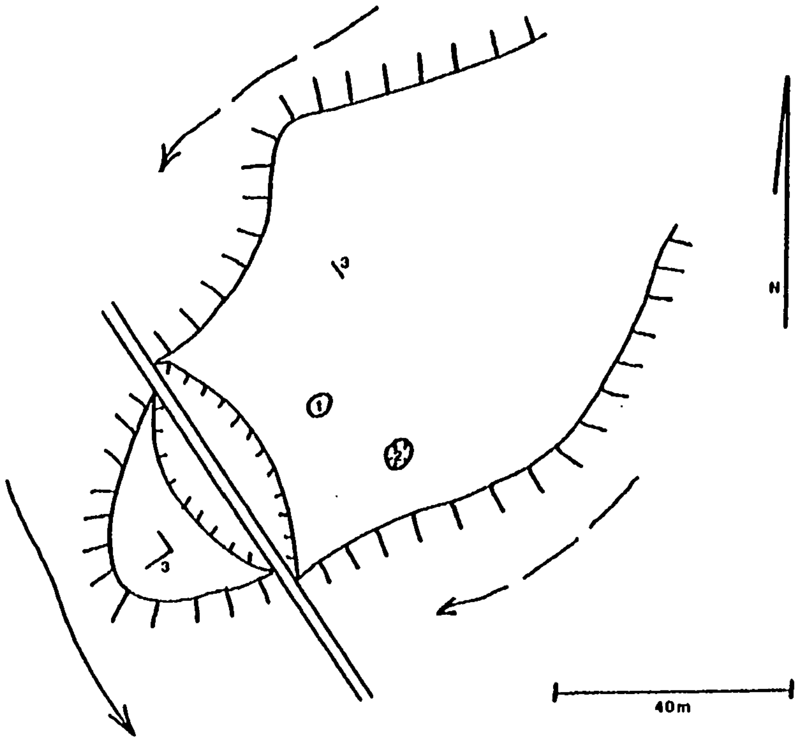

Son K:8:5 OU



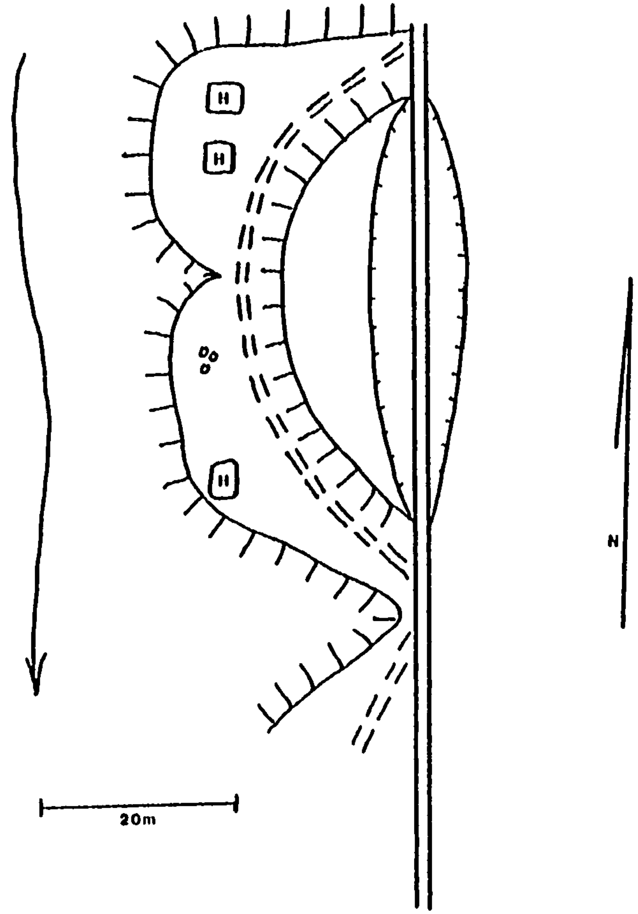

Son K:8:7 OU




Son K:8:8 OU

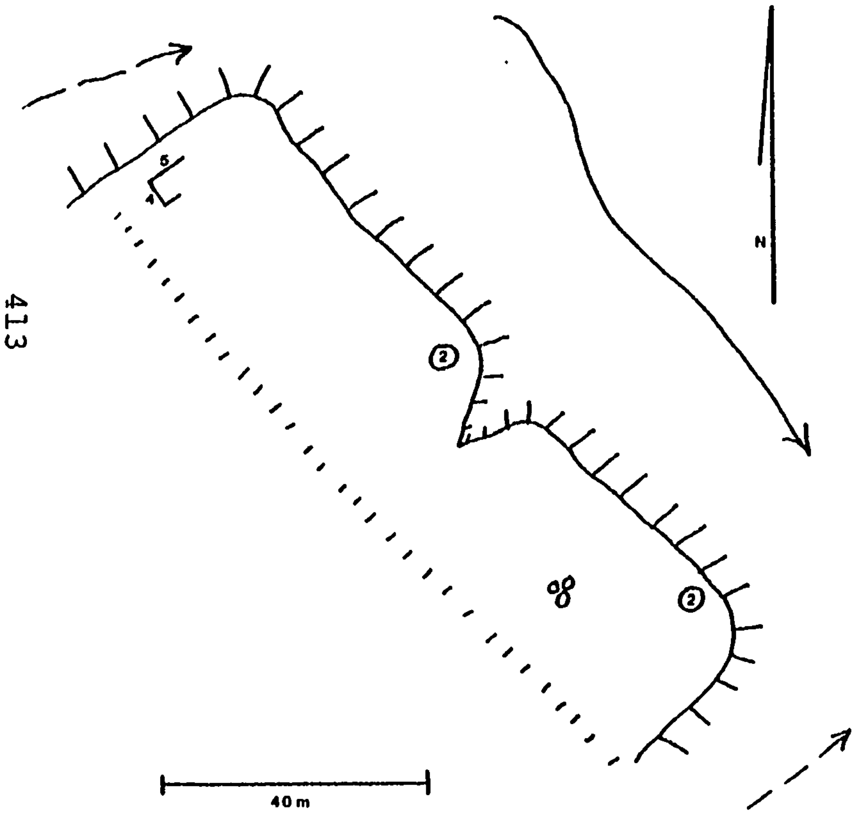



Son K:8:9 OU

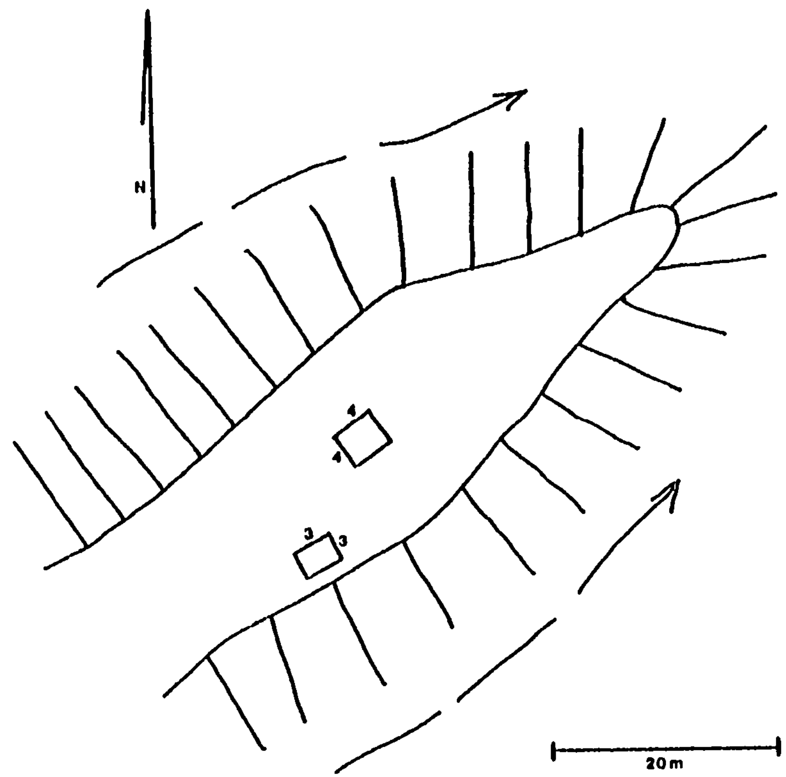



Son K:8:10 OU

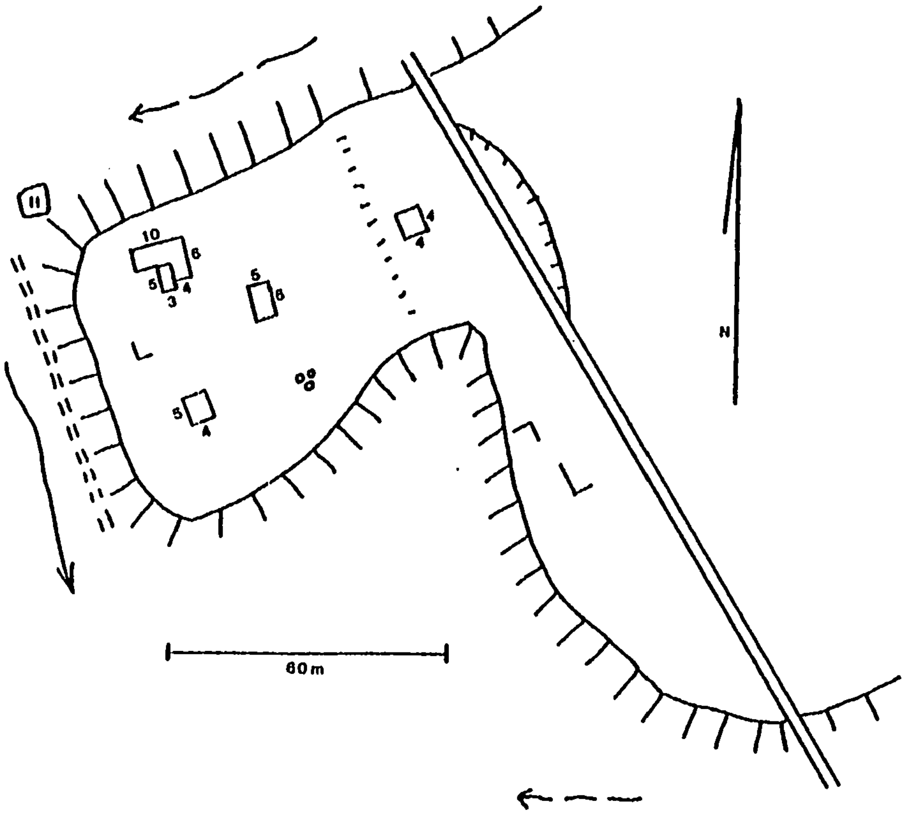
El Herrero South




Son K:8:12 OU

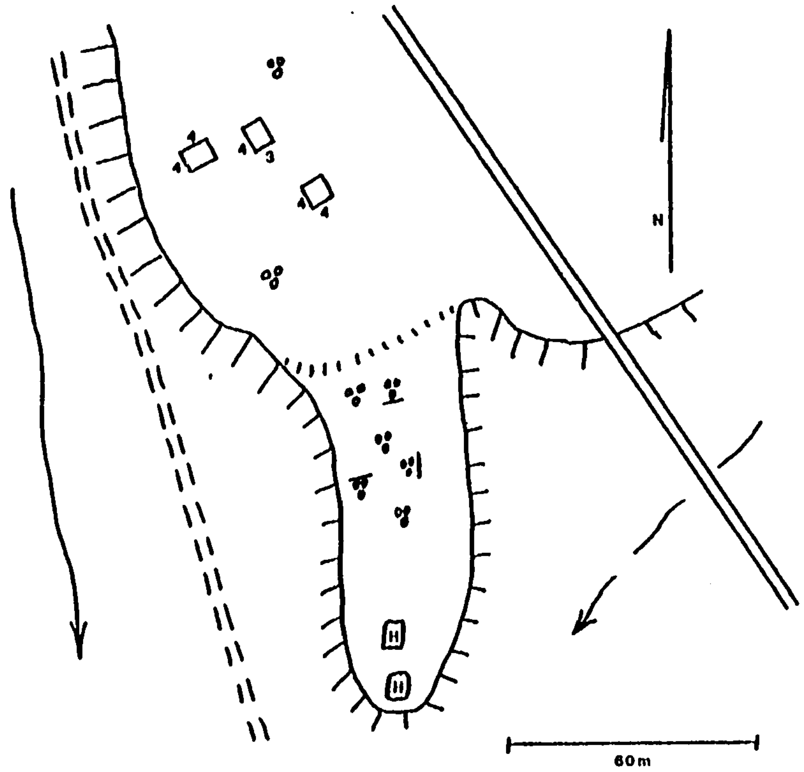



Son K:8:14 OU



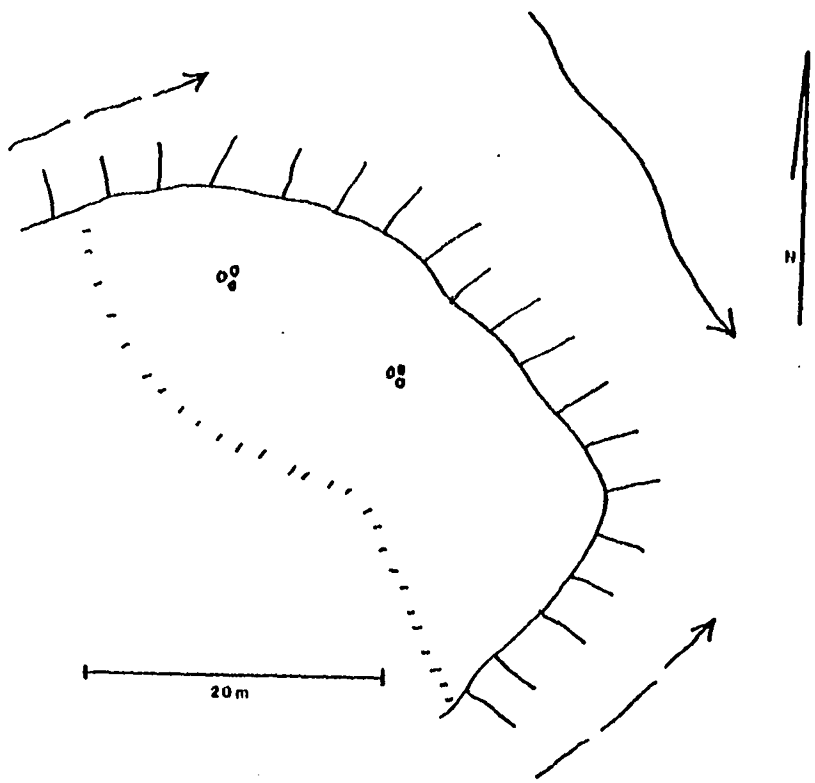

Son K:8:17 OU

Satebachi

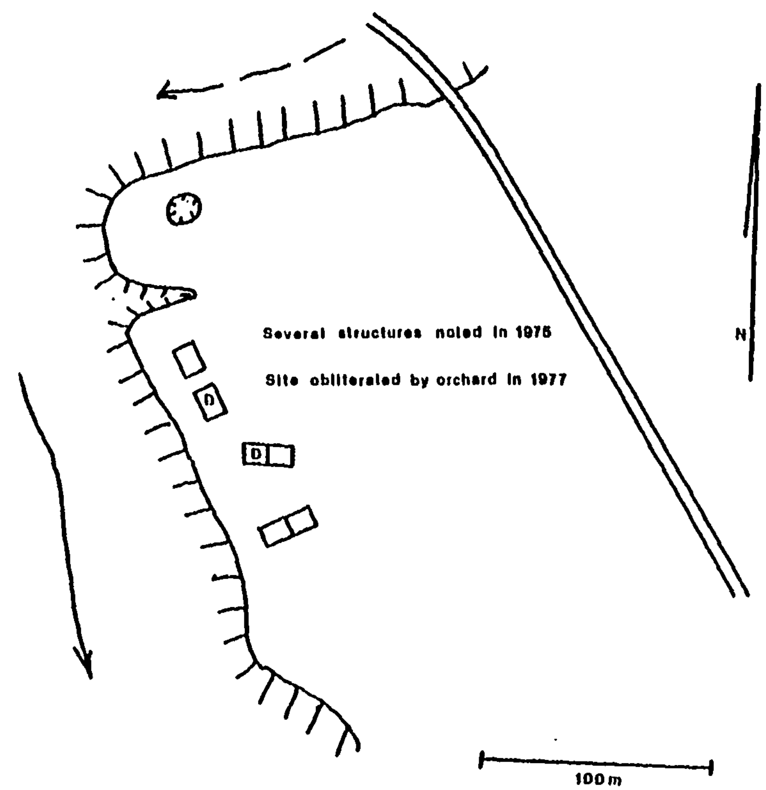



Son K:8:18 OU

San Jose Cemetary

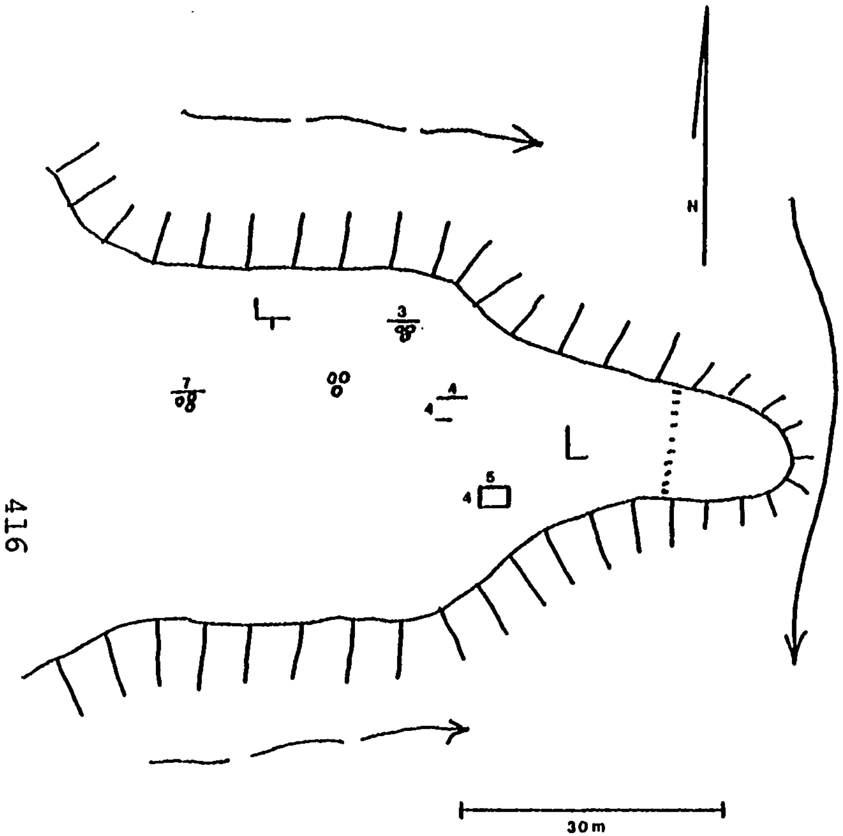



Son K:8:20 OU



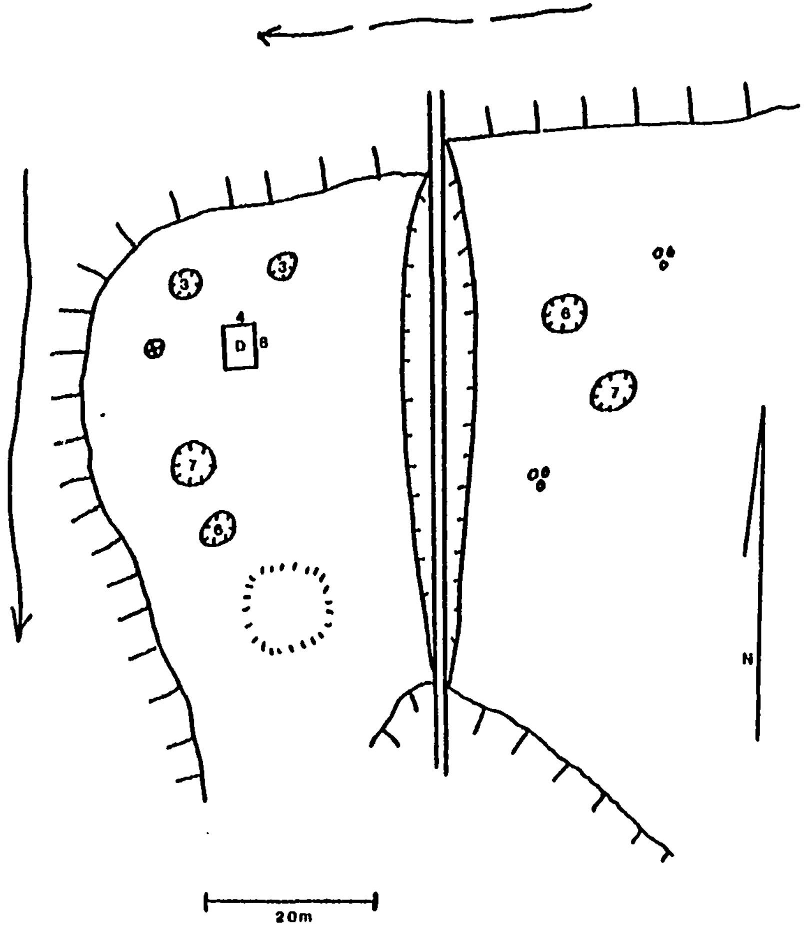

Son K:8:22 OU

La Capilla Orchard



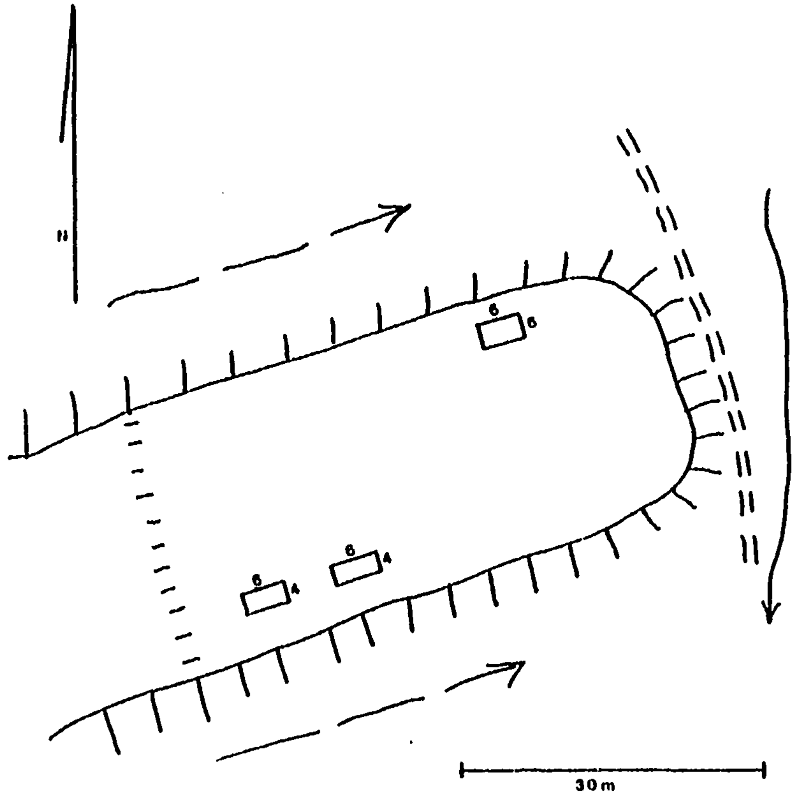

Son K:8:25 OU

La Vaca Mesa




Son K:8:26 OU

El Molinote South

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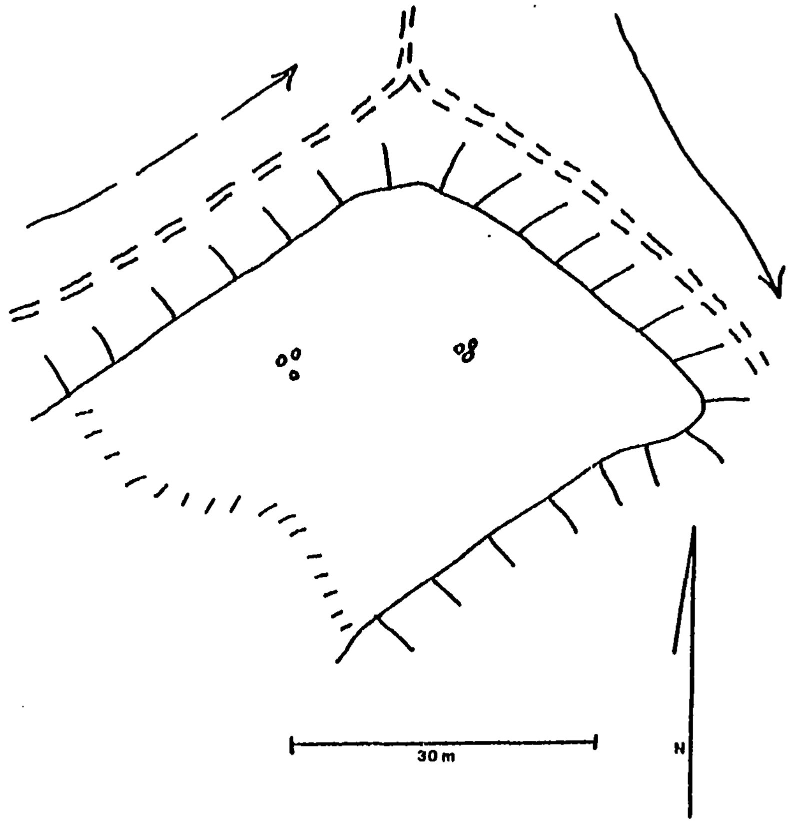
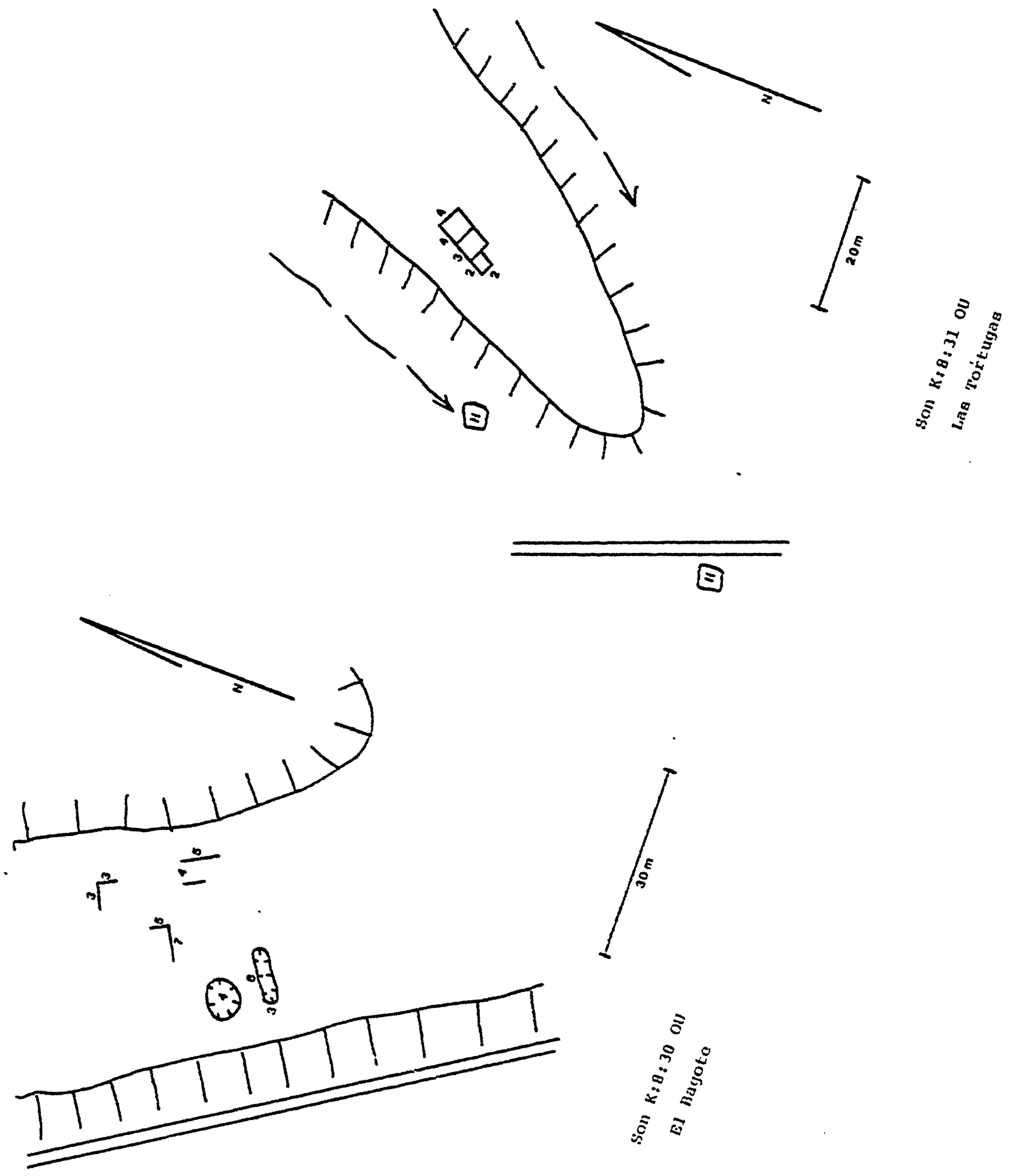
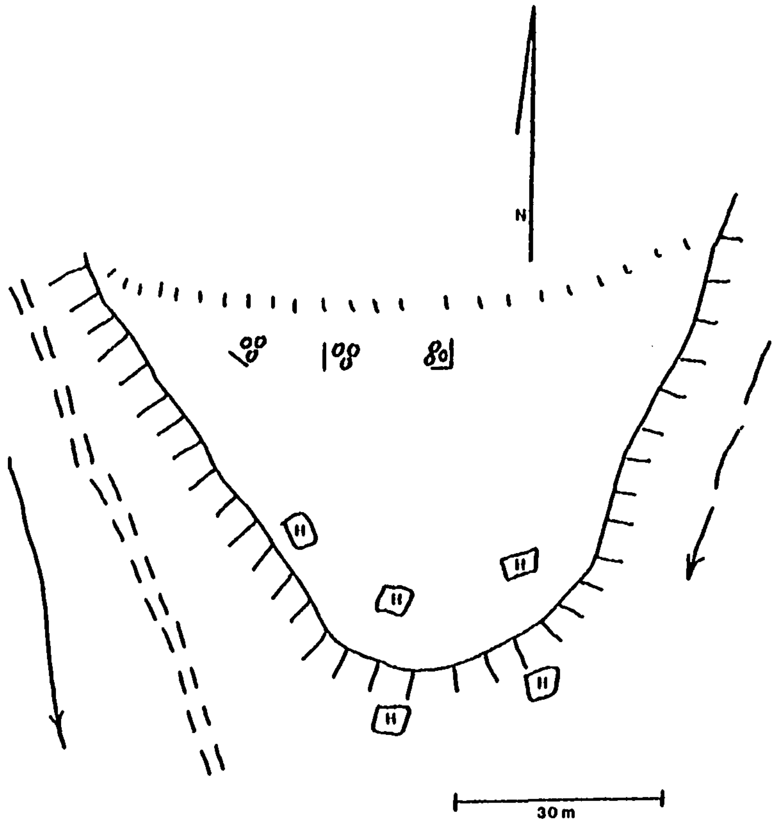



Son K:8:29 OU

Tungsteno Mine Mill


N
20m
Son K:8:31 OU
Las Tortugas
N
30m
Son K:8:30 OU
El Bagote

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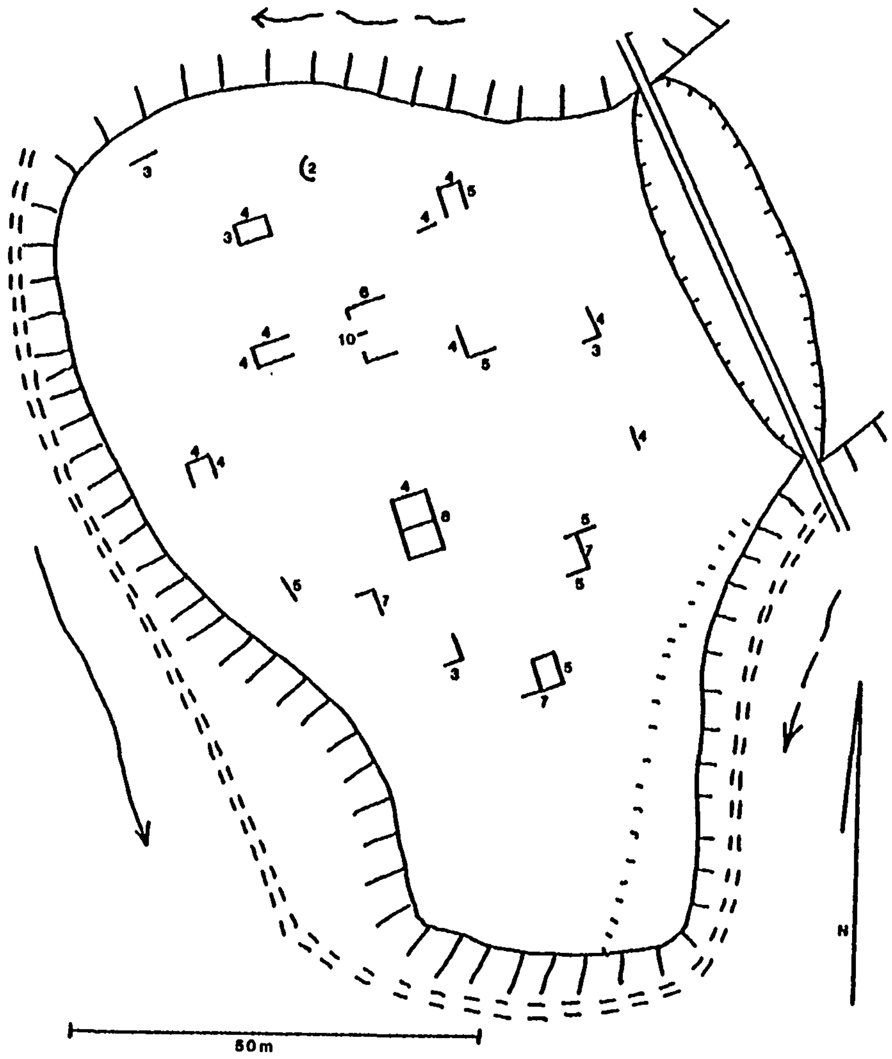
Ranchito San Jose




Son K:8:34 OU

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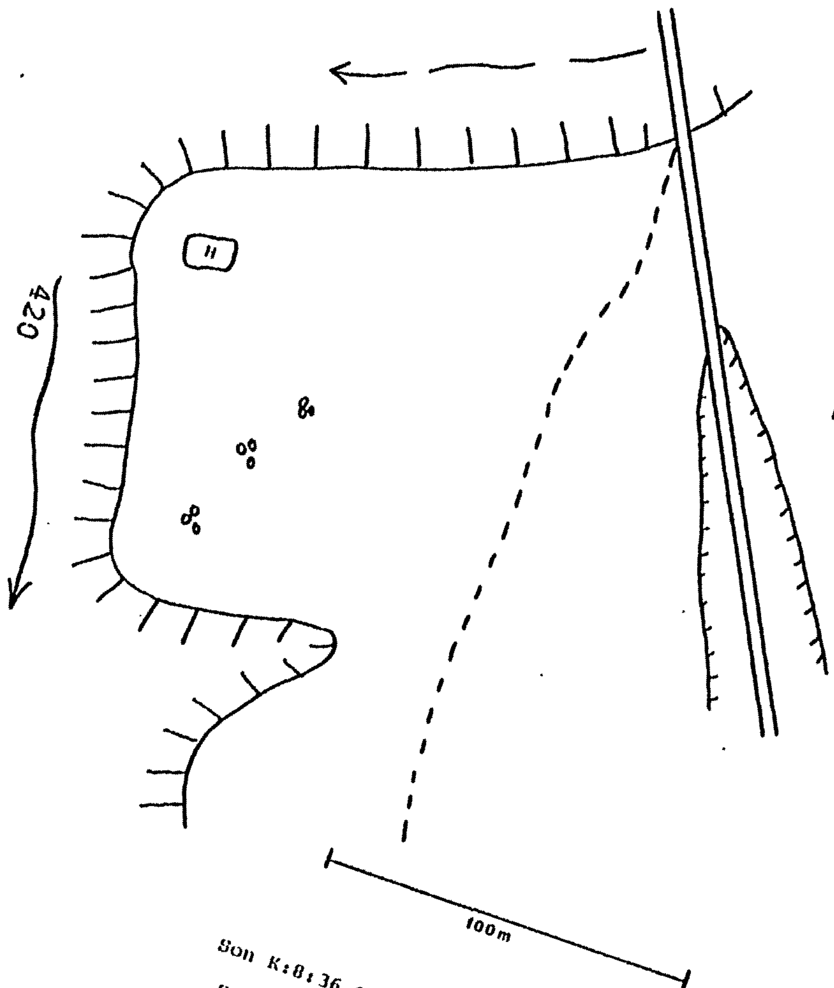


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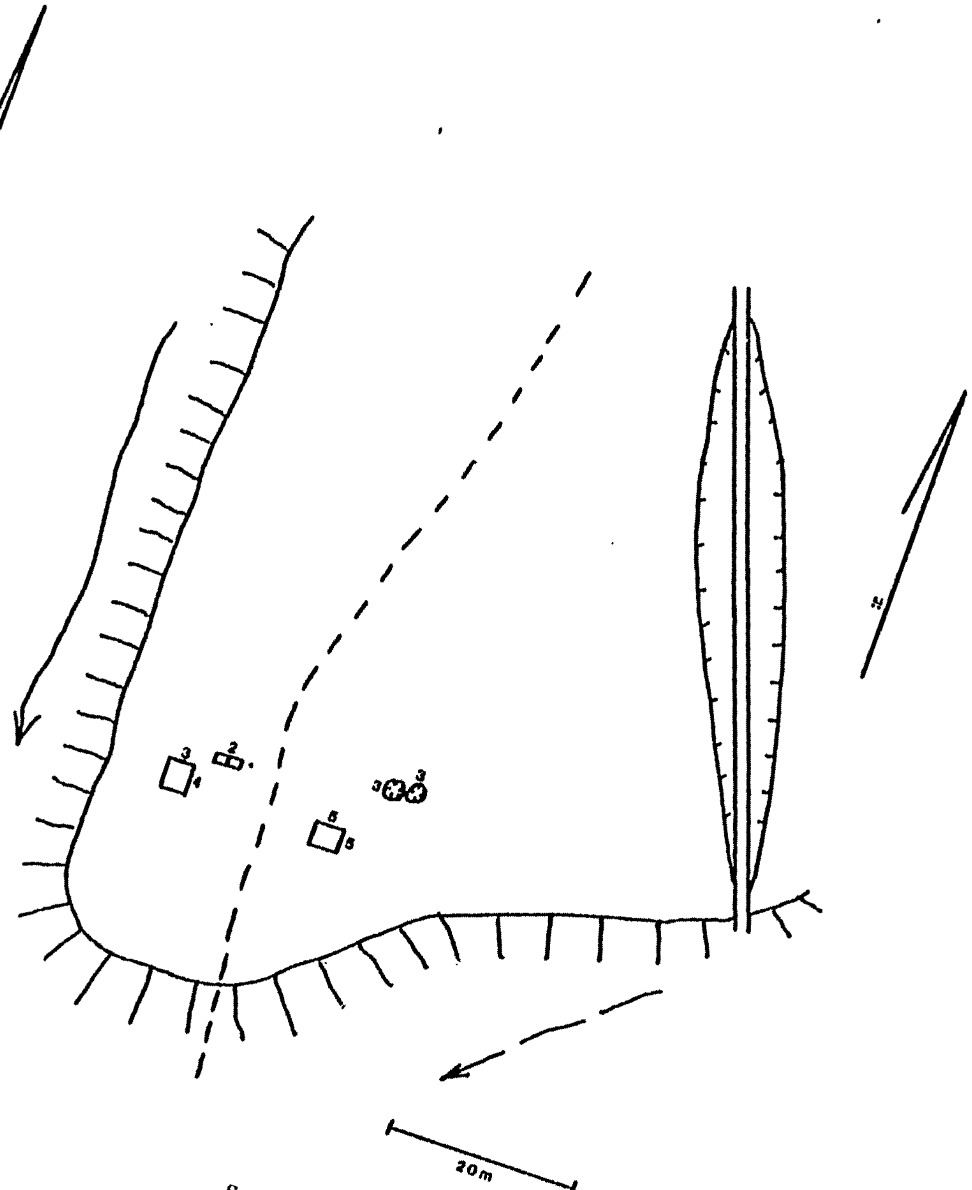


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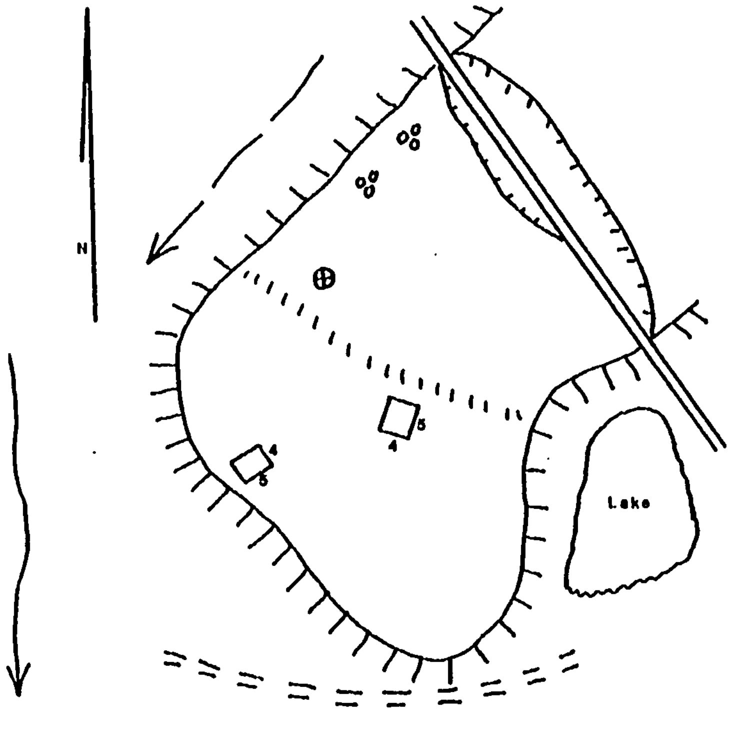


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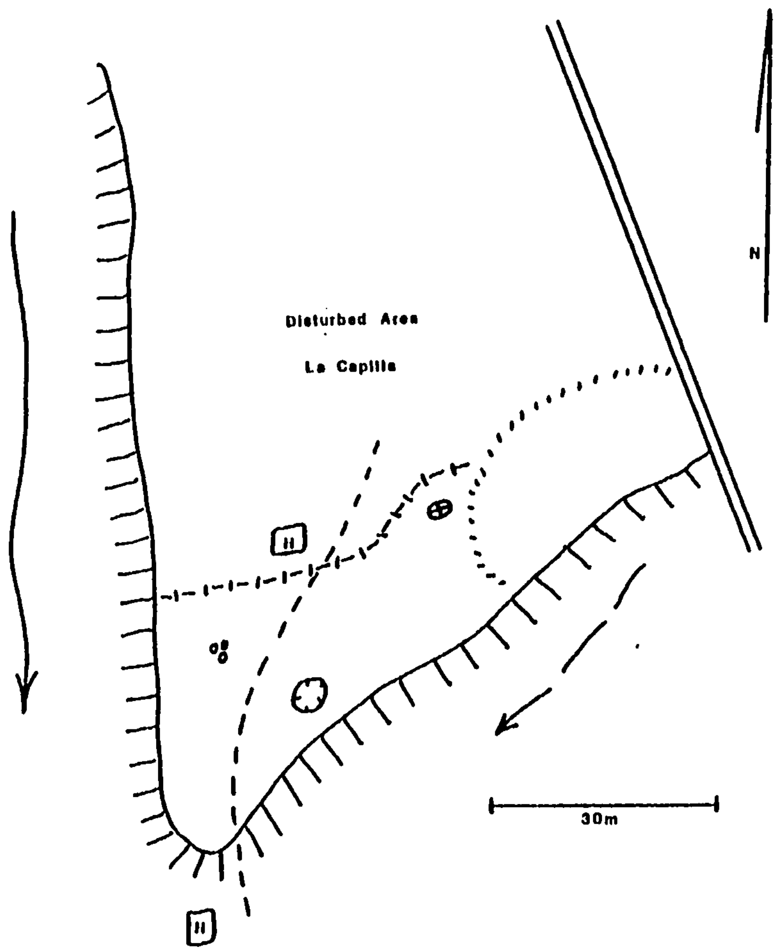
Lago La Capilla

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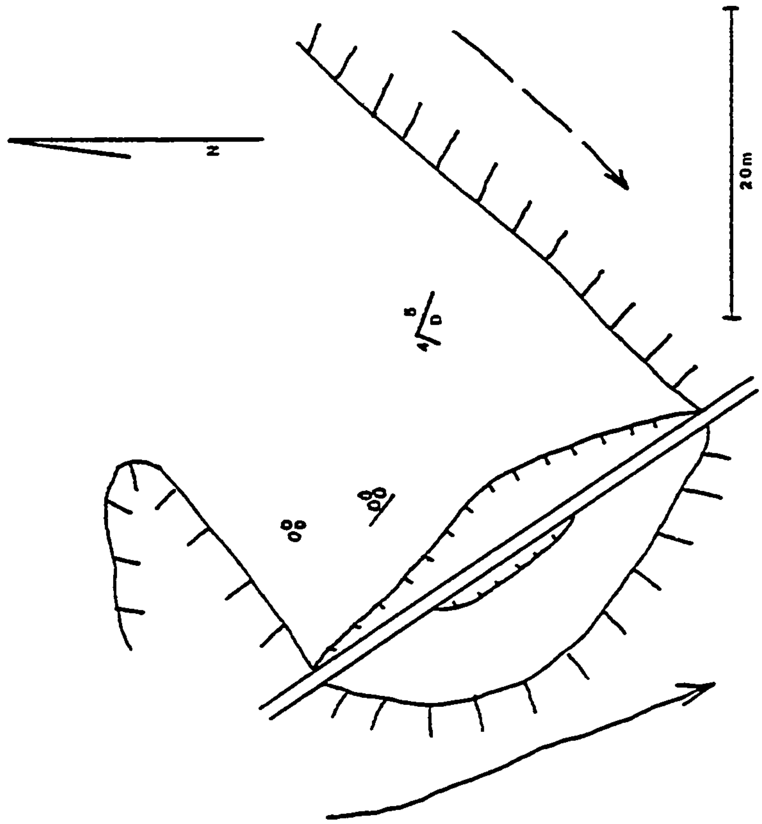
La Capilla

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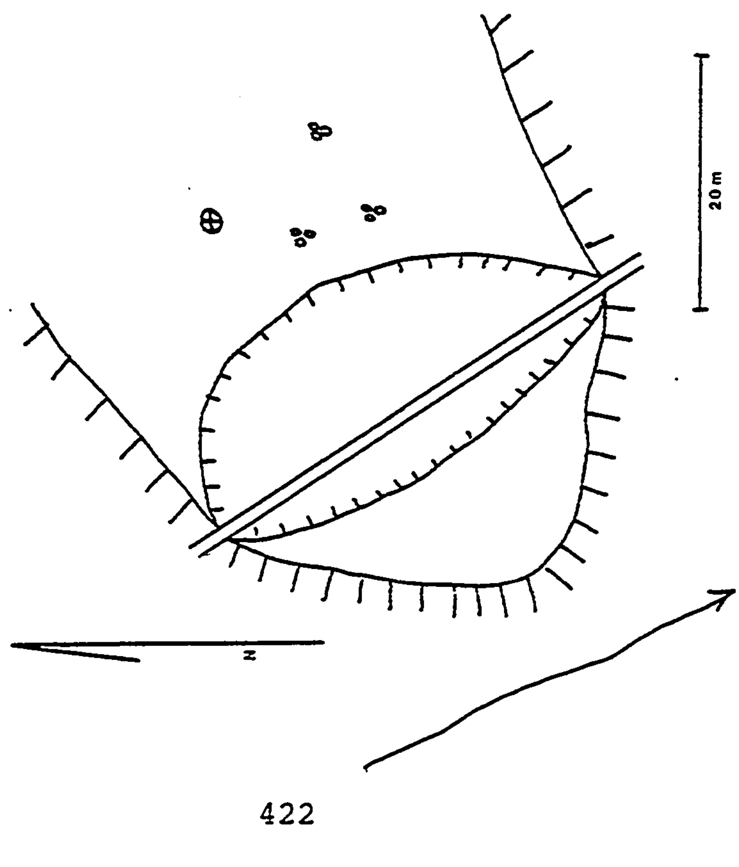


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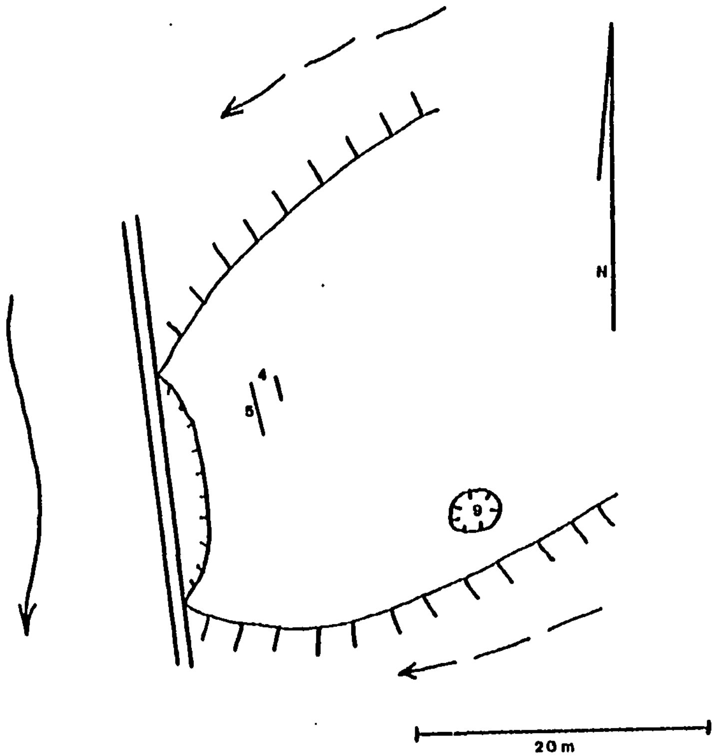


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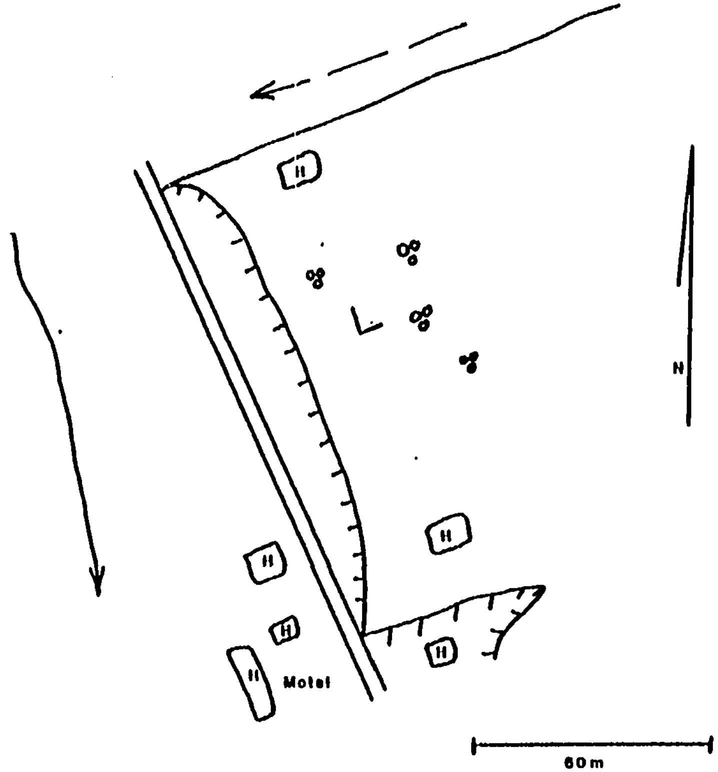
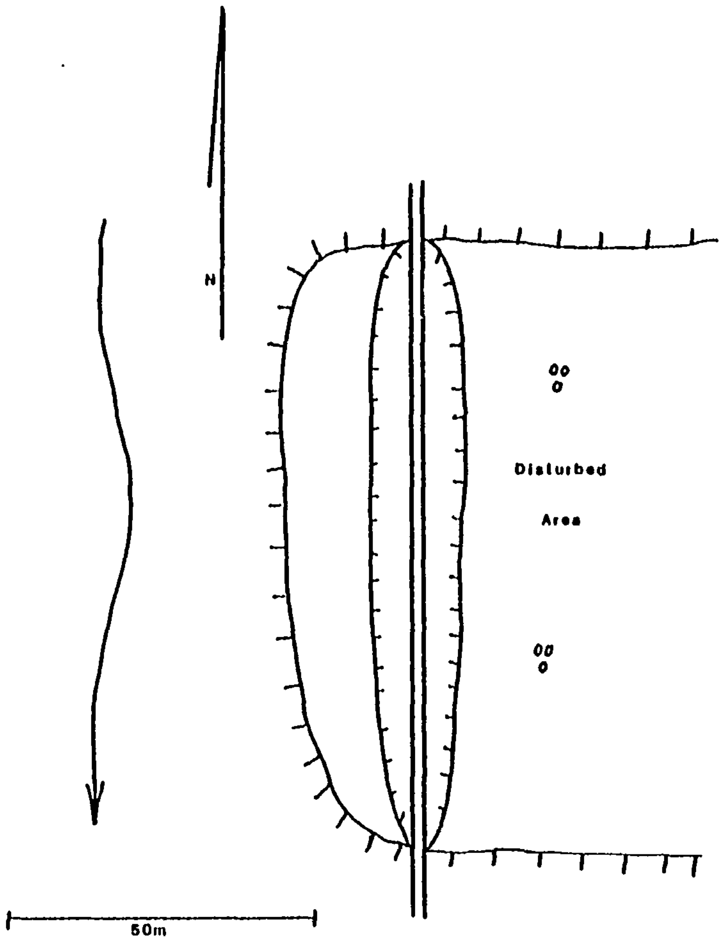



Son K:8:45 OU

Loera's Motel

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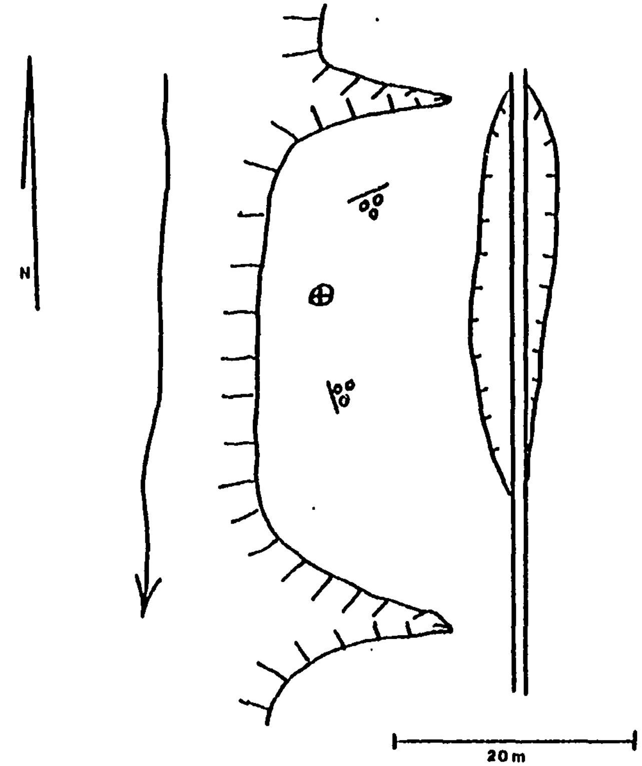


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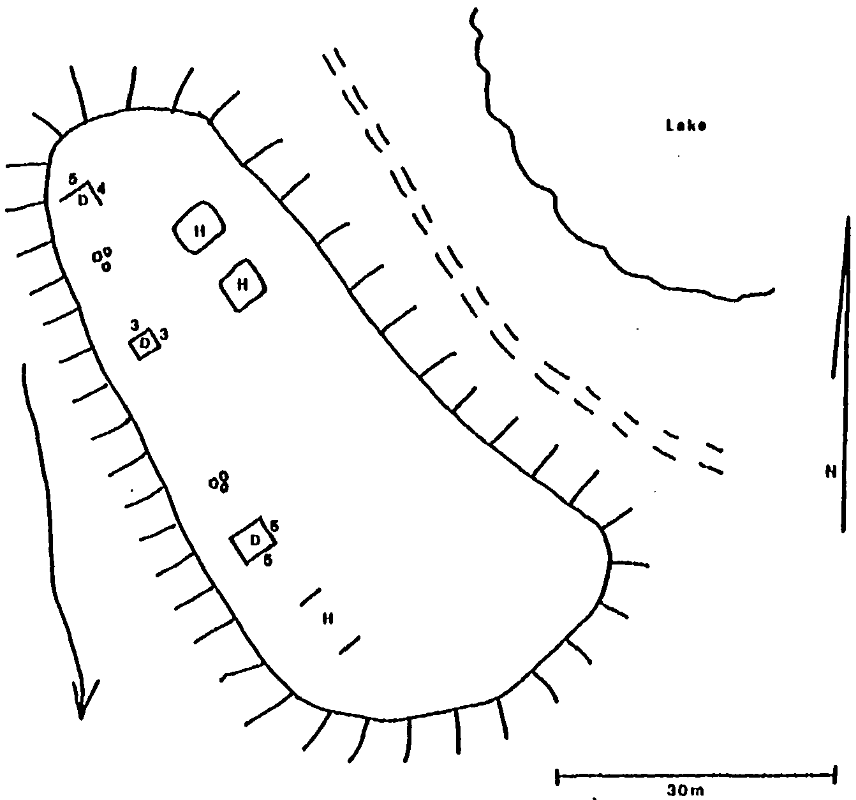


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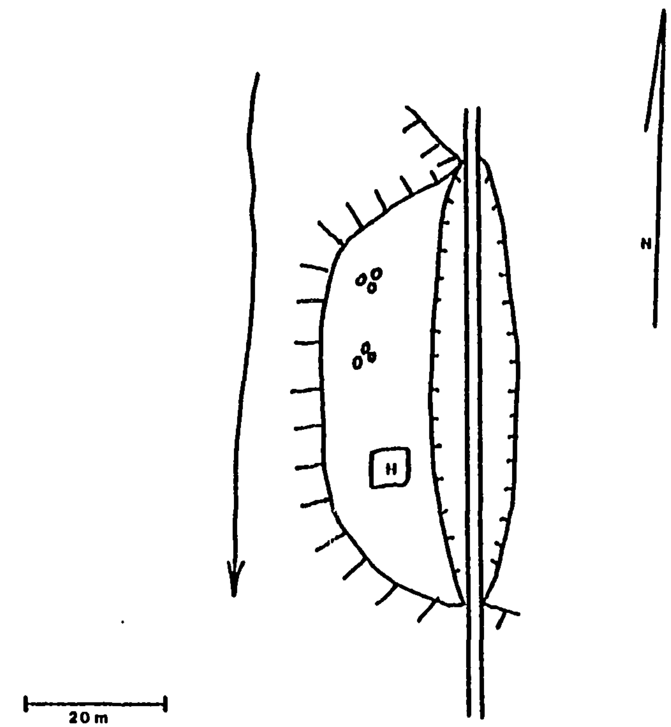


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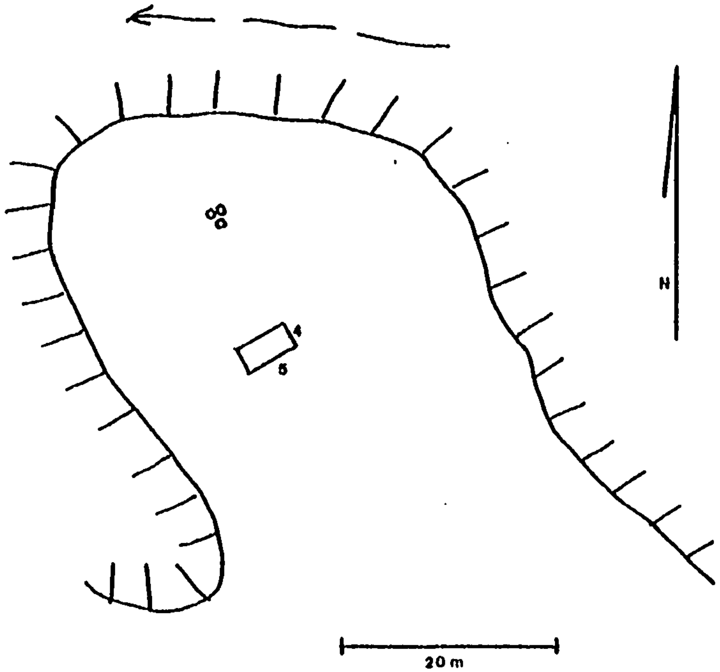


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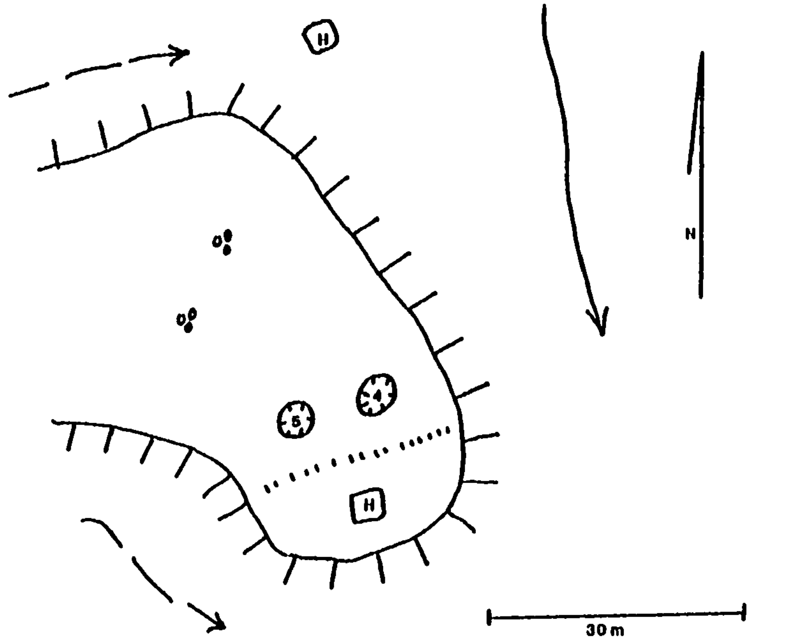
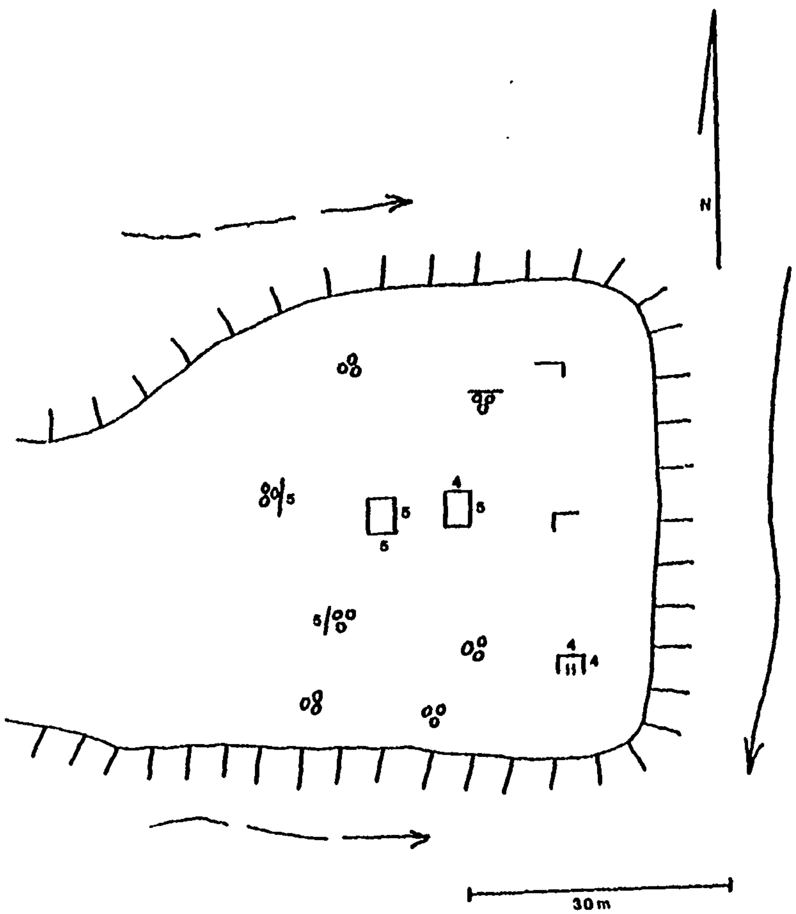



Son K:8:56 OU

La Labor West

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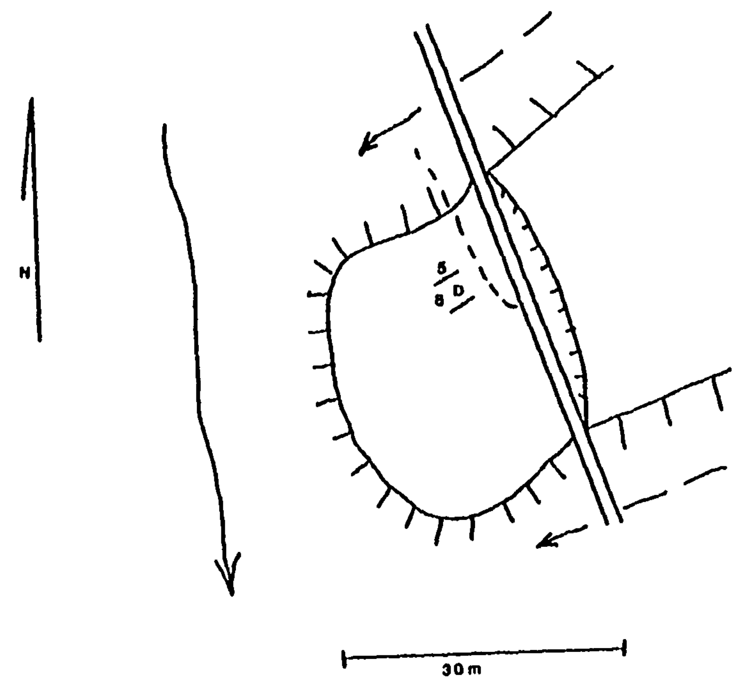


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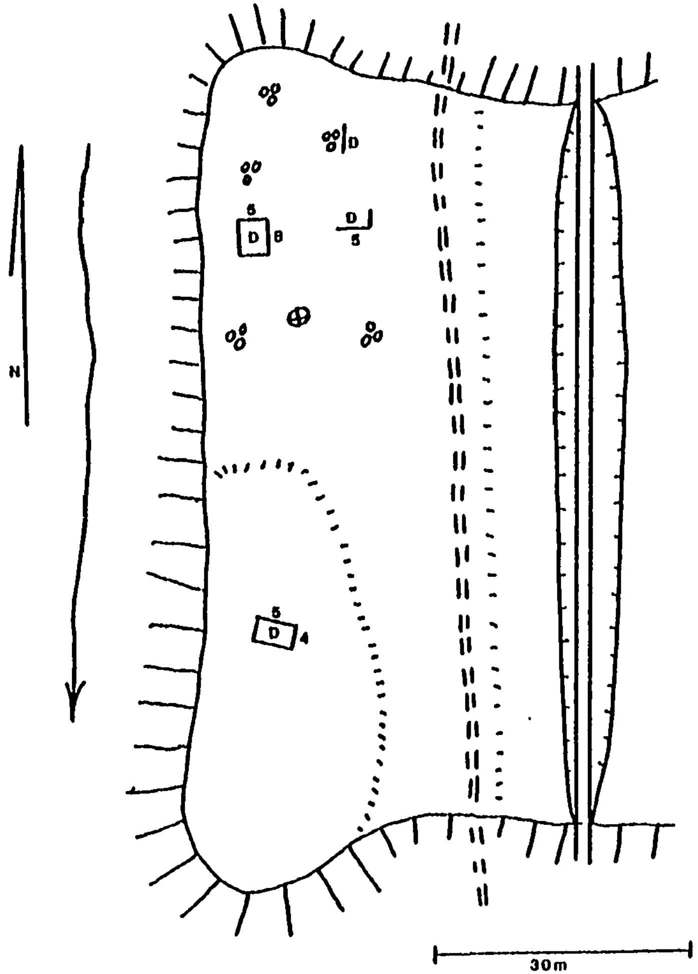
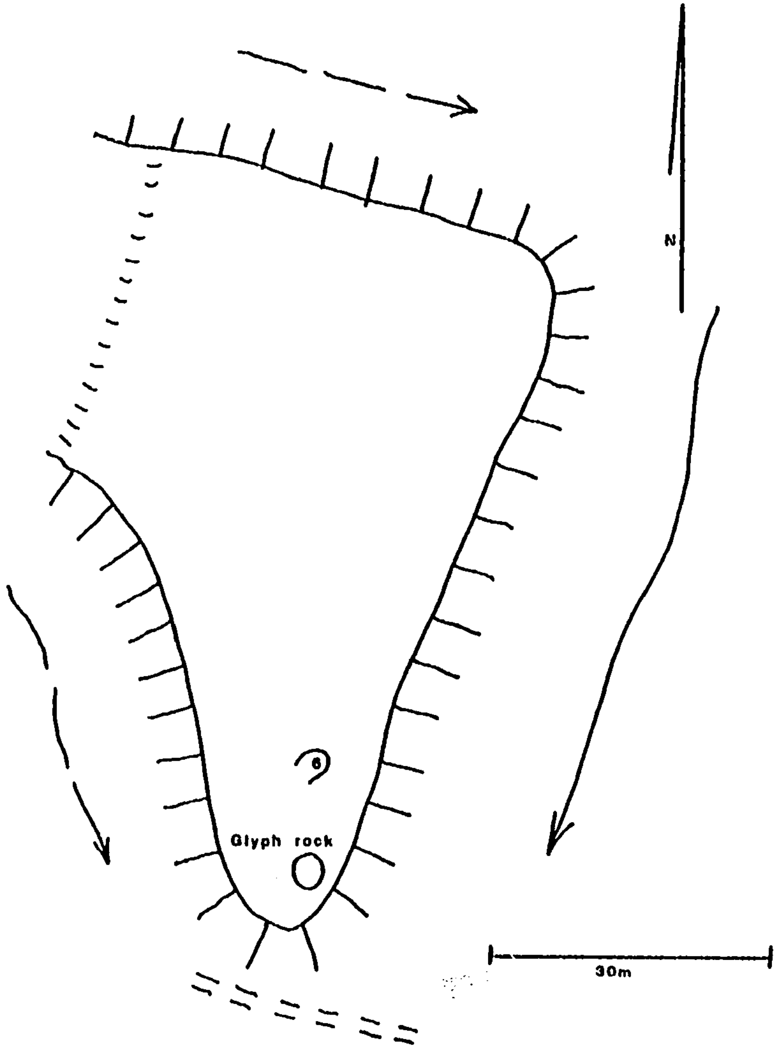



Son K:8:59 OU

La Labor South

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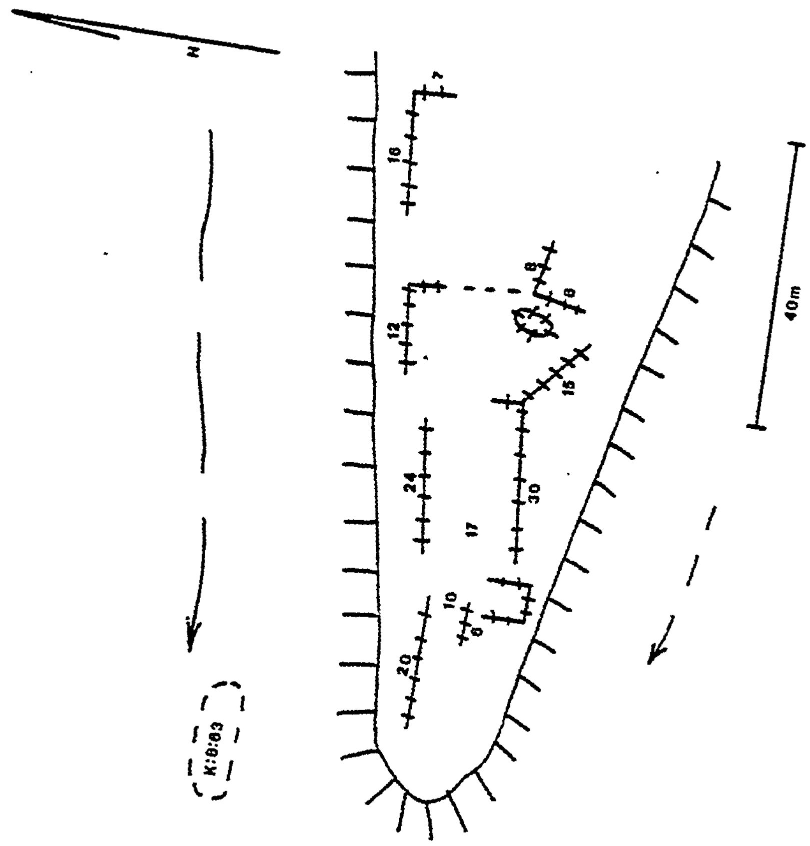


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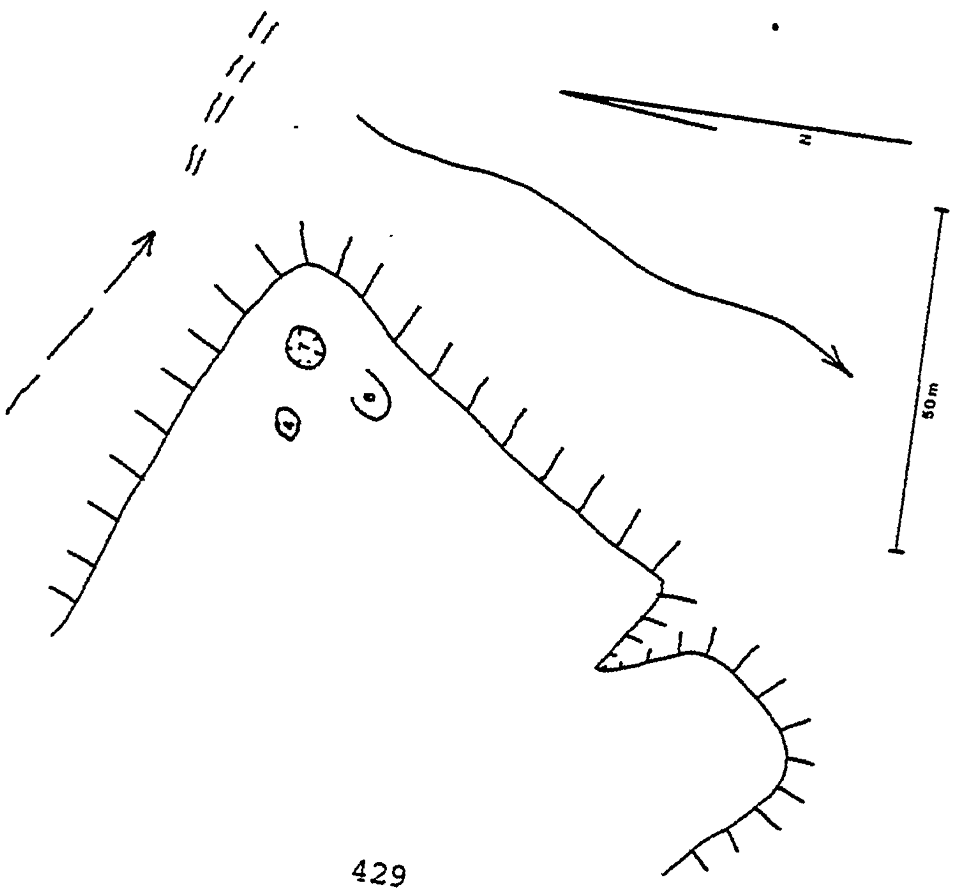


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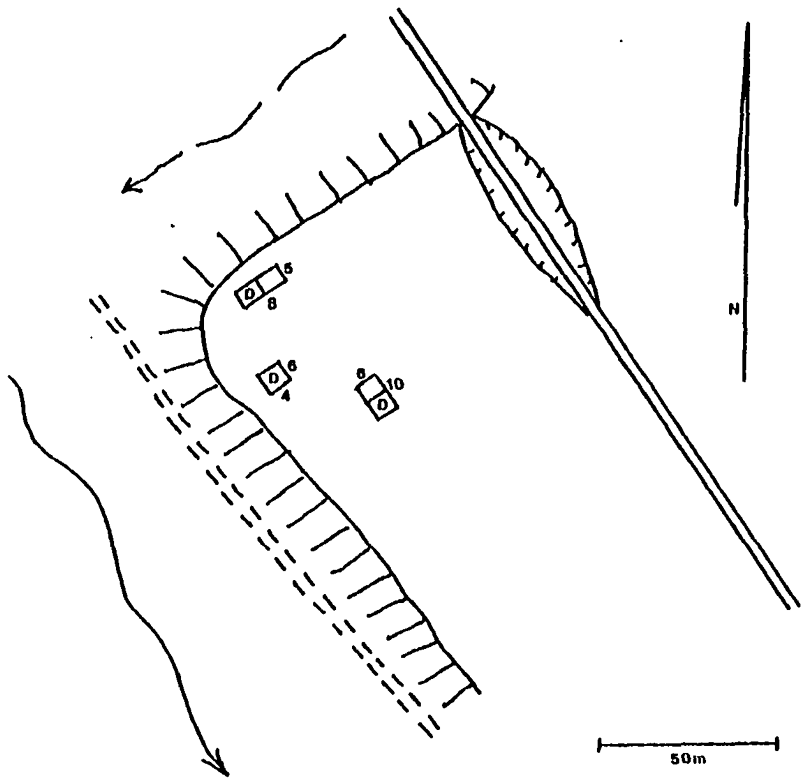


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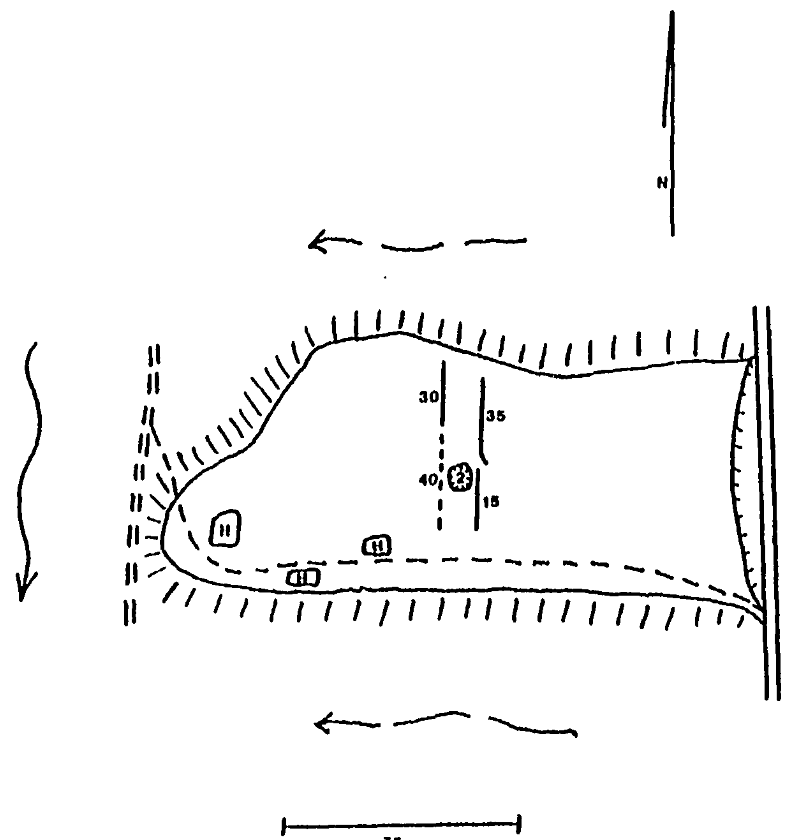
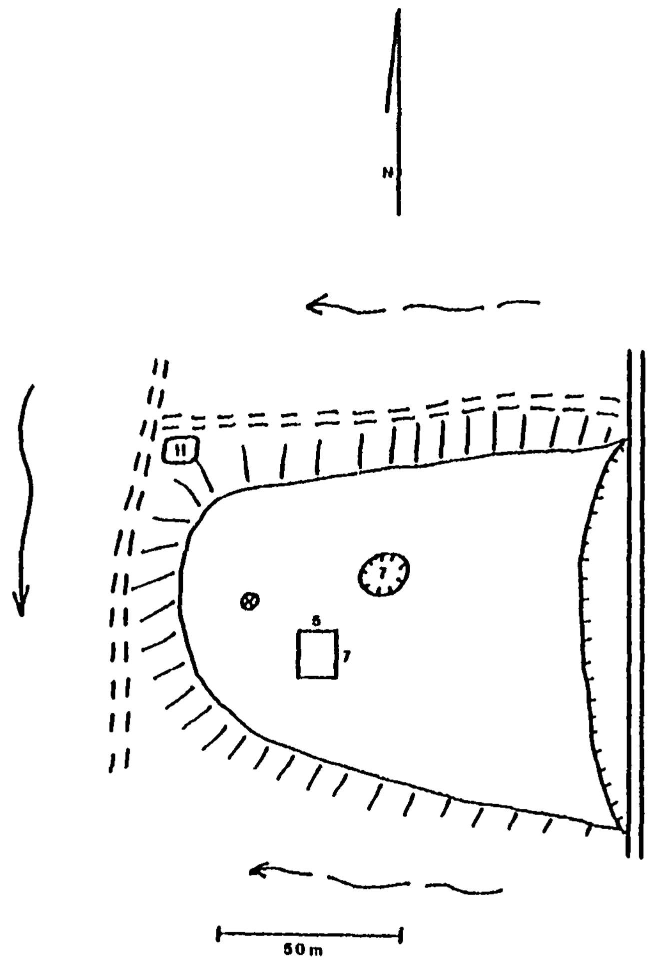


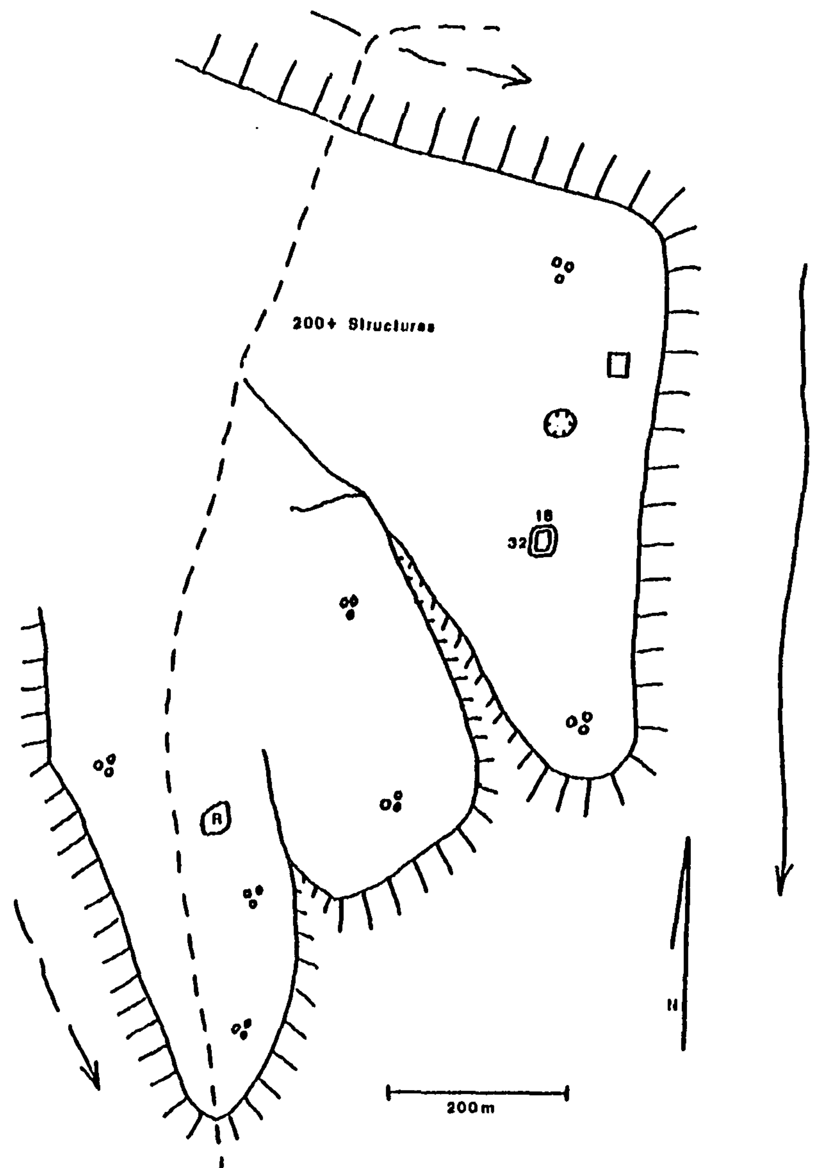

Son K:4:2 OU

El Rodeo



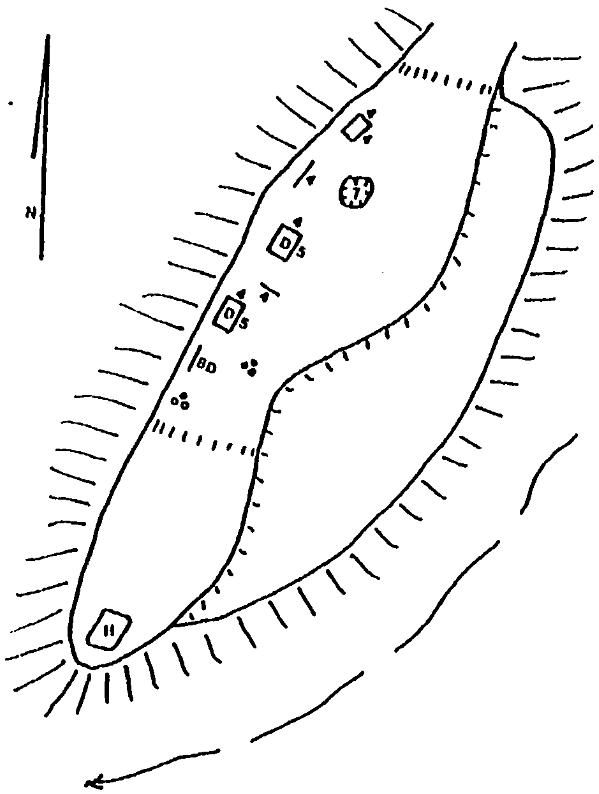

Son K:4:4 OU

San Pablo South




Son K:4:16 OU

Las Delicias, Palo de Hierra

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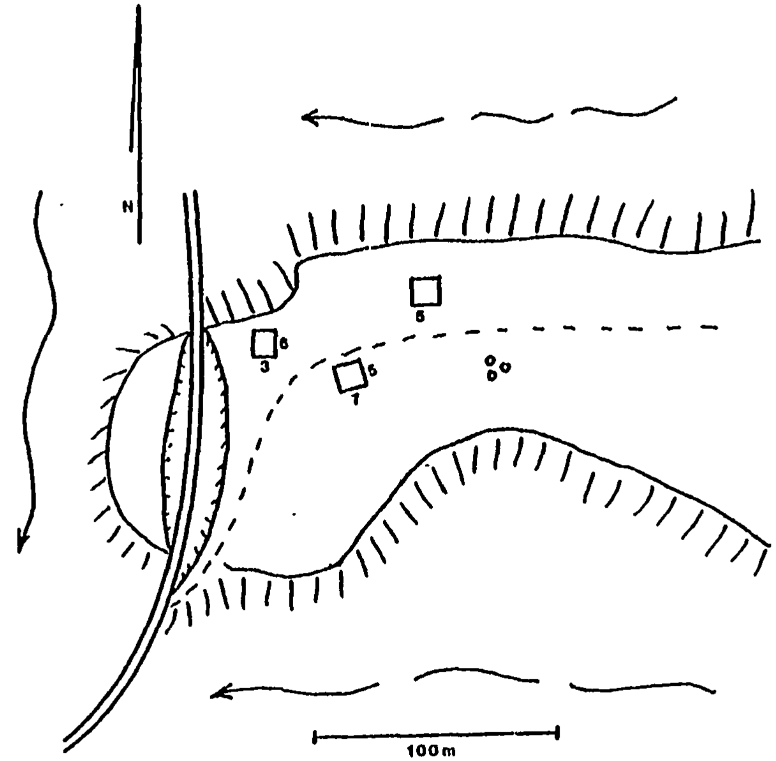
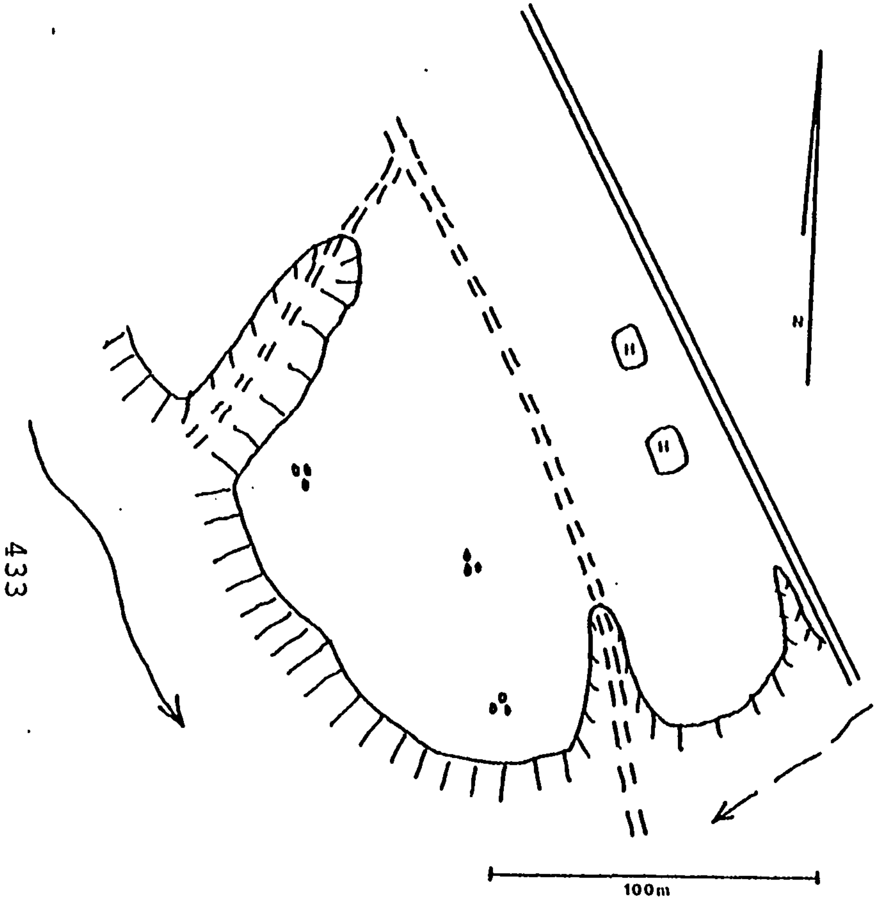


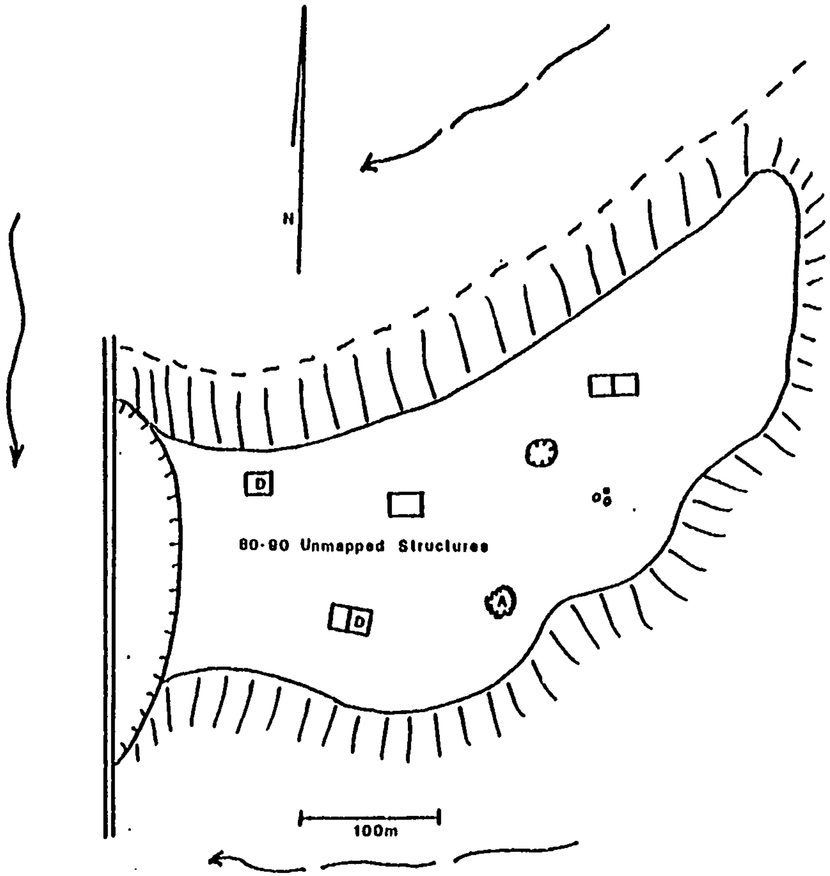

Son K:4:18 OU

Ranchito de Huepac North



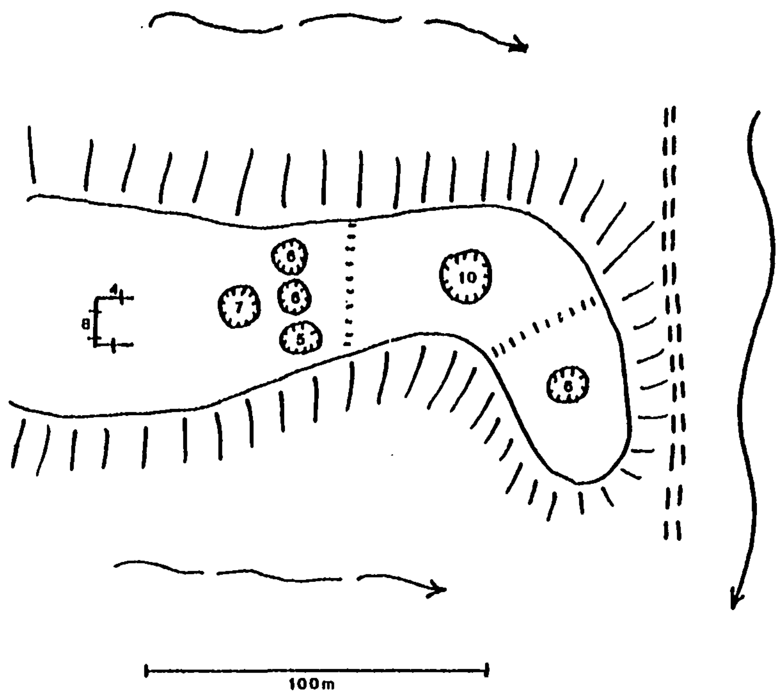

Son K:4:19 OU

La Estancia




Son K:4:20 OU

Ojo de Agua

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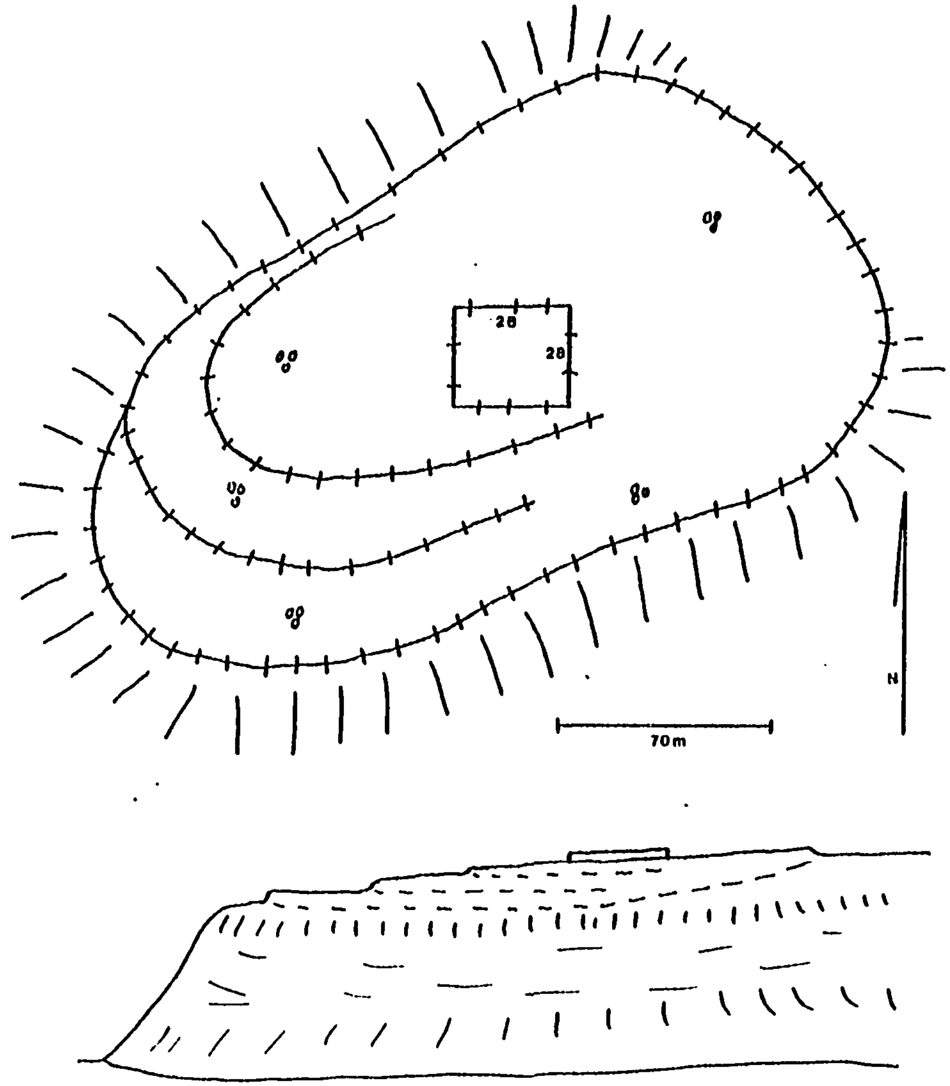
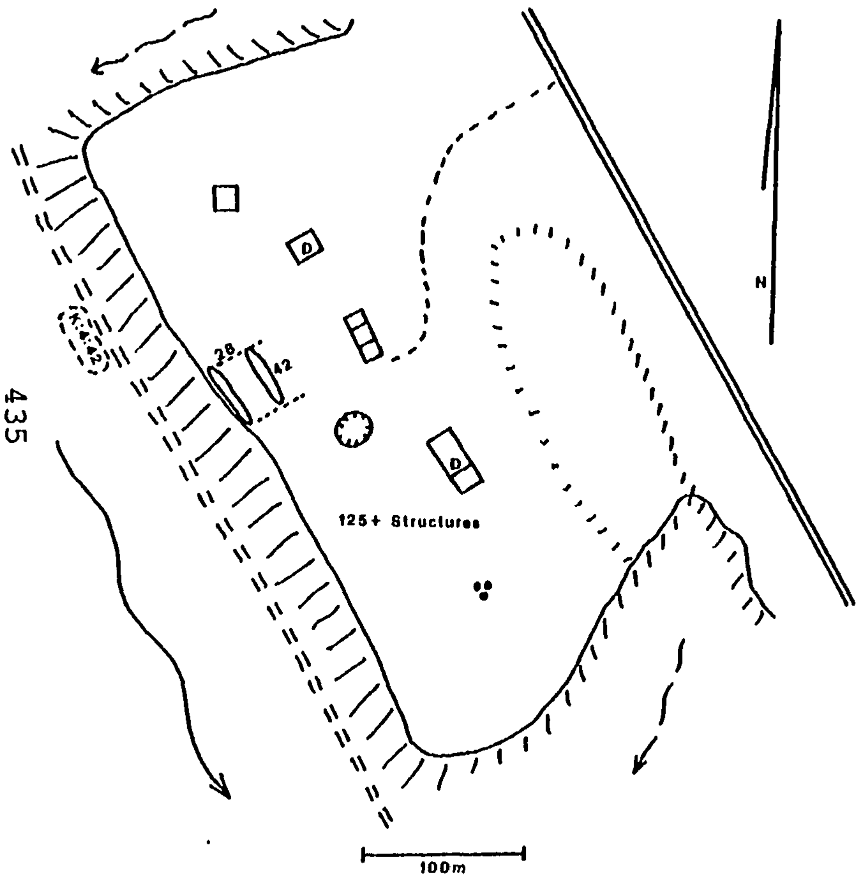


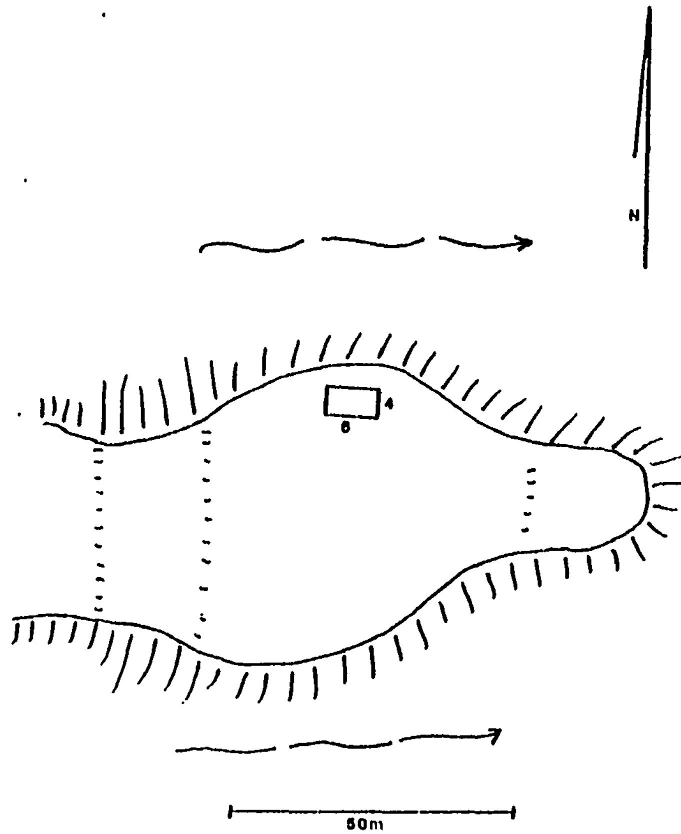

Son K:4:22 OU

Cerro Batonapa




Son K:4:24 OU

San Jose

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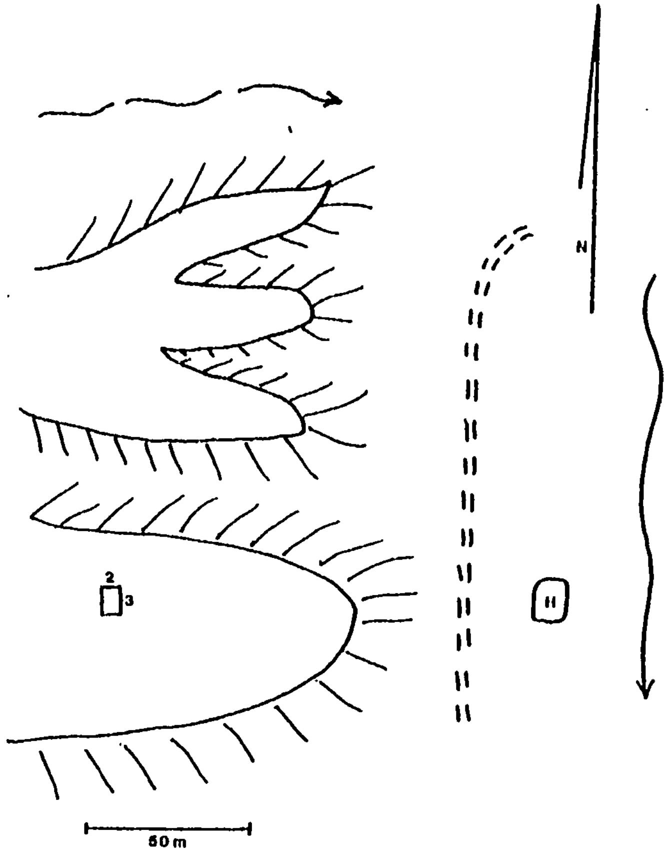


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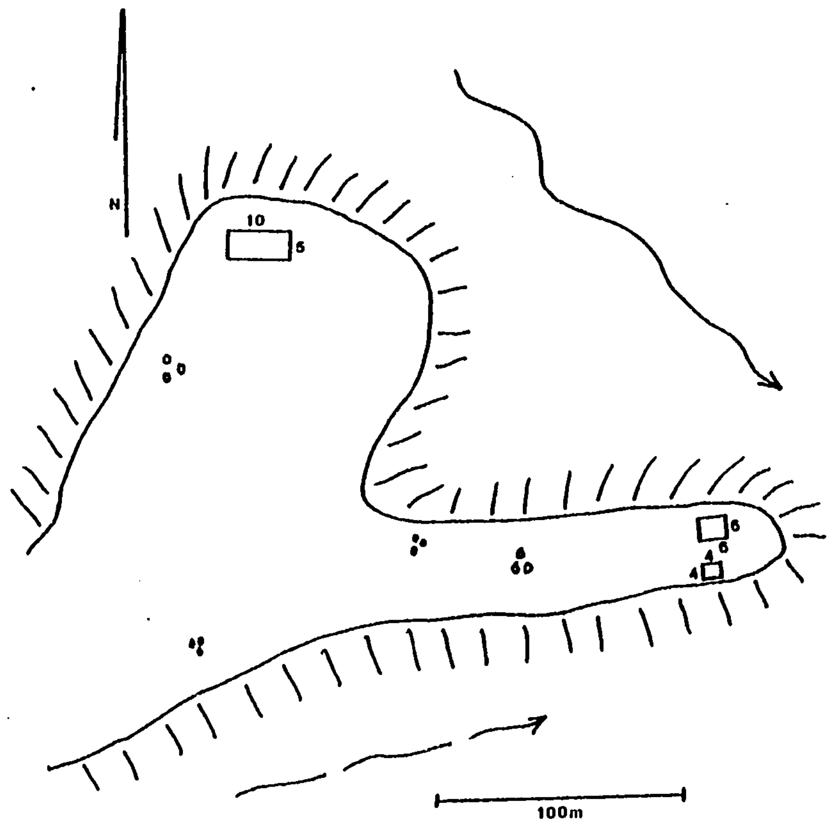


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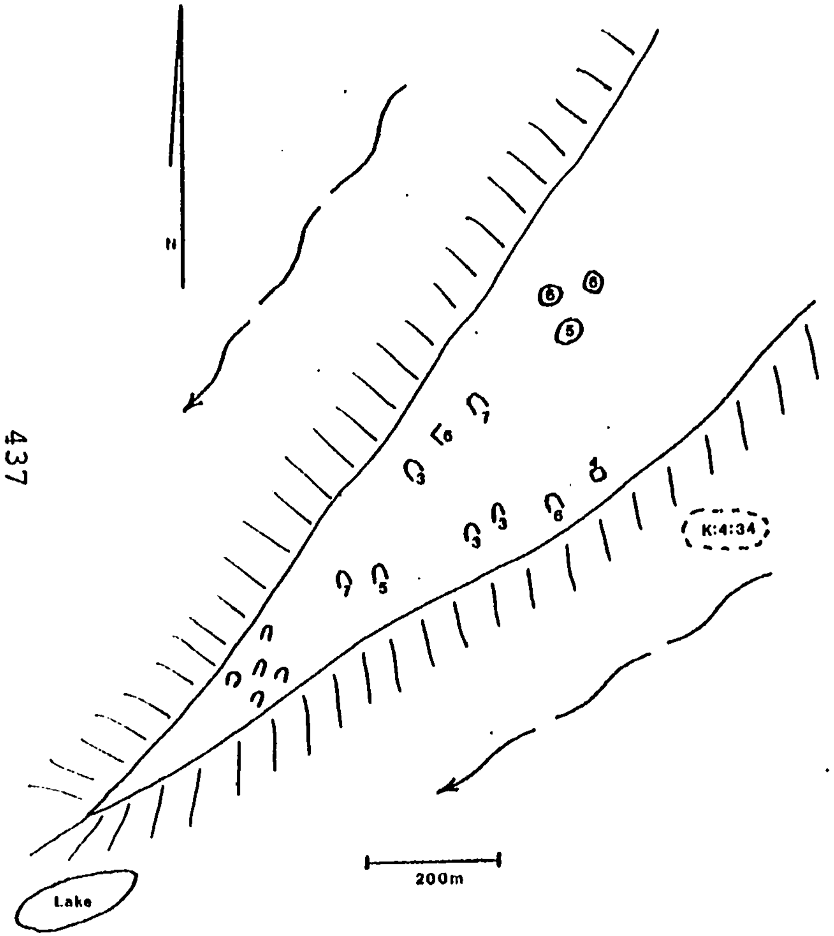
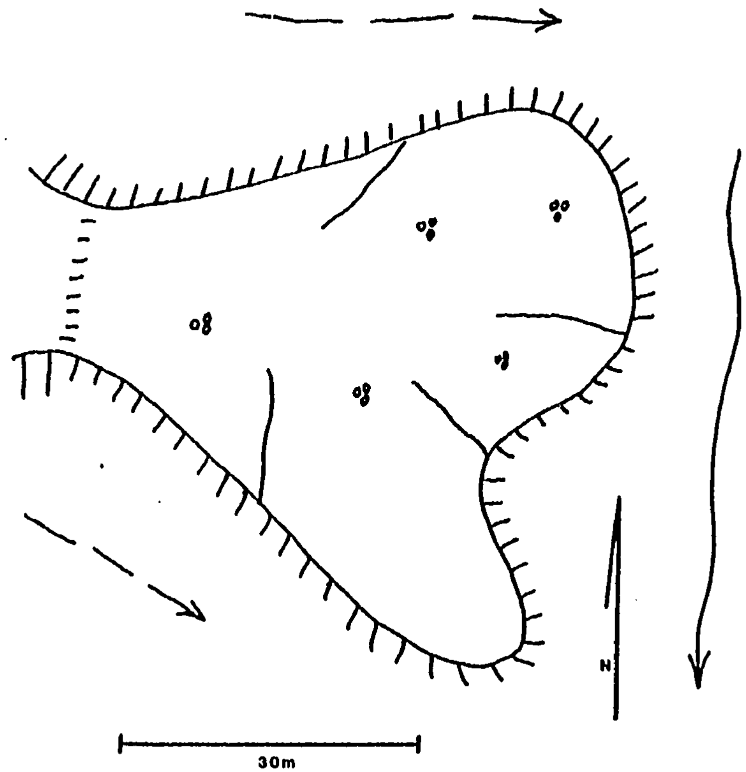



Son K:4:32 OU

Arroyo del Rancho

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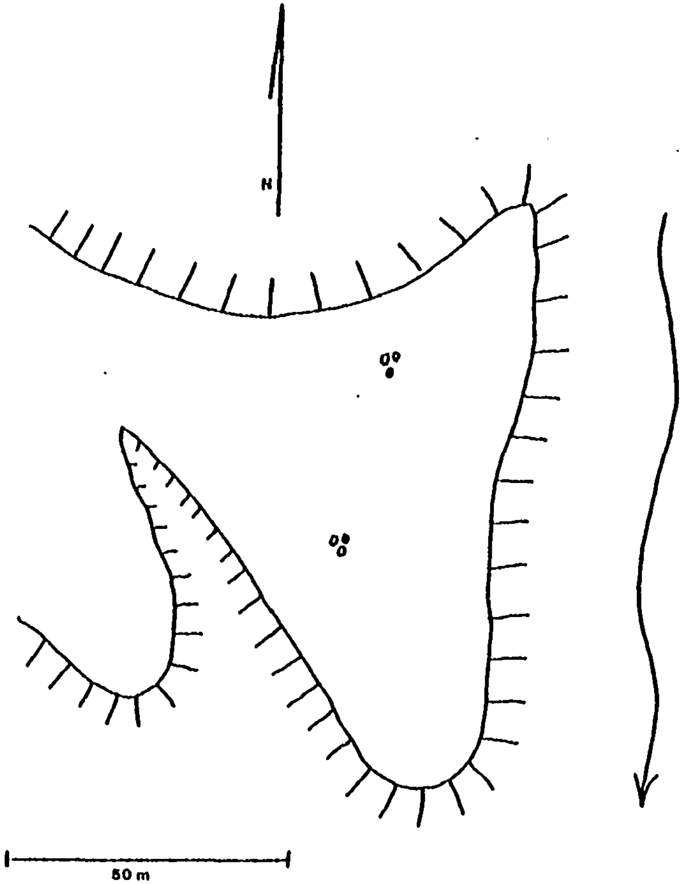


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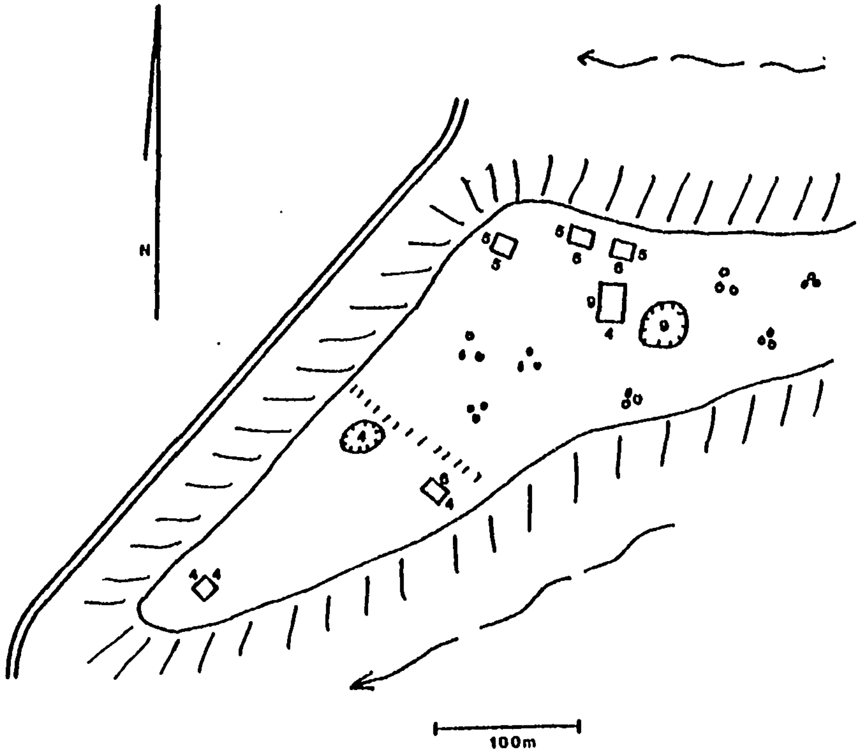
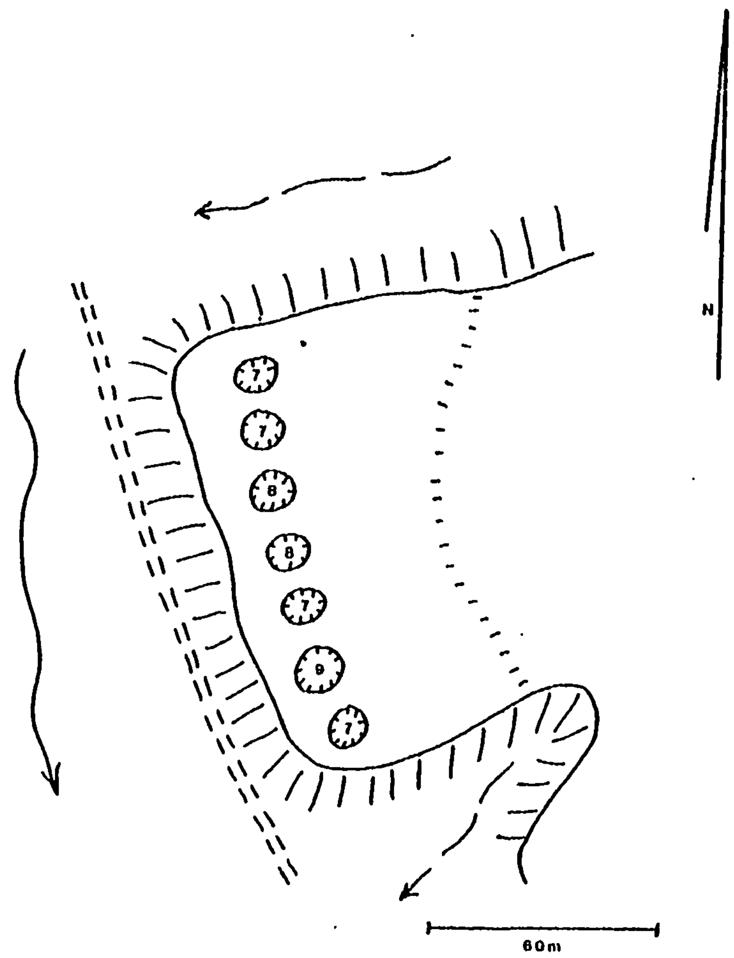



Son K:4:40 OU

Ranchito de Huepac South

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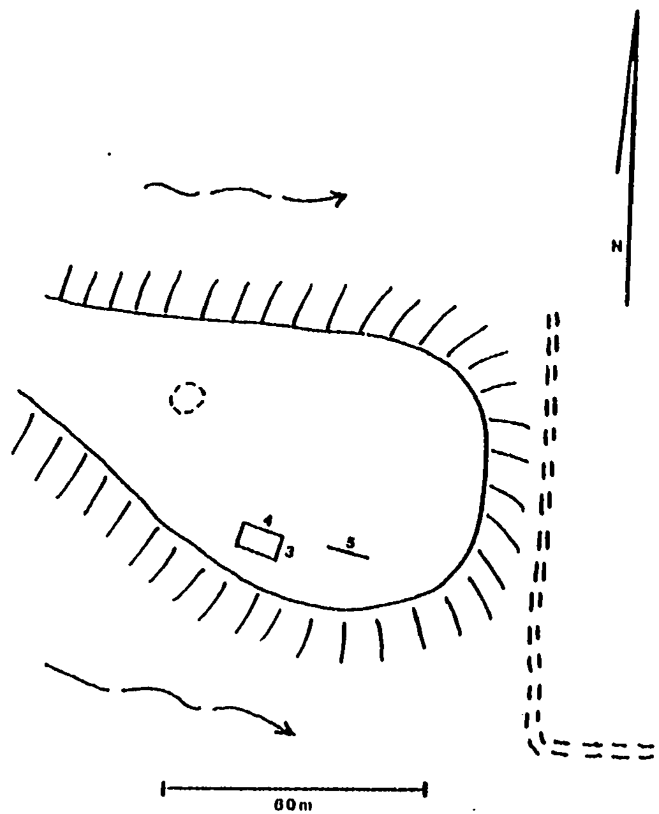


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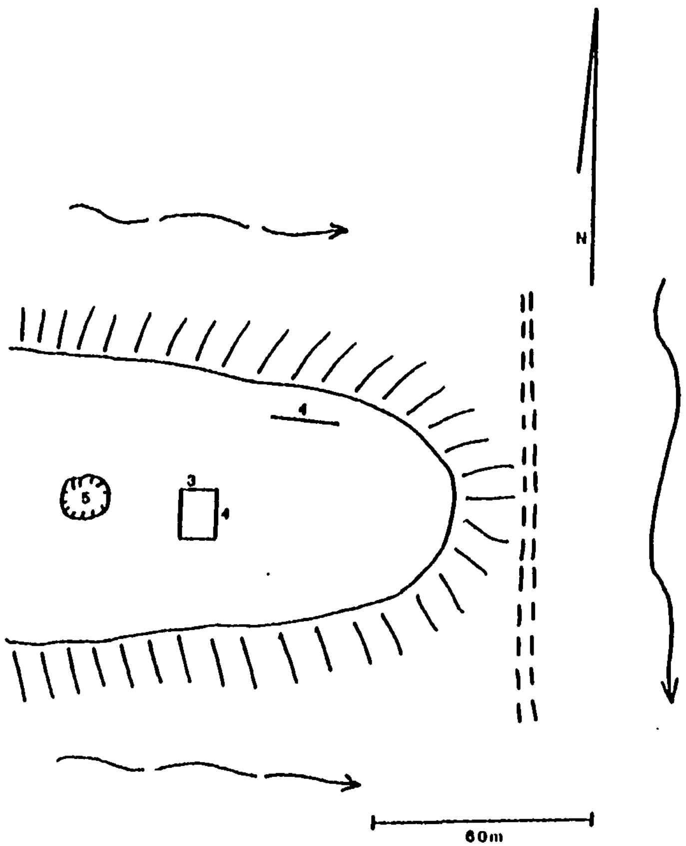


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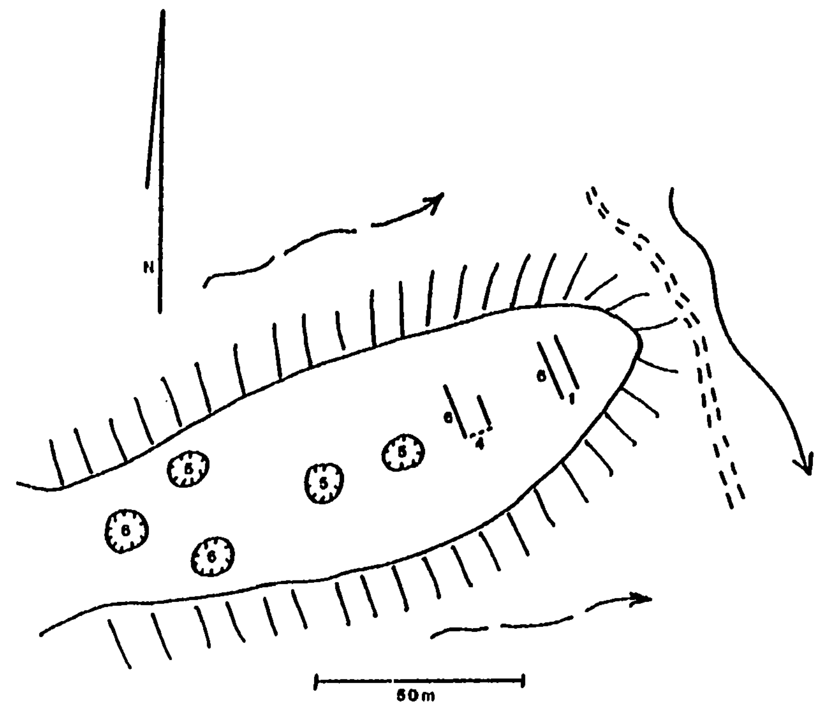


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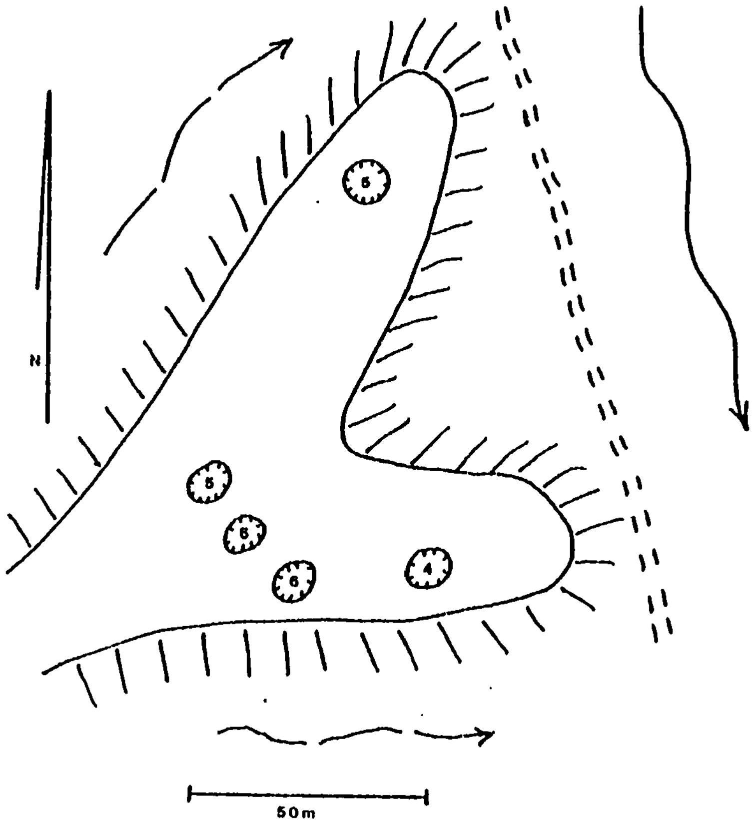


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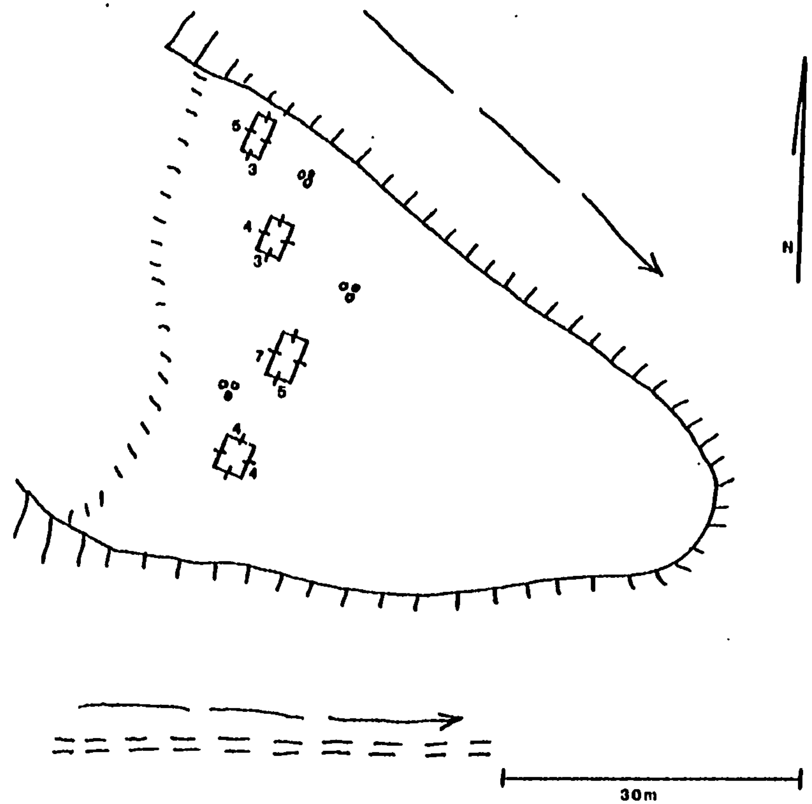
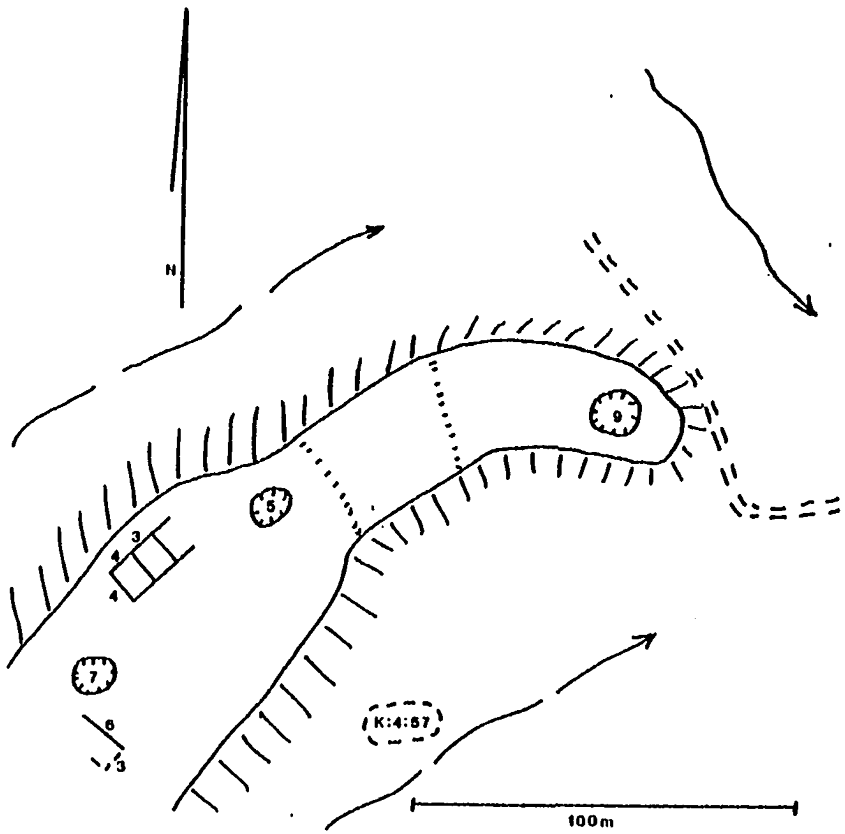



Son K:4:48 OU

Pichobabi West

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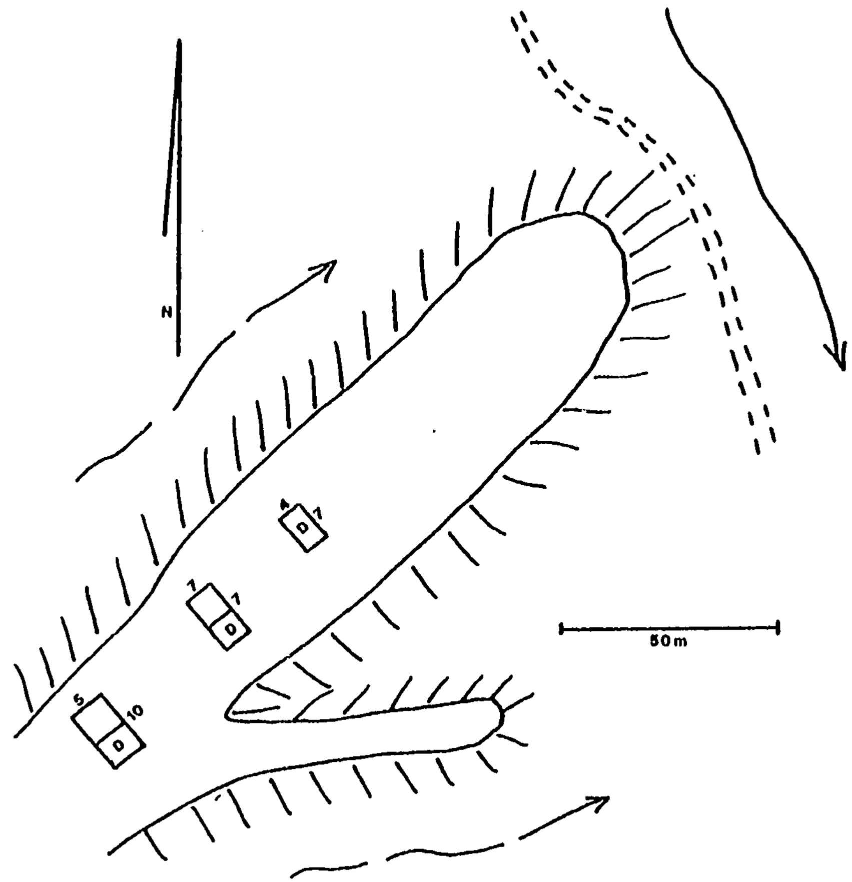


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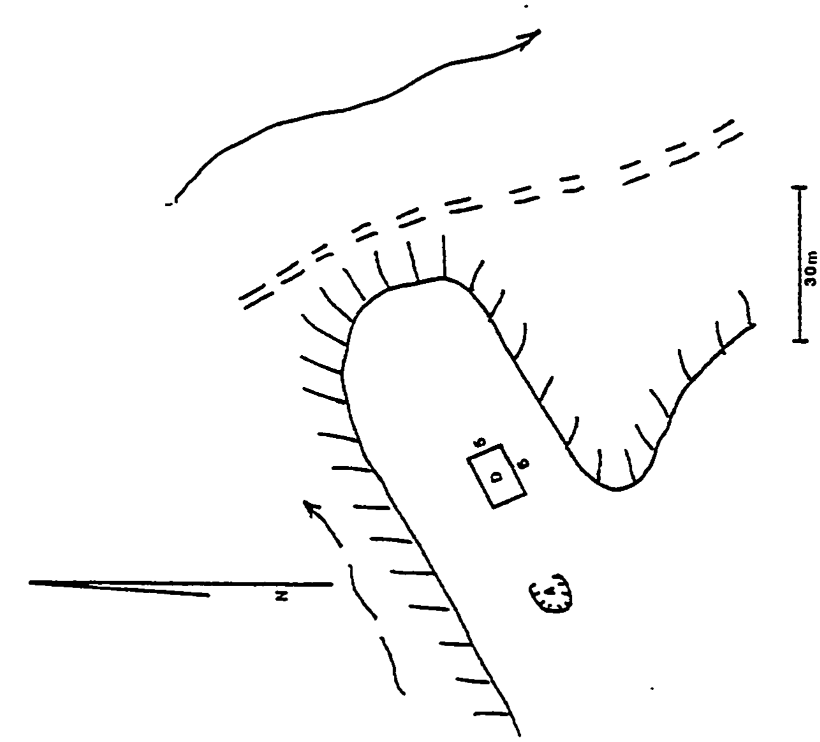


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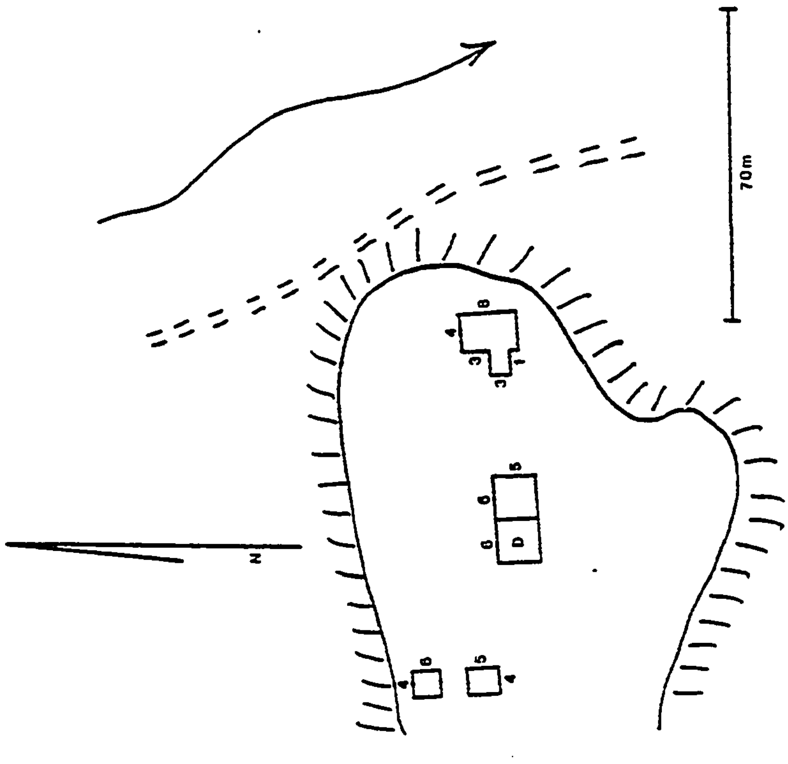


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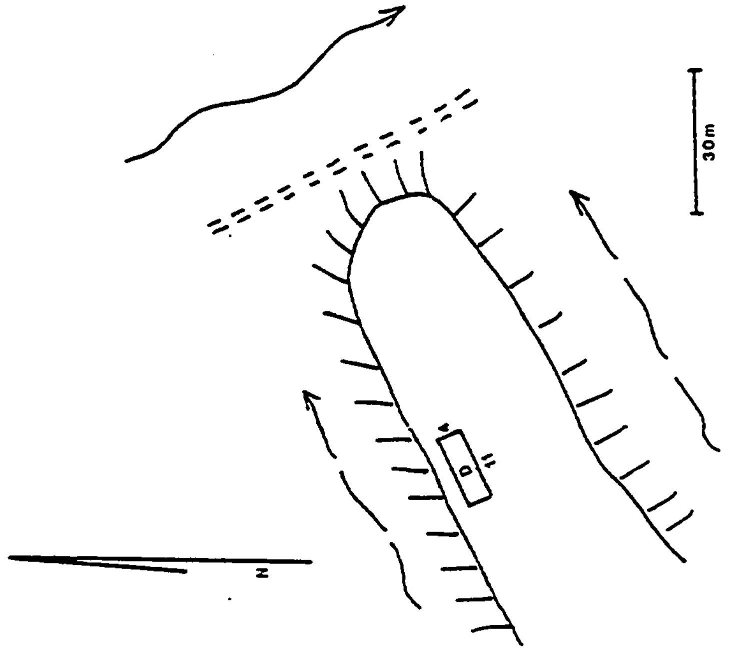


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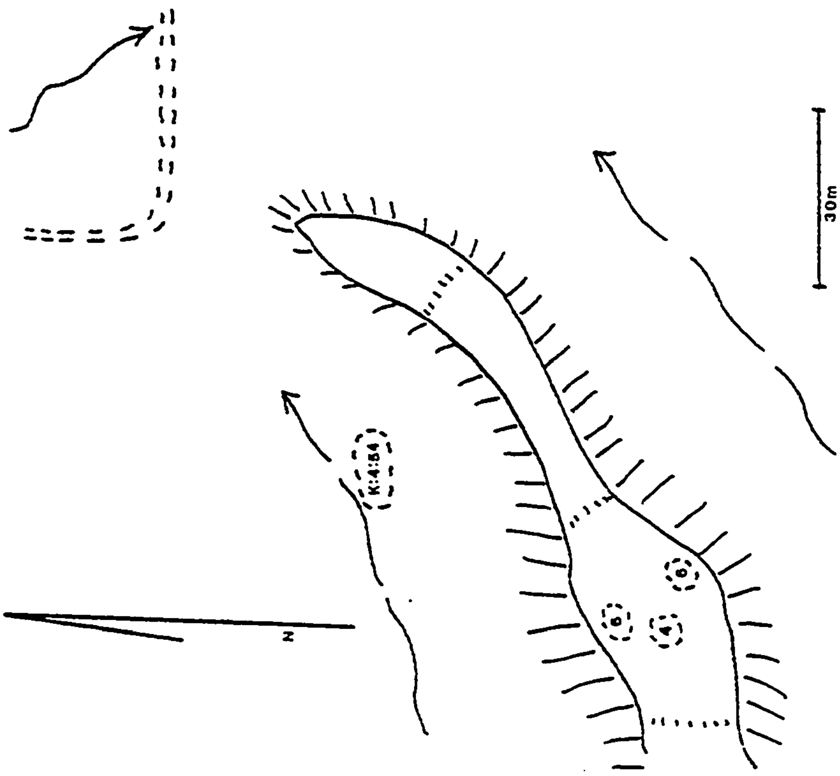


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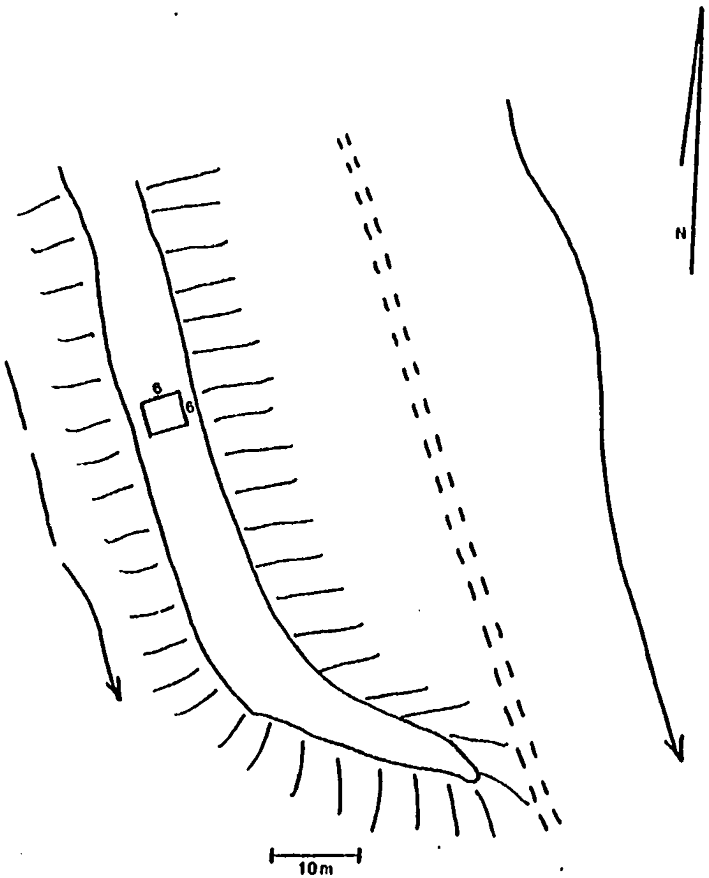


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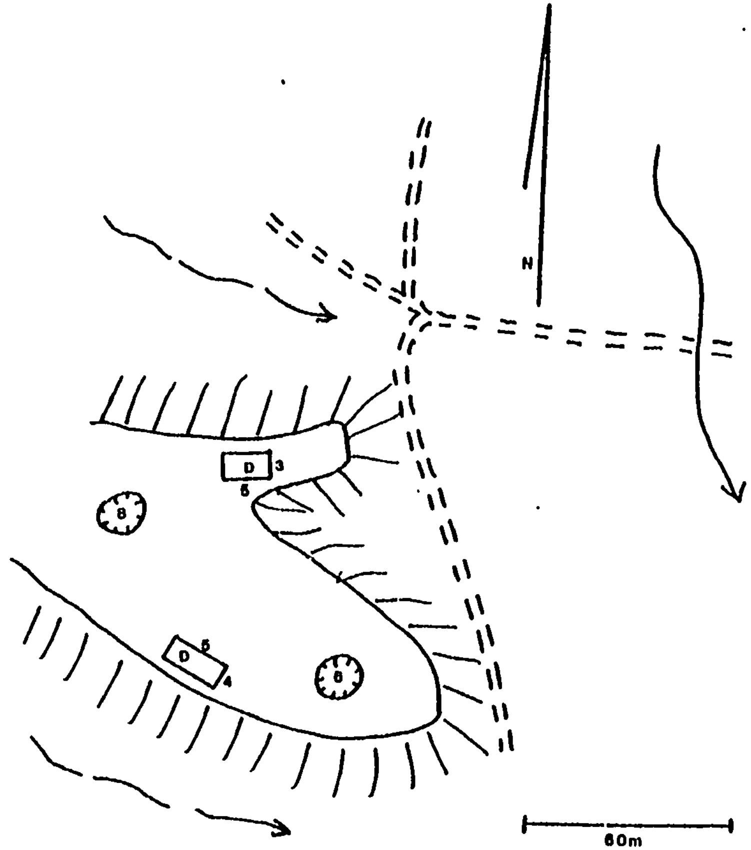


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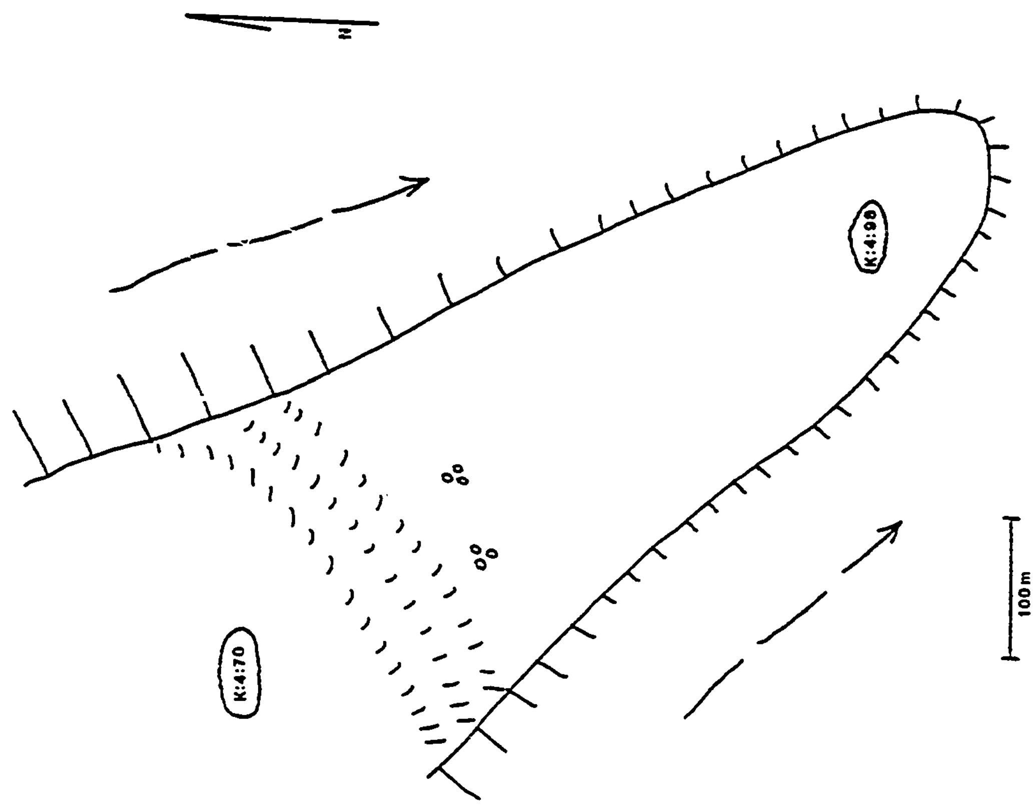


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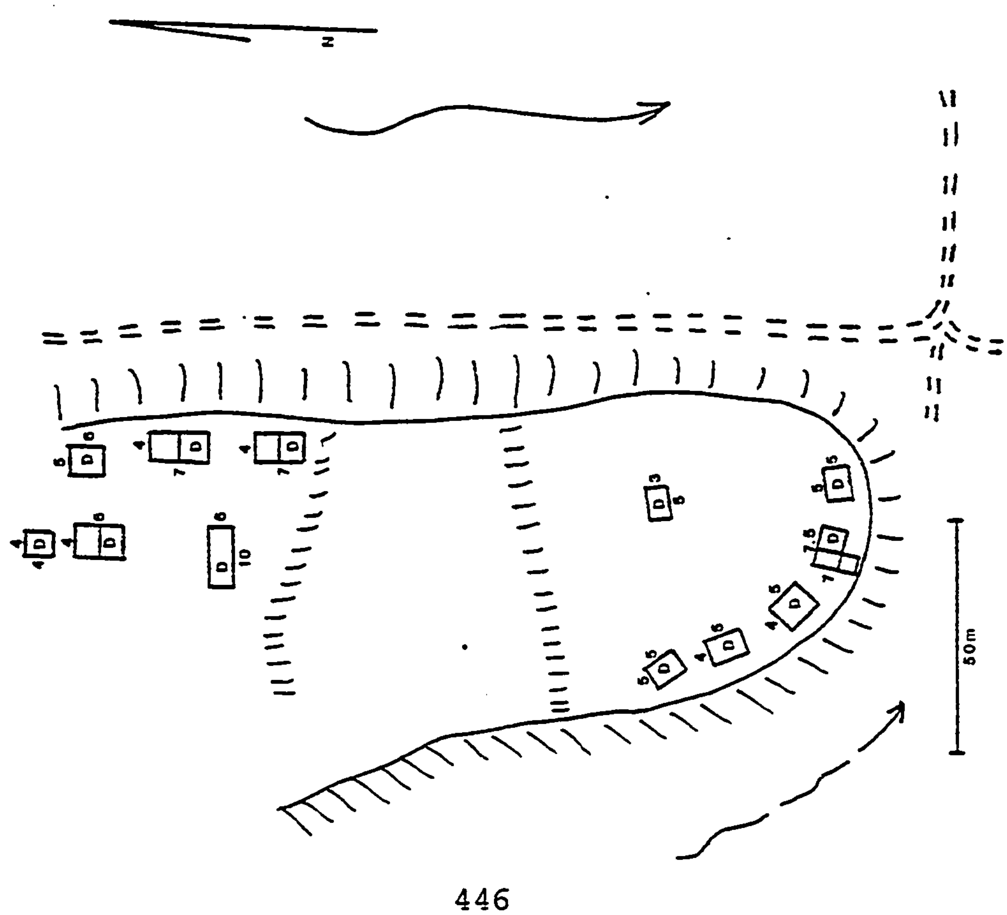


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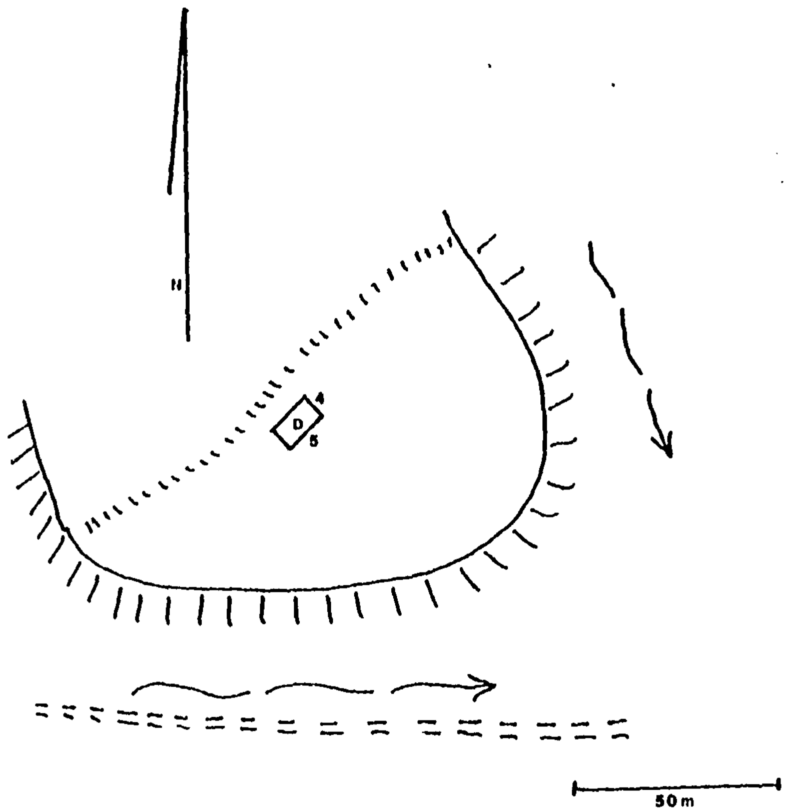


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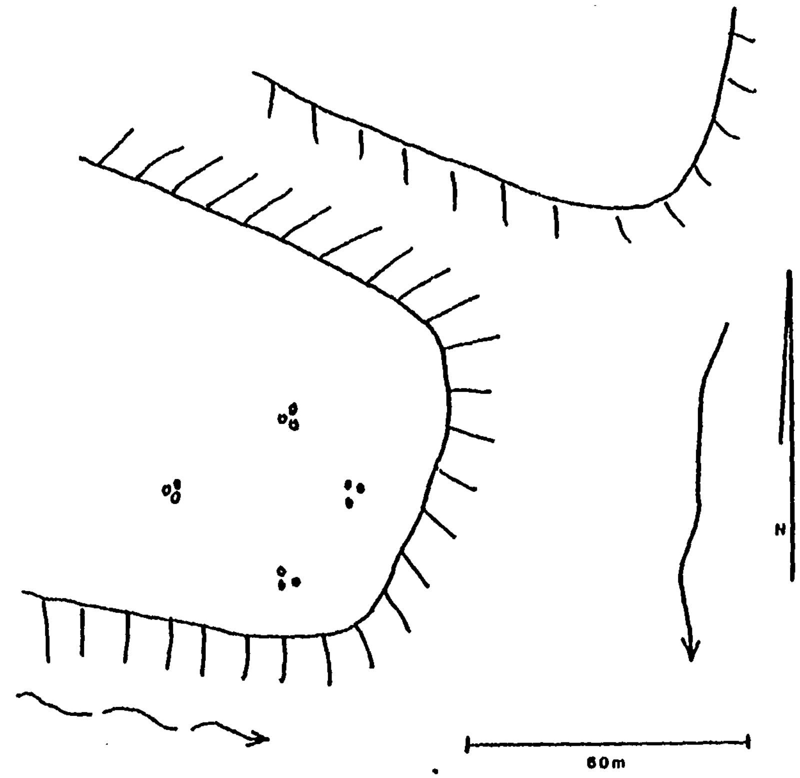


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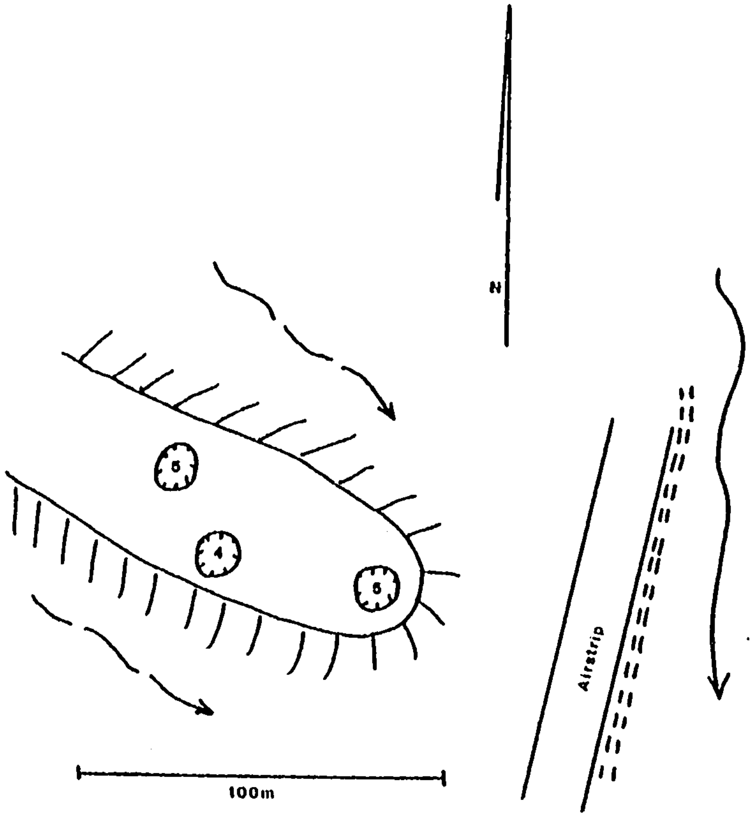
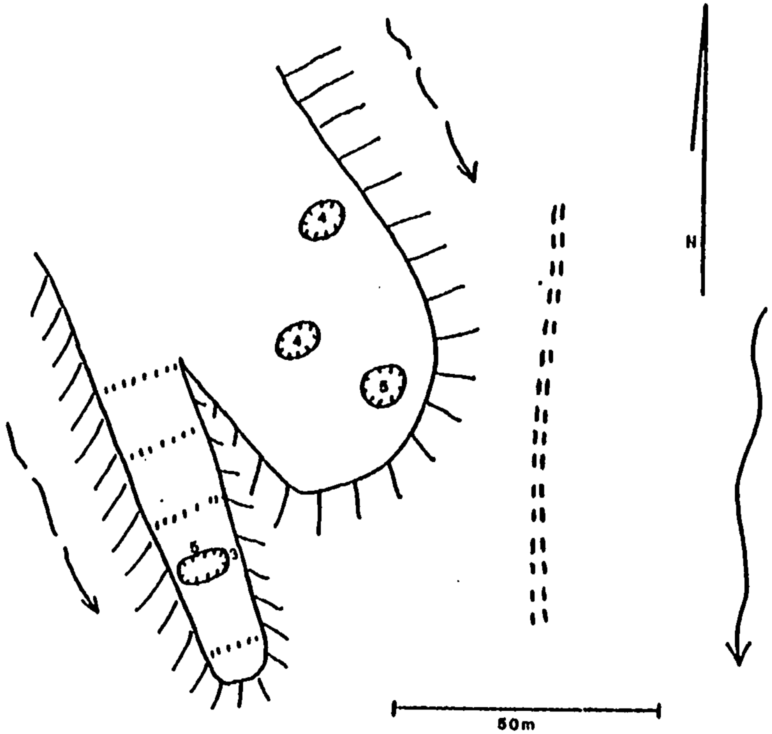



Son K:4:64 OU

San Felipe Airstrip

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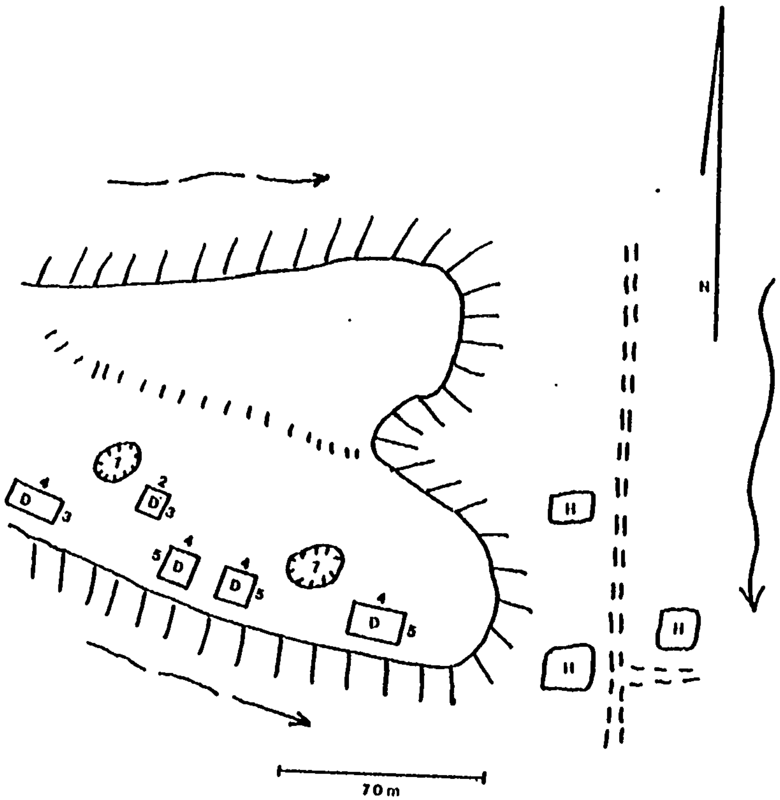
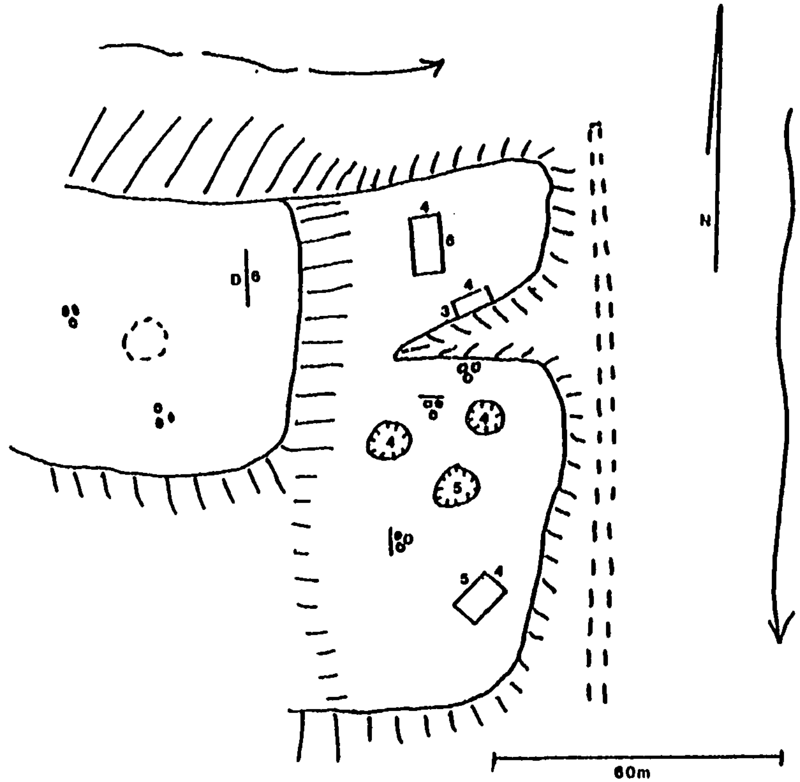



Son K:4:68 OU

El Jojobal North

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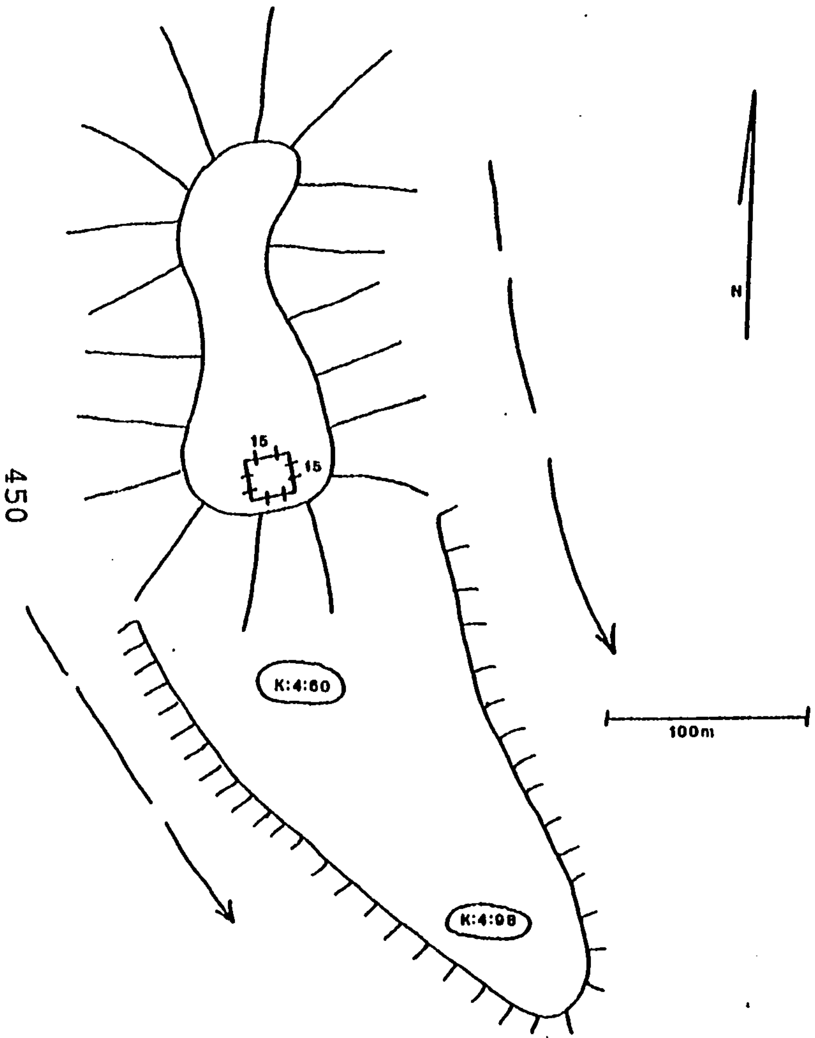


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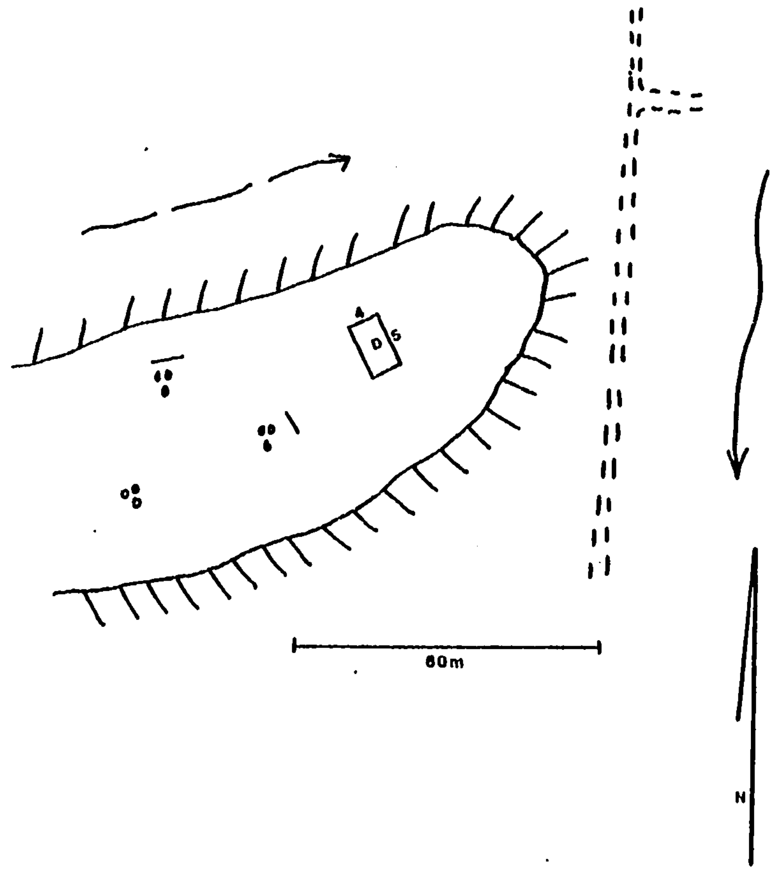
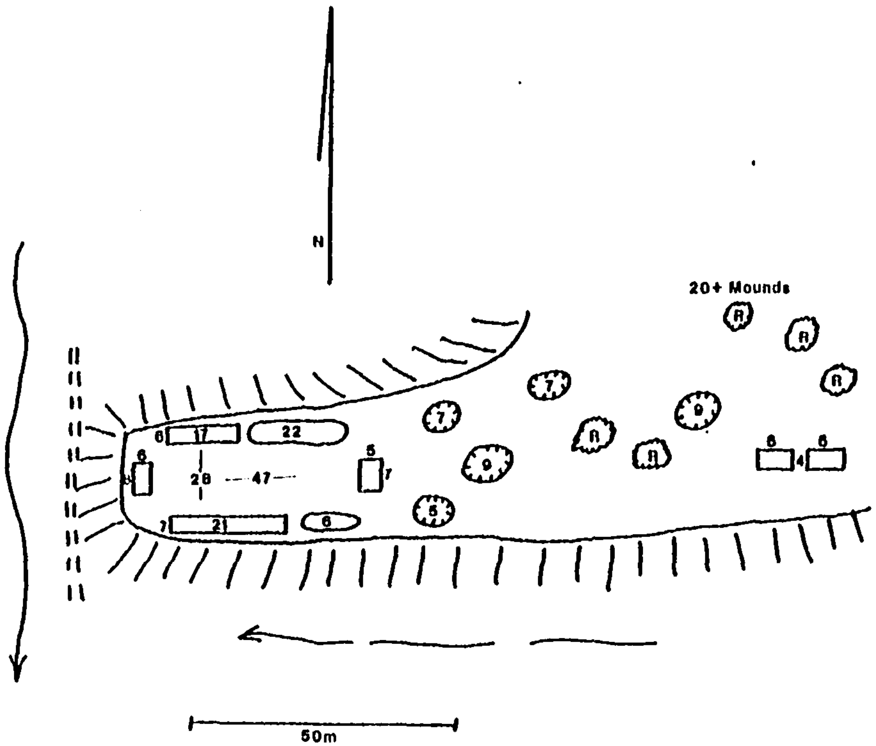


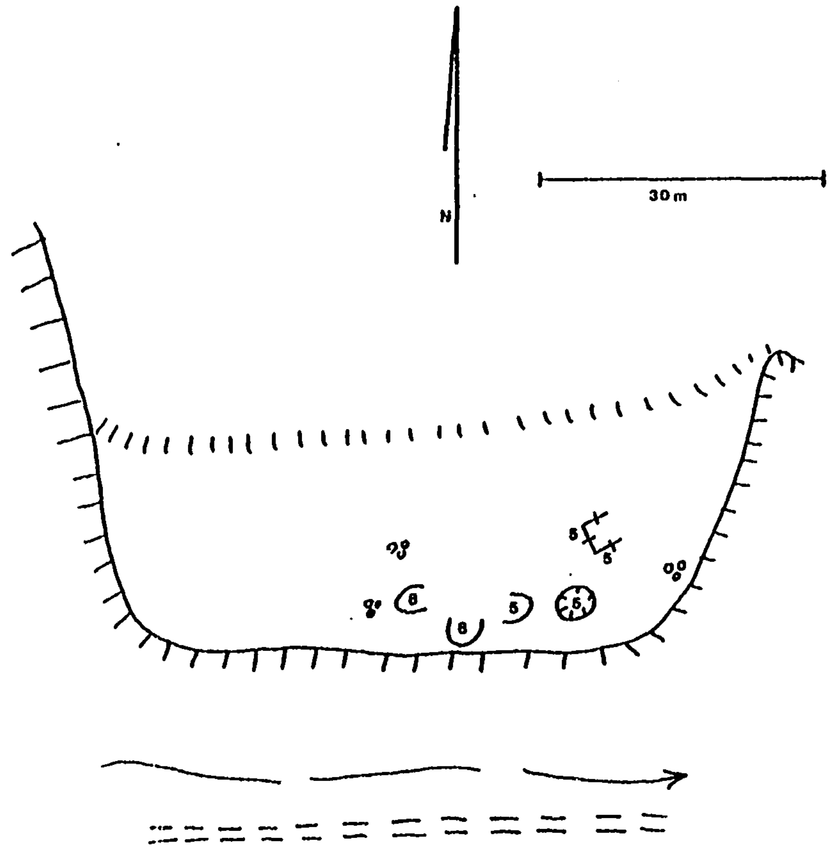

Son K:4:71 OU

El Jojobal South



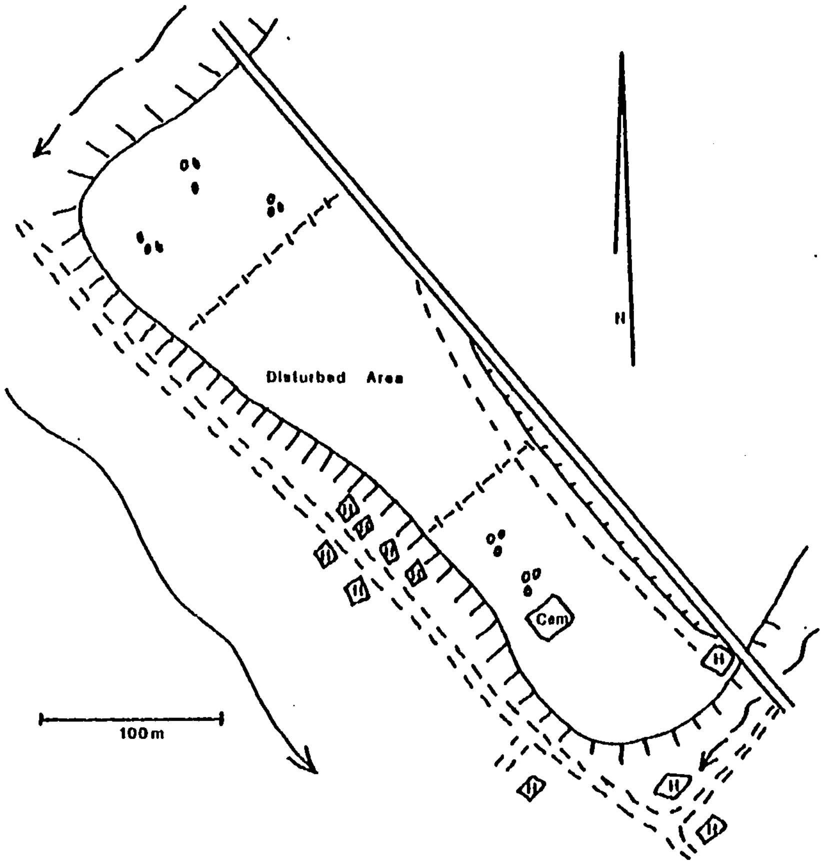

Son K:4:72 OU

La Mora



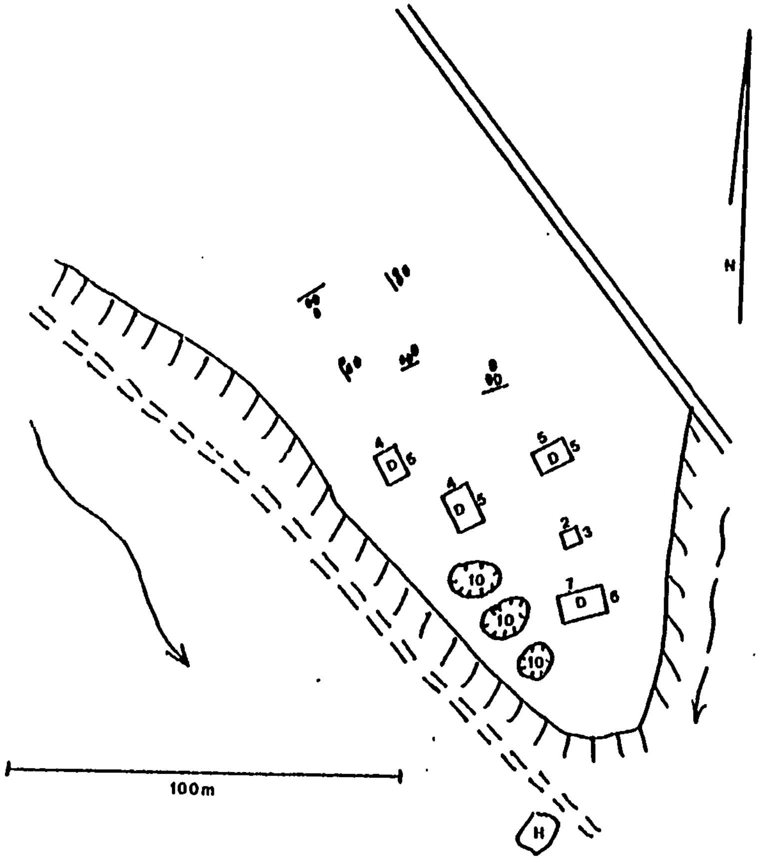

Son K:4:73 OU

Pichobabi East

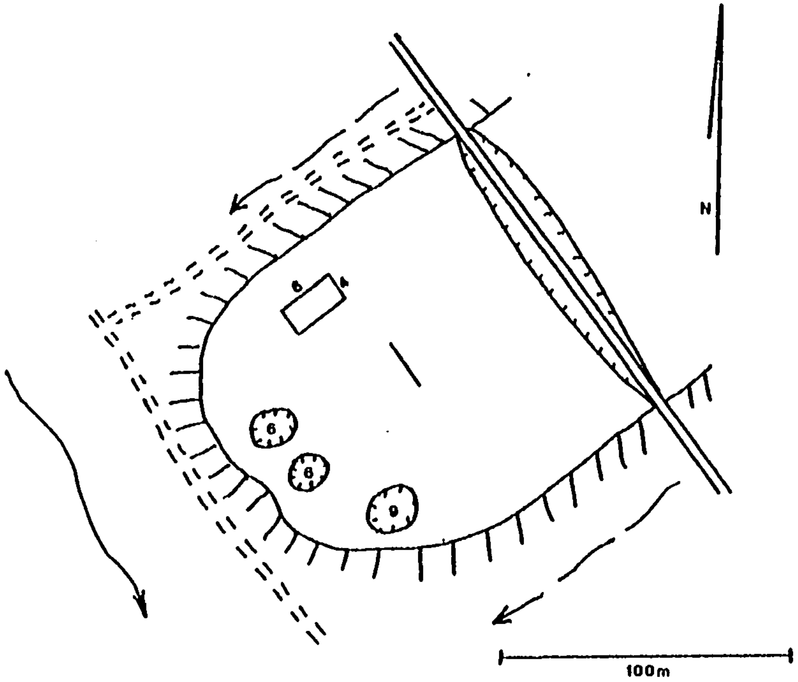



Son K:4:75 OU

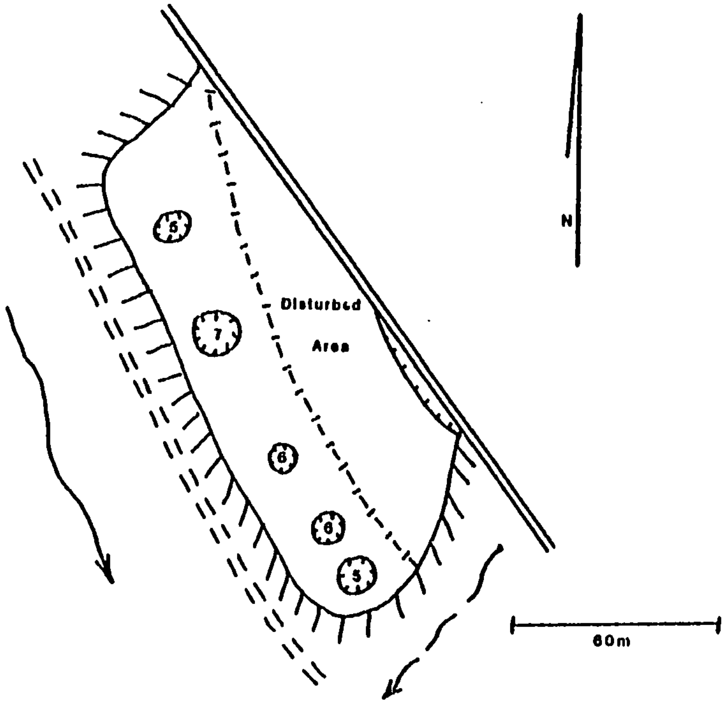
San Pablo North



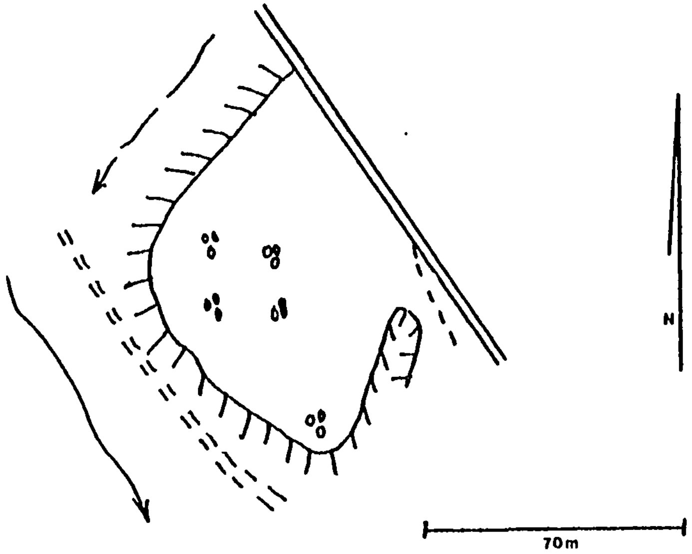

Son K:4:76 OU



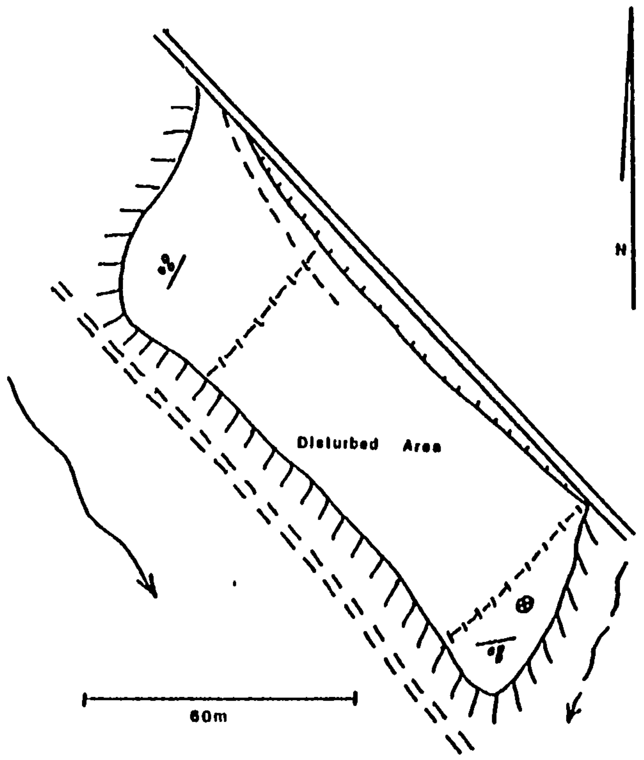

Son K:4:77 OU



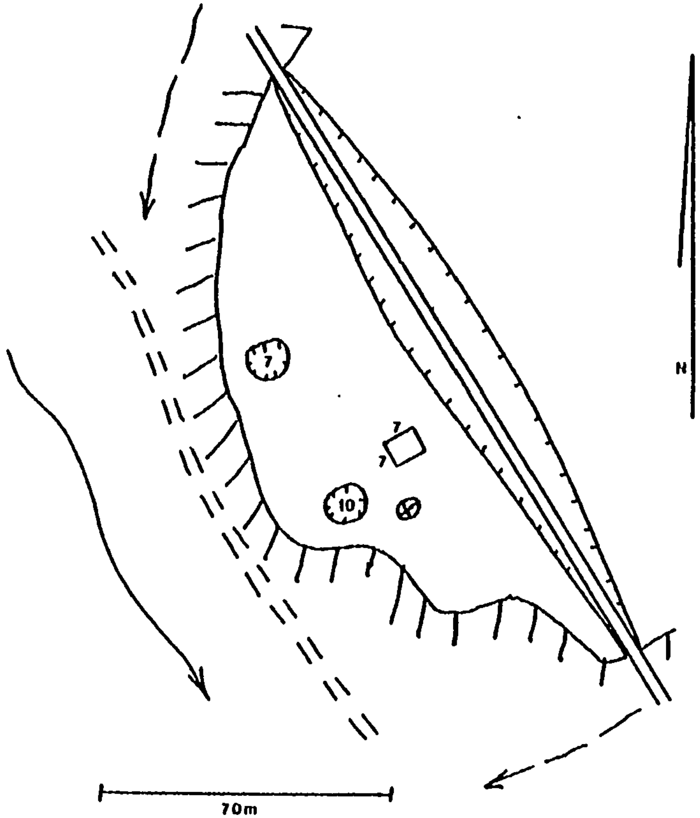

Son K:4:78 OU




Son K:4:79 OU




Son K:4:80 OU

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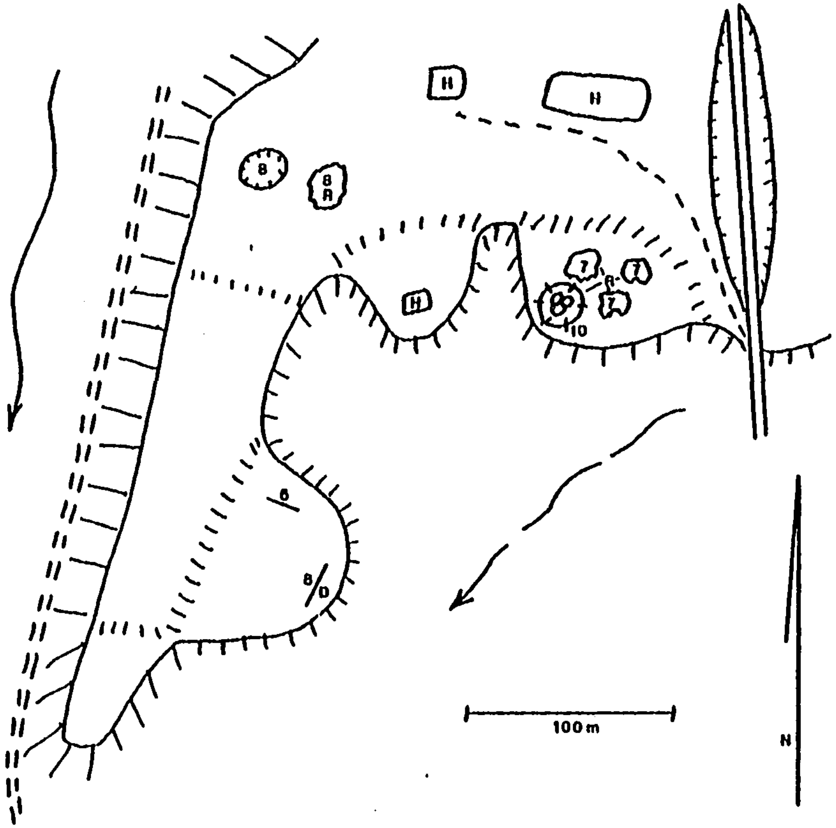
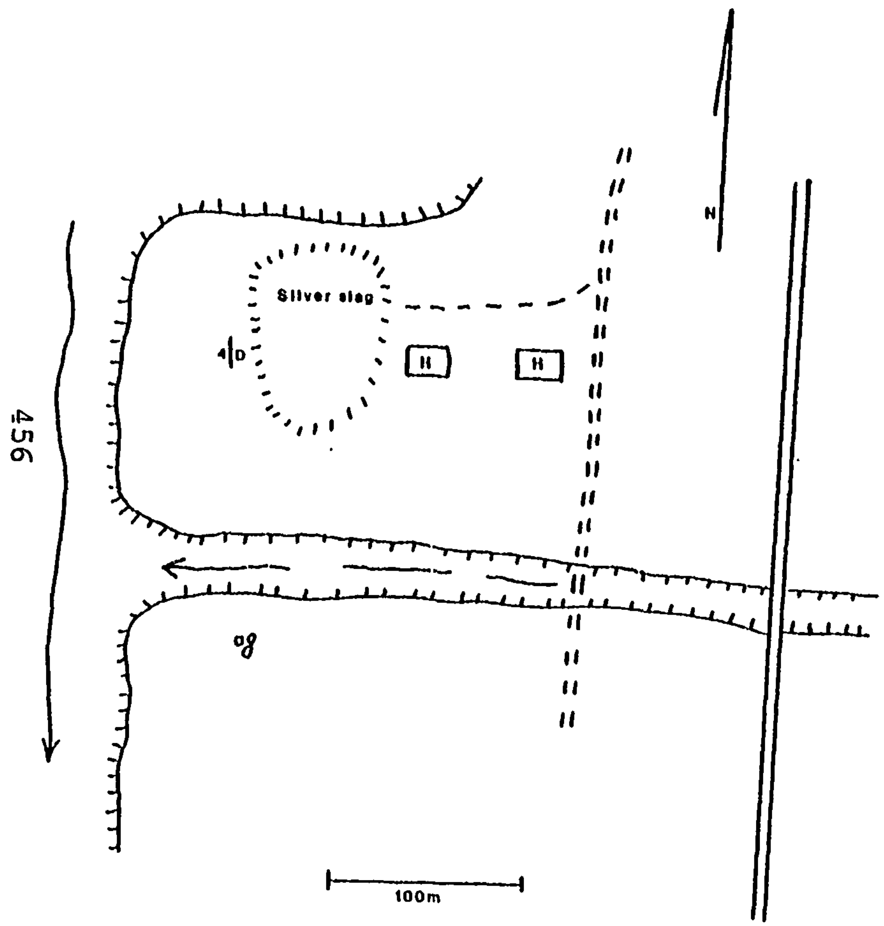


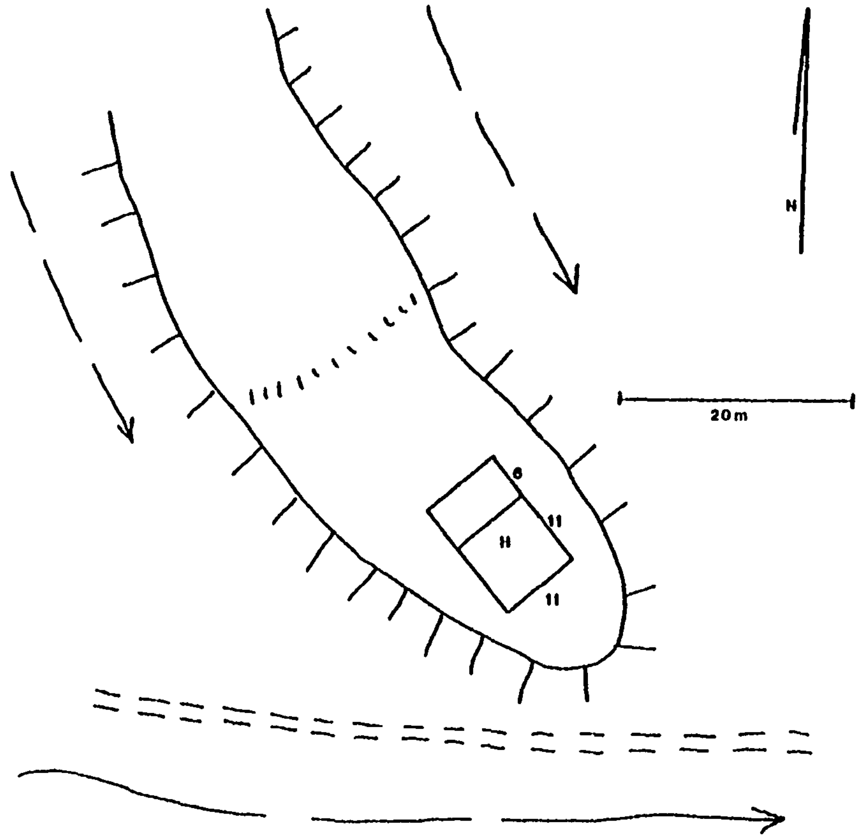

Son K:4:82 OU

Aconchi North



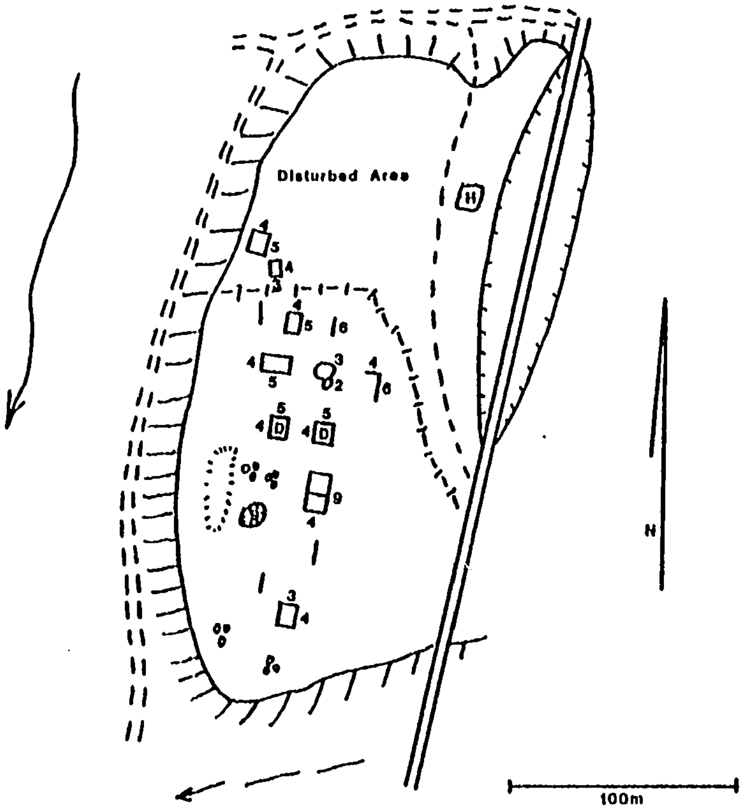

Son K:4:83 OU

Huepac South



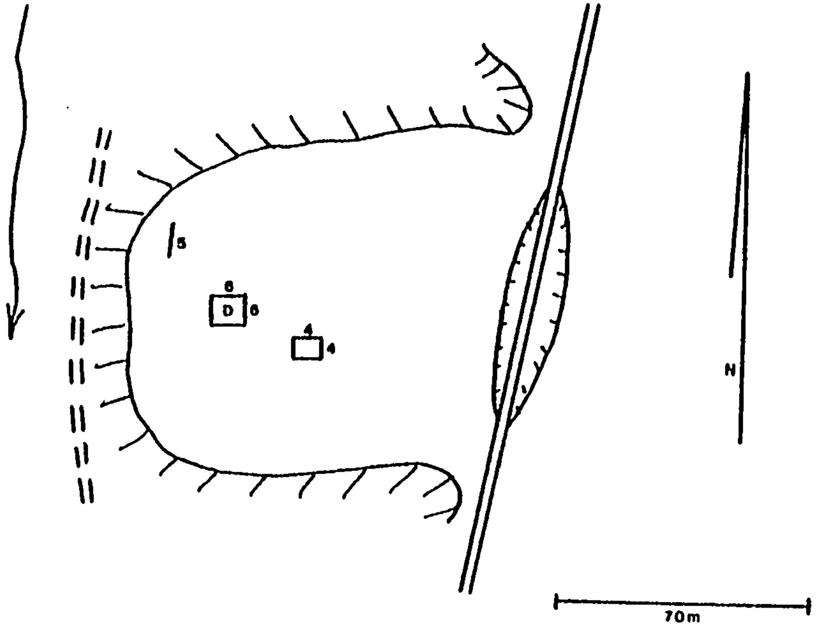

Son K:4:84 OU

Hueverachi Ranch




Son K:4:85 OU

San Felipe Turnoff

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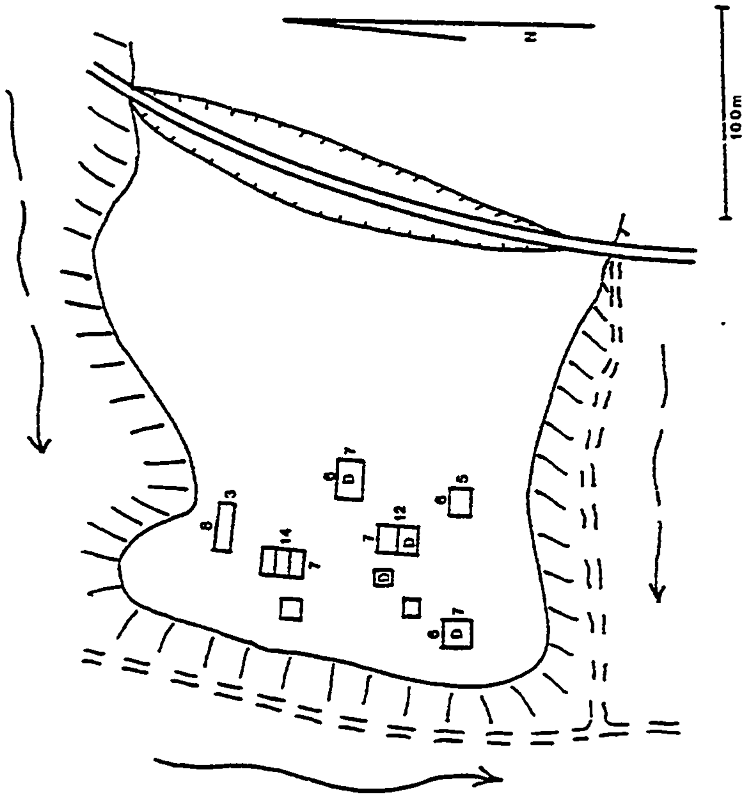
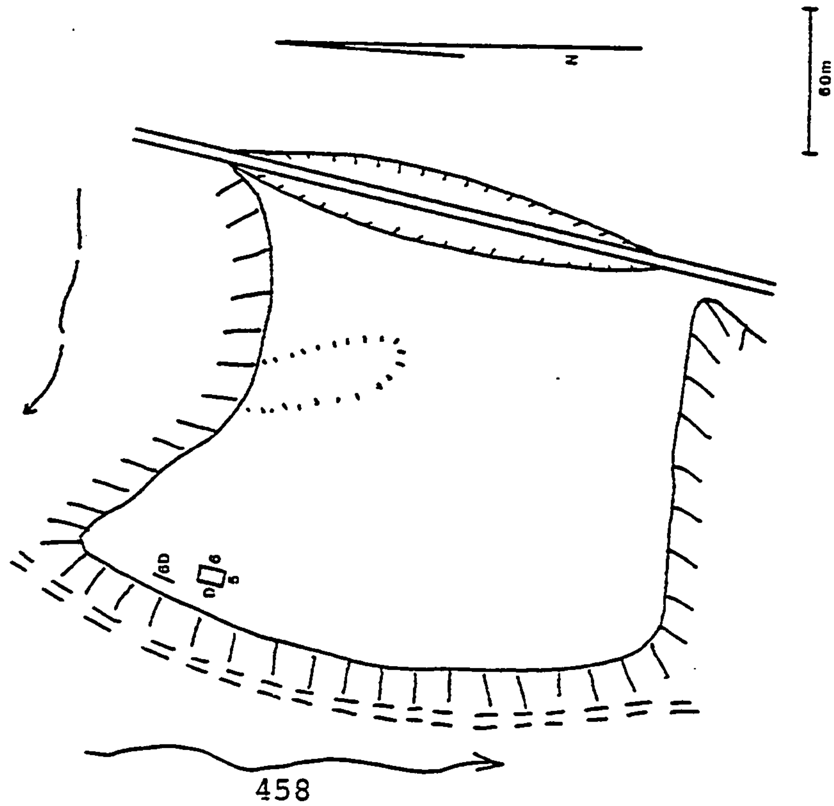



Son K:4:91 OU

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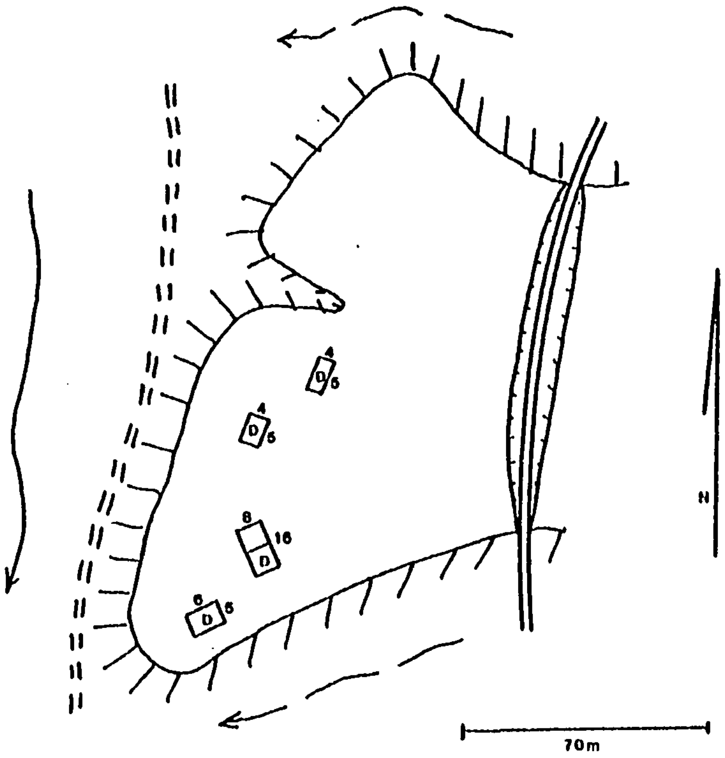
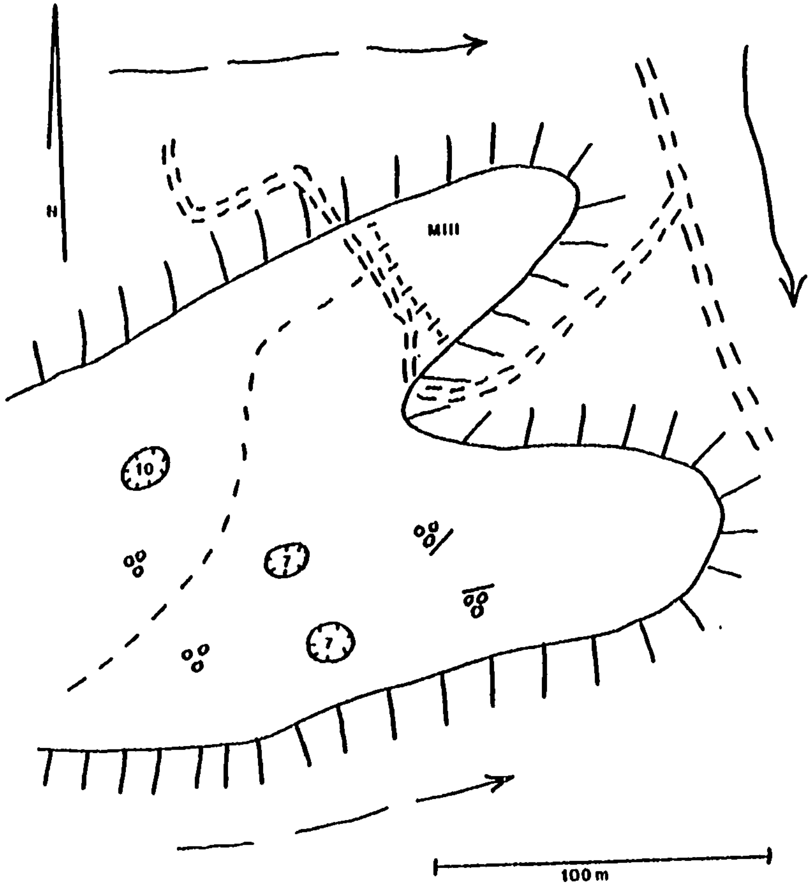
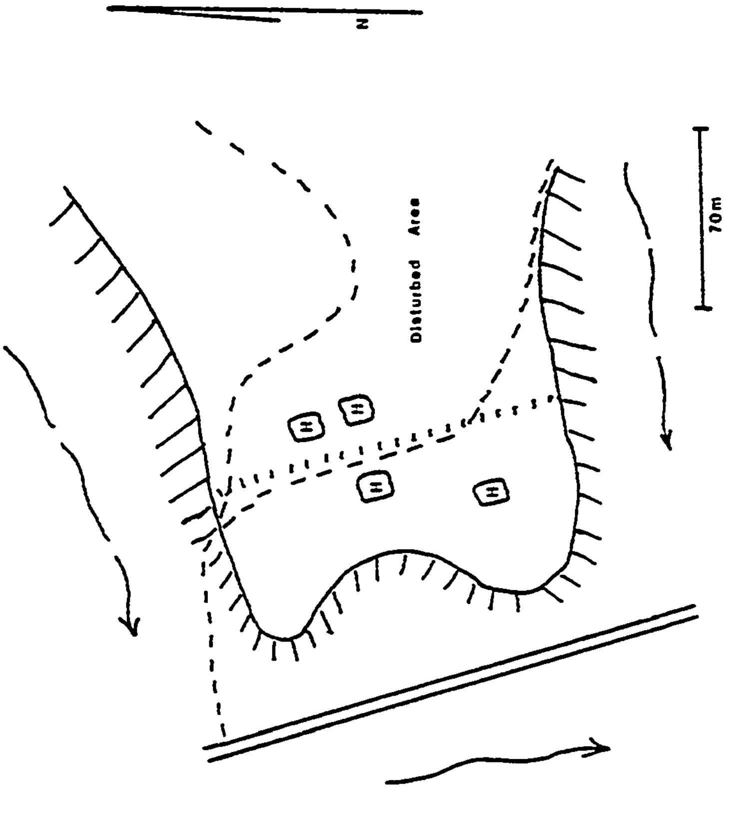



Son K:4:92 OU

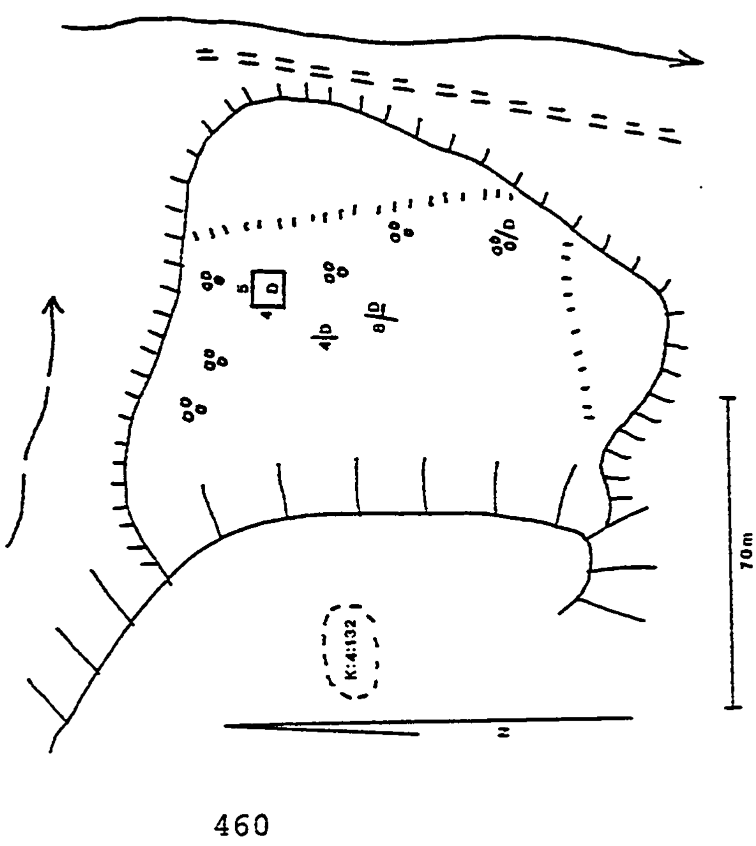



Son K:4:93 OU

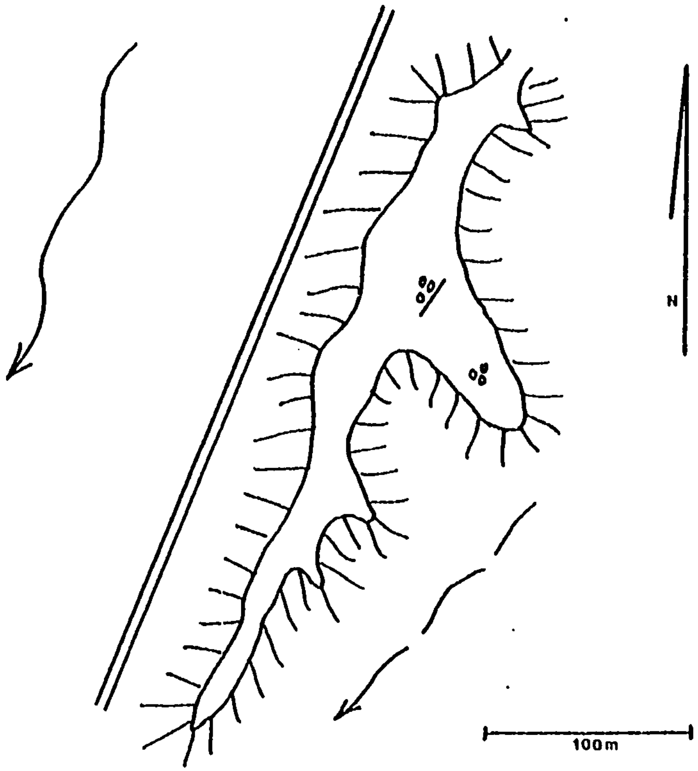
Artemisa Mine Mill



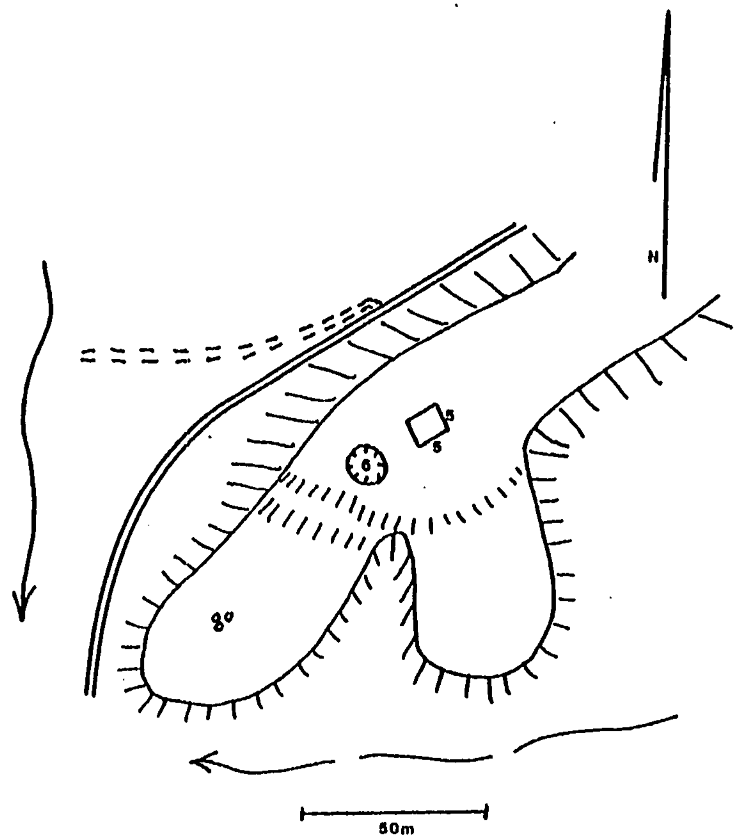

Son K:4:95 OU




Son K:4:94 OU

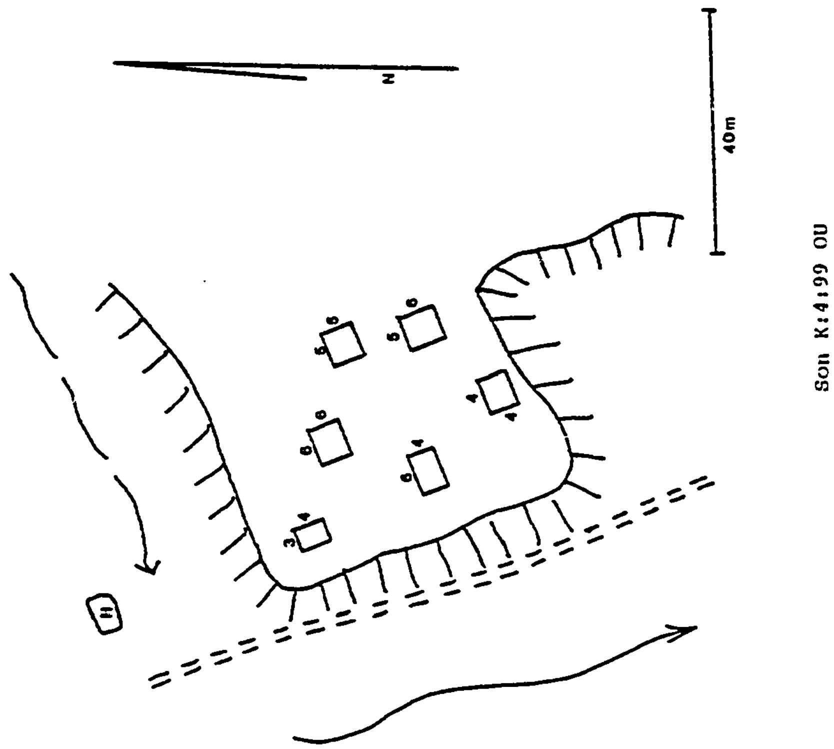


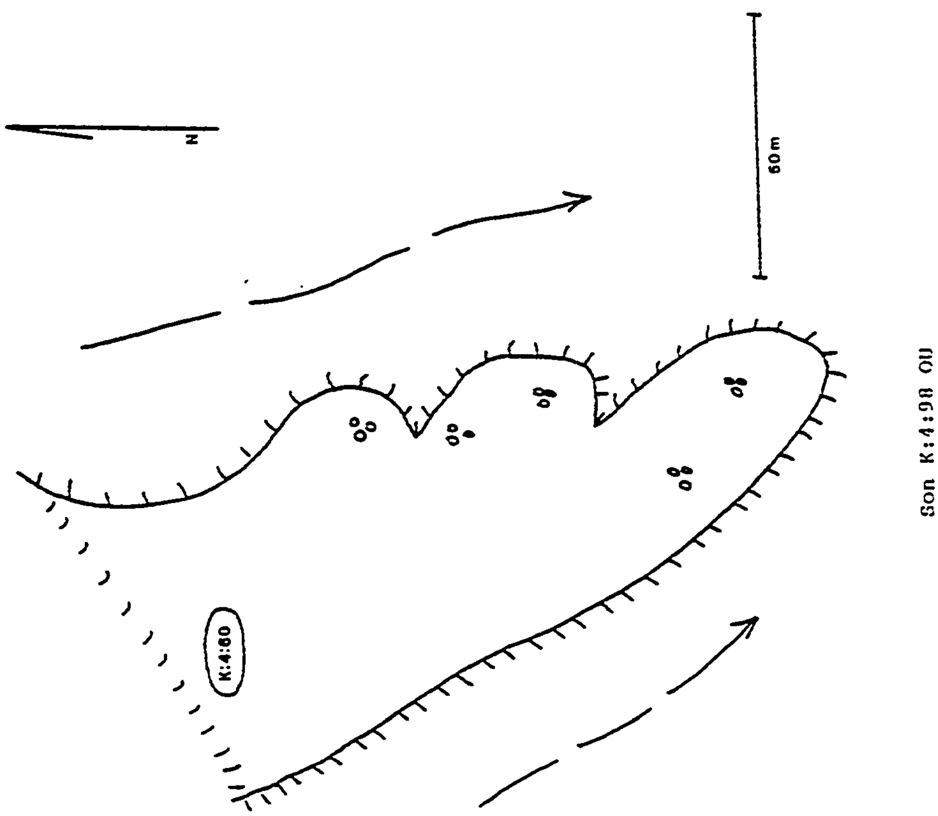

Son K:4:96 OU

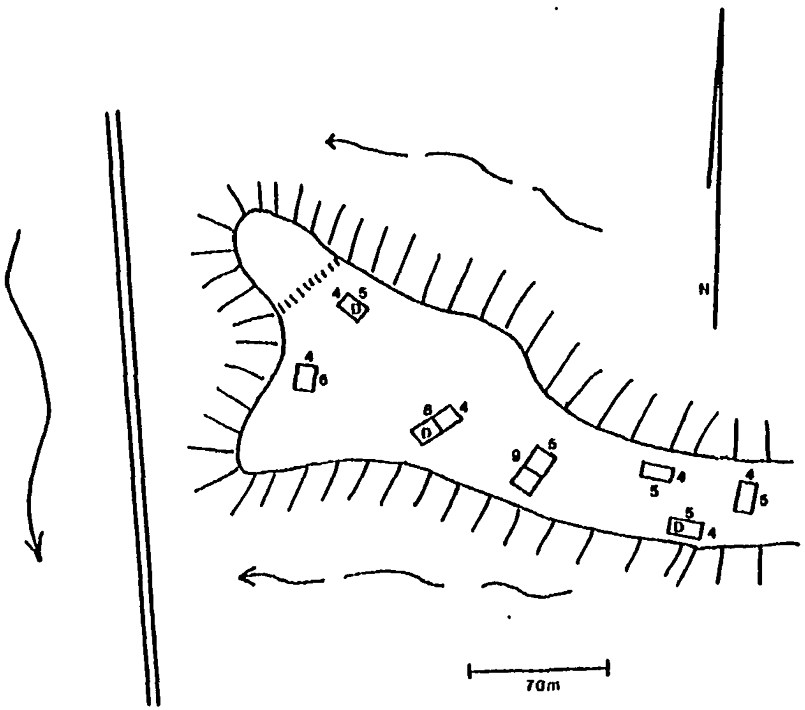



Son K:4:97 OU

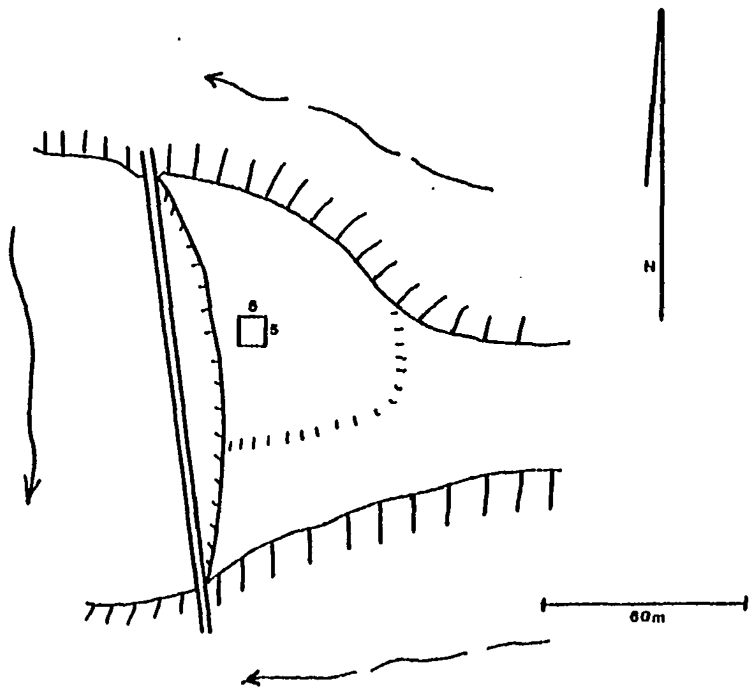
El Jojobal Turnoff


N
40m
Son K:4:99 OU

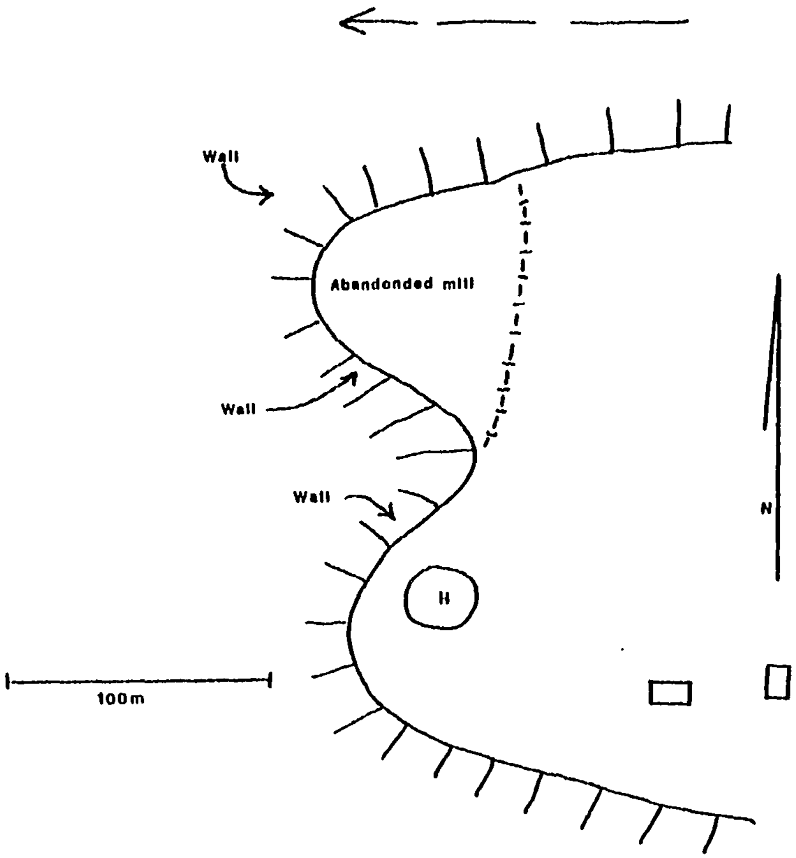

N
60m
K:4:80
Son K:4:98 OU




Son K:4:101 OU

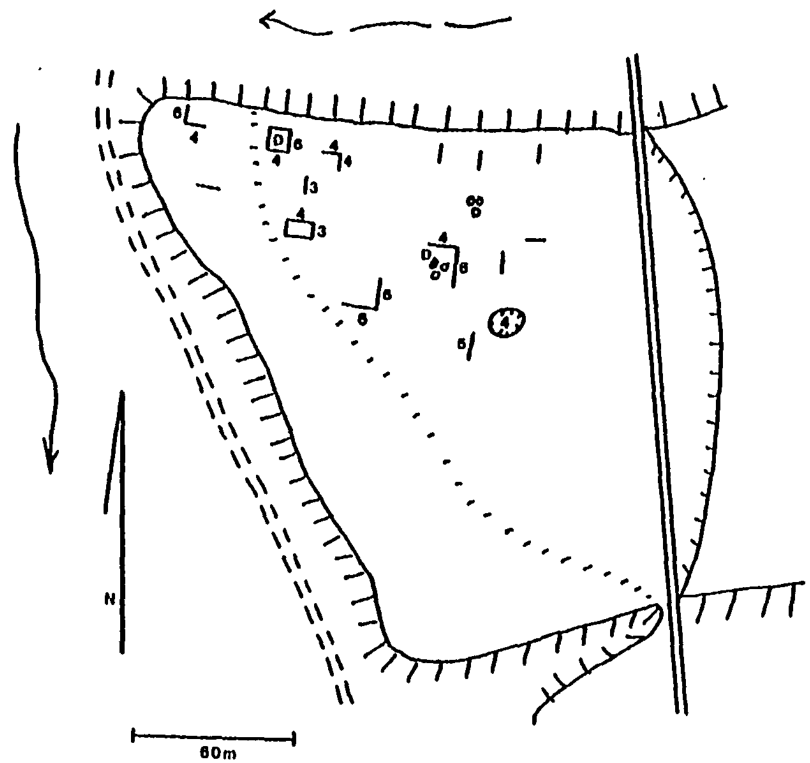



Son K:4:102 OU

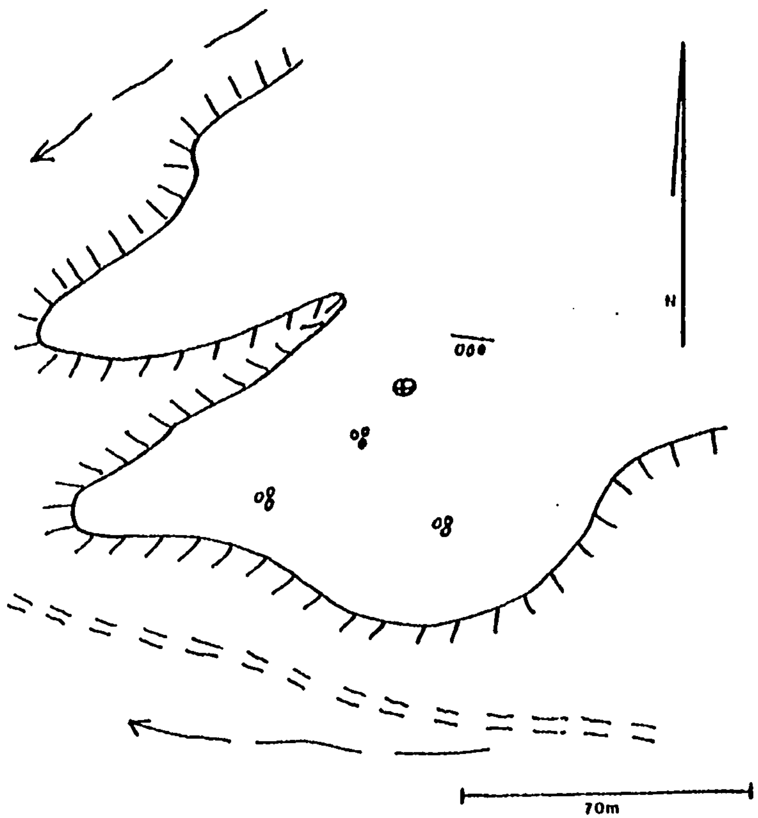



Son K:4:105 OU

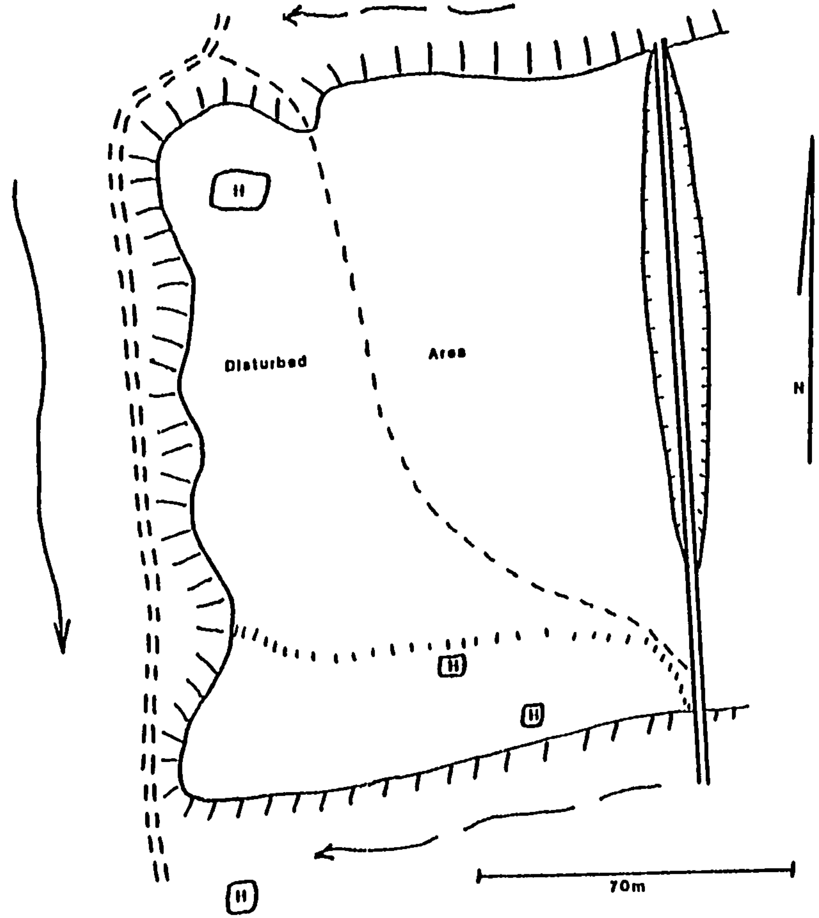
Washington Mine Mill



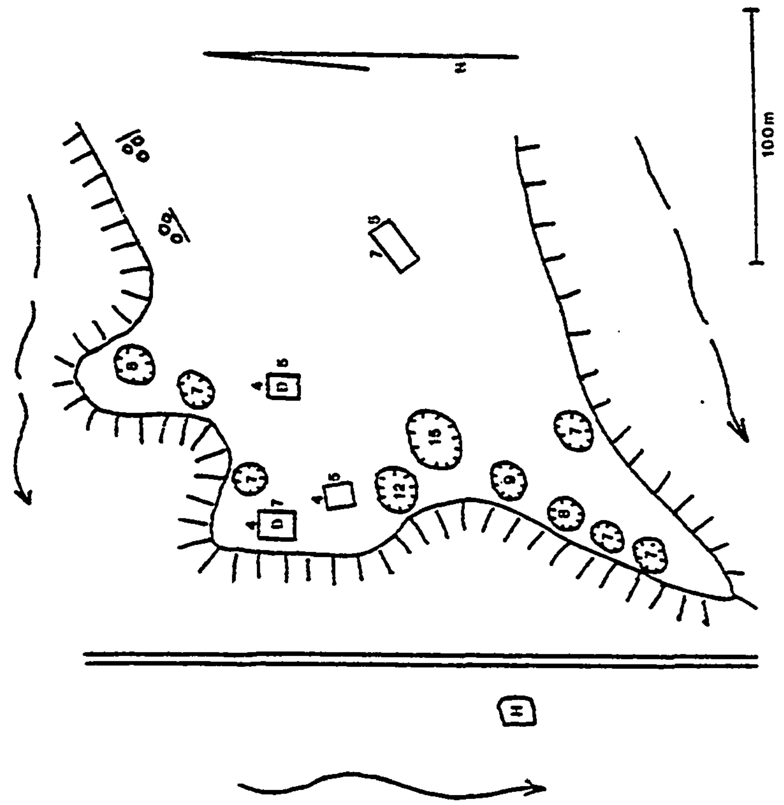

Son K:4:106 OU



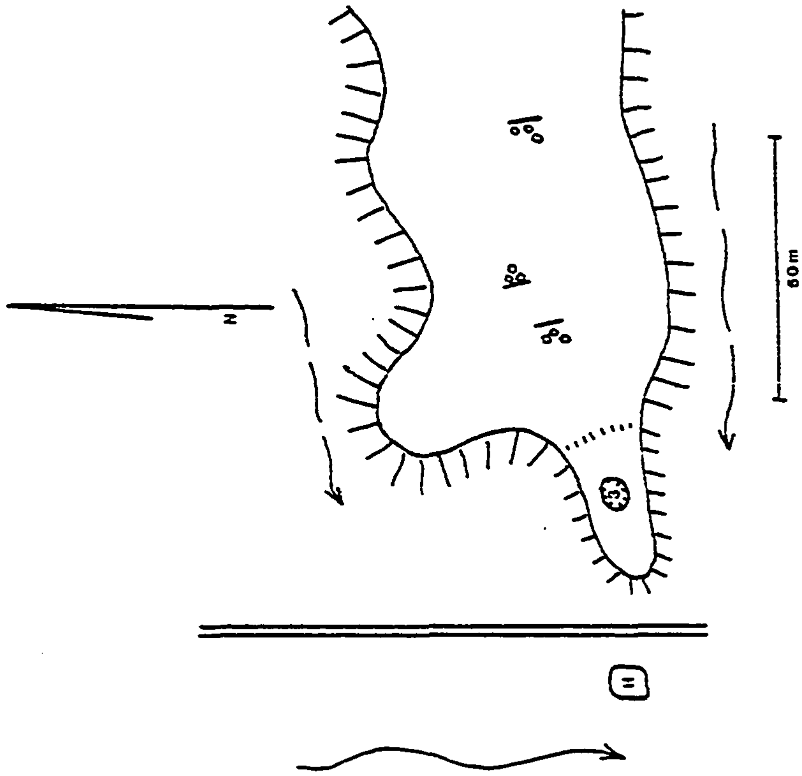

Son K:4:107 OU



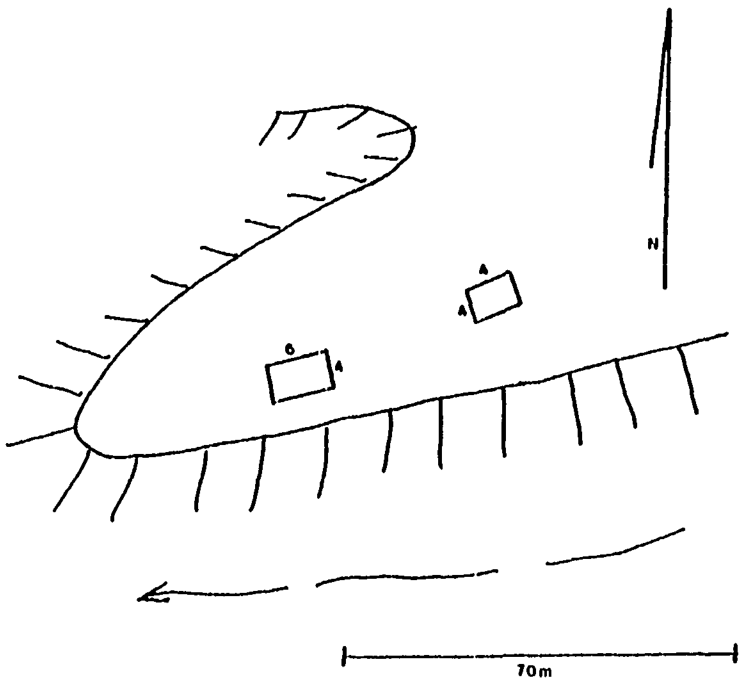

Son K:4:108 OU



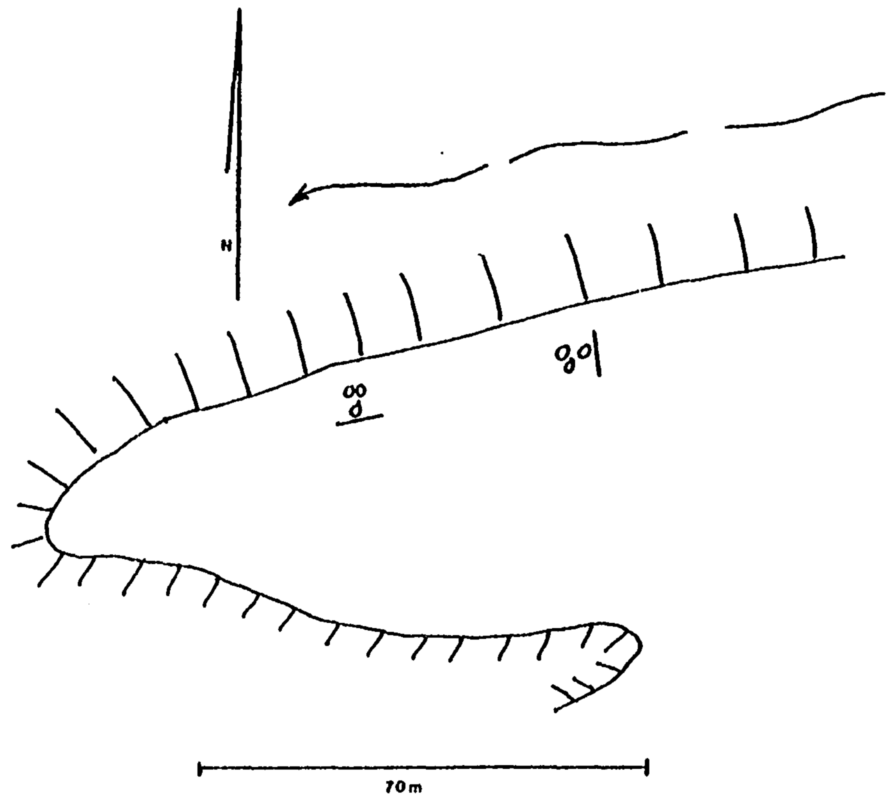
Son K:4:110 OU



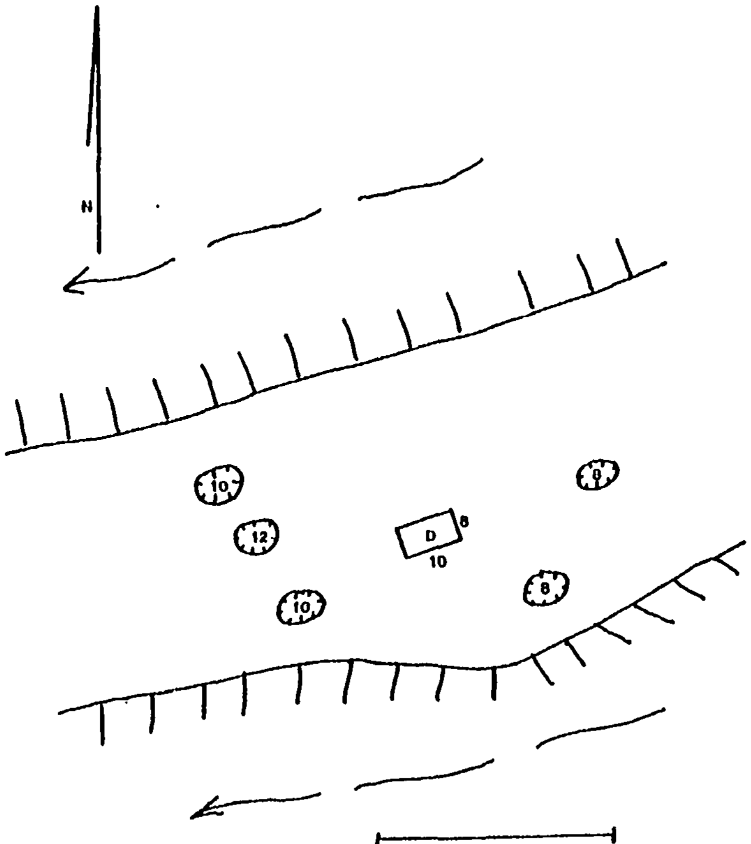
Son K:4:109 OU



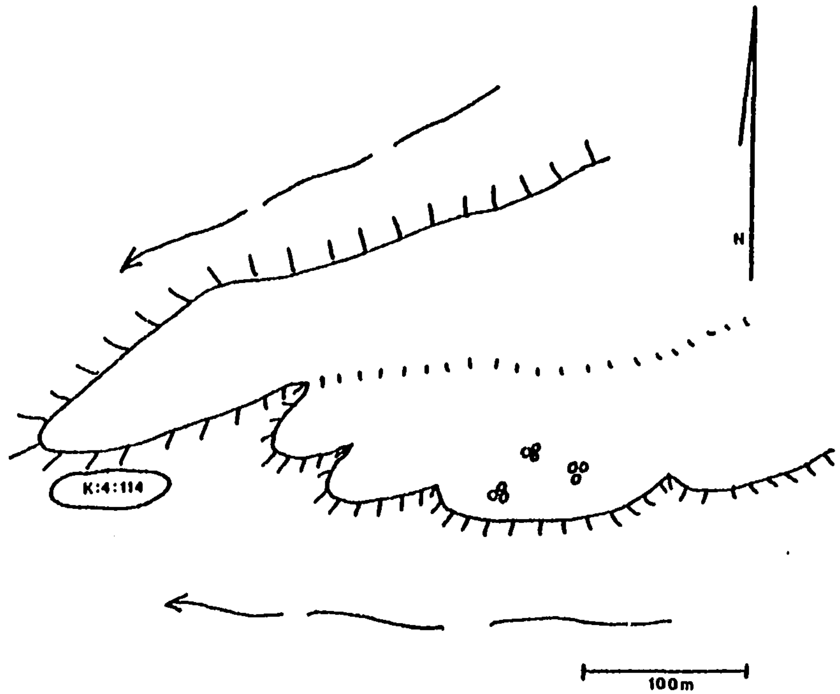

Son K:4:111 OU




Son K:4:112 OU




Son K:4:113 OU

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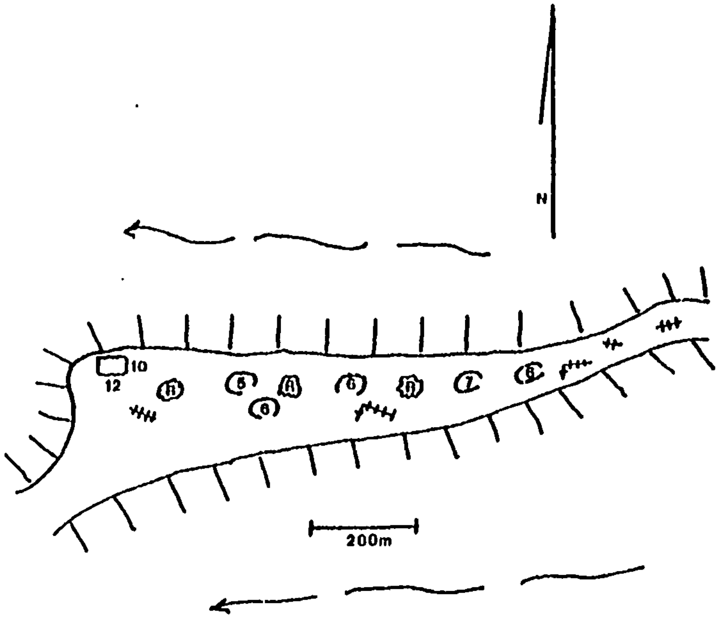


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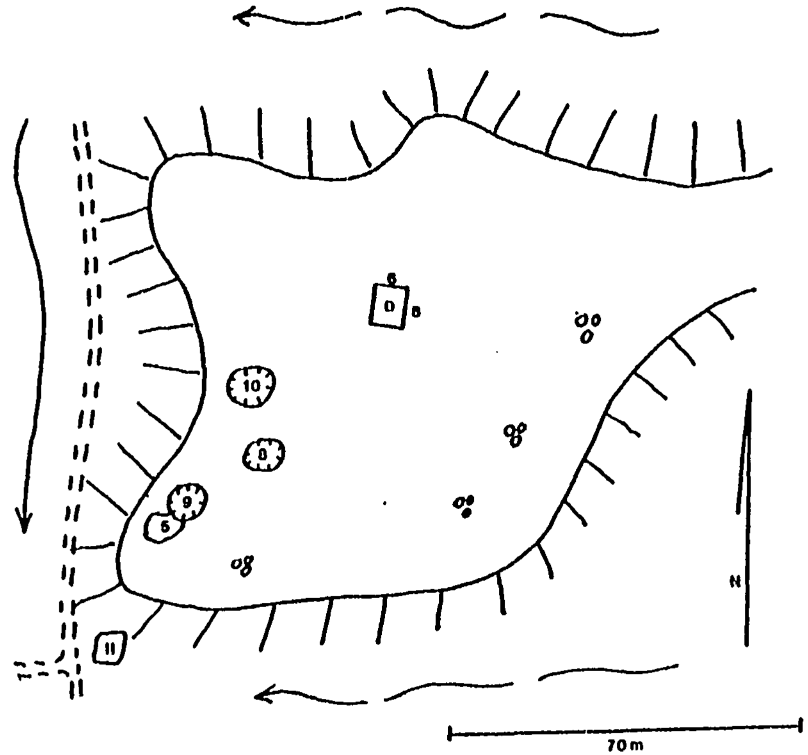
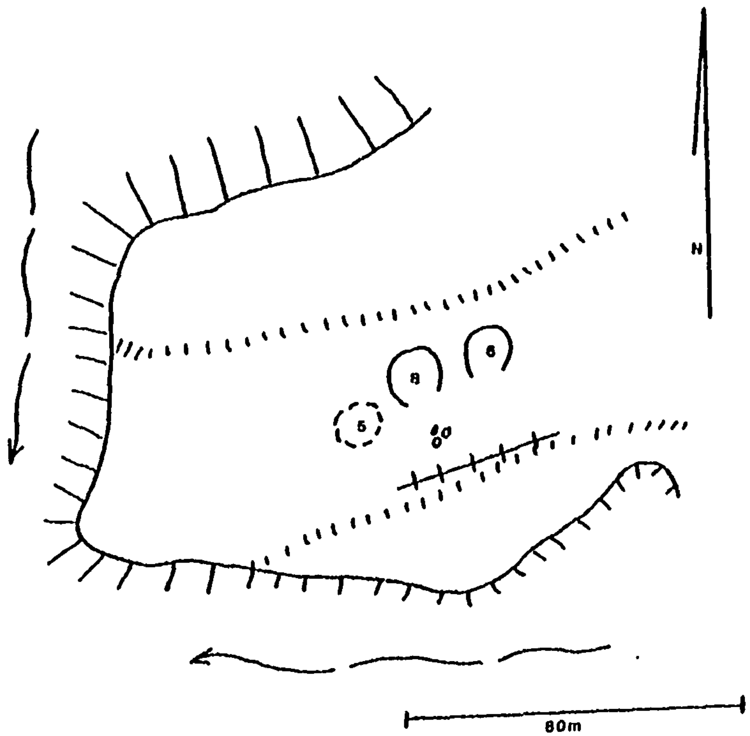
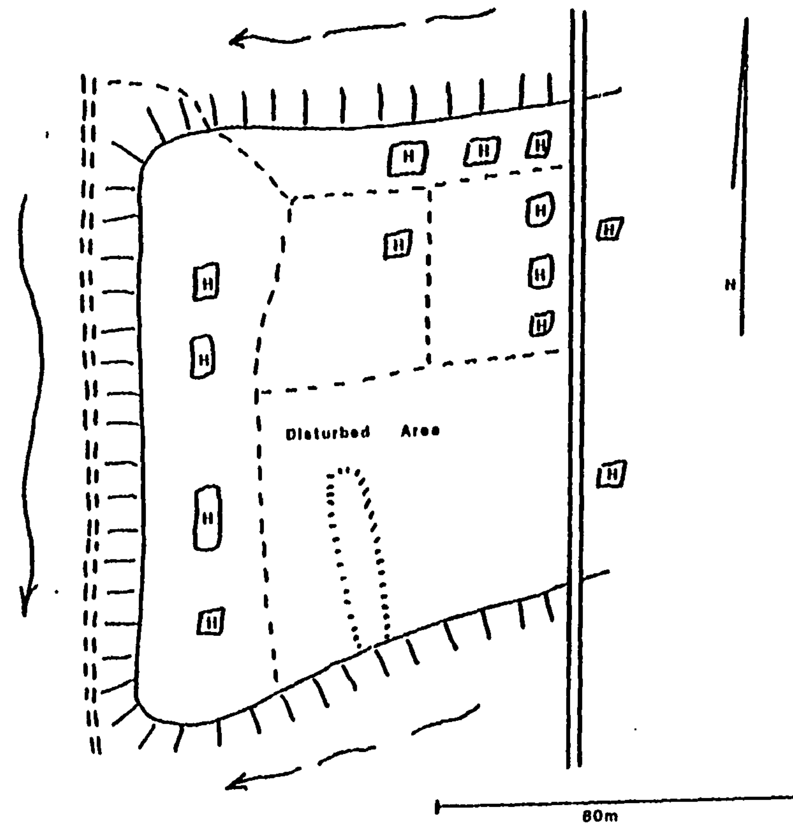



Son K:4:117 OU

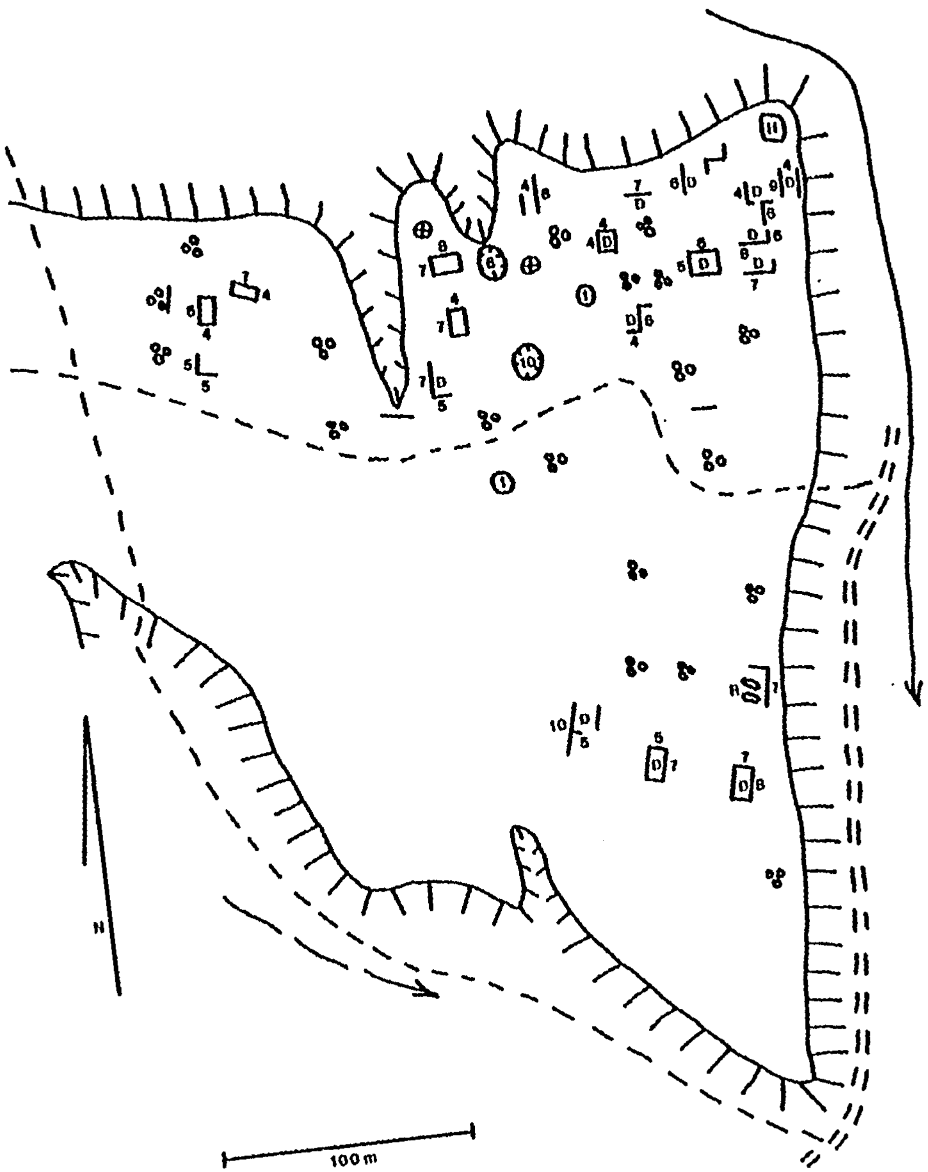



Son K:4:118 OU



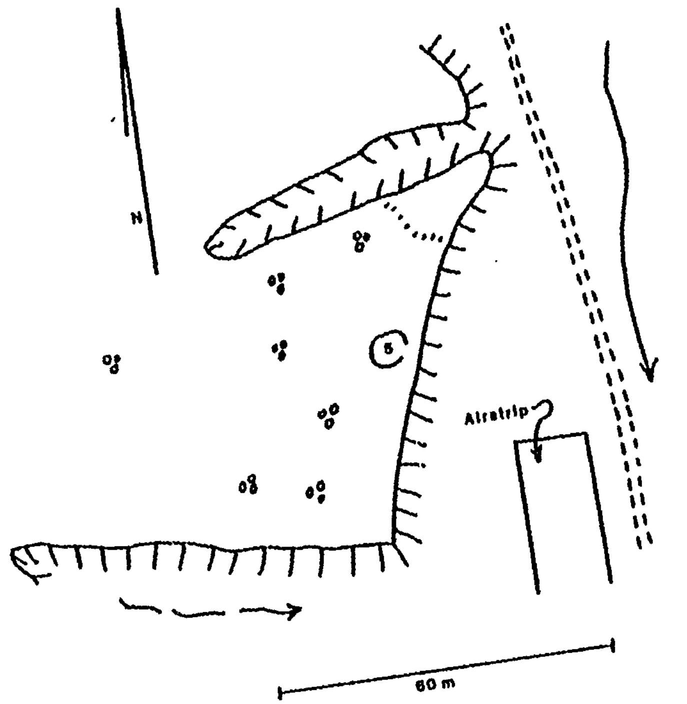

Son K:4:119 OU

Huepac North

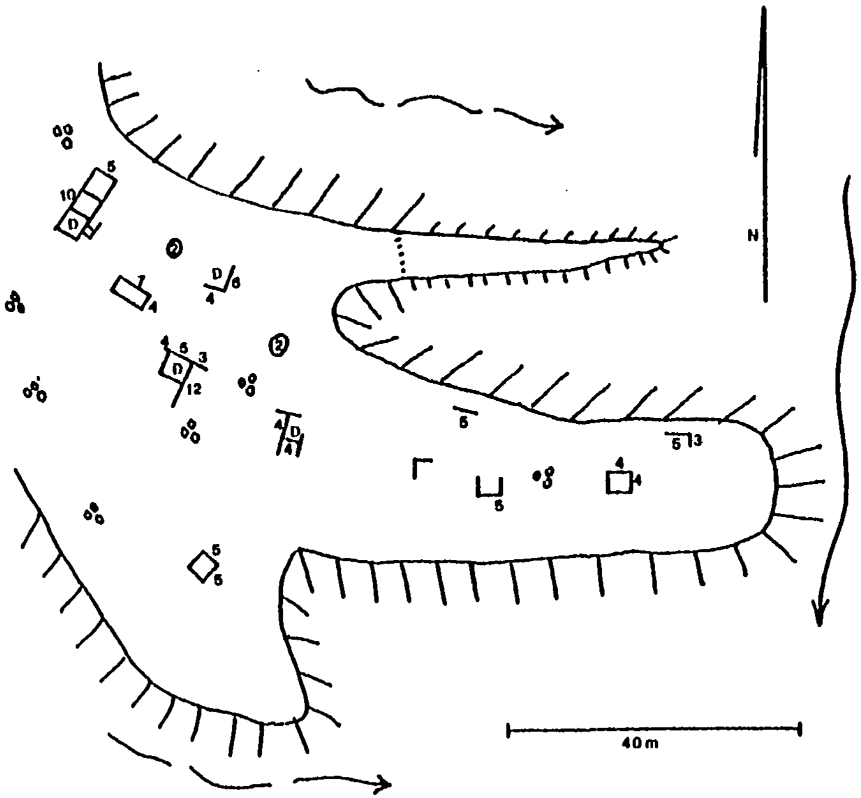



Son K:4:120 OU

Las Delicias North

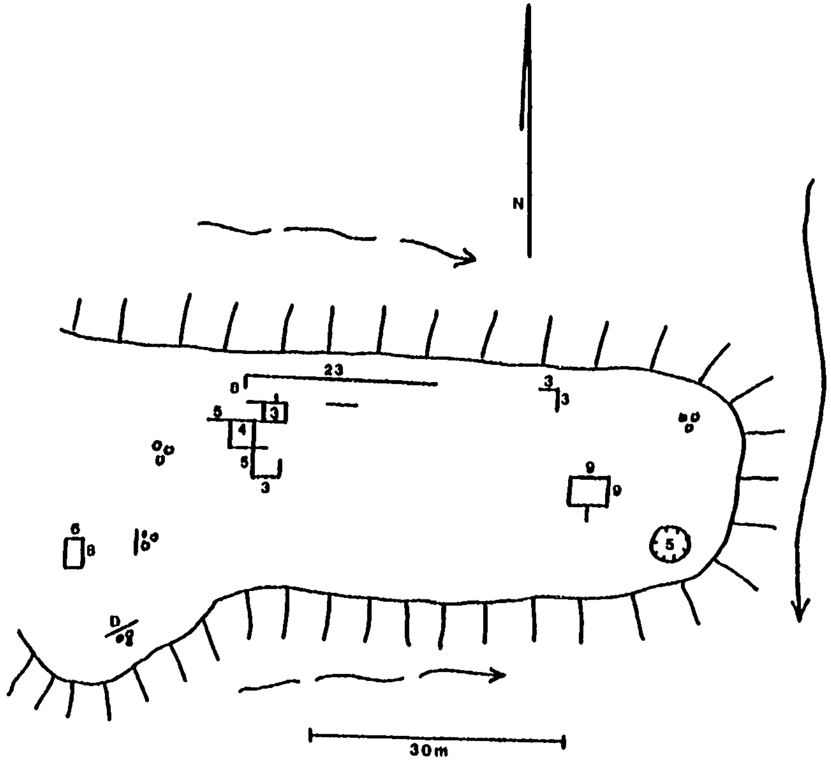



Son K:4:121 OU

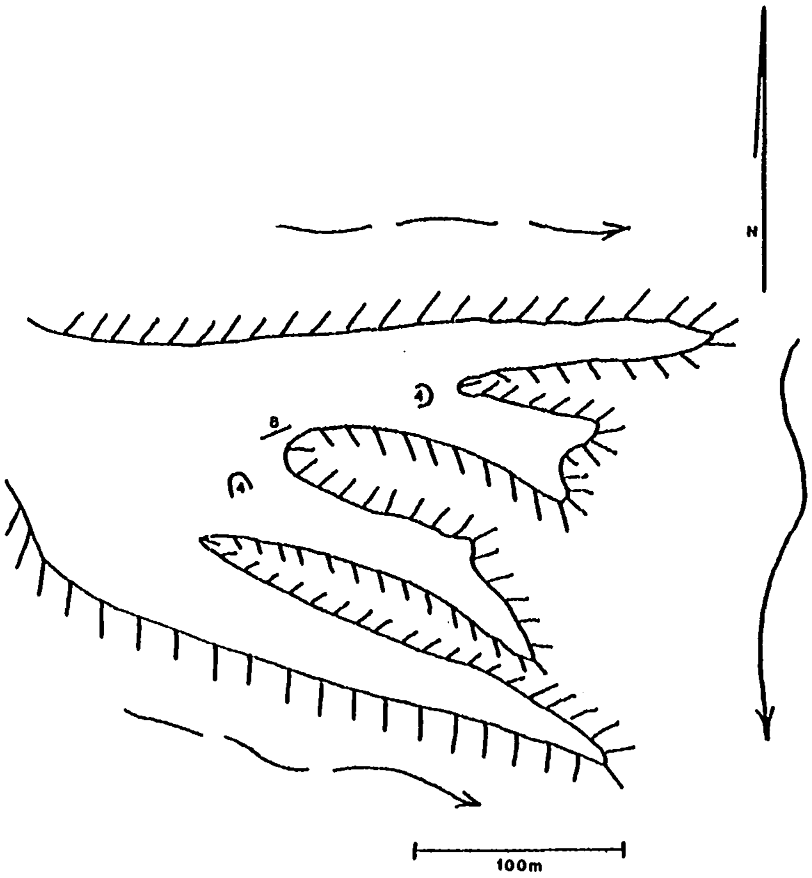



Son K:4:122 OU

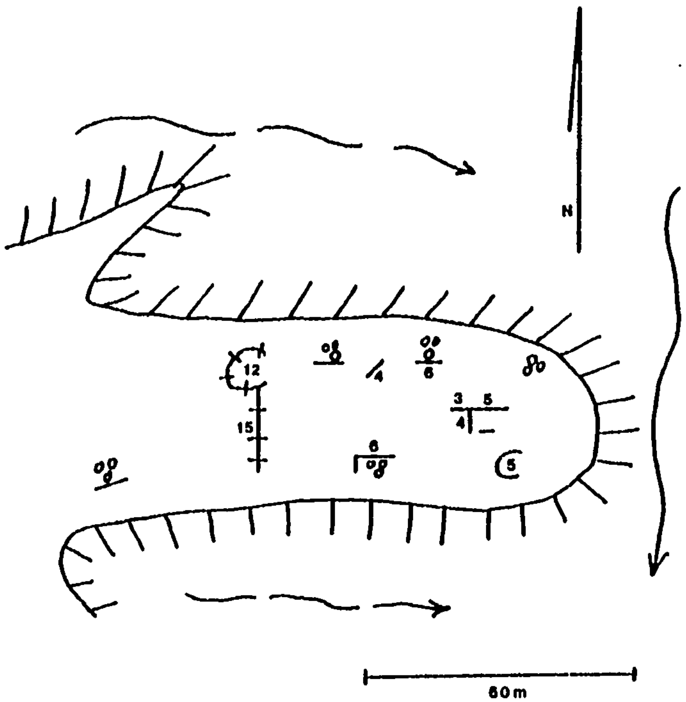
Huepac West



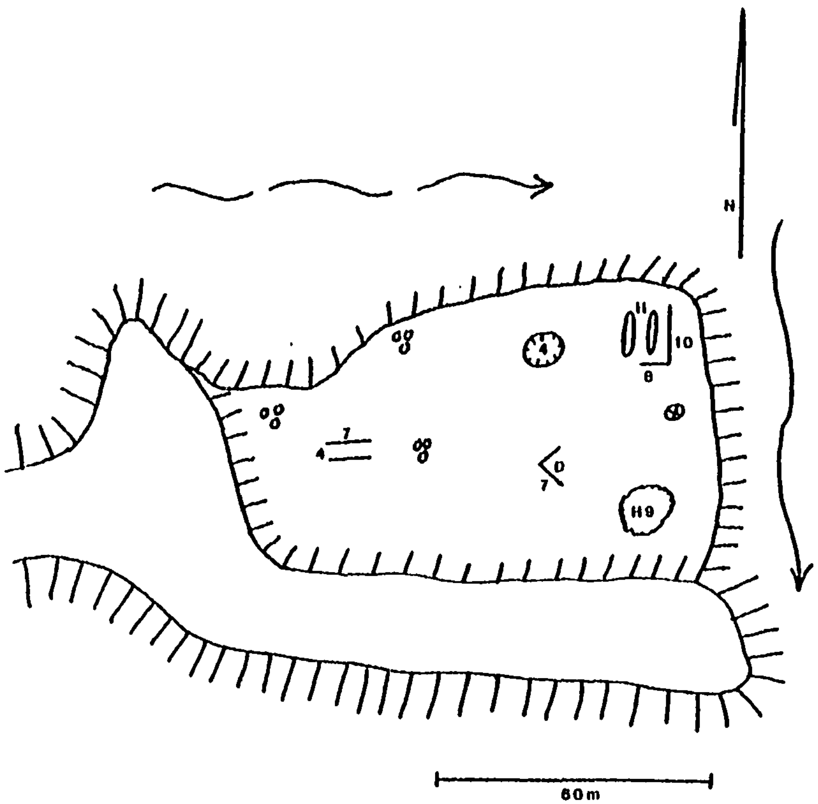

Son K:4:123 OU




Son K:4:124 OU




Son K:4:125 OU

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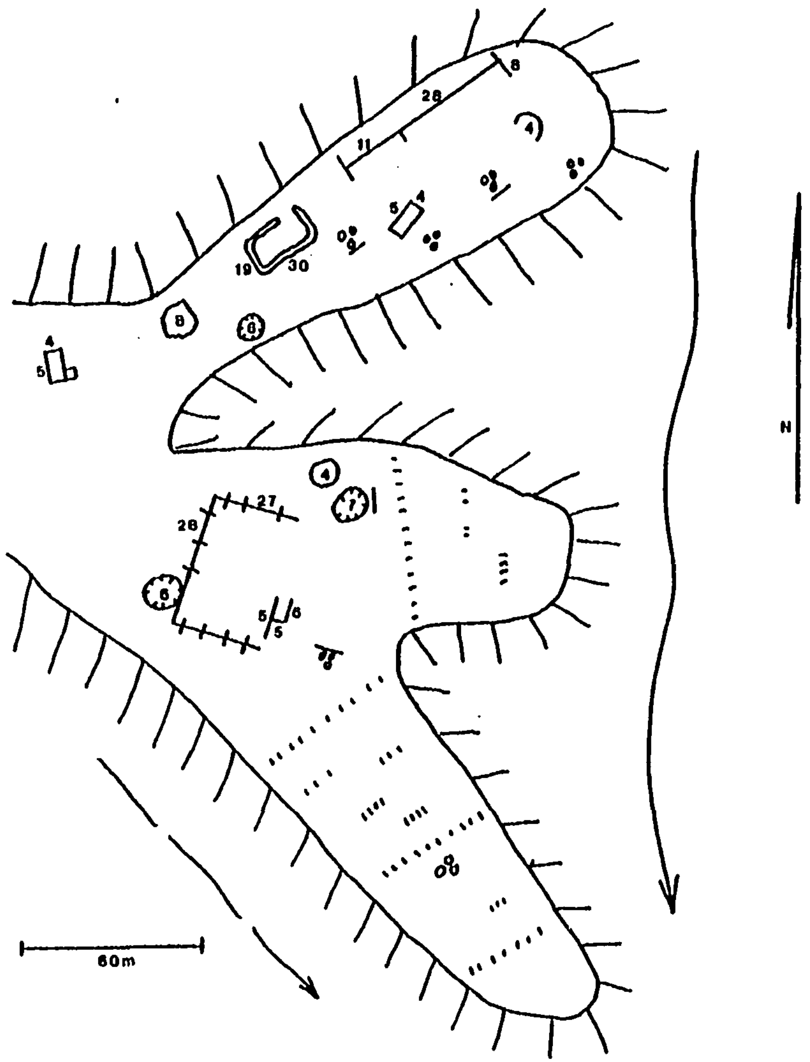
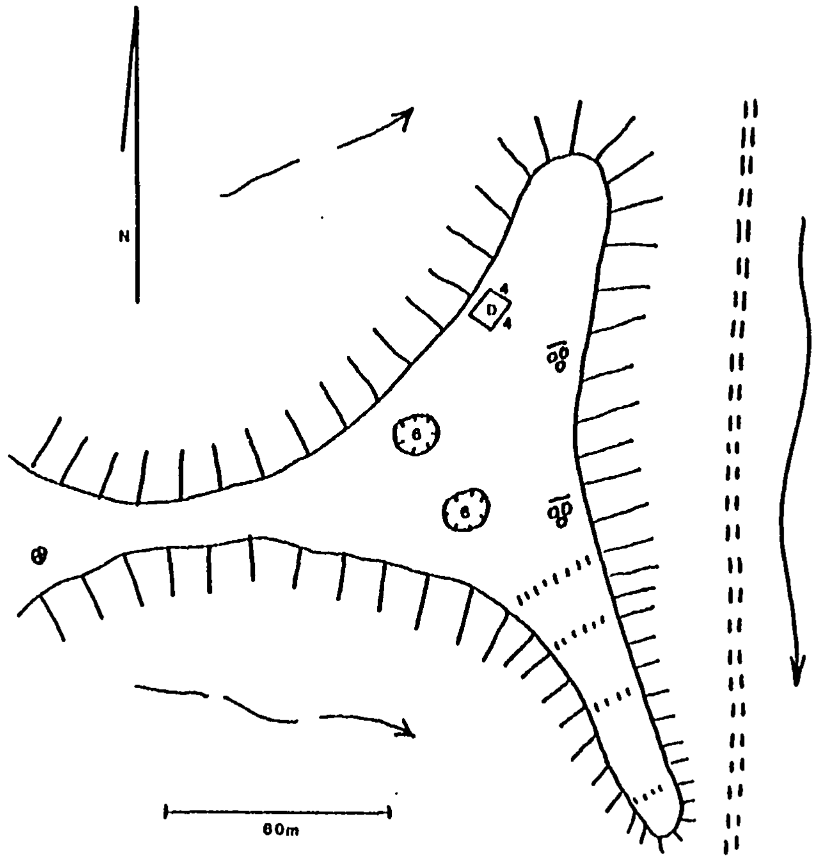
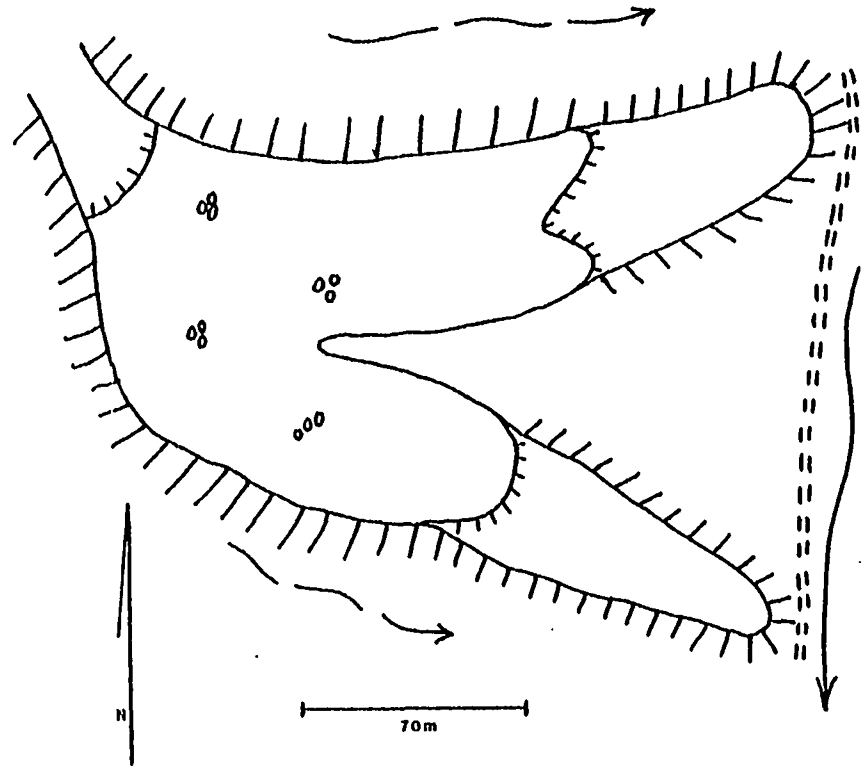


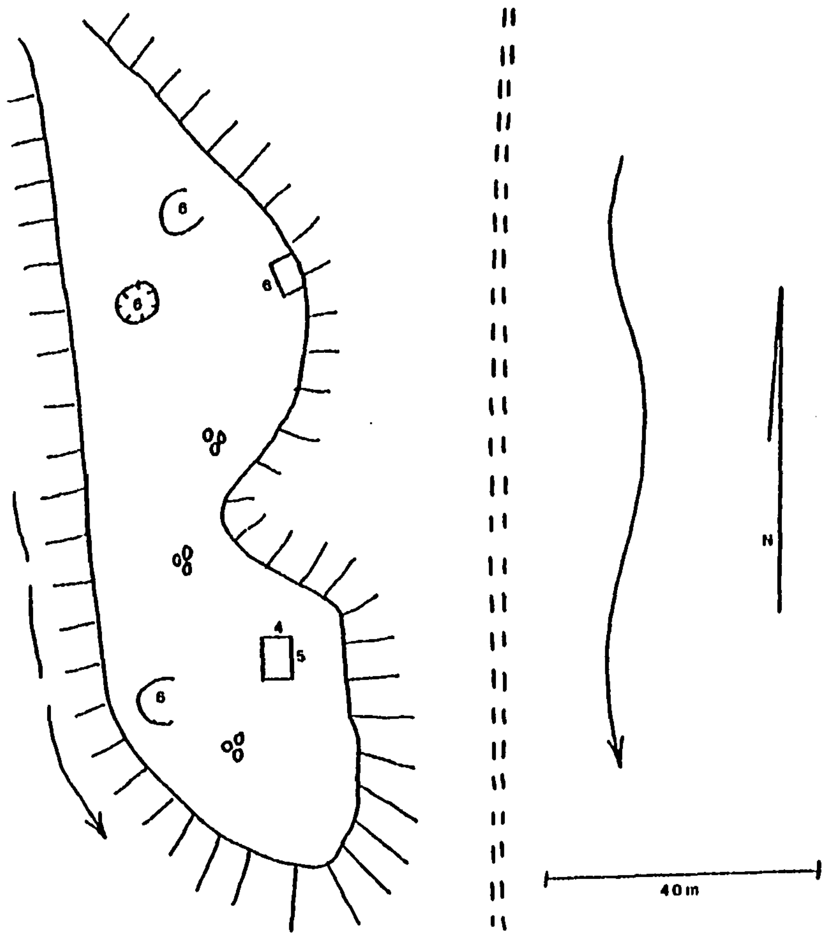

Son K:4:127 OU



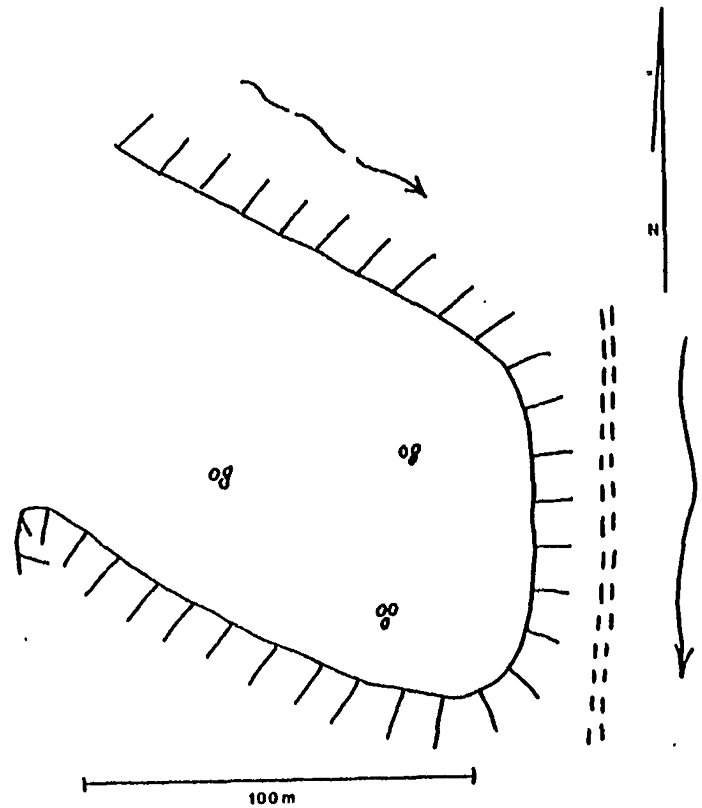

Son K:4:128 OU



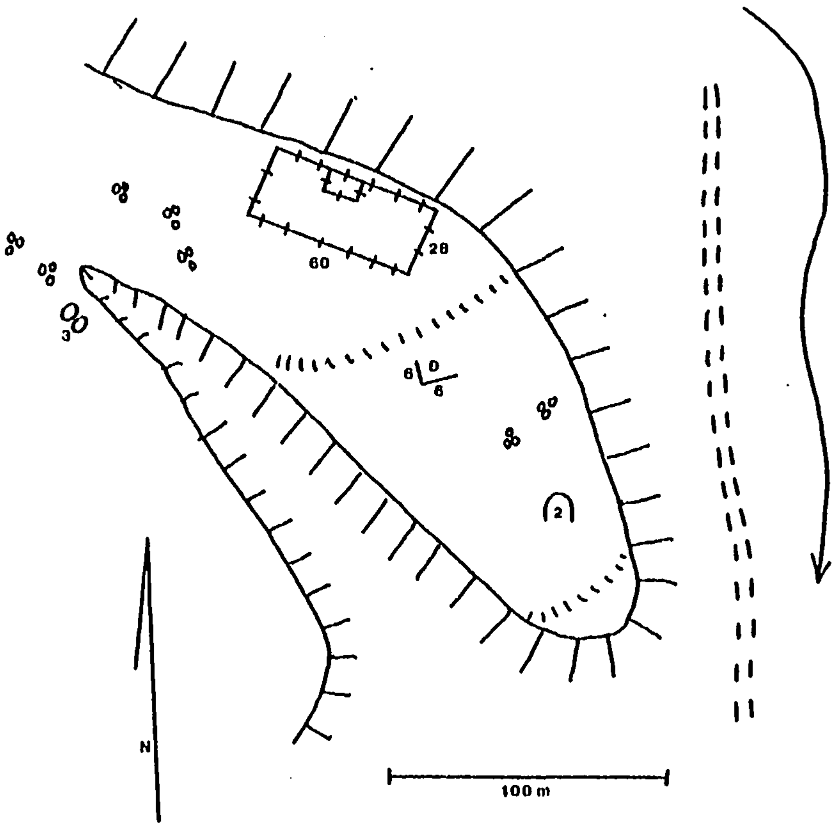

Son K:4:129 OU




Son K:4:130 OU




Son K:4:131 OU

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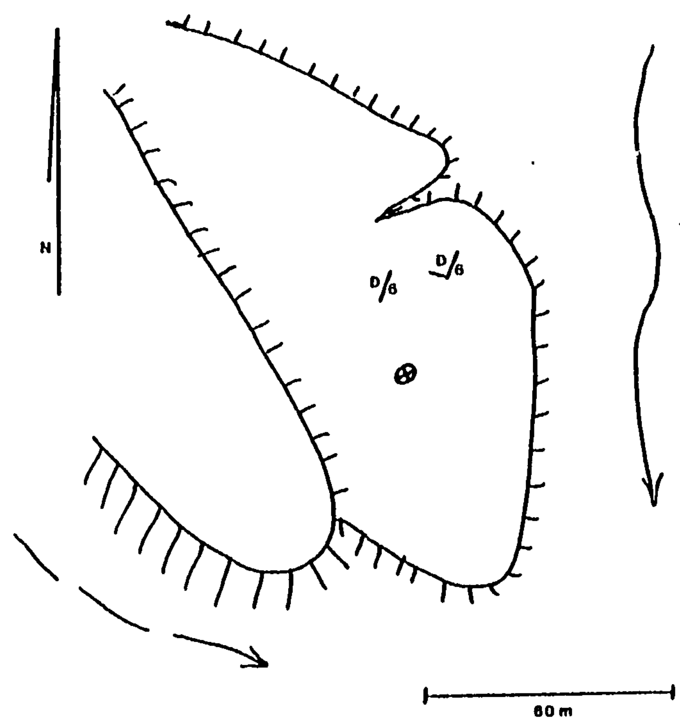
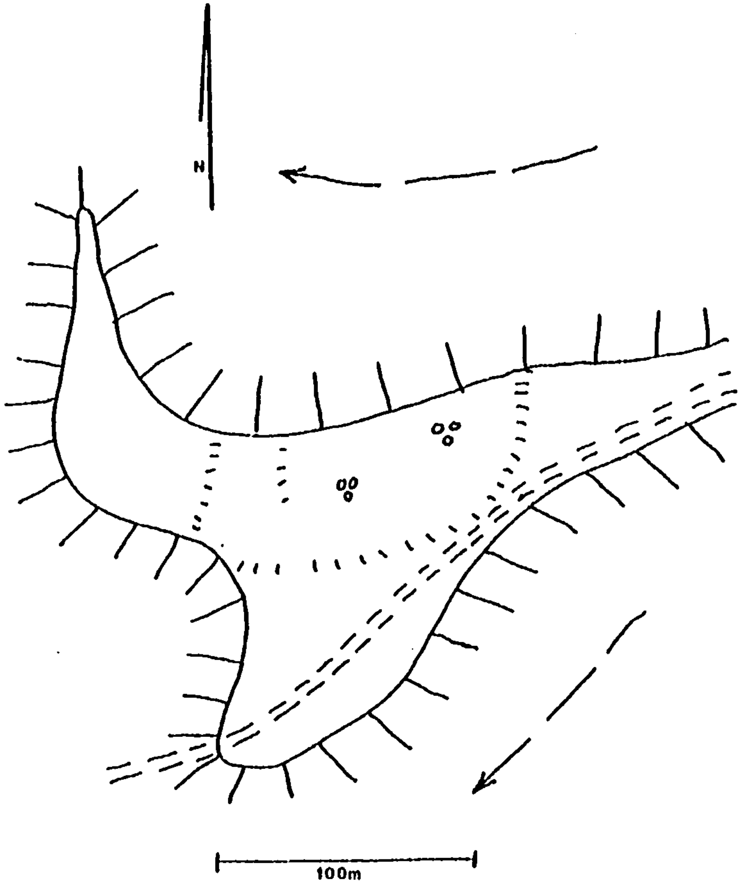
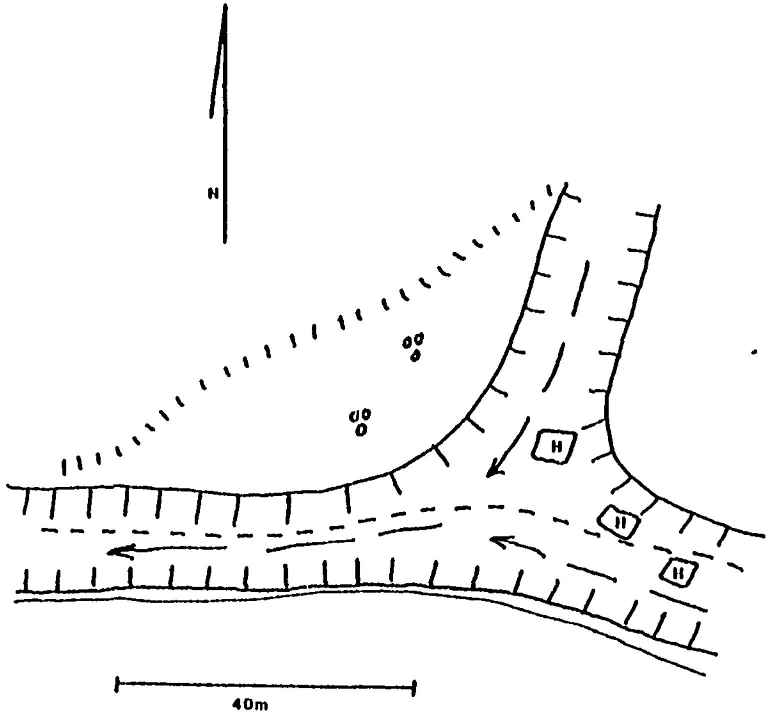



Son K:4:133 OU



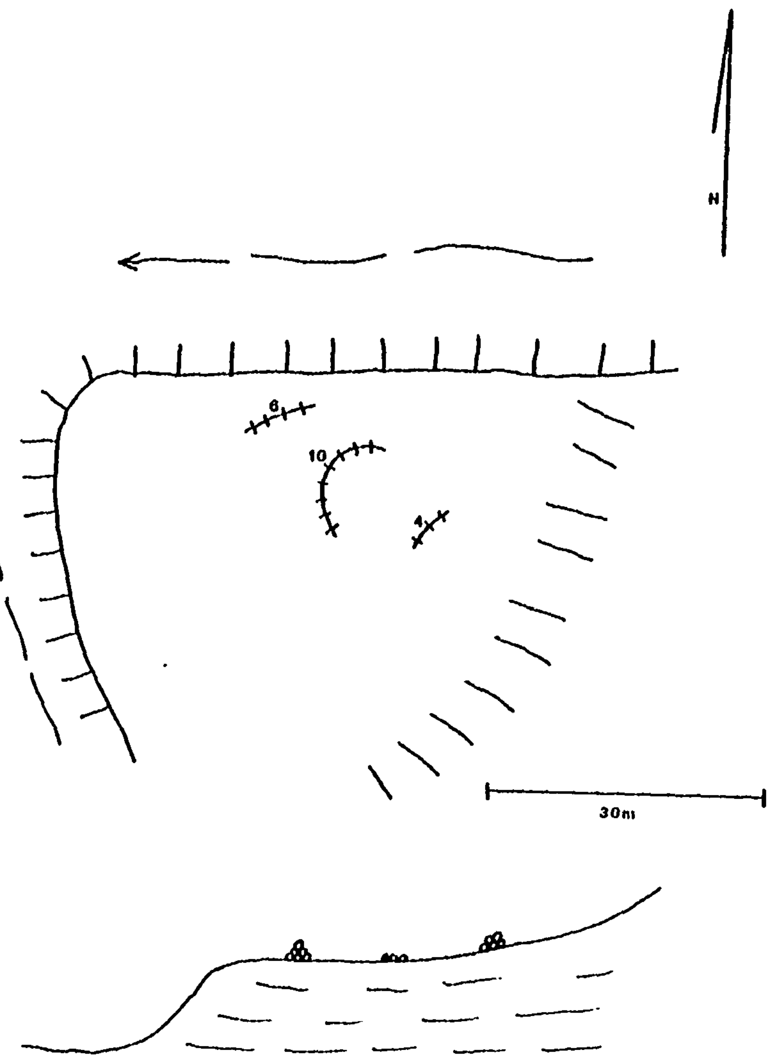

Son K:4:135 OU

Molina Ranch Road

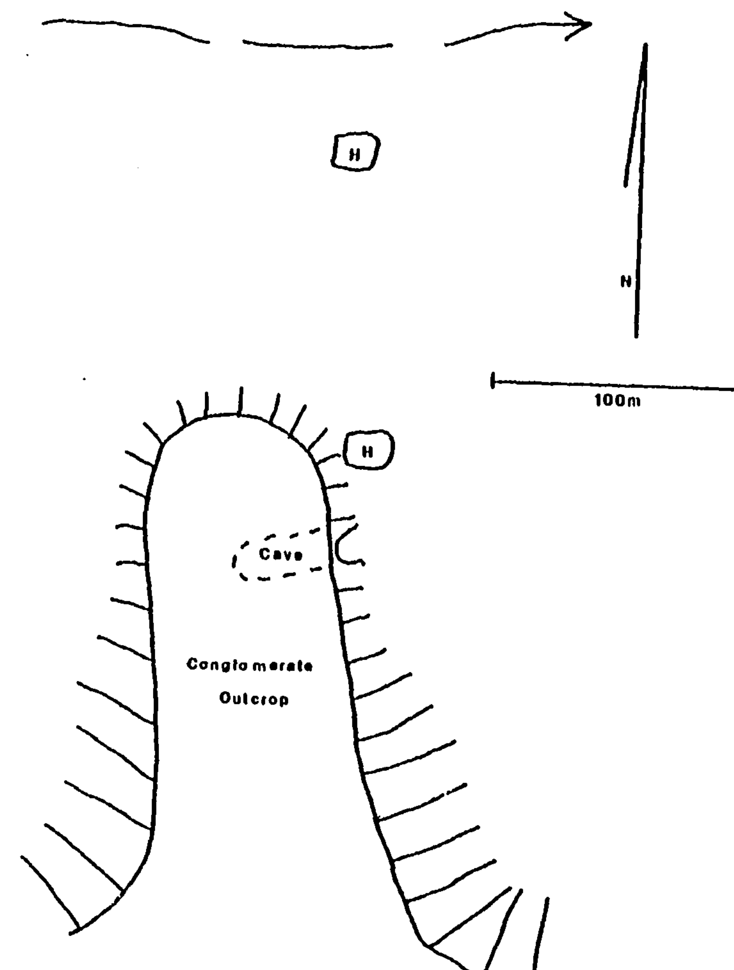



Son K:4:137 OU

Batamote

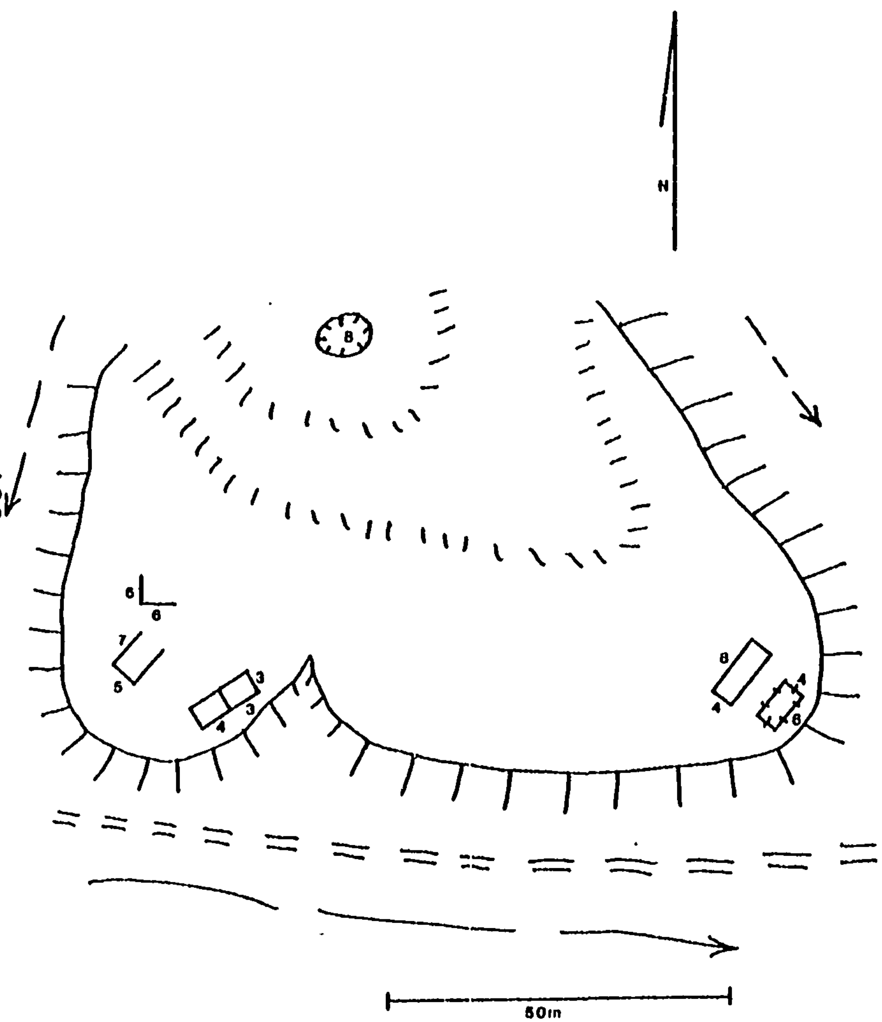



Son K:4:138 OU



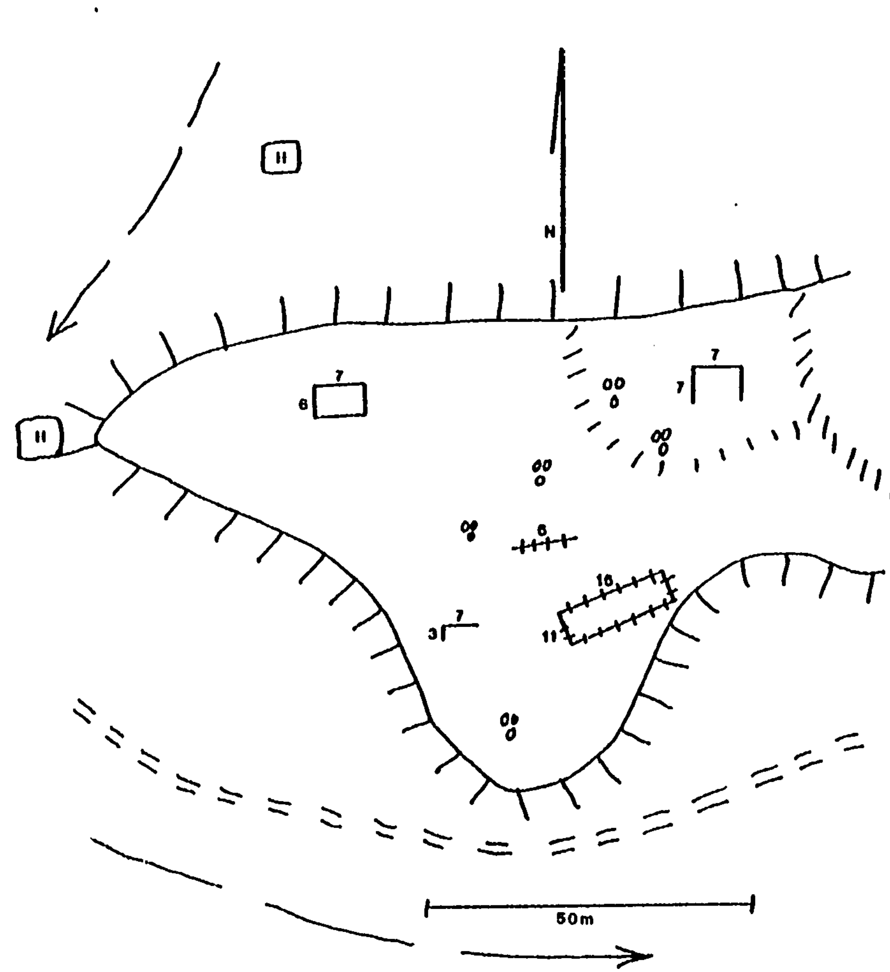

Son K:4:139 OU

Daco's Ranch Cave



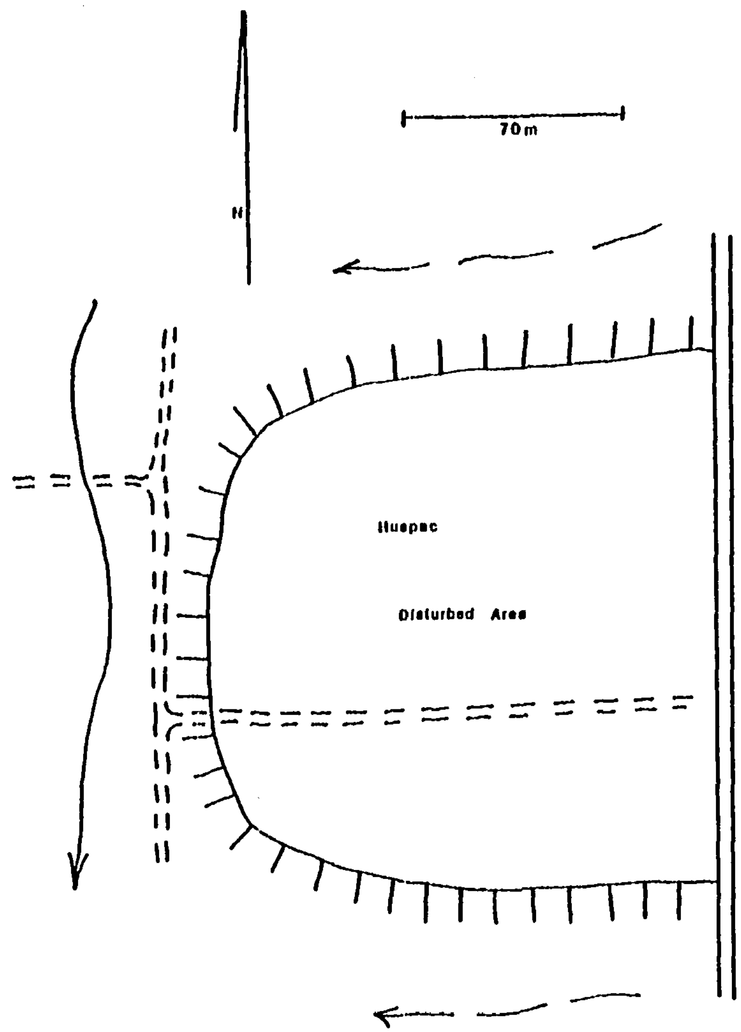

Son K:4:144 OU

Huerobabi Nuevo Ranch



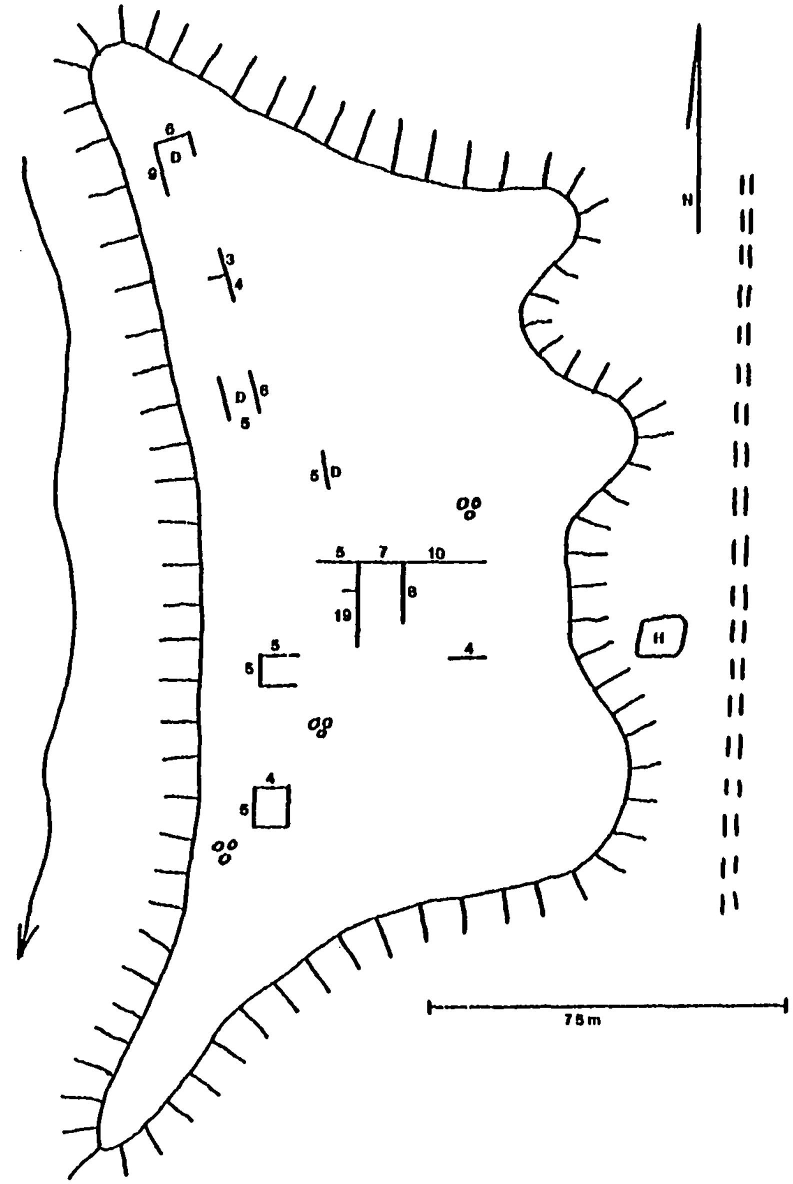

Son K:4:145 OU

El Carrizo Ranch

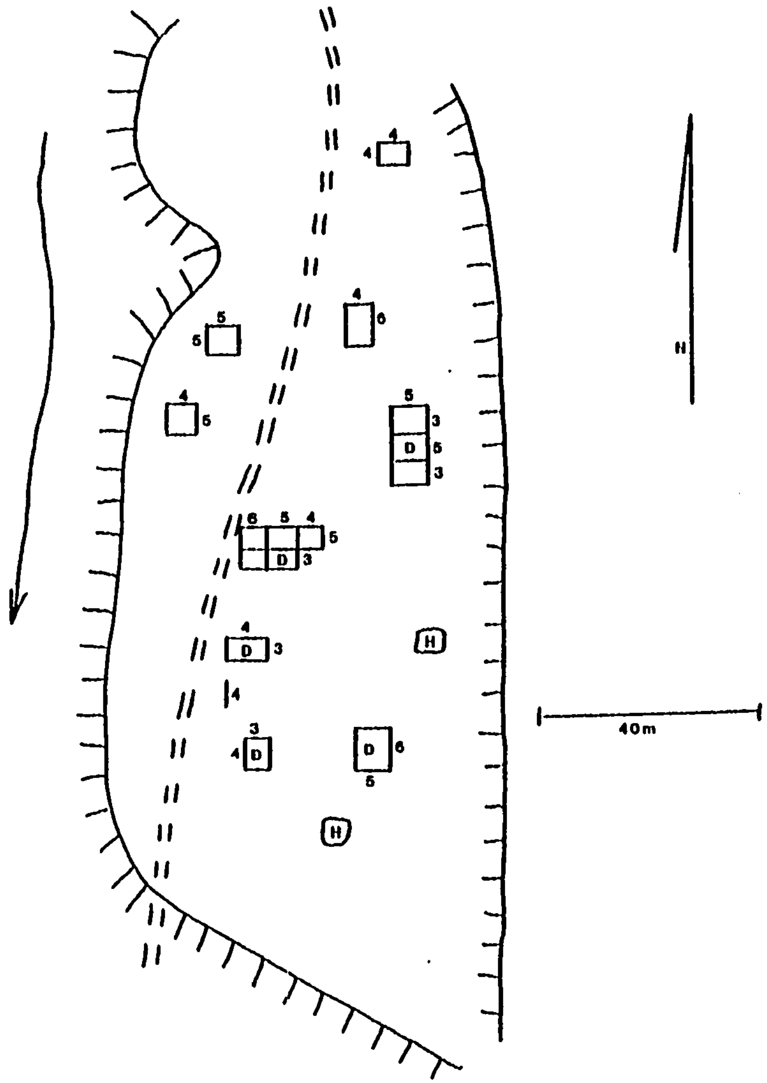



Son K:4:146 OU

Huepac

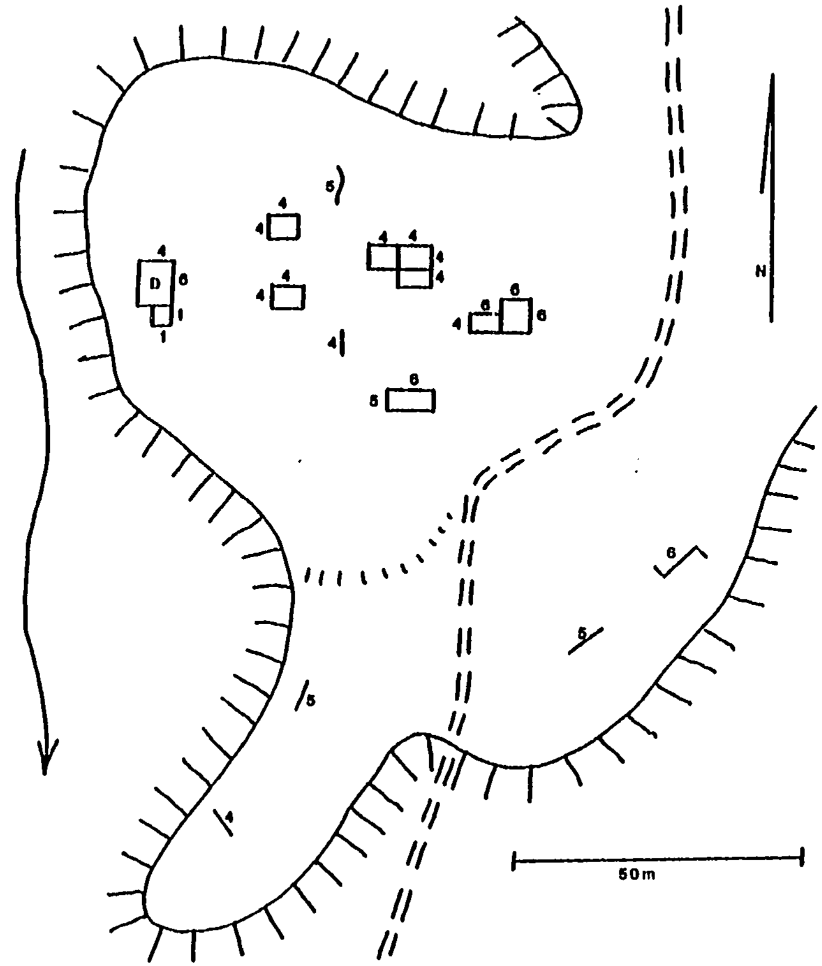



Son G:16:1 OU

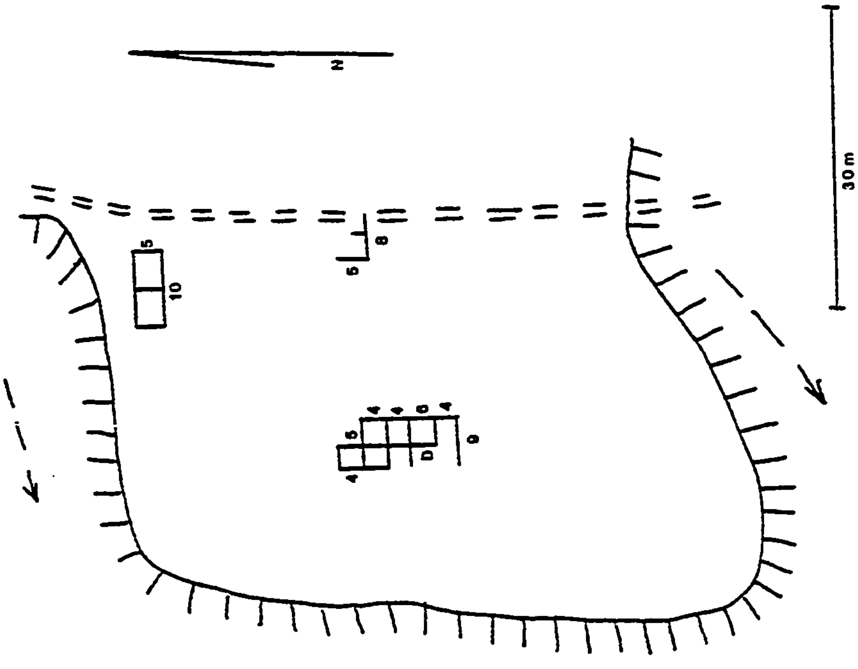



Son G:16:6 OU

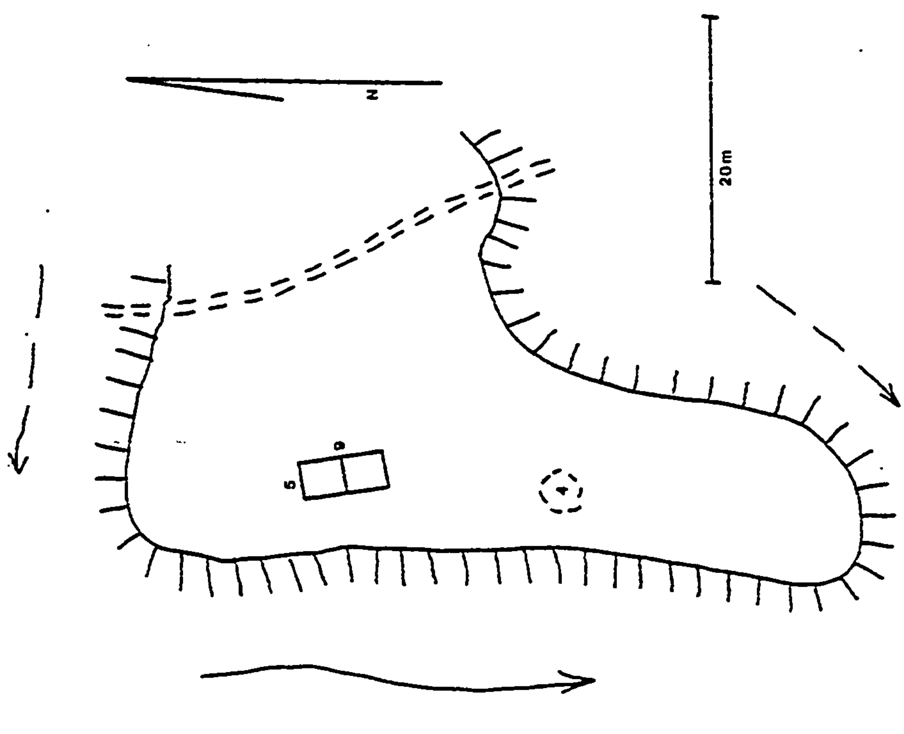
Mesita de la Cruz



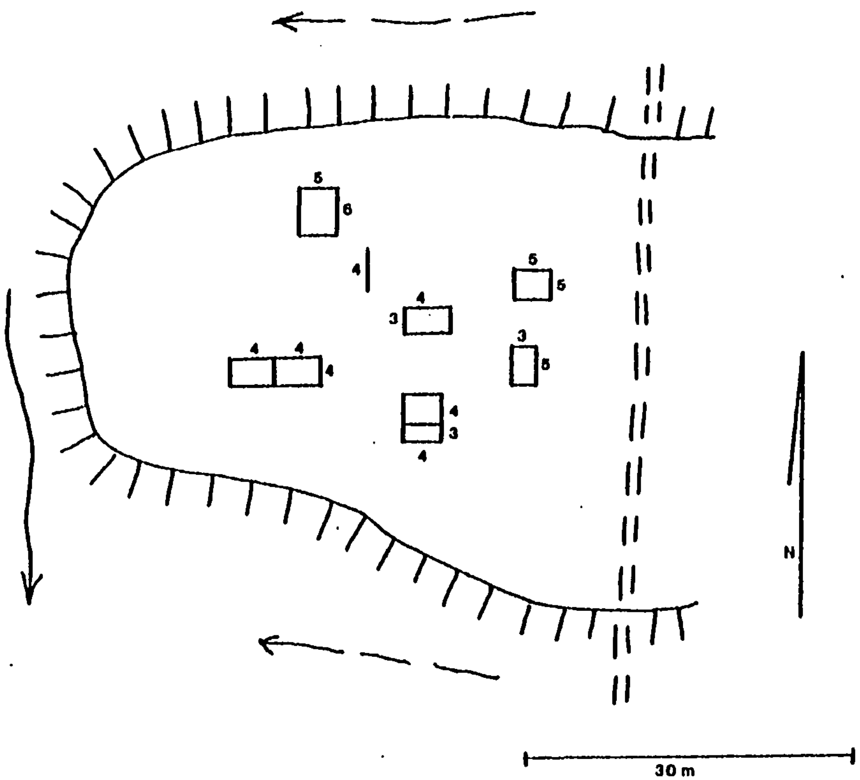

Son G:16:7 OU



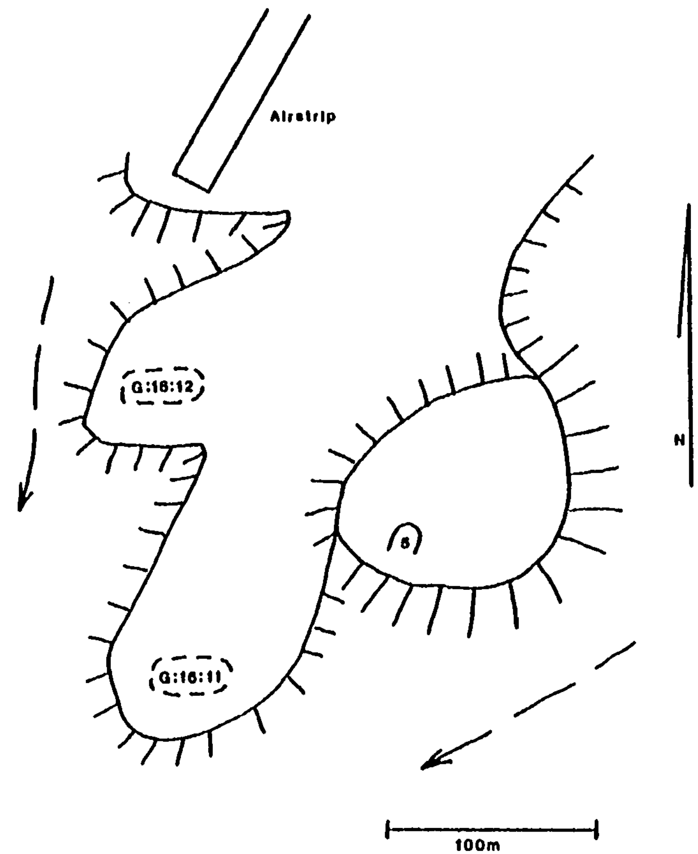

Son G:16:9 OU



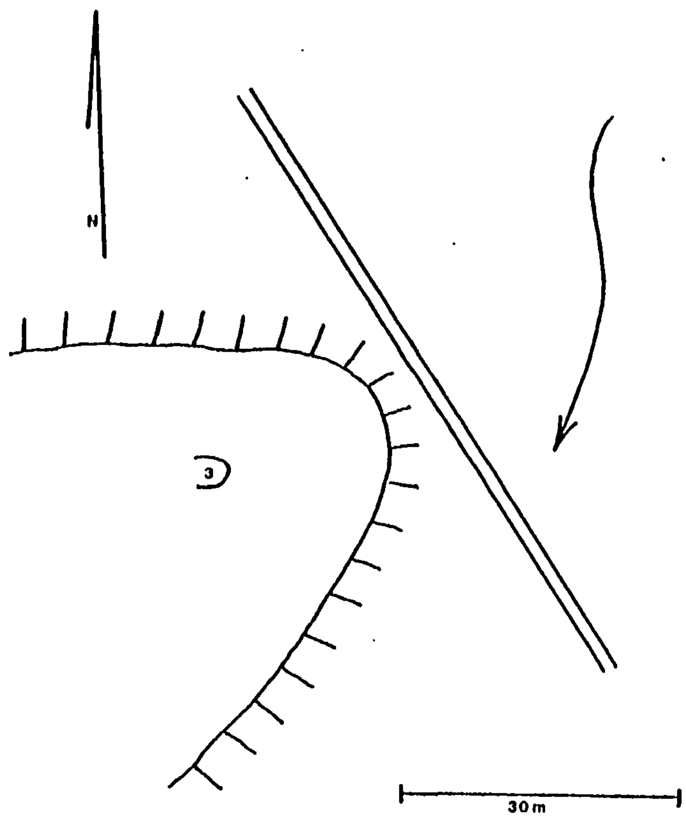

Son G:16:8 OU




Son G:16:10 OU




Son G:16:13 OU

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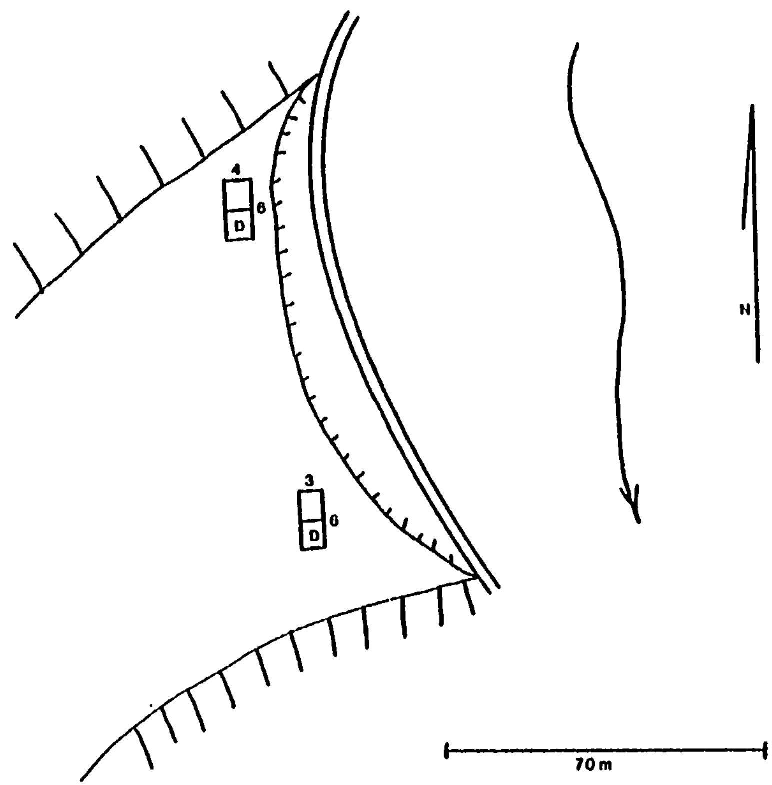
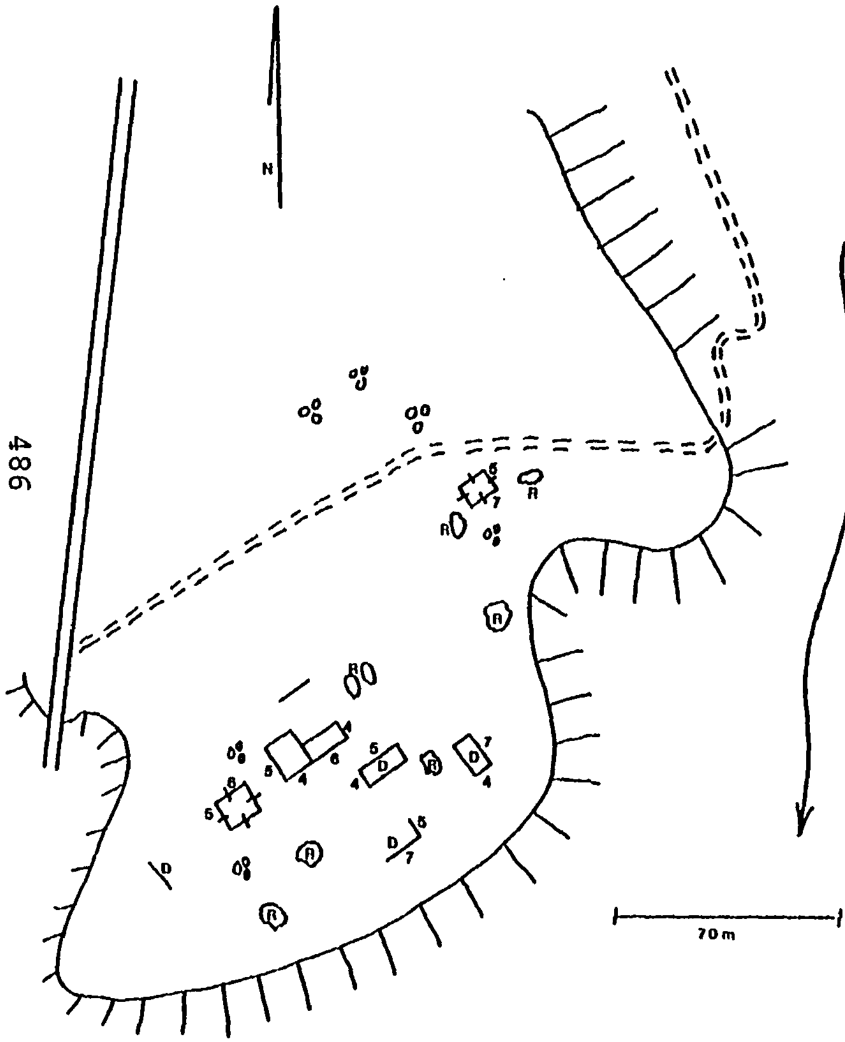
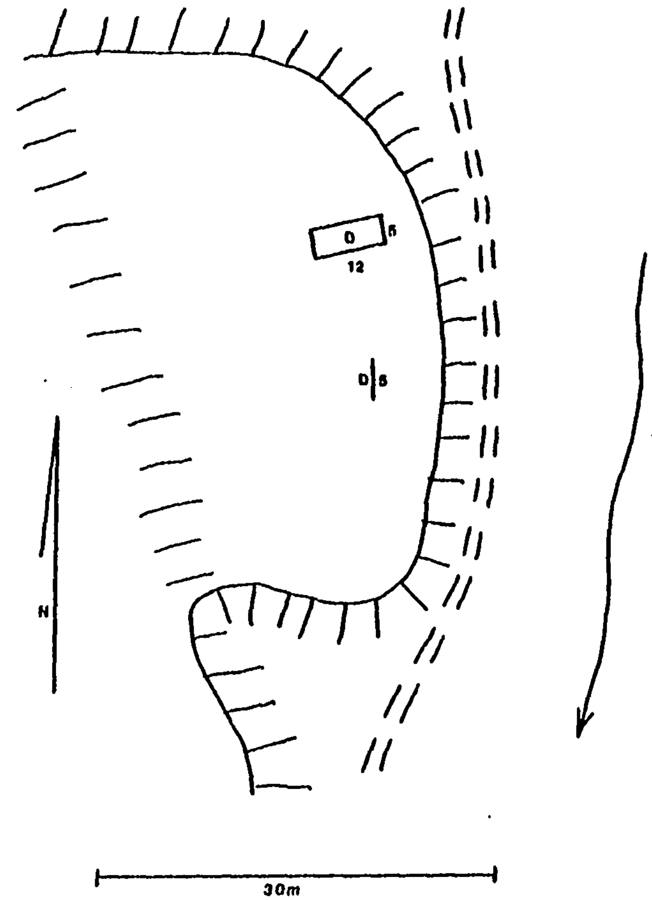


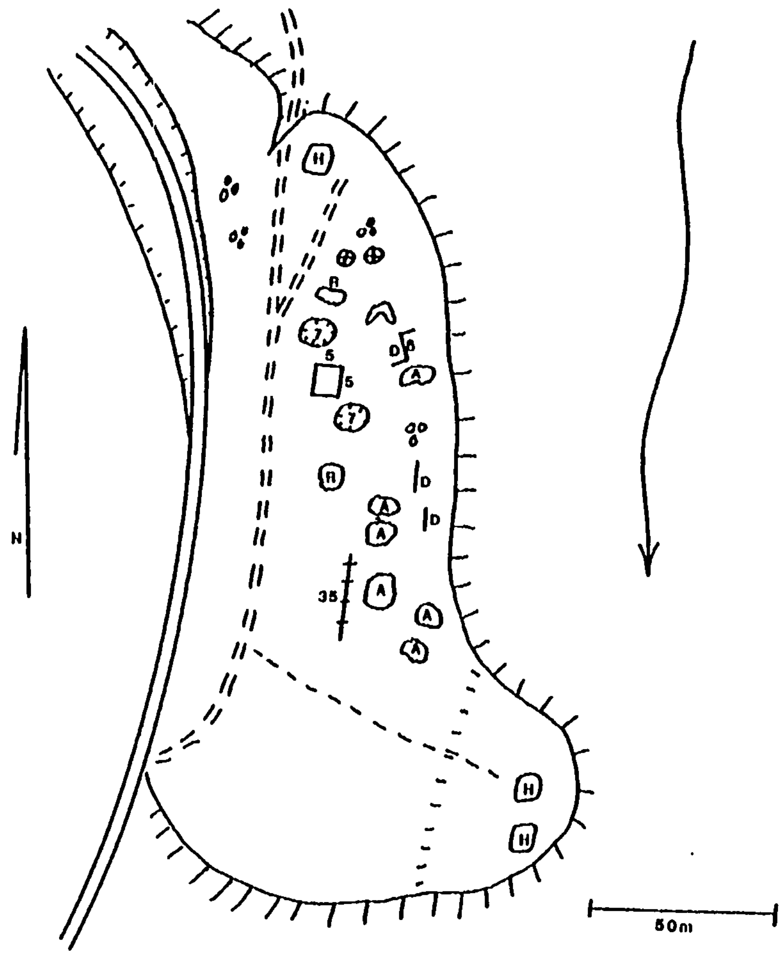

Son G:16:15 OU



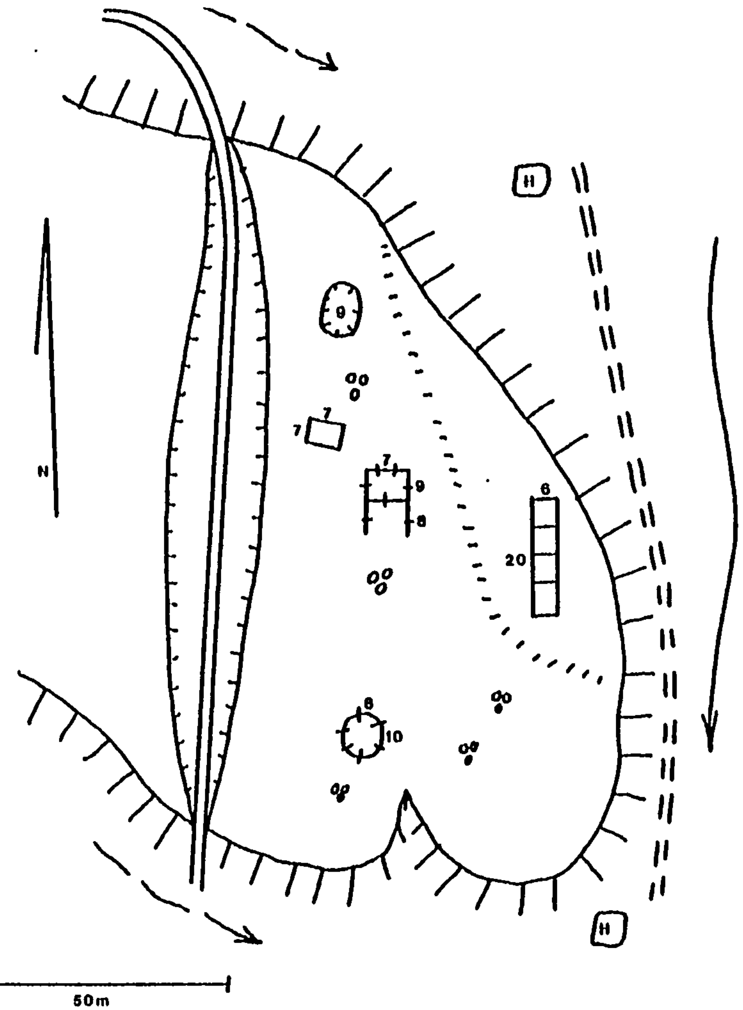

Son G:16:22 OU



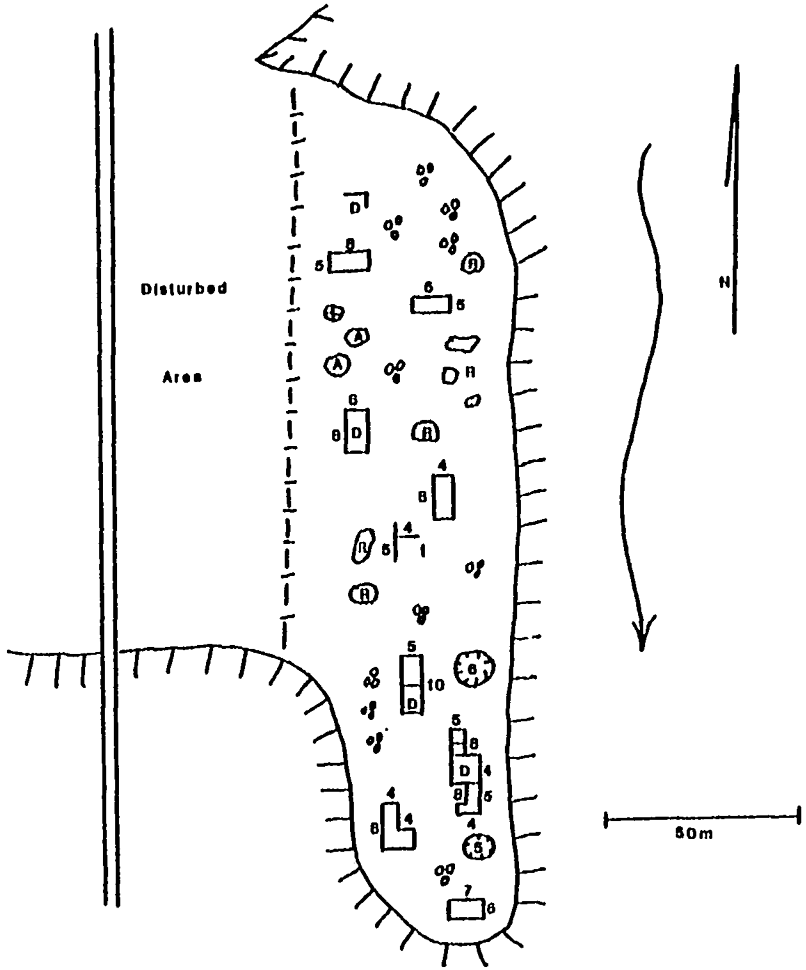

Son G:16:23 OU



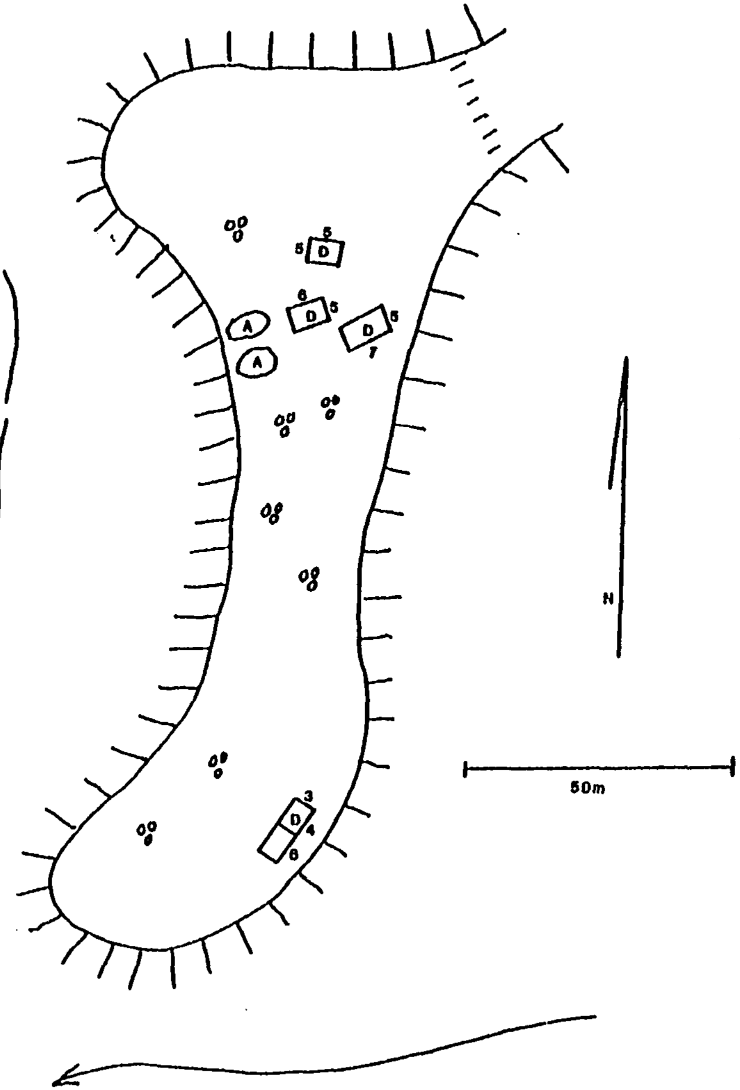

Son G:16:25 OU




Son G:16:26 OU



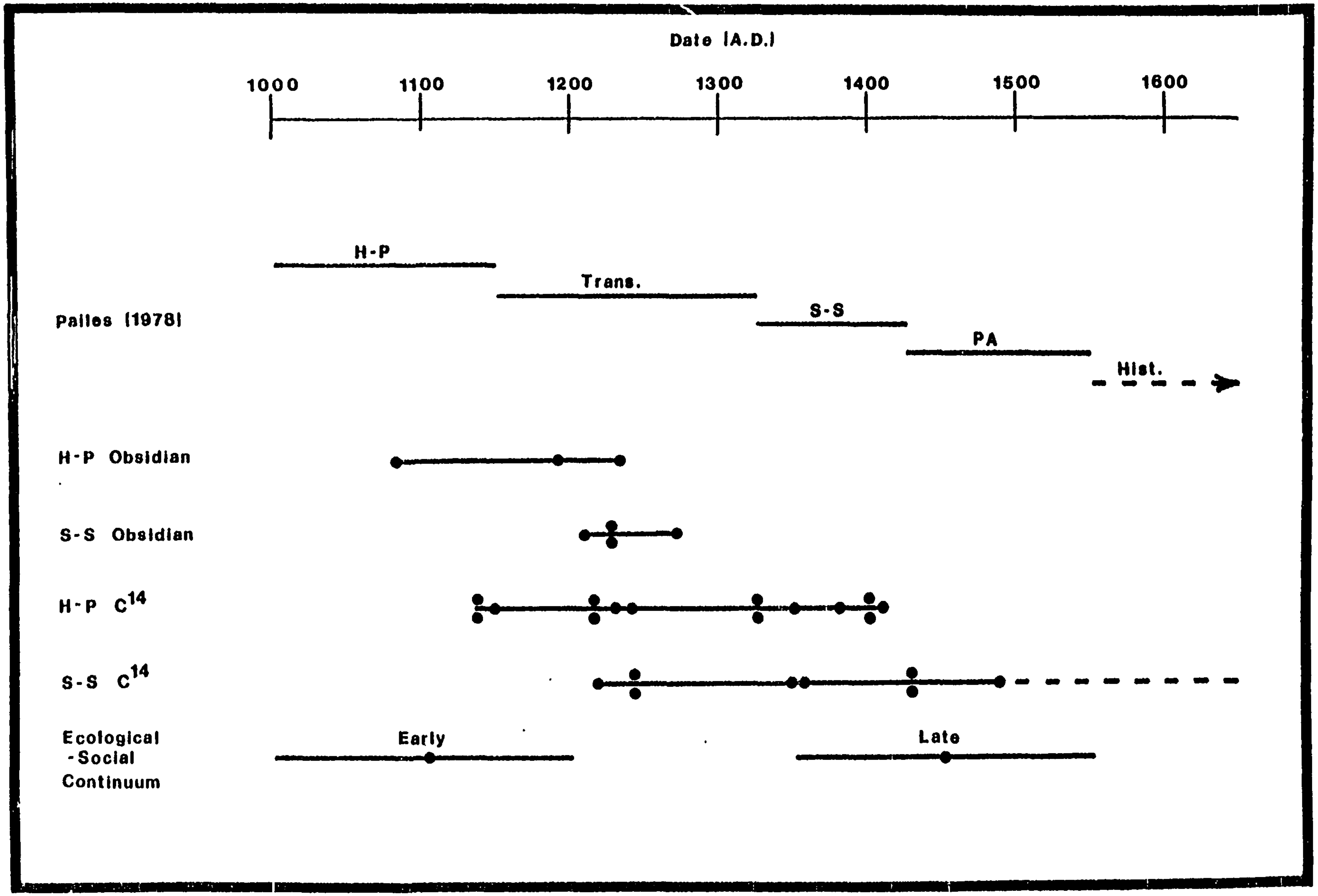

Son G:16:27 OU




Son G:16:28 OU

# APPENDIX VI

## DATED MATERIALS


Date (A.D.)
1000
1100
1200
1300
1400
1500
1600
H-P
Trans.
S-S
PA
Hist.
Pailes (1978)
H-P Obsidian
S-S Obsidian
H-P C14
S-S C14
Ecological -Social Continuum
Early
Late

## RADIOCARBON ($C^{14}$) DATA

| Site Number | Depth | Sample No. (NSF Proj.) | Analyzing Laboratory | $C^{14}$ Date[2] (A.D.) | Calibrated Date (A.D.)[3] |
|---|---|---|---|---|---|
| <u>Surface Structures</u> | | | | | |
| Son K:4:24 OU | 30-40cm | 1977/63 | Washington St. | Mod. | Mod. |
| Son K:4:24 OU | 23cm | 1976/1 | Georgia | 1840 | 1745* |
| Son K:4:24 OU | Floor | 1976/15 | Georgia | 1600 | 1490 |
| Son K:4:24 OU | 23cm/floor | 1976/16 | Georgia | 1505 | 1430* |
| Son K:4:24 OU | 0-10cm | 1975/3 | Gakushuin | 1500 | 1430* |
| Son K:8:17 OU | 40cm | 1977/2 | Washington St. | 1360 | 1360 |
| Son K:4:99 OU | 20cm/floor | 1977/44 | Washington St. | 1335 | 1345 |
| Son K:4:24 OU | 50cm | 1977/39 | Washington St. | 1190 | 1230 |
| Son K:4:24 OU | 60-70cm | 1975/4 | Gakushuin | 1200 | 1230* |
| Son K:8:34 OU | 20cm/floor | 1977/48 | Washington St. | 1160 | 1210 |
| <u>Houses-in-Pits</u> | | | | | |
| Son K:4:41 OU | Floor | 1976/36 | Georgia | 1465 | 1415** |
| Son K:4:41 OU | Floor | 1976/38 | Georgia | 1430 | 1400 |
| Son K:4:41 OU | Floor | 1976/36 | Georgia | 1425 | 1395** |
| Son K:4:24 OU | 70cm/below ballcourt | 1977/40 | Washington St. | 1390 | 1380 |
| Son K:4:32 OU | ? | 1975/5 | Gakushuin | 1350 | 1350 |
| Son K:4:24 OU | Floor | 1976/29 | Georgia | 1315 | 1320 |
| Son K:4:24 OU | Floor | 1976/32 | Georgia | 1305 | 1320 |
| Son K:4:24 OU | Floor | 1977/67 | Washington St. | 1220 | 1240 |
| Son K:4:24 OU | 70cm/below ballcourt | 1977/41 | Washington St. | 1190 | 1230 |
| Son K:4:41 OU | Floor | 1976/35 | Georgia | 1175 | 1210 |
| Son K:4:41 OU | 90cm/floor | 1976/37 | Georgia | 1150 | 1210 |
| Son K:4:24 OU | 60-70cm/ floor | 1977/60 | Washington St. | 1090 | 1140 |
| Son K:4:24 OU | Floor | 1976/11 | Georgia | 1075 | 1125 |
| Son K:4:24 OU | Floor | 1976/21 | Georgia | 1085 | 1125 |

## RADIOCARBON ($C^{14}$) DATA

| Site Number | Depth | Sample No. (NSF Proj.) | Analyzing Laboratory[1] | $C^{14}$ Date[2] (A.D.) | Calibrated Date (A.D.)[3] |
|---|---|---|---|---|---|
| Roasting Pits | | | | | |
| Son K:4:34 OU | ? | ? | Gakushuin | 1670 | 1570 |
| Son K:4:42 OU | 10cm | 1976/34 | Georgia | 1585 | 1480 |
| Son K:4:34 OU | ? | ? | Gakushuin | 1370 | 1370 |
| Son K:8:25 OU | 100-110cm | 1977/49 | Washington St. | 1260 | 1275 |
| Son K:8:25 OU | 50-60cm | 1977/52 | Washington St. | 1100 | 1165 |
| Son K:4:24 OU | 55cm/below ballcourt | 1976/33 | Georgia | 1000 | 1040 |
| Public Architecture | | | | | |
| Son K:4:24 OU | 70cm/floor | 1977/42 | Washington St. | 990 | 1030[4] |
| Misc. Test Pits with no Structures | | | | | |
| Son K:8:25 OU | 10-20cm | 1977/54 | Washington St. | 1010 | 1050 |
| Son K:4:25 OU | 98cm | 1977/56 | Washington St. | 470B.C. | 450B.C. |

[1]All labs are university affiliated. Gakushuin University is in Japan.

[2]All dates are measured in radiocarbon years and have a margin of error of approximately ±100 years.

[3]Calibrated dates are based on the MASCA correction factor utilizing the midpoints of radiocarbon dates (Ralph, Michael, and Han 1974).

[4]Dated materials found under or in the debris used in the construction of Public Architecture (ballcourt). This sample was found below a razed adobe wall under the lowest level of fill in association with a structure in many ways similar to other surface structures. That the structure did not have an embedded stone foundation, however, makes it unique and distinctive from other surface structures. This sample, therefore, is not included with samples from other surface structures.

The symbols * and ** indicate samples are from the same pit.

OBSIDIAN HYDRATION DATA[1]

| Site Number | Depth | OHL No. (UCLA) | Hydration Thickness | Date[2] (A.D.) | Calibrated Date (A.D.) |
|---|---|---|---|---|---|
| **Surface Collections** | | | | | |
| **Surface Structures** | | | | | |
| Son K:4:24 OU | 0 | 5552 | 2.6 | 1247 | 1275 |
| Son K:8:34 OU | 0 | 5560 | 2.8 | 1191 | 1230 |
| Son K:8:17 OU | 0 | 5550 | 2.8 | 1191 | 1230 |
| Son K:8:91 OU | 0 | 5557 | 2.8/3.0 | 1191/1135 | 1210 |
| **Houses-in-Pits** | | | | | |
| Son K:8:30 OU | 0 | 5559 | 0 | - | - |
| Son K:8:44 OU | 0 | 5561 | 2.7 | 1219 | 1240 |
| Son K:4:77 OU | 0 | 5556 | 3.0 | 1135 | 1190 |
| Son K:8:26 OU | 0 | 5558 | 3.3 | 1051 | 1090 |
| **Excavated Collections[3]** | | | | | |
| **Surface Structures** | | | | | |
| Son K:8:34 OU | 10-20 | 5552 | 2.2 | 1359 | 1360 |
| Son K:4:77 OU | 20-30 | 5551 | 3.0 | 1135 | 1190 |
| Son K:8:34 OU | 20-30 | 5553 | 3.1 | 1107 | 1180 |
| **Public Architecture** | | | | | |
| Son K:4:24 OU | 20-40 | 5554 | 2.5 | 1275 | 1290 |

[1]All samples were analyzed at the Obsidian Lab, Department of Anthropology, University of California-Los Angeles.

[2]Dates were computed by using Meighan's (1978) rate for west Mexico of 280 years per micron. All dates have a margin of error of approximately 50 years (Meighan, *et al.* 1968). These dates are the equivalent of uncalibrated radiocarbon dates.

[3]Obsidian samples hydrate differently depending on (a) source, (b) temperature, and (c) humidity. Dates from surface collections, therefore, can not be compared with excavated samples as, assuming a common source, the subsurface temperatures and humidity differ from those of the surface (Findlow, *et al.* 1975). The increase in the hydration thickness, and hence age, with depth verifies that the deepest samples are, indeed, earlier than shallower samples.

ASSOCIATION OF ARCHITECTURAL TYPES WITH POLYCHROME CERAMICS[1]

| Site Number[2] | Surface Structure[3] | House-in-Pit |
|---|---|---|
| Son K:8:5 OU | X | |
| Son K:8:28 OU | X | |
| Son K:8:32 OU | X | |
| Son K:8:36 OU | X | |
| Son K:4:18 OU | X | |
| Son K:4:22 OU | X | |
| Son K:4:30 OU | X | |
| Son K:4:31 OU | X | |
| Son K:4:35 OU | X | |
| Son K:4:91 OU | X | |
| Son G:16:1 OU | X | |
| Son G:16:3 OU | X | |
| Son K:8:6 OU | X | X |
| Son K:4:16 OU | X | X |
| Son K:4:44 OU | X | X |
| Son K:4:52 OU | X | X |
| Son K:4:73 OU | X | X |
| Son K:4:120 OU | X | X |
| Son K:4:126 OU | X | X |
| Son K:4:47 OU | | X |
| Son K:8:7 OU | Disturbed | |
| Son K:4:2 OU | Disturbed | |
| Son K:4:119 OU | Disturbed | |

[1]Most of the polychrome ceramics are Carretas, Huerigas, Ramos, and Babicora, all of which date to the Paquime-Diablo Phases, A.D. 1205-1340, at Casas Grandes (DiPeso 1974). A few samples were Trincheras purple-on-red which is also thought to be relatively late (Sauer and Brand 1932).

[2]Sites in which polychrome ceramics were found during the surface surveys.

[3]Includes single and multiple room structures as well as those with single and double row rock foundations, undifferentiated foundations, mounds, and Trincheras foundations.

Polychrome ceramics were found during the surface survey at 23 pre-Hispanic settlements. Three of these sites were so badly disturbed that identification of specific foundation types was impossible. Of the remaining 20 sites, 12 (60 percent) had surface structures exclusively, 7 (35 percent) had both surface structures and houses-in-pits, and only one (5 percent) had houses-in-pits exclusive of other structural types. The initial conclusion to be drawn from this distribution is that there is probably some association between surface structures and polychrome ceramics. The relative dates of surface structures and the specific types of polychrome pottery might, therefore, be considered contemporaneous. Such a conclusion, however, would be premature and naive.

Of the 162 settlements found in the middle Río Sonora Valley, 97 (59.9 percent) had surface structures only, 53 (32.2 percent) had both surface structures and houses-in-pits, while 12 (7.4 percent) had houses-in-pits exclusively. The relative proportions of sites with specific types of architecture throughout the entire valley are nearly identical to the architectural proportions of sites with polychrome ceramics. In effect, when the proportions of architectural types are considered, the sites with polychrome ceramics are an accurate sample (n=20) of the total population (N=162). This similarity of percentages indicates that the association of polychrome ceramics to surface structures is largely a function of stochastic processes with the observed distribution conforming to the expected distribution. This conclusion verifies a late phase contemporaneity between all structural types. Such a contemporaneity would not eliminate the possibility that houses-in-pits were initially occupied earlier than surface structures, rather it suggests a continued occupance for earlier structures. That houses-in-pits predate surface structures was verified by architectural superposition, $C^{14}$ and obsidian hydration analyses.

# APPENDIX VII

# ENVIRONMENTAL SURVEY DATA

| Transect Area No. | Longitude | Latitude | Elev. (M) | Slope | Plants/ 10M | Cacti No./% | Shrubs No./% | Trees No./% |
|---|---|---|---|---|---|---|---|---|
| 1/1 | W110°11'35" | N29°46'05" | 580 | 1°W | 58 | 5/8.6 | 51/87.9 | 2/3.5 |
| 1/2 | W110°11'45" | N29°45'55" | 565 | 1°W | 4 | 0/0 | 2/50. | 2/50. |
| 1/3 | W110°12'00" | N29°45'50" | 560 | 0 | 43 | 0/0 | 43/100. | 0/0 |
| 1/4 | W110°12'20" | N29°45'45" | 560 | 0 | 16 | 0/0 | 13/81.3 | 3/18.7 |
| 1/5 | W110°12'30" | N29°45'40" | 565 | 1°E | 22 | 0/0 | 1/4.5 | 21/95.5 |
| 1/6 | W110°12'45" | N29°45'35" | 572 | 4°E | 22 | 0/0 | 18/81.8 | 4/18.2 |
| 1/7 | W110°11'40" | N29°46'00" | 575 | 25°W | 40 | 1/2.5 | 36/90. | 3/7.5 |
| 2/1 | W110°12'52" | N29°46'00" | 620 | 1°E | 24 | 3/12.5 | 19/79.2 | 2/8.3 |
| 2/2 | W110°12'52" | N29°45'58" | 605 | 30°S | 27 | 2/7.4 | 24/88.9 | 1/3.7 |
| 2/3 | W110°12'52" | N29°45'50" | 590 | 4°E | 14 | 2/14.3 | 10/71.4 | 2/14.3 |
| 2/4 | W110°12'52" | N29°45'43" | 605 | 35°N | 25 | 2/8.0 | 23/92.0 | 0/0 |

| Transect Area No. | Predominant Plant | Height Avg. (M) | Diameter Avg. (M) | Principal Sub. Dom. | Canopy (%) | Grass Cover | Ecological Zone |
|---|---|---|---|---|---|---|---|
| 1/1 | *Mimosa laxiflora* | 1.3 | 1.3 | *Jatropha* sp. | 50 | Sparse | Desert Scrub (Edge) |
| 1/2 | *Prosopis juliflora* | 6.6 | 6.6 | *Celtis* sp. | 75 | Heavy | Riparian Woodland |
| 1/3 | *Senecio salignus* | 2.0 | 1.0 | *Jecota* | 40 | Heavy | Riparian Woodland |
| 1/4 | *Senecio salignus* | 2.0 | 1.0 | *Prosopis* sp. | 95 | Heavy | Riparian Woodland |
| 1/5 | *Populus fremontii* | 15.0 | 3.0 | *Salix* sp. | - | Medium | Riparian Woodland |
| 1/6 | *Prosopis juliflora* | 3.3 | 3.3 | *Jatropha* sp. | 65 | Sparse | Arroyo, Small |
| 1/7 | *Mimosa laxiflora* | 1.3 | 1.3 | - | - | Sparse | Mixed Scrub |
| 2/1 | *Mimosa laxiflora* | 1.3 | 1.3 | - | - | Sparse | Mixed Scrub |
| 2/2 | *Mimosa laxiflora* | 1.3 | 1.3 | - | - | Sparse | Arroyo, S-Slope |
| 2/3 | *Jatropha cardiophylla* | 1.0 | 1.0 | *Prosopis* sp. | - | Sparse | Arroyo Intermediate |
| 2/4 | Shrubs (Undiff.) | 1.6 | 1.6 | - | 50 | Sparse | Arroyo N-Slope |

| Transect/ Area No. | Longitude | Latitude | Elev. (M) | Slope | Plants/ 10M | Cacti No./% | Shrubs No./% | Trees No./% |
|---|---|---|---|---|---|---|---|---|
| 2/5 | W110°12'52" | N29°45'40" | 620 | 5°E | 41 | 8/19.5 | 32/78.0 | 1/2.5 |
| 2/6 | W110°12'52" | N29°45'38" | 605 | 40°S | 39 | 3/7.7 | 36/92.3 | 0/0 |
| 2/7 | W110°12'52" | N29°45'32" | 590 | 2°E | 28 | 1/3.6 | 21/75.0 | 6/21.4 |
| 2/8 | W110°12'52" | N29°45'25" | 620 | 30°N | 43 | 2/4.7 | 41/95.3 | 0/0 |
| 2/9 | W110°12'52" | N29°45'20" | 650 | 35°N | 36 | 1/2.8 | 35/97.2 | 0/0 |
| 3/1 | W110°09'15" | N29°45'35" | 650 | 0 | 33 | 2/6.1 | 28/84.8 | 3/9.1 |
| 3/2 | W110°09'20" | N29°45'35" | 630 | 35°N | 15 | 0/0 | 15/100. | 0/0 |
| 3/3 | W110°09'28" | N29°45'35" | 610 | 0 | 17 | 0/0 | 3/17.6 | 14/82.4 |
| 3/4 | W110°09'35" | N29°45'35" | 615 | 0 | 18 | 0/0 | 0/0 | 18/100. |
| 3/5 | W110°09'50" | N29°45'35" | 628 | 40°S | 19 | 2/10.5 | 14/73.7 | 3/15.8 |
| 3/6 | W110°09'00" | N29°45'35" | 640 | 1°S | 35 | 1/2.9 | 28/80. | 6/17.1 |

| Transect Area No. | Predominant Plant | Height Avg. (M) | Diameter Avg. (M) | Principal Sub. Dom. | Canopy (%) | Grass Cover | Ecological Zone |
|---|---|---|---|---|---|---|---|
| 2/5 | *Mimosa laxiflora* | 2.0 | 1.6 | - | - | Sparse | Mixed Scrub |
| 2/6 | *Mimosa laxiflora* | 2.0 | 2.0 | - | - | Sparse | Arroyo S-Slope |
| 2/7 | *Prosopis juliflora* | 3.6 | 5.0 | *Jatropha* sp. | - | Medium | Arroyo, Small |
| 2/8 | Shrubs (Undiff.) | 2.0 | 2.0 | - | 60 | Sparse | Arroyo, N-Slope |
| 2/9 | *Mimosa laxiflora* | 1.5 | 1.6 | - | 65 | Sparse | Mixed Scrub |
| 3/1 | *Mimosa laxiflora* | 1.6 | 1.6 | *Franseria* sp. | 50 | Sparse | Desert Scrub |
| 3/2 | *Jatropha cordata* | 2.3 | 2.0 | - | - | Sparse | Arroyo, N-Slope |
| 3/3 | *Prosopis juliflora* | 5.0 | 4.0 | - | 80 | Medium | Arroyo, Large |
| 3/4 | *Prosopis juliflora* | 2.0 | 2.0 | - | - | Medium | Arroyo, Large |
| 3/5 | *Mimosa laxiflora* | 1.6 | 1.6 | - | 50 | Sparse | Arroyo, S-Slope |
| 3/6 | *Mimosa laxiflora* | 1.3 | 1.3 | *Franseria* sp. | 45 | Sparse | Desert Scrub |

| Transect Area No. | Longitude | Latitude | Elev. (M) | Slope | Plants/ 10M | Cacti No./% | Shrubs No./% | Trees No./% |
|---|---|---|---|---|---|---|---|---|
| 4/1 | W110°07'00" | N29°40'30" | 600 | 5°W | 26 | 1/3.9 | 22/84.6 | 3/11.5 |
| 4/2 | W110°07'05" | N29°41'00" | 600 | 5°N | 42 | 1/2.4 | 35/83.3 | 6/14.3 |
| 4/3 | W110°07'45" | N29°40'50" | 570 | 1°W | 29 | 0/0 | 24/82.8 | 5/17.2 |
| 4/4 | W110°08'10" | N29°40'30" | 560 | 0 | 17 | 0/0 | 9/52.9 | 8/47.1 |
| 5/1 | W110°13'00" | N29°48'55" | 600 | 0 | 19 | 0/0 | 15/78.9 | 4/21.1 |
| 5/2 | W110°11'45" | N29°49'10" | 650 | 42°N | 9 | 7/77.8 | 2/22.2 | 0/0 |
| 6/1 | W110°12'10" | N29°49'00" | 660 | 5°SW | 55 | 1/1.8 | 51/92.7 | 3/5.5 |
| 6/2 | W110°12'12" | N29°49'04" | 642 | 35°N | 29 | 0/0 | 28/96.6 | 1/3.4 |
| 6/3 | W110°12'14" | N29°49'08" | 625 | 0 | 28 | 2/7.1 | 21/75. | 5/17.9 |
| 6/4 | W110°12'16" | N29°49'12" | 640 | 25°S | 65 | 2/3.1 | 61/93.8 | 2/3.1 |
| 6/5 | W110°12'18" | N29°49'15" | 650 | 4°S | 52 | 13/25. | 39/75. | 0/0 |

| Transect Area No. | Predominant Plant | Height Avg. (M) | Diameter Avg. (M) | Principal Sub. Dom. | Canopy (%) | Grass Cover | Ecological Zone |
|---|---|---|---|---|---|---|---|
| 4/1 | *Mimosa laxiflora* | 1.6 | 1.6 | - | 70 | Sparse | Desert Scrub |
| 4/2 | *Mimosa laxiflora* | 1.6 | 1.6 | - | 85 | Sparse | Desert Scrub |
| 4/3 | *Jatropha cardiophylla* | 1.0 | 1.0 | *Olneya* sp. | 40 | Sparse | Arroyo, Small |
| 4/4 | *Prosopis juliflora* | 3.0 | 3.0 | *Celtis* sp. | 50 | Medium | Arroyo, Intermediate |
| 5/1 | *Jatropha cardiophylla* | 1.0 | 1.0 | *Prosopis* sp. | 55 | Medium | Arroyo, Intermediate |
| 5/2 | *Yucca* sp. | 1.0 | 1.0 | - | - | Sparse | Arroyo, N-Slope |
| 6/1 | *Mimosa laxiflora* | 1.3 | 1.3 | *Franseria* sp. | 65 | Sparse | Desert Scrub |
| 6/2 | *Mimosa laxiflora* | 1.6 | 1.6 | - | - | Sparse | Arroyo, N-Slope |
| 6/3 | *Jatropha cardiophylla* | 1.0 | 1.0 | Undiff. Trees | 50 | Sparse | Arroyo, Intermediate |
| 6/4 | *Mimosa laxiflora* | 1.3 | 1.3 | *Jatropha* sp. | - | Sparse | Arroyo, S-Slope |
| 6/5 | *Mimosa laxiflora* | 1.3 | 1.3 | *Foquieria* sp. | 40 | Sparse | Desert Scrub |

| Transect/ Area No. | Longitude | Latitude | Elev. (M) | Slope | Plants/ 10M | Cacti No./% | Shrubs No./% | Trees No./% |
|---|---|---|---|---|---|---|---|---|
| 6/6 | W110°12'25" | N29°49'25" | 650 | 20°S | 28 | 4/14.3 | 20/71.4 | 4/14.3 |
| 7/1 | W110°09'18" | N29°42'05" | 562 | 4°W | 41 | 0/0 | 38/927 | 3/7.3 |
| 7/2 | W110°09'19" | N29°42'05" | 550 | 15°W | 39 | 6/15.4 | 30/76.9 | 3/7.7 |
| 8/1 | W110°12'20" | N29°47'08" | 600 | 1°W | 54 | 22/40.7 | 27/50. | 5/9.3 |
| 8/2 | W110°12'25" | N29°47'07" | 590 | 30°W | 57 | 2/3.5 | 51/89.5 | 4/7.0 |
| 9/1 | W110°01'15" | N29°34'50" | 1060 | 14°W | 17 | 0/0 | 15/88.2 | 2/11.8 |
| 9/2 | W110°00'55" | N29°34'45" | 1040 | 15°N | 32 | 1/3.1 | 27/84.4 | 4/12.5 |
| 10/1 | W110°14'55" | N29°49'45" | 630 | 0 | 44 | 3/6.8 | 39/88.6 | 2/4.6 |
| 10/2 | W110°14'57" | N29°49'42" | 610 | 20°SW | 86 | 3/3.5 | 76/88.4 | 7/8.1 |
| 10/3 | W110°15'00" | N29°49'38" | 595 | 0 | 12 | 0/0 | 3/25. | 9/75. |
| 10/4 | W110°14'55" | N29°49'28" | 615 | 30°N | 41 | 1/2.4 | 38/92.7 | 2/4.9 |

| Transect Area No. | Predominant Plant | Height Avg. (M) | Diameter Avg. (M) | Principal Sub. Dom. | Canopy (%) | Grass Cover | Ecological Zone |
|---|---|---|---|---|---|---|---|
| 6/6 | *Mimosa laxiflora* | 1.3 | 1.3 | Undiff. Shrub | 80 | Sparse | Arroyo, S-Slope |
| 7/1 | *Mimosa laxiflora* | 1.3 | 1.3 | *Jatropha* sp. | 50 | Sparse | Desert Scrub (Edge) |
| 7/2 | *Mimosa laxiflora* | 1.3 | 1.3 | - | 80 | Sparse | Mixed Scrub |
| 8/1 | *Mimosa laxiflora* | 1.3 | 1.3 | *Jatropha* sp. | 50 | Sparse | Desert Scrub (Edge) |
| 8/2 | *Mimosa laxiflora* | 1.3 | 1.3 | - | 65 | Medium | Mixed Scrub |
| 9/1 | *Acacia* sp. | 2.3 | 2.0 | - | 70 | Heavy | Piedmont Transition |
| 9/2 | Shrubs (Undiff.) | 2.0 | 2.0 | - | 70 | Heavy | Piedmont Transition |
| 10/1 | Shrubs (Undiff.) | 2.0 | 2.0 | - | 50 | Sparse | Mixed Scrub |
| 10/2 | *Mimosa laxiflora* | 2.0 | 2.0 | *Franseria* sp. | 70 | Sparse | Arroyo, S-Slope |
| 10/3 | *Prosopis juliflora* | 4.0 | 4.0 | - | 50 | Medium | Arroyo, Large |
| 10/4 | *Mimosa laxiflora* | 1.6 | 1.3 | *Jatropha* sp. | 80 | Medium | Arroyo, N-Slope |

| Transect Area No. | Longitude | Latitude | Elev. (M) | Slope | Plants/ 10M | Cacti No./% | Shrubs No./% | Trees No./% |
|---|---|---|---|---|---|---|---|---|
| 10/5 | W110°14'53" | N29°49'20" | 625 | 0 | 35 | 1/2.9 | 21/60.0 | 13/37.1 |
| 10/6 | W110°14'51" | N29°49'18" | 617 | 30°S | 58 | 3/5.2 | 55/94.8 | 0/0 |
| 10/7 | W110°14'49" | N29°49'17" | 610 | 0 | 28 | 0/0 | 23/82.1 | 5/17.9 |
| 10/8 | W110°14'47" | N29°49'16" | 620 | 32°N | 15 | 3/20. | 11/73.3 | 1/6.7 |
| 10/9 | W110°14'45" | N29°49'15" | 630 | 35°S | 52 | 6/11.5 | 46/88.5 | 0/0 |
| 11/1 | W110°06'35" | N29°48'45" | 830 | 35°SE | 40 | 7/17.5 | 29/72.5 | 4/10 |
| 11/2 | W110°07'50" | N29°47'35" | 800 | 35°S | 31 | 2/6.5 | 27/87. | 2/6.5 |
| 12/1 | W110°19'15" | N30°01'00" | 940 | 4°E | - | - | - | - |
| 12/2 | W110°19'15" | N30°01'00" | 860 | 28°W | - | - | - | - |
| 12/3 | W110°16'40" | N30°00'00" | 760 | 1°E | 38 | 0/0 | 37/97.4 | 1/2.6 |
| 12/4 | W110°15'00" | N29°59'30" | 700 | 0 | 40 | 2/5 | 38/95. | 0/0 |

| Transect Area No. | Predominant Plant | Height Avg. (M) | Diameter Avg. (M) | Principal Sub. Dom. | Canopy (%) | Grass Cover | Ecological Zone |
|---|---|---|---|---|---|---|---|
| 10/5 | *Mimosa laxiflora* | 2.0 | 2.0 | - | 50 | Sparse | Mixed Scrub |
| 10/6 | *Mimosa laxiflora* | 2.0 | 2.0 | *Franseria* sp. | 50 | Medium | Arroyo, S-Slope |
| 10/7 | *Jatropha cardiophylla* | 1.0 | 1.0 | - | 50 | Sparse | Arroyo, Small |
| 10/8 | Shrubs (Undiff.) | 1.3 | 1.3 | - | 30 | Sparse | Arroyo, N-Slope |
| 10/9 | *Mimosa laxiflora* | 1.6 | 1.6 | *Franseria* sp. | - | Medium | Arroyo, S-Slope |
| 11/1 | Shrubs (Undiff.) | 2.6 | 2.6 | - | 70 | Medium | Thorn Forest |
| 11/2 | *Mimosa laxiflora* | 1.3 | 1.3 | *Jatropha* sp. | 70 | Medium | Thorn Forest |
| 12/1 | *Mimosa laxiflora* | 2.5 | 2.0 | *Prosopis* sp. | - | Medium | Thorn Forest |
| 12/2 | *Mimosa laxiflora* | 1.3 | 1.3 | *Ipomoea* sp. | - | Sparse | Thorn Forest |
| 12/3 | *Mimosa laxiflora* | 1.6 | 1.5 | *Franseria* sp. | 55 | Sparse | Desert Scrub |
| 12/4 | *Mimosa laxiflora* | 1.6 | 1.6 | *Franseria* sp. | - | Sparse | Desert Scrub |

| Transect/ Area No. | Longitude | Latitude | Elev. (M) | Slope | Plants/ 10M | Cacti No./% | Shrubs No./% | Trees No./% |
|---|---|---|---|---|---|---|---|---|
| 13/1 | W110°17'50" | N29°55'15" | 1230 | 0 | 27 | 1/3.7 | 20/74.1 | 6/22.2 |
| 13/2 | W110°17'30" | N29°55'35" | 980 | 35°N | - | - | - | - |
| 14/1 | W110°07'20" | N29°58'20" | 1000 | 27°NW | 32 | 6/18.9 | 22/68.8 | 4/12.3 |
| 14/2 | W110°08'15" | N29°58'00" | 900 | 36°NE | 39 | 6/15.4 | 28/71.8 | 5/12.8 |
| 14/3 | W110°10'00" | N29°58'00" | 760 | 4°N | 43 | 5/11.6 | 35/81.4 | 3/7. |
| 14/4 | W110°10'50" | N29°58'45" | 720 | 0 | 39 | 0/0 | 32/82.1 | 7/17.9 |
| 15/1 | W110°05'00" | N29°54'20" | 1100 | 22°W | 23 | 3/13. | 14/60.9 | 6/26.1 |
| 15/2 | W110°05'30" | N29°54'30" | 1100 | 27°W | 9 | 0/0 | 2/22.2 | 7/77.8 |
| 15/3 | W110°06'30" | N29°54'15" | 1000 | 27°S | 38 | 5/13.1 | 24/63.2 | 9/23.7 |
| 15/4 | W110°08'00" | N29°54'10" | 900 | 32°N | 34 | 6/17.6 | 25/73.5 | 3/8.9 |
| 15/5 | W110°10'00" | N29°54'00" | 760 | 2°W | 46 | 2/4.3 | 39/84.8 | 5/10.9 |

| Transect Area No. | Predominant Plant | Height Avg. (M) | Diameter Avg. (M) | Principal Sub. Dom. | Canopy (%) | Grass Cover | Ecological Zone |
|---|---|---|---|---|---|---|---|
| 13/1 | *Lysiloma watsoni* | 1.0 | .7 | - | 70 | Heavy | Piedmont Transition |
| 13/2 | *Bursera* sp. | 3.0 | 2.0 | *Ipomoea* sp. | -- | Heavy | Piedmont Transition |
| 14/1 | *Jatropha* sp. | 2.0 | 2.0 | - | 65 | Medium | Thorn Forest |
| 14/2 | *Mimosa laxiflora* | 2.0 | - | *Prosopis* sp. | 50 | Sparse | Thorn Forest |
| 14/3 | *Mimosa laxiflora* | 1.6 | 1.6 | *Jatropha* sp. | 60 | Sparse | Desert Scrub |
| 14/4 | *Mimosa laxiflora* | - | - | *Franseria* sp. | 60 | Sparse | Desert Scrub |
| 15/1 | *Lysiloma watsoni* | - | - | *Prosopis* sp. | - | Heavy | Piedmont Transition |
| 15/2 | *Quercus* sp. | 4.0 | 4.0 | - | 50 | Medium | Oak Woodland |
| 15/3 | *Franseria cordifolia* | - | - | *Ipomoea* sp. | 65 | Medium | Thorn Forest |
| 15/4 | *Mimosa laxiflora* | 2.0 | 1.6 | *Jatropha* sp. | 70 | Medium | Thorn Forest |
| 15/5 | *Mimosa laxiflora* | 1.6 | 1.6 | *Prosopis* sp. | 60 | Sparse | Desert Scrub |

| Transect/ Area No. | Longitude | Latitude | Elev. (M) | Slope | Plants/ 10M | Cacti No./% | Shrubs No./% | Trees No./% |
|---|---|---|---|---|---|---|---|---|
| 15/6 | W110°11'00" | N29°54'20" | 725 | 1°W | 47 | 1/2.1 | 42/89.4 | 4/8.5 |
| SS-1 | W110°10'45" | N29°43'05" | 640 | 5°E | 36 | 11/30.6 | 35/69.4 | 0/0 |
| SS-2 | W110°14'50" | N29°40'40" | 1180 | 0 | 8 | 0/0 | 3/37.5 | 5/62.7 |
| SS-3 | W110°09'35" | N29°40'45" | 640 | 35°E | 28 | 5/17.9 | 21/75.0 | 2/7.1 |
| SS-4 | W110°20'00" | N38°10'20" | 850 | 6°SE | 41 | 3/7.3 | 30/73.2 | 8/19.5 |
| SS-5 | W110°00'30" | N29°50'40" | 1300 | 20°NW | 8 | 0/0 | 0/0 | 8/100 |
| SS-6 | W110°14'45" | N30°05'45" | 695 | 0 | - | - | - | - |
| SS-7 | W110°13'30" | N29°53'40" | 610 | 0 | - | - | - | - |

| Transect Area No. | Predominant Plant | Height Avg. (M) | Diameter Avg. (M) | Principal Sub. Dom. | Canopy (%) | Grass Cover | Ecological Zone |
|---|---|---|---|---|---|---|---|
| 15/6 | Mimosa laxiflora | 1.6 | 1.6 | Franseria sp. | 55 | Sparse | Desert Scrub |
| SS-1 | Mimosa laxiflora | 1.3 | 1.3 | Jatropha sp. | 40 | Sparse | Mixed Scrub |
| SS-2 | Quercus sp. | 4.0 | 4.0 | - | 40 | Medium | Oak Woodland |
| SS-3 | Mimosa laxiflora | 1.3 | 1.6 | Jatropha sp. | 80 | Sparse | Mixed Scrub |
| SS-4 | Mimosa laxiflora | 2.0 | 2.0 | Prosopis sp. | 60 | Medium | Thorn Forest |
| SS-5 | Quercus sp. | 3.0 | 3.5 | - | 50 | Medium | Oak Woodland |
| SS-6 | Senecio salignus | 2.0 | 1.0 | Jecota | 0 | Heavy | Riparian Woodland |
| SS-7 | Senecio salignus | 2.0 | 1.0 | Jecota | 0 | Heavy | Riparian Woodland |

APPENDIX VIII

SOIL DATA*

| Trans./ Area No. | Depth (cm) | Color | pH | Organic Matter (%) | Phosphorus (ppm) | Potassium (ppm) | Nitrate Nitrogen (ppm) |
|---|---|---|---|---|---|---|---|
| 1/1 | 30 | 7.5YR 5/4 Brown | 6.3 | - | - | - | - |
| 1/2 | 45 | 10YR 5/3 Brown | 8.1 | 1.0 | 50 | 162 | 10 |
| 1/3 | 15 | 7.5YR 6/2 Pinkish gray | 7.7 | <1.0 | 25 | 75 | 10 |
| 1/4 | 30 | 5YR 6/3 Light reddish brown | 6.3 | 2.0 | 75 | 175 | 15 |
| 1/5 | 45 | 10YR 5/4 Yellowish brown | 7.3 | 2.0 | 50 | 62 | 20 |
| 1/6 | 45 | 10YR 5/4 Yellowish brown | 7.1 | <1.0 | 25 | 125 | 20 |
| 1/7 | 37 | 10YR 6/3 Pale brown | 7.2 | - | - | - | - |
| 2/1 | 45 | 10YR 5/2 Grayish brown | 7.8 | - | - | - | - |
| 2/2 | 15 | 10YR 7/1 Light gray | 8.0 | - | - | - | - |
| 2/3 | 45 | 10YR 5.5/3 Pale brown | 8.0 | <1.0 | 50 | 125 | 10 |
| 2/4 | 12 | 10YR 7/1 Light gray | 8.4 | - | - | - | - |

| Trans./ Area No. | Percent Sand | Percent Silt | Percent Clay | Texture | Classification |
|---|---|---|---|---|---|
| 1/1 | 80.0 | 10.4 | 9.6 | Loamy sand | Arent |
| 1/2 | 75.0 | 13.4 | 11.6 | Sandy loam | Torripsamment |
| 1/3 | 81.0 | 15.4 | 3.6 | Loamy sand | Torripsamment |
| 1/4 | 50.0 | 42.4 | 7.6 | Loam | Torrifluvent |
| 1/5 | 86.0 | 10.4 | 3.6 | Loamy sand | Torripsamment |
| 1/6 | 86.0 | 12.4 | 1.6 | Sand | Torripsamment |
| 1/7 | 76.0 | 14.4 | 9.6 | Sandy loam | Torriorthent |
| 2/1 | 82.4 | 10.6 | 7.0 | Loamy sand | Camborthid |
| 2/2 | 76.4 | 19.6 | 4.0 | Loamy sand | Quartzipsamment |
| 2/3 | 86.4 | 9.6 | 4.0 | Sand | Torripsamment |
| 2/4 | 76.4 | 20.0 | 3.6 | Loamy sand | Quartzipsamment |

| Trans./ Area No. | Depth (cm) | Color | pH | Organic Matter (%) | Phosphorus (ppm) | Potassium (ppm) | Nitrate Nitrogen (ppm) |
|---|---|---|---|---|---|---|---|
| 2/5 | 37 | 10YR 5/3 Brown | 7.5 | - | - | - | - |
| 2/6 | 30 | 10YR 7/2 Light gray | 7.7 | - | - | - | - |
| 2/7 | - | 5YR 6/3 Pale olive | 7.5 | $<$1.0 | 60 | 125 | 10 |
| 2/8 | 30 | 7.5YR 6/6 Reddish yellow | 6.8 | - | - | - | - |
| 2/9 | 37 | 10YR 6/3 Pale brown | 8.4 | - | - | - | - |
| 3/1 | 15 | 5YR 4/5 Yellowish red | 6.2 | - | - | - | - |
| 3/2 | 15 | 7.5YR 5/4 Brown | 6.8 | - | - | - | - |
| 3/3 | 15 | 10YR 5/3 Brown | 6.4 | 1.0 | 25 | 155 | 10 |
| 3/4 | 30 | 10YR 6/3 Pale brown | 8.1 | 1.0 | 75 | 120 | 15 |
| 3/5 | 15 | 7.5YR 4.5/4 Brown | 7.5 | - | - | - | - |
| 3/6 | 7 | 5YR 5/6 Yellowish red | 5.4 | - | - | - | - |

| Trans./ Area No. | Percent Sand | Percent Silt | Percent Clay | Texture | Classification |
|---|---|---|---|---|---|
| 2/5 | 72.4 | 15.6 | 12.0 | Sandy loam | Camborthid |
| 2/6 | 76.4 | 18.6 | 5.0 | Loamy sand | Quartzipsamment |
| 2/7 | 91.4 | 3.6 | 4.0 | Sand | Torripsamment |
| 2/8 | 76.4 | 15.6 | 8.0 | Sandy loam | Quartzipsamment |
| 2/9 | 84.4 | 10.6 | 5.0 | Loamy sand | Camborthid |
| 3/1 | 70.0 | 16.0 | 14.0 | Sandy loam | Haplargid |
| 3/2 | 74.4 | 19.6 | 6.0 | Sandy loam | Gypsiorthid |
| 3/3 | 69.4 | 22.6 | 8.0 | Sandy loam | Torripsamment |
| 3/4 | 67.4 | 23.6 | 9.0 | Sandy loam | Torripsamment |
| 3/5 | 56.4 | 35.6 | 8.0 | Sandy loam | Torriorthent |
| 3/6 | 55.4 | 32.6 | 12.0 | Sandy loam | Haplargid |

| Trans./ Area No. | Depth (cm) | Color | pH | Organic Matter (%) | Phosphorus (ppm) | Potassium (ppm) | Nitrate Nitrogen (ppm) |
|---|---|---|---|---|---|---|---|
| 4/1 | 22 | 5YR 4/6 Yellowish red | 6.2 | - | - | - | - |
| 4/2 | 15 | 7.5YR 5.5/2 Brown-pinkish gray | 6.1 | - | - | - | - |
| 4/3 | 45 | 10YR 5/3 Brown | 7.2 | < 1.0 | 37 | 90 | 10 |
| 4/4 | 30 | 10YR 5/3 Brown | 6.7 | < 1.0 | 75 | 125 | 20 |
| 5/1 | 22 | 10YR 6/3 Pale brown | 7.8 | 1.0 | 25 | 125 | 5 |
| 5/2 | 15 | 2.5Y 7/2 Light gray | 8.2 | - | - | - | - |
| 6/1 | 12 | 5YR 4/6 Yellowish red | 6.0 | - | - | - | - |
| 6/2 | 15 | 10YR 5/2 Grayish brown | 7.8 | - | - | - | - |
| 6/3 | 22 | 10YR 4/3 Brown | 7.4 | 1.0 | 37 | 80 | 10 |
| 6/4 | 12 | 5YR 4/4 Reddish brown | 5.8 | - | - | - | - |
| 6/5 | 12 | 5YR 4/8 Yellowish red | 6.5 | - | - | - | - |

| Trans./ Area No. | Percent Sand | Percent Silt | Percent Clay | Texture | Classification |
|---|---|---|---|---|---|
| 4/1 | 58.4 | 19.2 | 22.4 | Sandy clay loam | Aridic Haplustoll |
| 4/2 | 78.4 | 18.0 | 3.6 | Loamy sand | Haplargid |
| 4/3 | 90.0 | 5.4 | 4.6 | Sand | Torripsamment |
| 4/4 | 80.0 | 14.0 | 6.0 | Loamy sand | Torripsamment |
| 5/1 | 92.4 | 7.0 | 0.6 | Sand | Torripsamment |
| 5/2 | 82.4 | 12.0 | 5.6 | Loamy sand | Quartzipsamment |
| 6/1 | 60.0 | 29.0 | 11.0 | Sandy loam | Aridic Haplustoll |
| 6/2 | 75.0 | 15.0 | 10.0 | Sandy loam | Quartzipsamment |
| 6/3 | 81.0 | 13.0 | 6.0 | Loamy sand | Torripsamment |
| 6/4 | 70.0 | 21.0 | 9.0 | Sandy loam | Torriorthent |
| 6/5 | 70.0 | 20.0 | 10.0 | Sandy loam | Aridic Haplustoll |

| Trans./ Area No. | Depth (cm) | Color | $p^H$ | Organic Matter (%) | Phosphorus (ppm) | Potassium (ppm) | Nitrate Nitrogen (ppm) |
|---|---|---|---|---|---|---|---|
| 6/6 | 15 | 5YR 6/3 Light reddish brown | 8.1 | - | - | - | - |
| 7/1 | 45 | 7.5YR 5/2 Brown | 8.2 | - | - | - | - |
| 7/2 | 15 | 7.5YR 4/2 Brown | 8.1 | - | - | - | - |
| 8/1 | 30 | 7.5YR 5/2 Brown | 7.5 | - | - | - | - |
| 8/2 | 12 | 5YR 4/4 Reddish brown | 7.5 | - | - | - | - |
| 9/1 | 45 | 10YR 4/4 Dark yellowish brown | 6.6 | - | - | - | - |
| 9/2 | 13 | 10YR 3/3 Dark brown | 7.2 | - | - | - | - |
| 10/1 | 22 | 10YR 4.5/3.5 Brown-dark yellowish brown | 6.6 | - | - | - | - |
| 10/2 | 26 | 5YR 4/4 Reddish brown | 7.0 | - | - | - | - |
| 10/3 | 22 | 10YR 6/2.5 Pale brown | 8.2 | 2.0 | 25 | 95 | 10 |
| 10/4 | 15 | 10YR 5/3 Brown | 6.3 | - | - | - | - |

| Trans./ Area No. | Percent Sand | Percent Silt | Percent Clay | Texture | Classification |
|---|---|---|---|---|---|
| 6/6 | 76.0 | 16.0 | 8.0 | Sandy loam | Camborthid |
| 7/1 | 70.4 | 24.0 | 5.6 | Sandy loam | Arent |
| 7/2 | 62.4 | 33.0 | 4.6 | Sandy loam | Torriorthent |
| 8/1 | 68.4 | 26.0 | 5.6 | Sandy loam | Arent |
| 8/2 | 72.4 | 20.0 | 7.6 | Sandy loam | Torriorthent |
| 9/1 | 74.4 | 18.6 | 7.0 | Sandy loam | Lithic Torriorthent |
| 9/2 | 70.4 | 24.0 | 5.6 | Sandy loam | Lithic Aridic Haplustoll |
| 10/1 | 76.4 | 14.6 | 9.0 | Sandy loam | Aridic Haplustoll |
| 10/2 | 68.4 | 13.6 | 18.0 | Sandy loam | Torriorthent |
| 10/3 | 82.4 | 12.6 | 5.0 | Loamy sand | Torripsamment |
| 10/4 | 80.0 | 14.4 | 5.6 | Loamy sand | Gypsiorthid |

| Trans./ Area No. | Depth (cm) | Color | pH | Organic Matter (%) | Phosphorus (ppm) | Potassium (ppm) | Nitrate Nitrogen (ppm) |
|---|---|---|---|---|---|---|---|
| 10/5 | 15 | 2.5YR 4/6 Red | 7.3 | - | - | - | - |
| 10/6 | 15 | 2.5YR 4/6 Red | 6.9 | - | - | - | - |
| 10/7 | 15 | 2.5Y 5/2 Grayish brown | 8.1 | $<1.0$ | 37 | 70 | 10 |
| 10/8 | 15 | 5YR 6/3.5 Light reddish brown | 8.4 | - | - | - | - |
| 10/9 | 22 | 7.5YR 5.5/4 Light brown | 7.2 | - | - | - | - |
| 11/1 | 10 | 5YR 3/4 Dark reddish brown | 6.5 | - | - | - | - |
| 11/2 | 10 | 5YR 3.5/4 Dark reddish brown | 7.1 | - | - | - | - |
| 12/1 | 10 | 10YR 4.5/3 Brown | 5.8 | - | - | - | - |
| 12/2 | 10 | 10YR 5/3 Brown | 5.3 | - | - | - | - |
| 12/3 | 32 | 7.5YR 5/4 Brown | 5.5 | - | - | - | - |
| 12/4 | 38 | 7.5YR 6/4 Light brown | 4.8 | - | - | - | - |

| Trans./ Area No. | Percent Sand | Percent Silt | Percent Clay | Texture | Classification |
|---|---|---|---|---|---|
| 10/5 | 45.0 | 44.4 | 10.6 | Loam | Aridic Haplustoll |
| 10/6 | 65.0 | 13.4 | 21.6 | Sandy clay loam | Torriorthent |
| 10/7 | 78.0 | 14.4 | 7.6 | Loamy sand | Torripsamment |
| 10/8 | 74.0 | 22.4 | 3.6 | Loamy sand | Quartzipsamment |
| 10/9 | 66.0 | 23.4 | 11.6 | Sandy loam | Quartsipsamment |
| 11/1 | 47.4 | 30.2 | 22.4 | Loam | Lithic Torriorthent |
| 11/2 | 45.6 | 44.8 | 9.6 | Sandy loam | Lithic Torriorthent |
| 12/1 | 76.0 | 17.2 | 6.8 | Sandy loam | Lithic Torriorthent |
| 12/2 | 72.0 | 19.2 | 8.8 | Sandy loam | Lithic Torriorthent |
| 12/3 | 70.0 | 21.2 | 8.8 | Sandy loam | Haplargid |
| 12/4 | 82.0 | 13.6 | 4.4 | Loamy sand | Haplargid |

| Trans./ Area No. | Depth (cm) | Color | pH | Organic Matter (%) | Phosphorus (ppm) | Potassium (ppm) | Nitrate Nitrogen (ppm) |
|---|---|---|---|---|---|---|---|
| 13/1 | 30 | 10YR 5.5/3 Brown | 5.2 | - | - | - | - |
| 13/2 | - | - | - | - | - | - | - |
| 14/1 | 15 | 7.5YR 3/2 Dark brown | 6.7 | - | - | - | - |
| 14/2 | 10 | 10YR 5/3 Brown | 5.8 | - | - | - | - |
| 14/3 | 16 | 10YR 5/3 Brown | 5.6 | - | - | - | - |
| 14/4 | 12 | 7.5YR 6/4 Light brown | 7.5 | - | - | - | - |
| 15/1 | - | - | - | - | - | - | - |
| 15/2 | 12 | 10YR 4/2 Dark grayish brown | 4.0 | - | - | - | - |
| 15/3 | 5 | 7.5YR 4/2 Brown | 5.9 | - | - | - | - |
| 15/4 | 7 | 10YR 4/3 Dark brown | 6.4 | - | - | - | - |
| 15/5 | 18 | 5YR 5/4 Reddish brown | 5.5 | - | - | - | - |

| Trans./ Area No. | Percent Sand | Percent Silt | Percent Clay | Texture | Classification |
|---|---|---|---|---|---|
| 13/1 | 66.0 | 23.2 | 10.8 | Sandy loam | Lithic Camborthid |
| 13/2 | - | - | - | - | - |
| 14/1 | 52.0 | 33.6 | 14.4 | Loam/Sandy loam | Lithic Torriorthent |
| 14/2 | 68.0 | 17.6 | 14.4 | Sandy loam | Lithic Torriorthent |
| 14/3 | 68.0 | 21.6 | 10.4 | Sandy loam | Aridic Haplustoll |
| 14/4 | 66.0 | 23.6 | 10.4 | Sandy loam | Haplargid |
| 15/1 | - | - | - | - | - |
| 15/2 | 36.0 | 45.6 | 18.4 | Loam | Lithic Aridic Haplustoll |
| 15/3 | 56.0 | 36.0 | 8.0 | Sandy loam | Lithic Torriorthent |
| 15/4 | 50.0 | 29.6 | 20.4 | Loam | Lithic Torriorthent |
| 15/5 | 68.8 | 22.6 | 9.6 | Sandy loam | Aridic Haplustoll |

| Trans./ Area No. | Depth (cm) | Color | pH | Organic Matter (%) | Phosphorus (ppm) | Potassium (ppm) | Nitrate Nitrogen (ppm) |
|---|---|---|---|---|---|---|---|
| 15/6 | 8 | 5YR 5/4 Reddish brown | 5.0 | - | - | - | - |
| SS-1 | 12 | 10YR 6.5/3 Very pale brown | 8.0 | - | - | - | - |
| SS-2 | 12 | 2.5Y 5.5/4 Light Olive brown | 6.9 | - | - | - | - |
| SS-3 | 30 | 10YR 5/3 Brown | 6.3 | - | - | - | - |
| SS-4 | 13 | 10YR 4/3 Dark brown | 5.8 | - | - | - | - |
| SS-5 | 12 | 10YR 4/2 Dark yellowish brown | 4.5 | - | - | - | - |
| SS-6 | 45 | 7.5YR 6/2 Pinkish gray | 7.4 | 2.0 | 50 | 85 | 7 |
| SS-7 | 30 | 7.5YR 6/2 Pinkish gray | 7.4 | 3.0 | 50 | 110 | 5 |

| Trans./ Area No. | Percent Sand | Percent Silt | Percent Clay | Texture | Classification |
|---|---|---|---|---|---|
| 15/6 | 56.8 | 33.6 | 9.6 | Sandy loam | Aridic Haplustoll |
| SS-1 | 74.4 | 22.0 | 3.6 | Loamy sand | Quartzipsamment |
| SS-2 | 76.4 | 14.0 | 9.6 | Sandy loam | Lithic Torriorthent |
| SS-3 | 72.4 | 23.0 | 4.6 | Sandy loam | Torriorthent |
| SS-4 | 72.0 | 19.6 | 8.4 | Sandy loam | Lithic Torriorthent |
| SS-5 | 46.0 | 39.2 | 14.8 | Loam | Lithic Camborthid |
| SS-6 | 2.0 | 83.2 | 14.8 | Silt loam | Torrifluvent |
| SS-7 | 4.0 | 83.2 | 12.8 | Silt loam | Torrifluvent |

*All soil samples were taken with a hand auger.

Dry color was determined by comparison with the Munsell Soil Color Chart.

pH readings were taken with a Corning 610A portable pH meter equipped with a BJC electrode.

Organic matter, phosphorous, potassium, and nitrate nitrogen tests were made with a LaMotte Soil Test Outfit STH-5. These tests were limited to the floodplain and arroyo bottom soils (arable land.)

Particle size analysis was performed using the method outlined in the Wisconsin Soil Test and Plant Analysis Procedures, 1976.

Classification was determined according to the Soil Conservation Service 7th Approximation.

# APPENDIX IX

# EXPLANATION OF SOIL DATA AND ANALYSES

## Soil Color

Munsell color measurements include hue, value, and chroma. Hue is the spectral color governed by the dominant wavelength of light. Value refers to the relative lightness of color and is a function of the total amount of light. Chroma is the relative purity or strength of the spectral color and increases with decreasing grayness. The notation for hue is the letter abbreviation of the color, (R is for red, YR is for yellow-red, Y is for yellow) preceded by a number from 0 to 10. Within each letter range, the hue becomes more yellow and less red as the numbers increase. The notation for value consists of a number from 0, for absolute black, to 10, for absolute white. The notation for chroma consists of numbers beginning at 0 for neutral grays and increasing at equal intervals to a maximum of about 20, which is never really approached in the soil.

In writing the Munsell notation, the order is hue, value, chroma with a space between the hue letter and the succeeding value numbers, and a virgule between the two numbers for value and chroma. Accordingly, the notation for a color of hue 5YR, value of 5 and chroma of 4 is 5YR 5/4, a yellowish red.

Color is the most obvious and easily determined of soil characteristics. Although it has little direct influence on the functioning of soil, one may infer a great deal about a soil from its color, if it is considered with other observable features. Thus, the significance of soil color is almost entirely an indirect measure of other more important characteristics or qualities that are not so easily and accurately observed. Although the specifics are not dealt with here, knowing soil color relative to other features, including climate, lends insight into the nature of organic content, drainage, mineral content, parent material, and age (Soil Conservation Service 1975:463).

Soil pH Values

5.5 - 6.0 medium acidity

6.0 - 6.5 slightly acidic

6.5 - 7.0 very slightly acidic

7.0 neutral

7.0 - 7.5 very slightly alkaline

7.5 - 8.0 slightly alkaline

8.0 - 8.5 medium alkalinity

5.5 - 6.5. The soil is 70 - 90 percent base saturated, depending on the type of clay minerals present.

6.5 - 7.5. The soil is essentially fully base saturated; no exchangeable Al is present; free $CaCO_3$ may be present only if well protected inside soil aggregates with restricted diffusion rates.

7.5 - 8.5. The soil is fully base saturated and free $CaCO_3$ is present in the system; exchangeable cation populations are largely Ca+Mg.

The letters pH are an abbreviation for positively charge hydrogen ions. Briefly, soils contain minerals that are necessary for plant gorwth, but are unusable in their present form. The most important of these minerals are the cations (positively charged ions) called bases. The bases are calcium - Ca, magnesium - Mg, sodium - Na, and potassium - K. The degree to which the positively charged hydrogen ions (H+ or pH) are present in the soil is a measure of nutrient availability because when hydrogen cations dominate the micelles (negatively charged ions) they displace the bases and subject them to removal and utilization by vegetation. Therefore, the presence of minerals, especially the bases, plus a neutral to high pH value make for very fertile soils. Arid-land soils are highly fertile in their natural state. They are also highly alkaline. The paucity of moisture, however, leaves the false impression that the soils are not productive because plant growth is relatively sparse. (Source: Buol, Hole, and McCraken 1973; 67-68)

## Soil Nutrients

Phosphorous is necessary for hardy plant growth, stimulating early root development, and hastening plant maturity. Phosphorous increases the ration of grain and fruit to stalk. The minimum amount of phosphorous for good plant growth is 25 parts per million for sandy soils.

Potassium (potash) aids plant tone and vigor, improves the quality of the yield, promotes stamina and root development, and counteracts undue ripening. It is essential for starch formation and aids photosynthesis. The minimum amount of potassium for good plant growth is 100 parts per million.

Nitrate Nitrogen stimulates above-ground growth. It encourages plant plumpness and succulence of fruits and grains, increasing protein percentages. Soils ordinarily contain only small percentages of available nitrates. Because of the low amounts, nitrates are quickly removed by cropping and must be replaced. Beans from leguminous plants such as *Prosopis sp.* are excellent sources of nitrate nitrogen. Nitrogen is typically found in the organic matter and must be "fixed" (transformed) by oxidation caused by bacterial activity.

(Source: The LaMotte Soil Handbook 1974)

## Soil Classification

The taxonomic system devised by the U.S. Soil Conservation known colloqually as the 7th Approximation is used in this work (Soil Conservation Service 1975). A brief description of each of the soils found in the middle Río Sonora Valley is offered here. These descriptions are greatly simplified for the benefit of those not familiar with the soil classification.

Arents are young soils without horizon development that are man-made, either directly by such activities as plowing, or indirectly by such activities as grazing of domesticated animals.

Aridic Haplustolls have a mollic (dark) epipeden (upper horizon) greater than 18 cm thick. These soils are freely drained and are found in rainfall deficient grass-lands or steppes, with summer rainfall in the form of heavy showers. Parent materials below the epipeden are only slightly altered.

Camborthids are soils found in arid environs that are relatively young having only limited horizon development. There is no argillic (clay) or natric (salt) horizon but only a cambic (altered) horizon and an ochric (light colored) epipeden. The soils are usually formed on late Pleistocene age or younger surfaces.

Gypsiorthids are soils with ochric epipedens and are found in arid environs. These relatively young soils have only limited development, characterized by an illuvial gypsum horizon within 1.0 meter of the surface.

Haplargids are arid-land soils with an ochric epipeden. These soils have an illuvial horizon in which clays have accumulated. Characteristically, they lack duripan, natric, and petrocalcic horizons. Haplargids are often found on late Pleistocene sedimentary surfaces.

Lithic Aridic Haplustolls have a mollic epipeden greater than 18 cm thick. These soils are freely drained and are found in rainfall deficient grasslands or steppes, with summer rainfall. These soils have a lithic contact within 50 cm of the surface.

Lithic Torriorthents are young soils without horizon development that are found on erosional surfaces in regions that experience a torric moisture regime. In addition, these soils have a lithic contact within 50 cm of the surface.

Torrifluvents are young soils without horizon development. Such soils are water-deposited sediments of loamy texture and are only seasonally wet as they are found only in arid regions.

Torripsamments are young soils without horizon development. These soils have a sandy texture and are found in regions with a torric moisture regime and a soil temperature regime warmer than cryic.

Quartzipsamments are young, late Pleistocene or recent soils without horizon development. Such soils have a sandy texture, are found in regions of any climatic regime, and are noted by a high degree of quartz crystalline minerals. These soils are usually light in color.

# APPENDIX X

## PLANTS OF VARIOUS ECOLOGICAL ZONES WITH TAXONOMIC AND COMMON MEXICAN AND AMERICAN NAMES

| | Ecological Zone | | | | | | |
|---|---|---|---|---|---|---|---|
| PLANTS | RW | DS | TF | MS | PT | OW | POW* |
| *Trees* | | | | | | | |
| *Alnus oblongifolia* | | | | | | | x |
| *Arbutus arizonica* | | | | | | | x |
| *Arbutus xalapensis* | | | | | | | x |
| *Ceiba acuminata* | | | | | x | | |
| *Cercidium praecox* | | x | x | x | | | |
| *Erythrina flabelliformus* | | | | | | x | |
| *Eucalyptus globulus* | x | | | | | | |
| *Eysenhadtia orthocarpa* | | | x | | x | | |
| *Ficus* sp. | x | | | | | | |
| *Ipomoea arborescens* | | | x | | x | x | |
| *Juglans major* | x | | | | | | |
| *Juniperus monospermia* | | | | | | x | |
| *Lysiloma thornberi* | | | x | | x | | |
| *Lysiloma watsoni* | | | | | x | x | |
| *Olneya tesota* | | x | x | x | | | |
| *Palmaceae* spp. | x | | | | | x | |
| *Pinus engelmanni* | | | | | | | x |
| *Pinus leiophylla* | | | | | | | x |
| *Plantanus racemosa* | | | | | | | x |
| *Populus fremontii* | x | | | | | | |
| *Prosopis juliflora* | x | x | x | x | x | | |
| *Prosopis pubescens* | x | x | x | x | x | | |
| *Quercus arizonicas* | | | | | | x | x |
| *Quercus chihuahensis* | | | | | | x | |

| PLANTS | Ecological Zone RW | DS | TF | MS | PT | OW | POW |
|---|---|---|---|---|---|---|---|
| *Quercus emoryii* | | | | | | x | |
| *Quercus hypolencoides* | | | | | | | x |
| *Quercus oblongifolia* | | | | | | x | |
| *Salix* sp. | x | | | | | | |
| *Tamarix gallica* | x | | | | | | |
| *Tecoma stans* | | | | | | x | |
| *Shrubs* | | | | | | | |
| *Acacia constricta* | | x | x | x | x | | |
| *Acacia cymbispina* | | x | x | | x | | |
| *Berberis haematocarpa* | | | | | | x | |
| *Berberis trifoliata* | | | | | | x | |
| *Bumelia occidentalis* | | x | | | | | |
| *Bursera schaffneri* | | | x | | x | | |
| *Bursera* sp. | | | x | x | x | | |
| *Capsicum annum* | | | | | x | | |
| *Cassia leptocarpa* | | | | | | x | |
| *Ceanothus huichagare* | | | | | | | x |
| *Celtis pallida* | x | x | | | x | | |
| *Condalia lycoides* | x | x | x | x | | | |
| *Encelia farinosa* | | x | | | | | |
| *Franseria cordifolia* | | x | x | x | | | |
| *Jatropha cardiophylla* | x | x | x | x | | | |
| *Jatropha cordata* | | x | x | x | x | | |
| Jecota (Mex.) | x | | | | | | |
| *Lobelia laxiflora* | | | | | | | x |

| | Ecological Zone | | | | | | |
|---|---|---|---|---|---|---|---|
| PLANTS | RW | DS | TF | MS | PT | OW | POW |
| *Lycium andersonii* | | x | | | | | |
| *Mimosa laxiflora* | x | x | x | x | x | | |
| *Nicotiana glauca* | x | x | | | | | |
| *Pluchea sericea* | | x | x | x | | | |
| *Prunus virens* | | | | | | | x |
| *Rhamnus betulaefolia* | | | | | | | x |
| *Senecio salignus* | x | | | | | | |
| *Cacti* | | | | | | | |
| *Agave palmeri* | | | x | | | | |
| *Agave yaquia* | | | x | x | x | x | |
| *Cereus thurberi* | | x | | x | x | | |
| *Dasylirion* sp. | | | x | x | x | | |
| *Foquieria macdougalii* | | x | x | x | | | |
| *Foquieria splendens* | | x | x | x | | | |
| *Opuntia acanthocarpa* | | x | x | x | x | | |
| *Opuntia arbuscula* | | x | | | | | |
| *Opuntia engelmannii* | x | | | | | | |
| *Opuntia fulgida* | | x | x | | | | |
| *Opuntia tuna* | x | | | x | | | |
| *Yucca arizonica* | | | x | | x | x | |
| *Yucca elata* | | | x | | x | x | |
| *Grasses and Herbs* | | | | | | | |
| *Amaranthus palmeri* | x | | | | | | |
| *Arundo donax* | x | | | | | | |
| *Chenopodium murale* | x | | | | | | |

*Ecological Zones

RW = Riparian Woodland

DS = Desert Scrub Zone

TF = Thorn Forest

MS = Mixed Scrub Zone

PT = Piedmont Transition

OW = Oak Woodland

POW = Pine-oak Woodland

| TAXONOMIC NAME | AMERICAN NAME | MEXICAN NAME |
|---|---|---|
| Trees | | |
| Alnus oblongifolia | Arizona elder | - |
| Arbutus arizonica | Arizona madrone | - |
| Arbutus xalapensis | - | - |
| Ceiba acuminata | kapok | chapapote, pochote |
| Cercidium praecox | palo verde | palo verde |
| Erythrina flabelliformus | western coral bean | - |
| Eucalyptus globulus | eucalyptus | - |
| Eysenhadtia orthocarpa | - | samota |
| Ficus sp. | fig | higuera |
| Ipomoea arborescens | - | palo blanco |
| Juglans major | walnut | nuez |
| Juniperus monospermia | one-seed juniper | juniperus |
| Lysiloma thornberi | - | mauta |
| Lysiloma watsoni | borderpod acacia | tepequaje |
| Olneya tesota | ironwood | palo de hierra |
| Palmaceae spp. | palm | - |
| Pinus engelmanni | apache pine | pino ponderosa |
| Pinus leiophylla | Chihuahuan pine | pino |
| Plantanus racemosa | sycamore | - |
| Populus fremontii | cottonwood | - |
| Prosopis juliflora | honey mesquite | mezquite |
| Prosopis pubescens | screwbean mesquite | mezquite |
| Quercus arizonicas | Arizona white oak | encino blanco |

| TAXONOMIC NAME | AMERICAN NAME | MEXICAN NAME |
|---|---|---|
| Quercus chihuahensis | Chihuahuan oak | encino |
| Quercus emoryii | Emory oak | bellota |
| Quercus hypolencoides | silverleaf oak | encino |
| Quercus oblongifolia | mexican blue oak | bellota de cochi |
| Salix sp. | willow | - |
| Tamarix gallica | tamarisk, salt cedar | - |
| Tecoma stans | yellow elder | tronadora |
| Shrubs | | |
| Acacia constricta | mescat acacia | - |
| Acacia cymbispina | boatthorn acacia | vinorama |
| Berberis haematocarpa | barberry | - |
| Berberis trifoliata | Texas algerita | palo amarillo |
| Bumelia occidentalis | - | - |
| Bursera schaffneri | - | torrote negro |
| Bursera sp. | - | torrote blanco |
| Capsicum annum | - | chiltepin |
| Cassia leptocarpa | senna rattlewood | - |
| Ceanothus huichagare | - | - |
| Celtus pallida | desert hackberry | garambullo |
| Condalia lycoides | - | - |
| Encelia farinosa | - | chicurilla |
| Franseria cordifolia | - | - |
| Jatropha cardiophylla | bloodroot | sangregado negro |
| Jatropha cordata | bloodroot | sangregado blanco |
| Lobelia laxiflora | looseflowered lobelia | jecota |

| TAXONOMIC NAME | AMERICAN NAME | MEXICAN NAME |
|---|---|---|
| *Lycium andersonii* | - | - |
| *Mimosa laxiflora* | catclaw | una del gato |
| *Nicotiana glauca* | tree tobacco | - |
| *Pluchea sericea* | arrow herb | yerve la flecha |
| *Prunus virens* | southwestern chokeberry | - |
| *Rhamnus betulafolia* | birchleaf buckthorn | - |
| *Senecia salignus* | willow groundsel | jarilla |
| *Cacti* | | |
| *Agave palmeri* | century plant | lechugilla |
| *Agave yaquia* | century plant | bacanora |
| *Cereus thurberi* | organpipe | pitahaya |
| *Dasylirion* sp. | sotol | - |
| *Foquieria macdougalii* | Sonoran ocotillo | ocotillo |
| *Foquieria splendens* | coachwhip ocotillo | ocotillo |
| *Opuntia acanthocarpa* | buckhorn cholla | cholla |
| *Opuntia arbuscula* | pencil cholla | cholla |
| *Opuntia engelmannii* | prickly pear | nopal |
| *Opuntia fulgida* | jumping cholla | cholla |
| *Opuntia tuna* | prickly pear | - |
| *Yucca arizonica* | broadleaf yucca | yucca |
| *Yucca elata* | soaptree yucca | palmilla |

| TAXONOMIC NAME | AMERICAN NAME | MEXICAN NAME |
|---|---|---|
| Grasses and Herbs | | |
| Amaranthus palmeri | amaranth | quelite |
| Arundo donax | reed | carrizo |
| Chenopodium murale | - | chual |

APPENDIX XI

RECENT LANDSCAPE MODIFICATIONS

Legend

Modern Pueblos

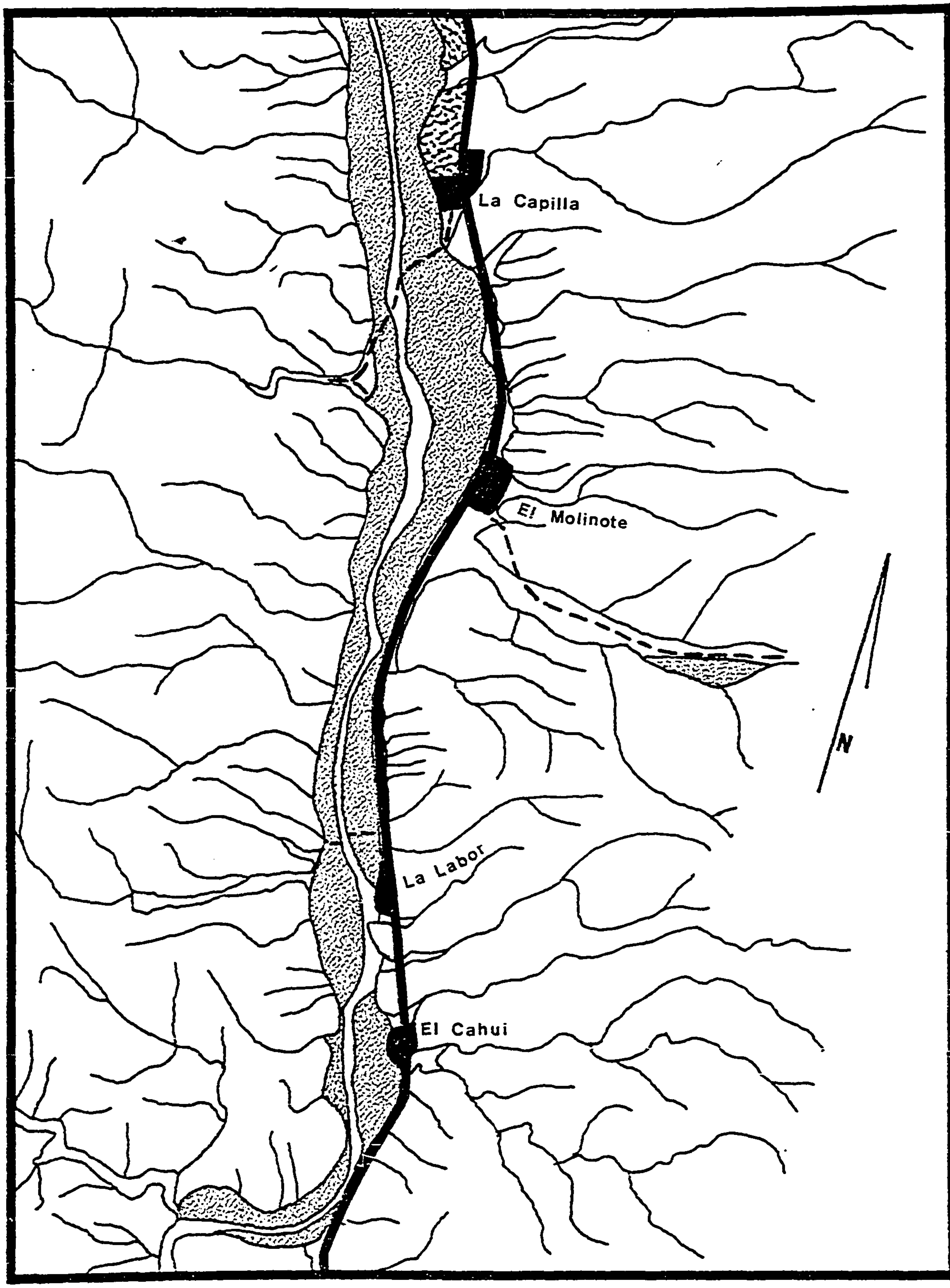
Intensive Agricultural Land

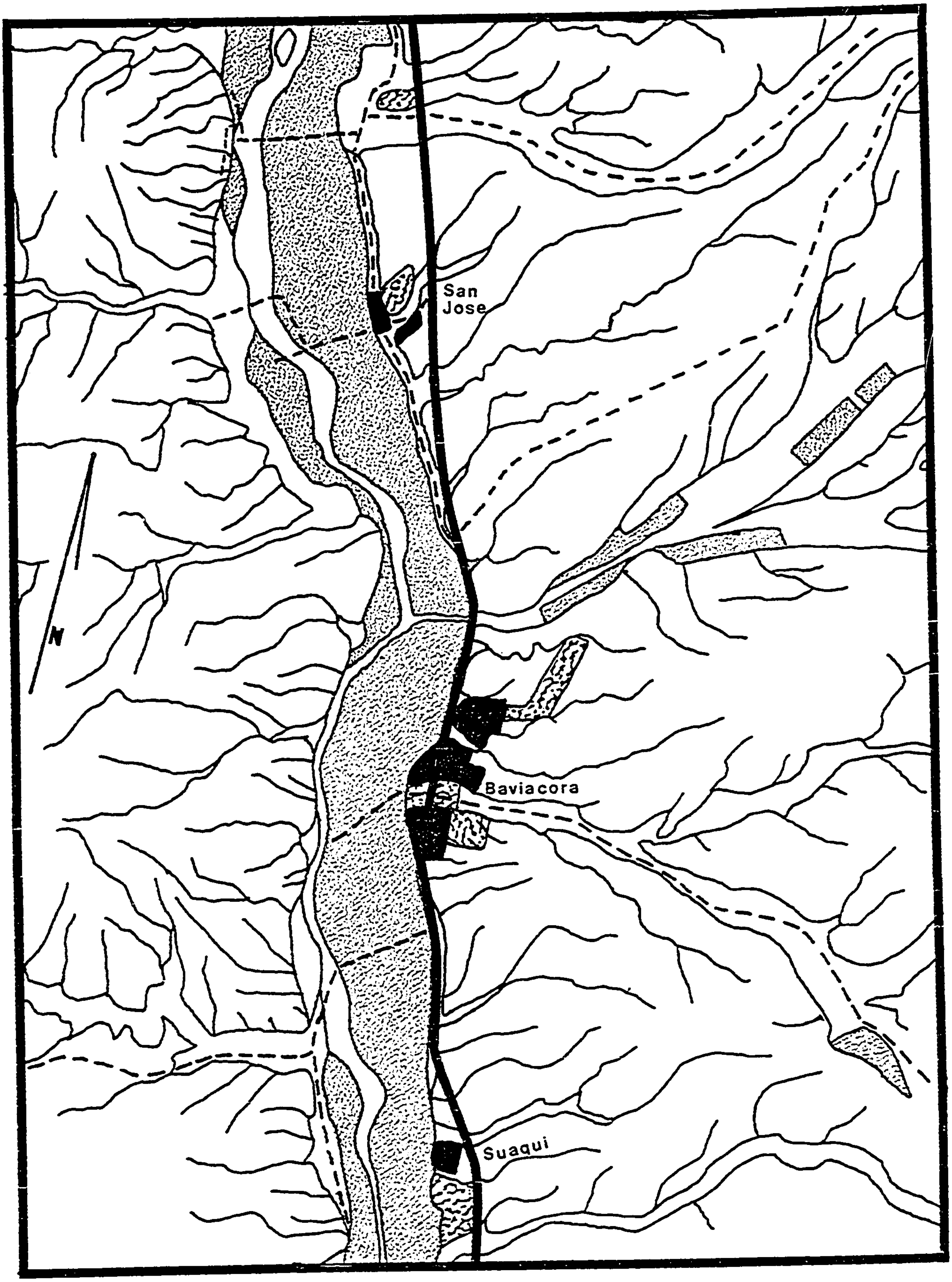
Airports, Orchards, etc.

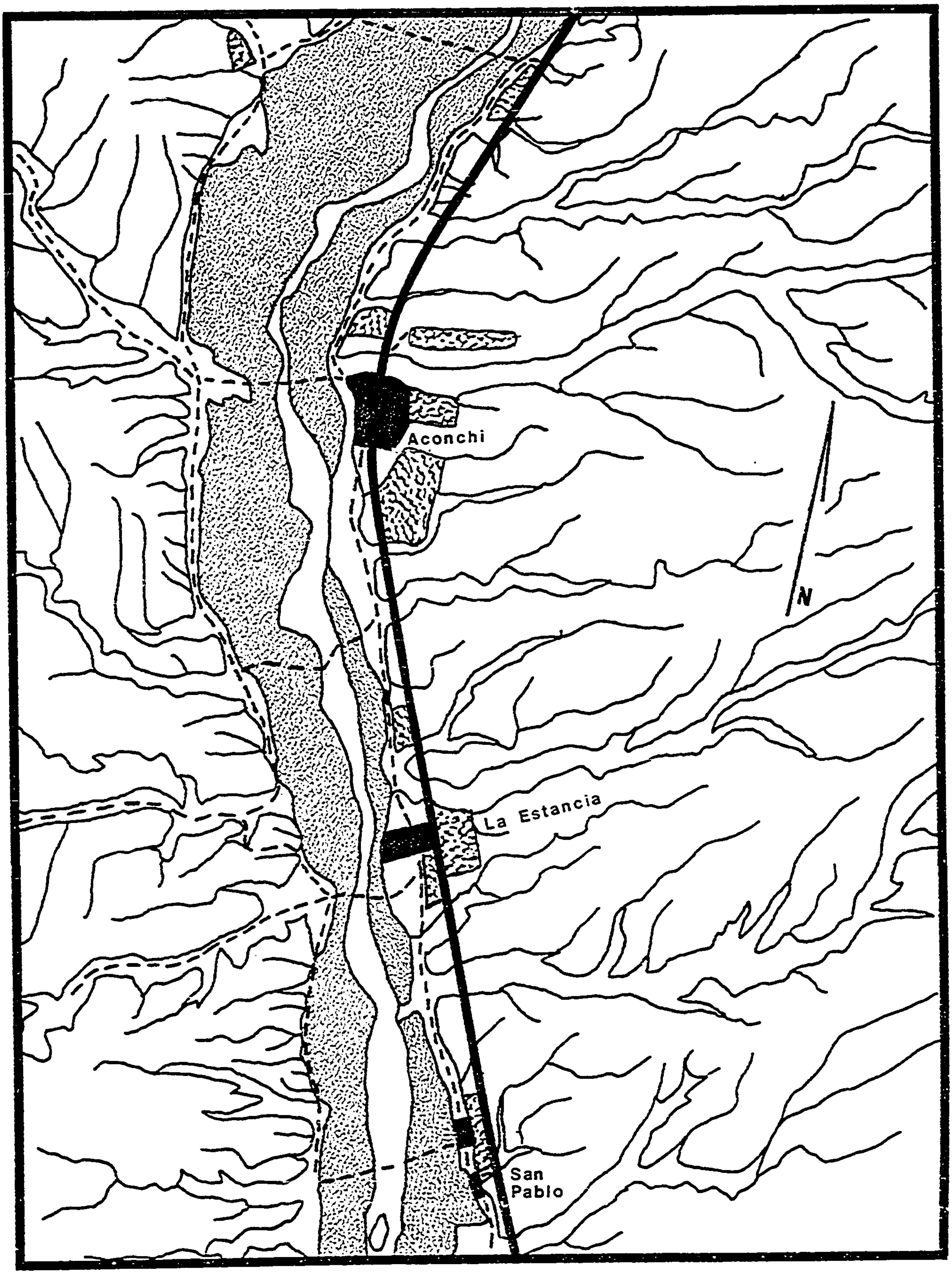
Pavement (Sonora 118)

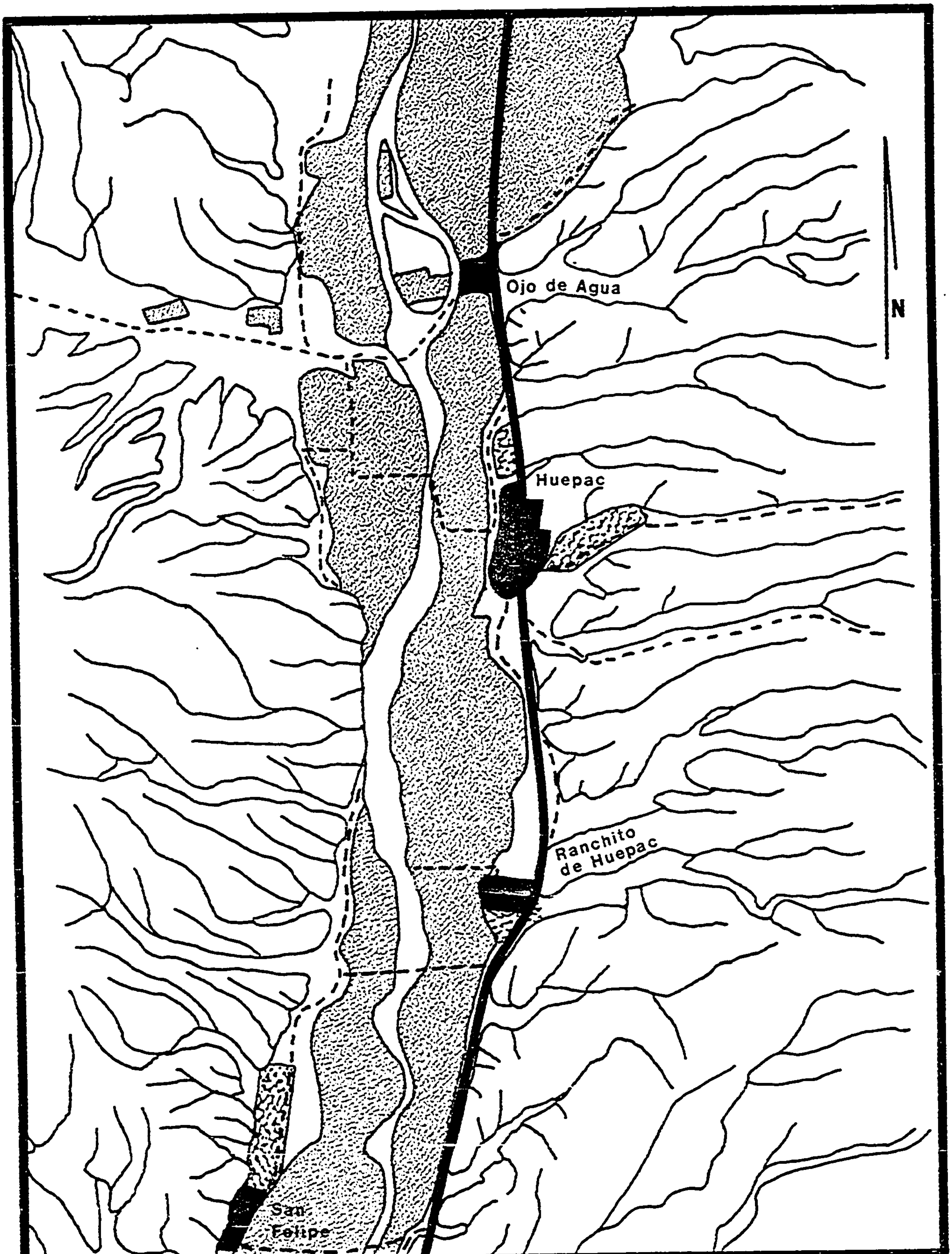
Unpaved roads

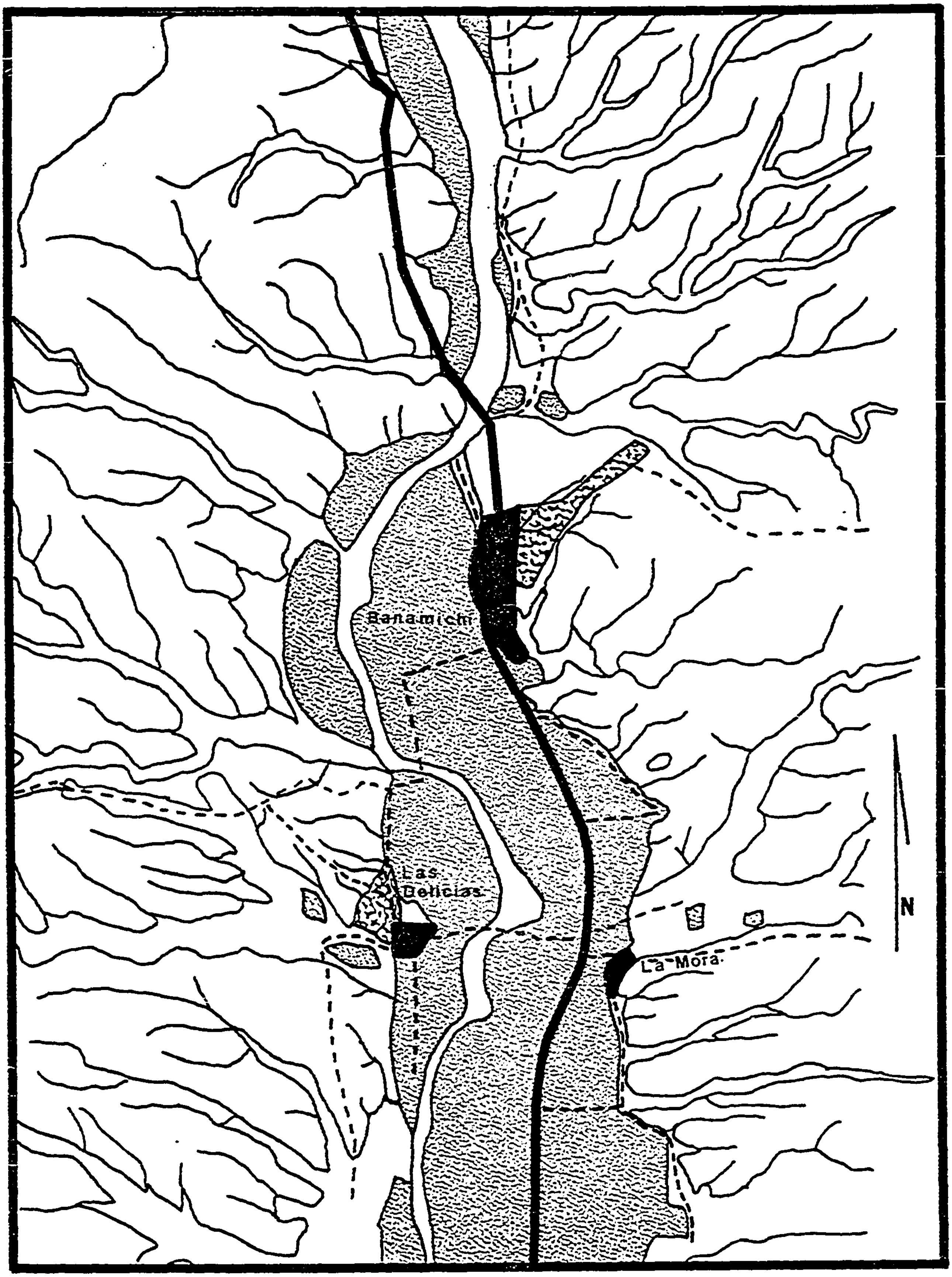
Scale 1:50,000


La Capilla
El Molinote
N
La Labor
El Cahui


San
Jose
N
Baviacora
Suaqui


Aconchi
N
La Estancia
San
Pablo


Ojo de Agua
N
Huepac
Ranchito de Huepac
San Felipe


Banamichi
Las
Delicias
La Mora
N

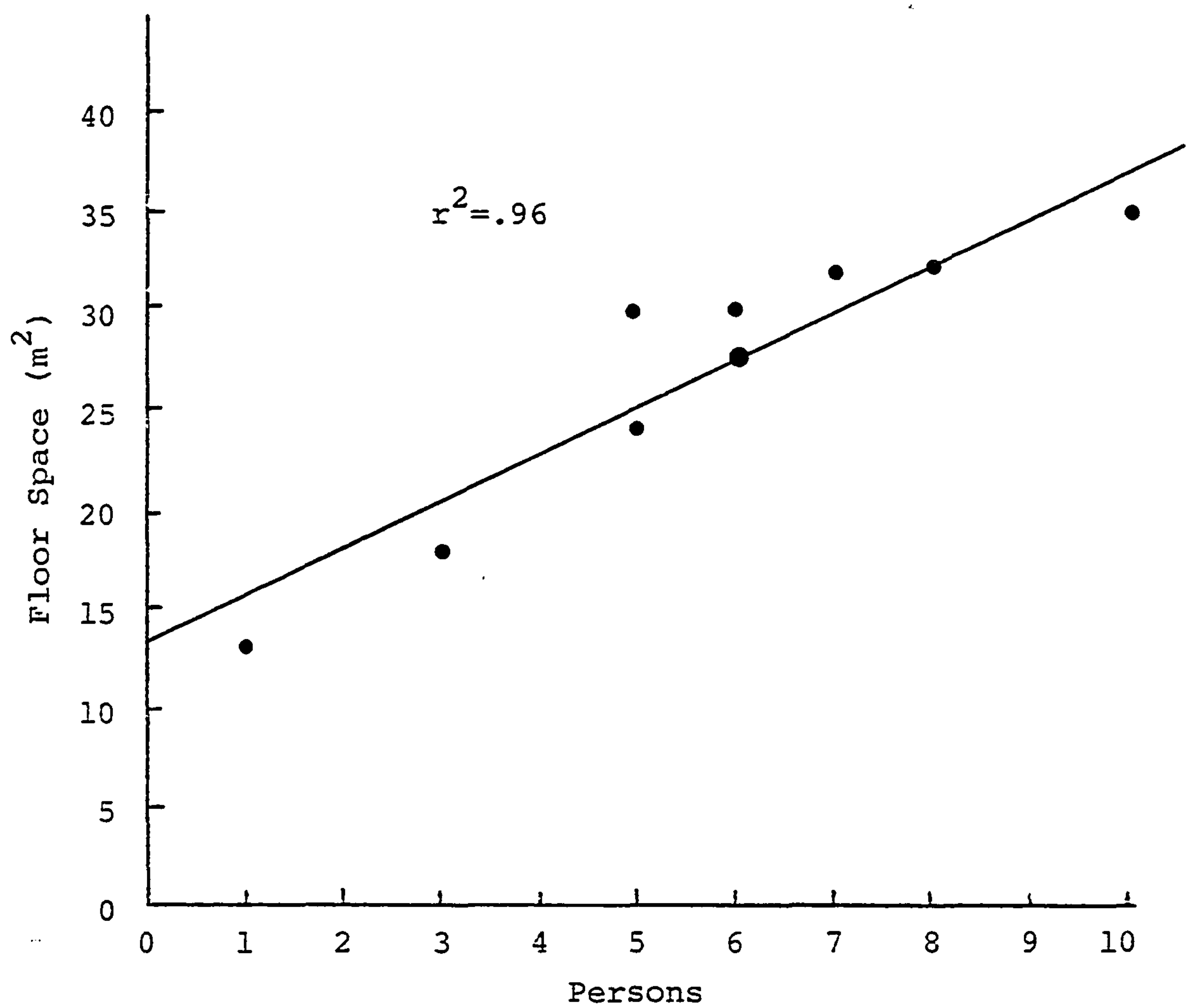
APPENDIX XII

MODERN HOUSE SURVEY DATA

| No. | Pueblo | Door Location | Rooms No. | Floor Space ($M^2$) | Residents No. | Electricity | Roof Mat. | Floor Mat. | Fence Mat. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | N. Banámichi | east | 2 | 28 | 6 | no | carrizo | dirt | none |
| 2 | Banámichi | west | 2 | 24 | 5 | yes | tin | adobe | none |
| 3 | Las Delicias | west | 2 | 32 | 8 | yes | carrizo | dirt | ocotillo |
| 4 | Banámichi | west | 2 | 30 | 6 | yes | carrizo | dirt | ocotillo |
| 5 | El Rodeo | east | 2 | 30 | 6 | yes | tin | adobe | ocotillo |
| 6 | San Pablo | south | 2 | 27 | 6 | yes | tin | adobe | wire |
| 7 | Aconchi | east | 1 | 18 | 3 | yes | carton* | adobe | ocotillo |
| 8 | Huepac | west | 2 | 35 | 10 | yes | tin | adobe | wire |
| 9 | Las Delicias | east | 3 | 27 | 6 | no | carrizo | adobe | ocotillo |
| 10 | Las Delicias | west | 2 | 32 | 7 | yes | carrizo | adobe | ocotillo |

*Carton is a creosote-covered corregated cardboard.

All structures were rectangular surface structures with embedded rock foundations, adobe brick walls, and no indoor plumbing or kitchens.




FLOOR SPACE PER RESIDENT OF MODERN HOUSES

APPENDIX XIII

SURVEY FORMS

ENVIRONMENTAL SURVEY

Area No.__________ Recorder______________
Date ______________

LOCATION:
Map No.__________ Photo No.____________
Long.____________ Lat. ______________
Directions to area:______________________

PHYSIOGRAPHY:
Landuse (current) ____________________
Elev. ____________ Relief ______________
Slope (degree & orientation) ____________
% outcrop __________ Geology ______________

SOIL: Bag No. ______________

| Depth | Description |
|---|---|
| ____________ | ____________________ |
| ____________ | ____________________ |
| ____________ | ____________________ |
| ____________ | ____________________ |

Soil origin____________________________
Erosional Evidence:

Comments:

VEGETATION:

Plants per 10m. ______________________________
Max. dist. between plants ________________
Dominant plant ______________________________
Avg. Ht. _____________ Avg. Dia. ___________

Grass--(present?, characteristics)

Cacti--(type/no./ht.)

Shrubs--(type/no./ht.)

Trees--(type/no./ht.)

Possible resources--

Comments--

SURVEY FORM

Site No.__________________ Site Name________________________

Recorded by:______________________________Date:____________

Location:

Map No.:__________________Coordinates:___________________

Other Maps:________________Aerial Photo:_________________

Directions to site:_________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

Owner:______________________Address:_____________________

____________________________________________________________

Description:

Type:

Size:____________________ No. of Structures:____________

Type of structures: Pithouse__________; Mound_________;

Rectangular Surf.________;Platform_______;Terrace_______;

Circular_________;Pitoven__________;Other_____________

Describe:

Foundations: Single Row_____;Double Row_____;Other________

Contiguous or Separate rooms:_____________________________

Vegetation: ____________________________________________

____________________________________________

Subsistence evidence: Canals ________; Check dams ________;

Terraces ________; Grinding Tools ______; Roasting pits ______;

Bone __________; Other ______________________________

Water Source: Type ______________________________

Distance from site: ______________________________

Arable Land: Amount ______________________________

Distance from site: ______________________________

Condition of site:

Logistics for Excavation:

Additional Comments:

Photos:

Site: ____________________

Other structures or features: ____________________

____________________

____________________

Historic Occupation--describe:

Collections:

Control (describe): Bag No. ________

________

________

General: ________

Special (describe): ________

________

________

Material Collected: Sherds ______; Ground stone ________;

Chipped Stone _______; Shell _________; Bone __________

Other: ____________________

____________________

Surface Pollen: ____________ Sample No. ______________

Location: ____________________

Plant Collection: ________ Describe: ______________

____________________

Soil Sample: ____________ Sample No. ______________

Physiographic province: ____________________

Regional Topography: ____________________

Local Topography: ____________________

____________________

Site Surface: ____________________

____________________

Draw Map:

Add Pages as Necessary.

MODERN HOUSE SURVEY

House No.____________ Pueblo_______________

Orientation (door faces)___________________

Rooms No. _________ Room Types

Total Sq. Meterage________________________

Persons in Residence (No.) _________________

Adults_____________ Children_______________

Foundation Type____________________________

Wall Material______________________________

Roof Material______________________________

Plumbing____________ Indoor kitchen________

Floor Material_____________________________

Fenced Yard_________ Fence Type____________

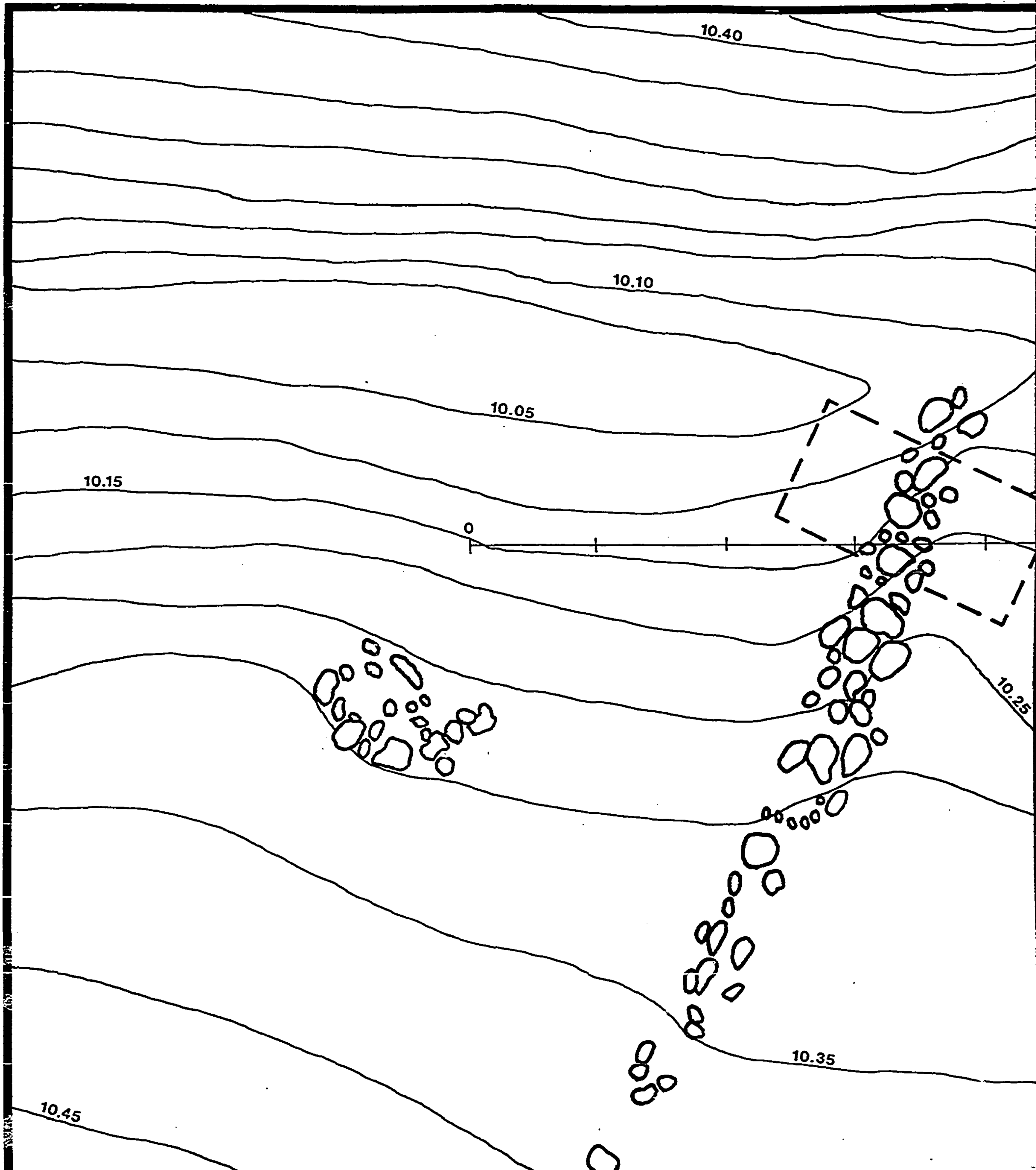
No. Residence sleeping outdoors in
the summer______________________________

Household head employment__________________

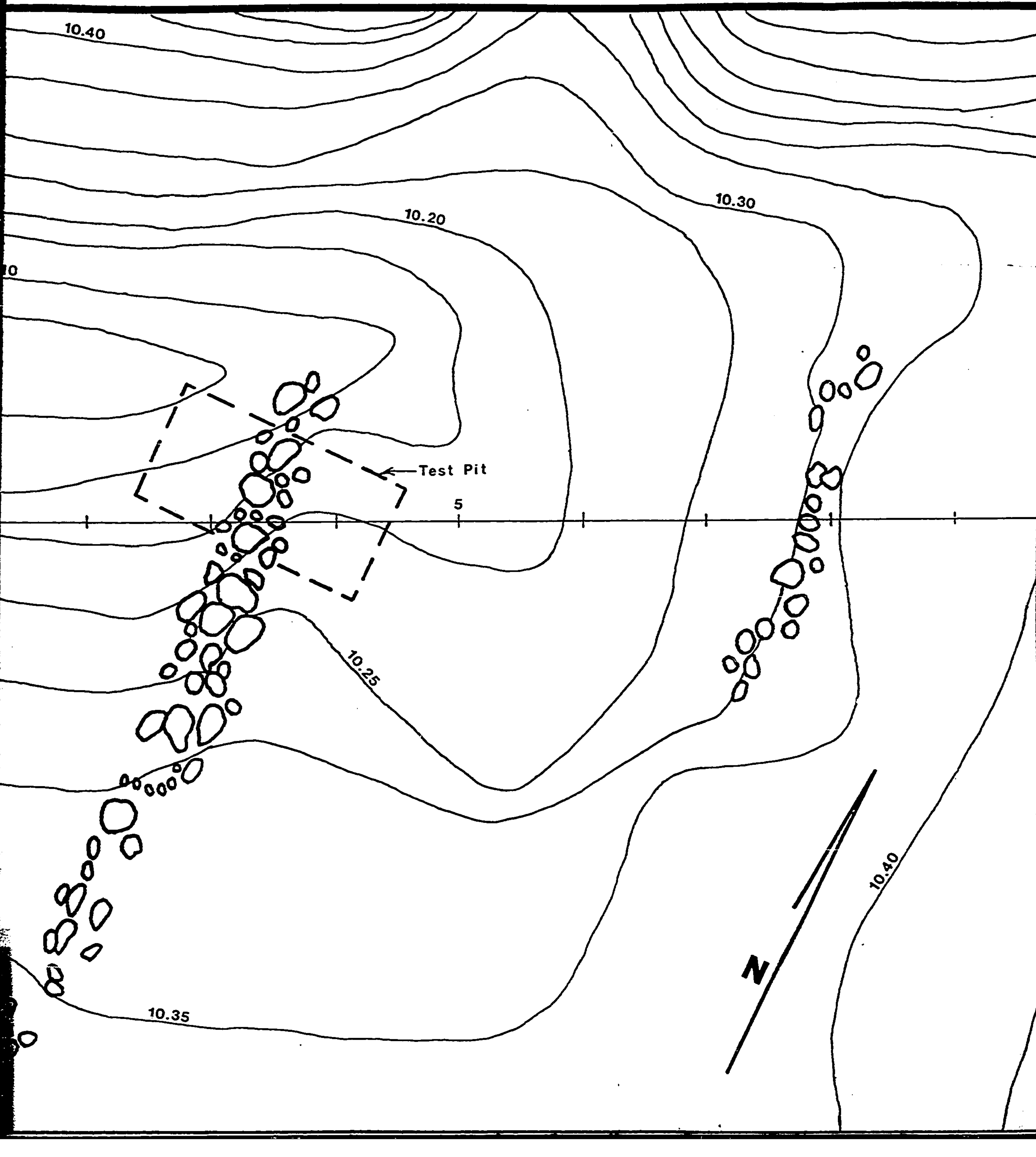
Recorder_________________ Date_____________

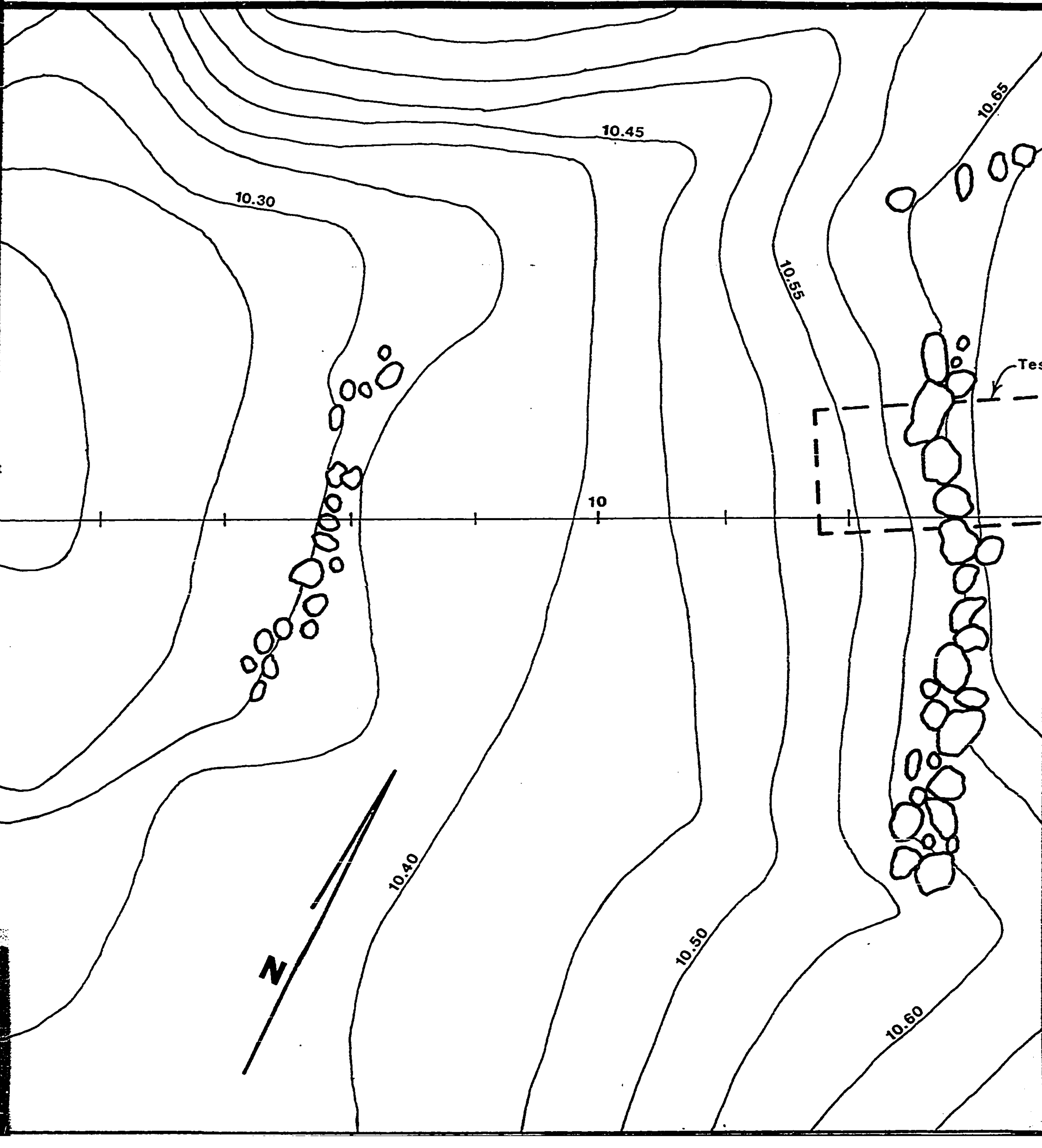
Comments:

Draw floor plan with dimensions on back.



10.40
10.10
10.05
10.15
0
10.25
10.35
10.45


10.40
10.30
10.20
10
Test Pit
5
10.25
10.40
N
10.35



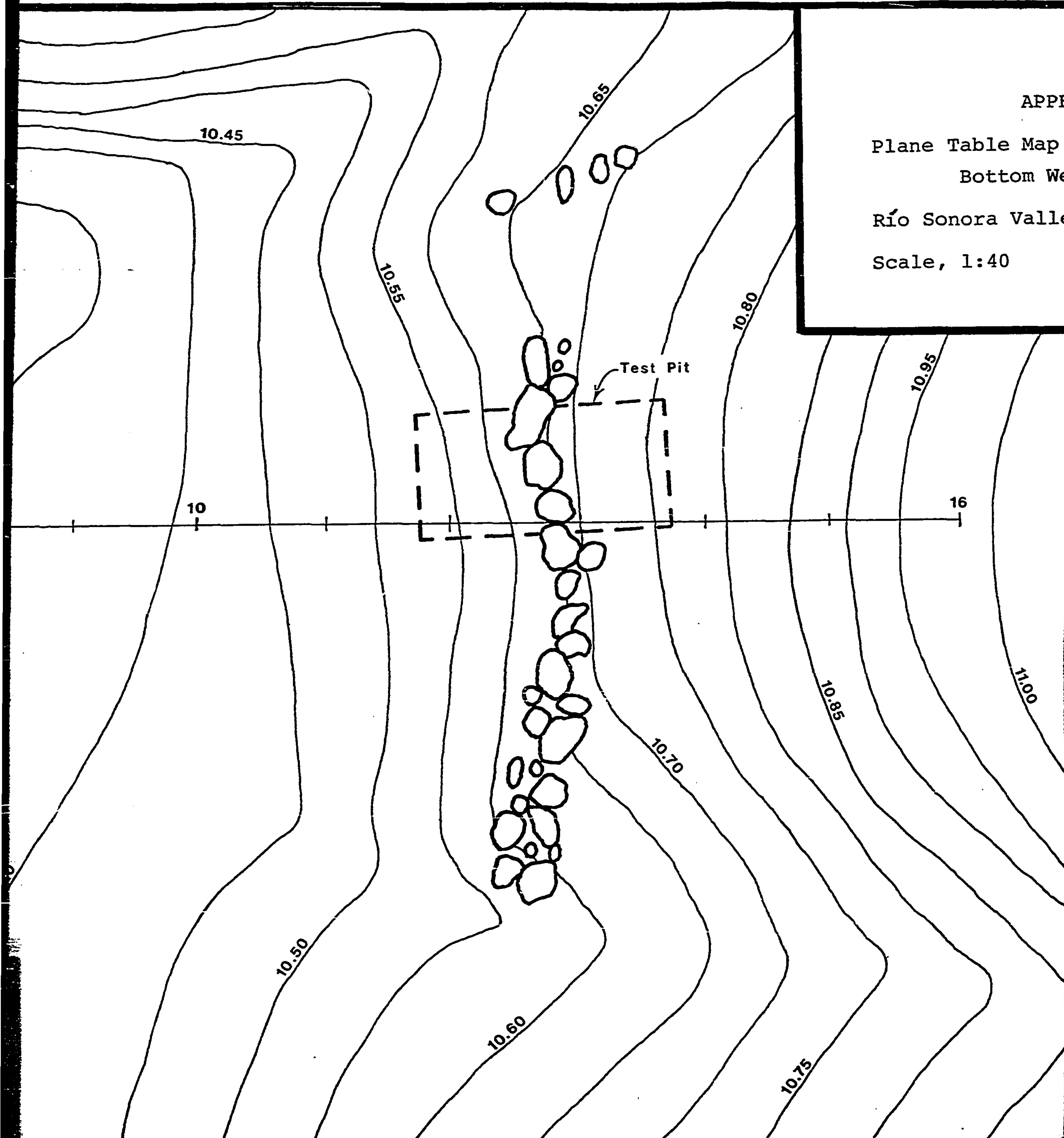
10.30
10.45
10.55
10.65
Tes
10
10.40
N
10.50
10.60

APPE

Plane Table Map
Bottom We

Río Sonora Valle

Scale, 1:40



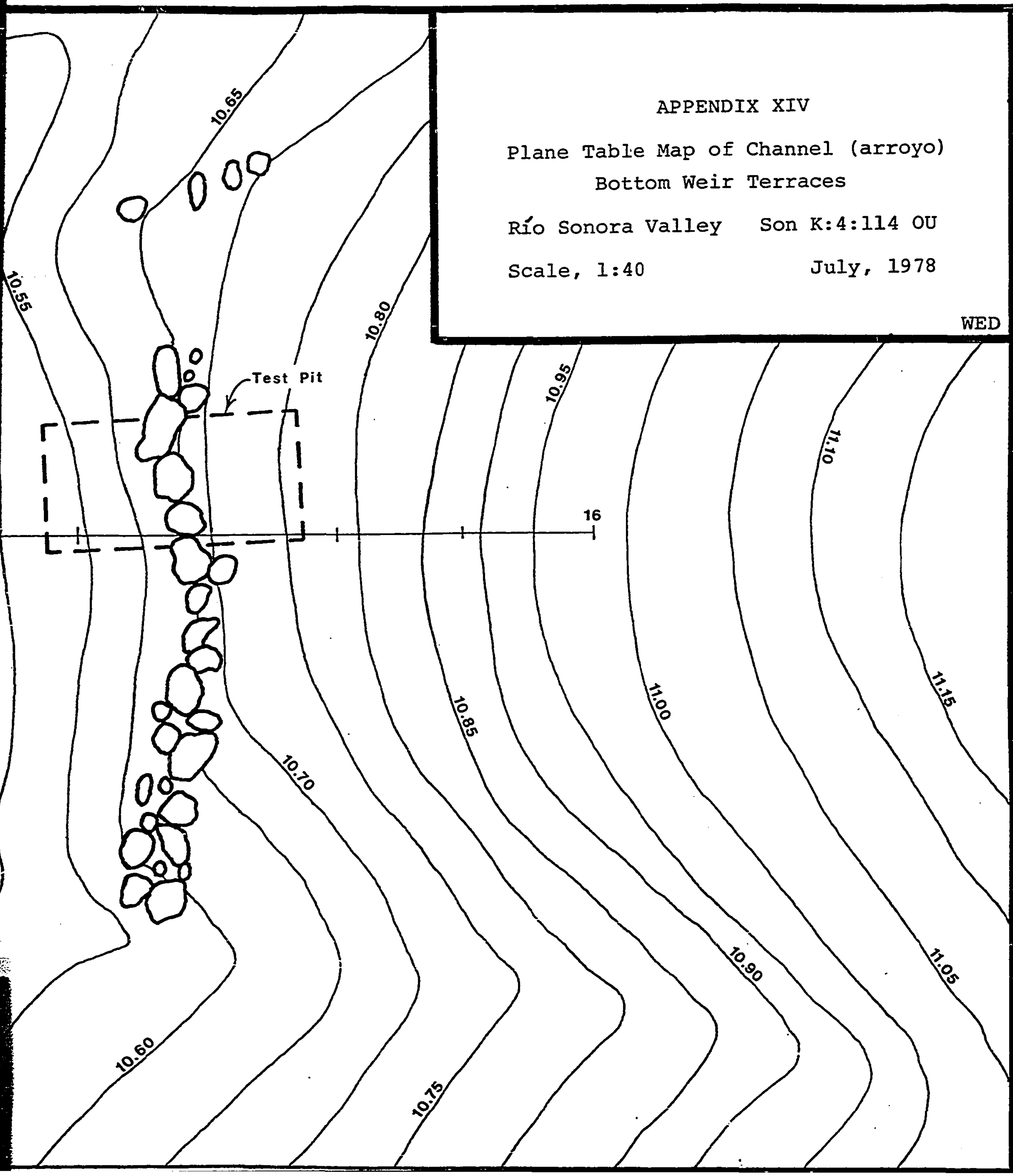
APPENDIX XIV

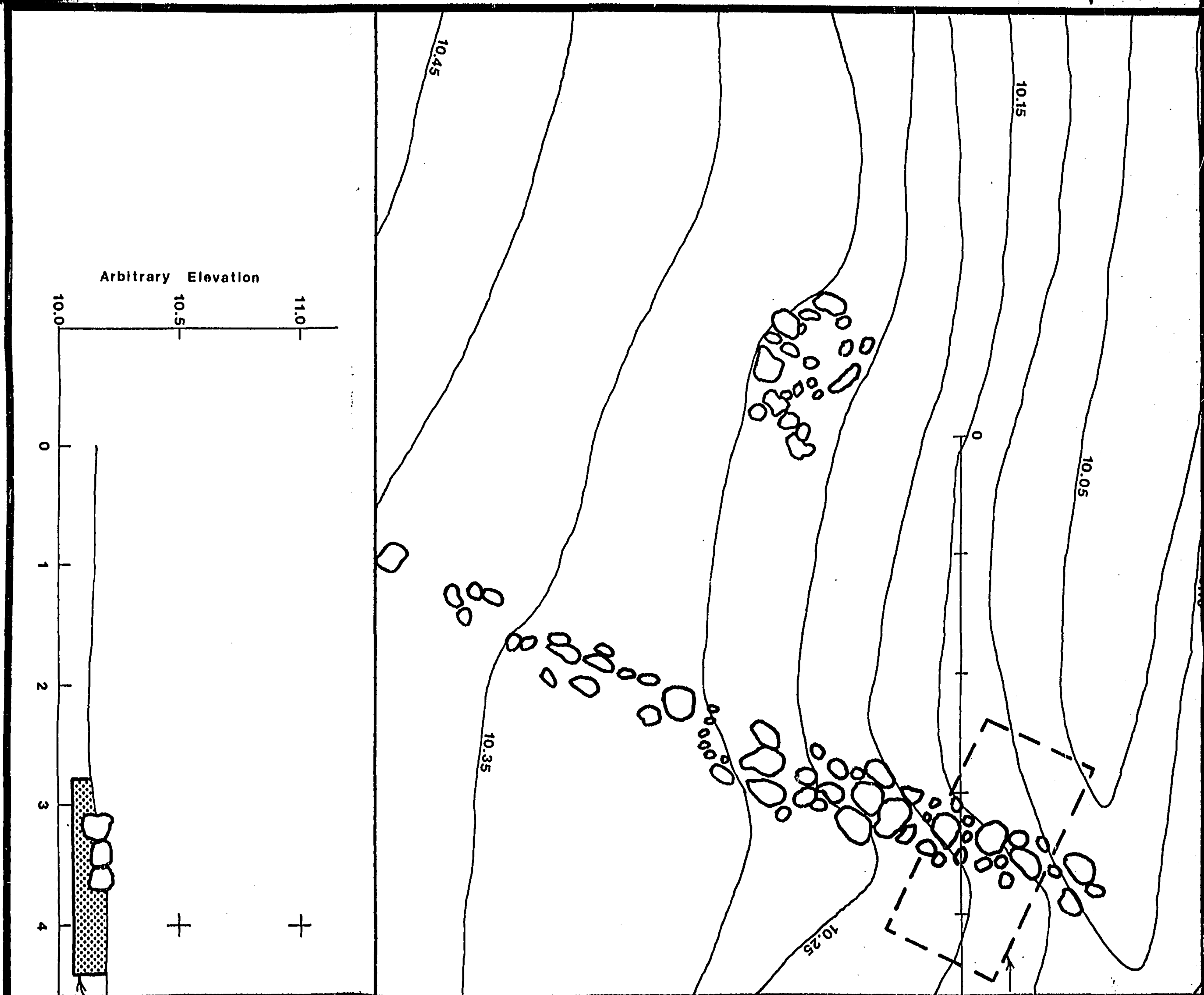
Plane Table Map of Channel (arroyo) Bottom Weir Terraces

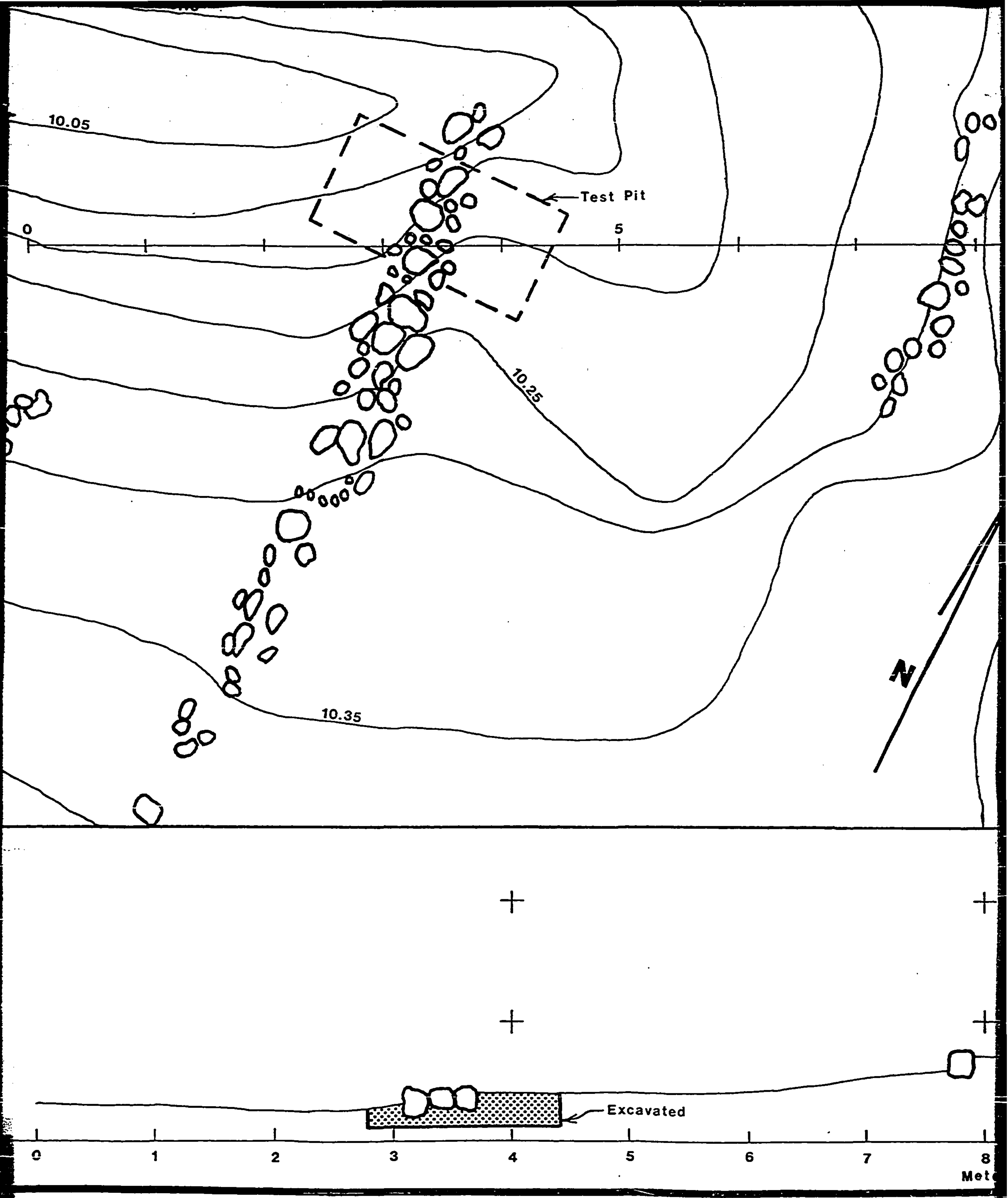
Río Sonora Valley Son K:4:114 OU

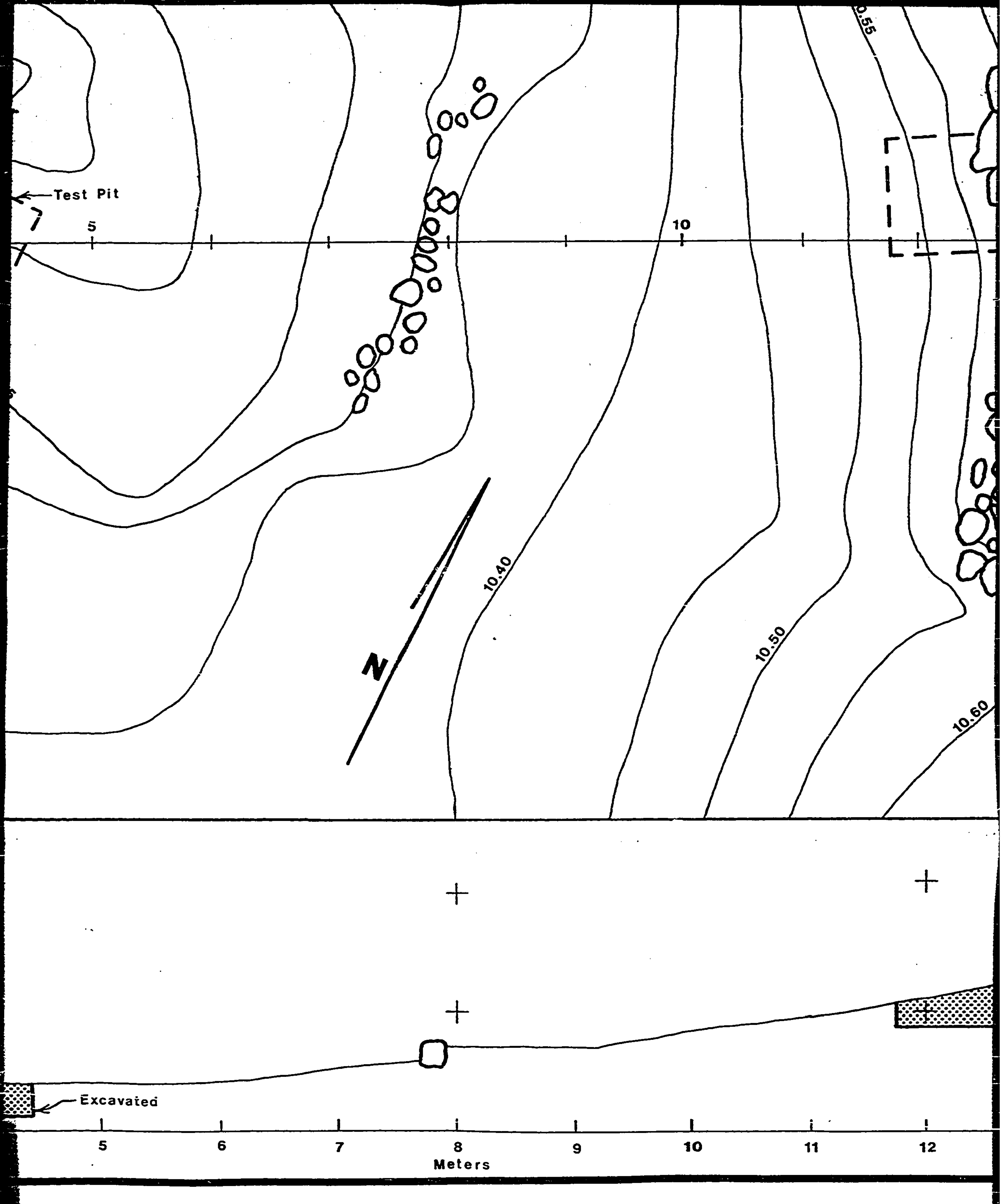
Scale, 1:40 July, 1978

WED

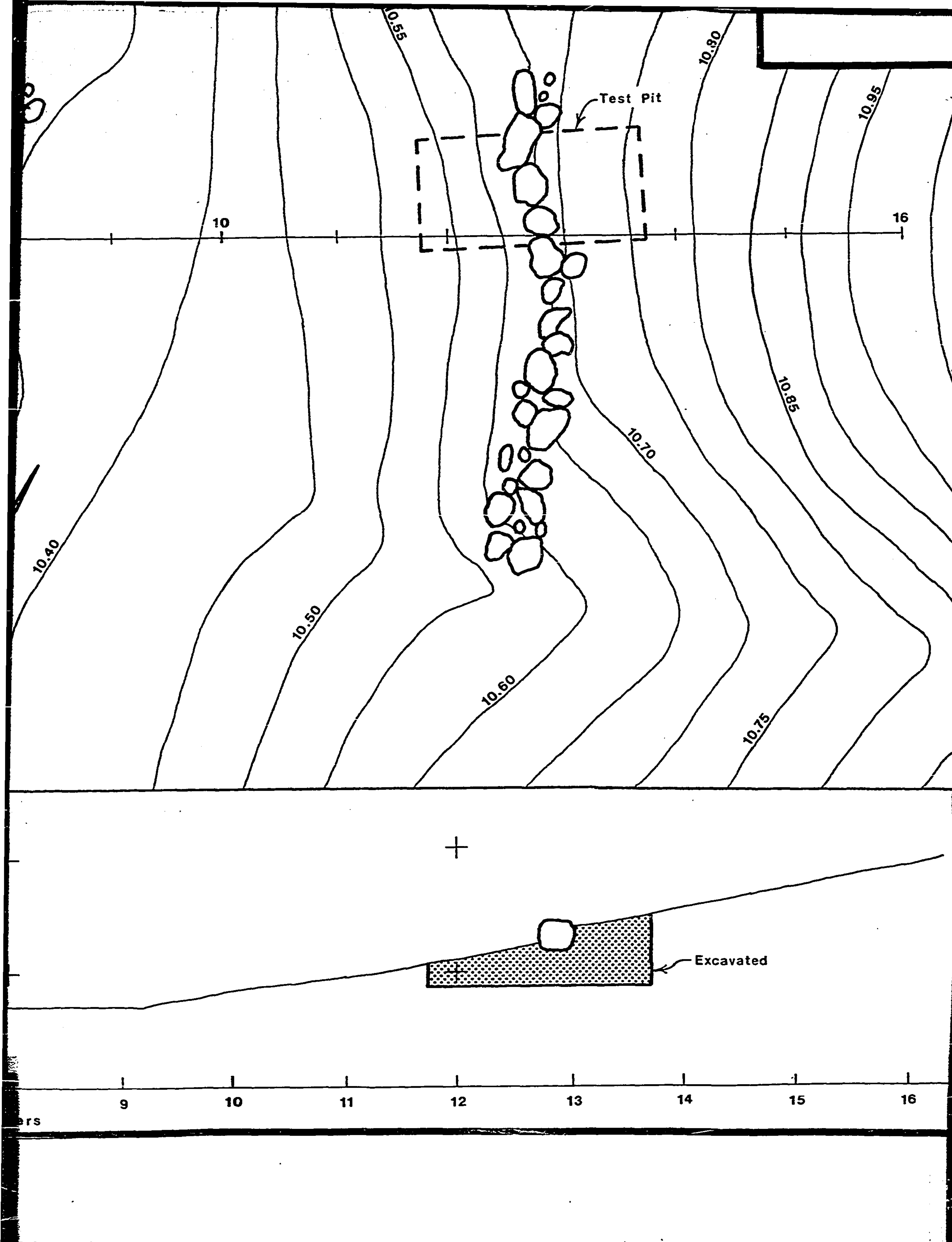



Arbitrary Elevation
10.0
10.5
11.0
0
1
2
3
4
10.45
10.35
10.25
10.15
10.05
0

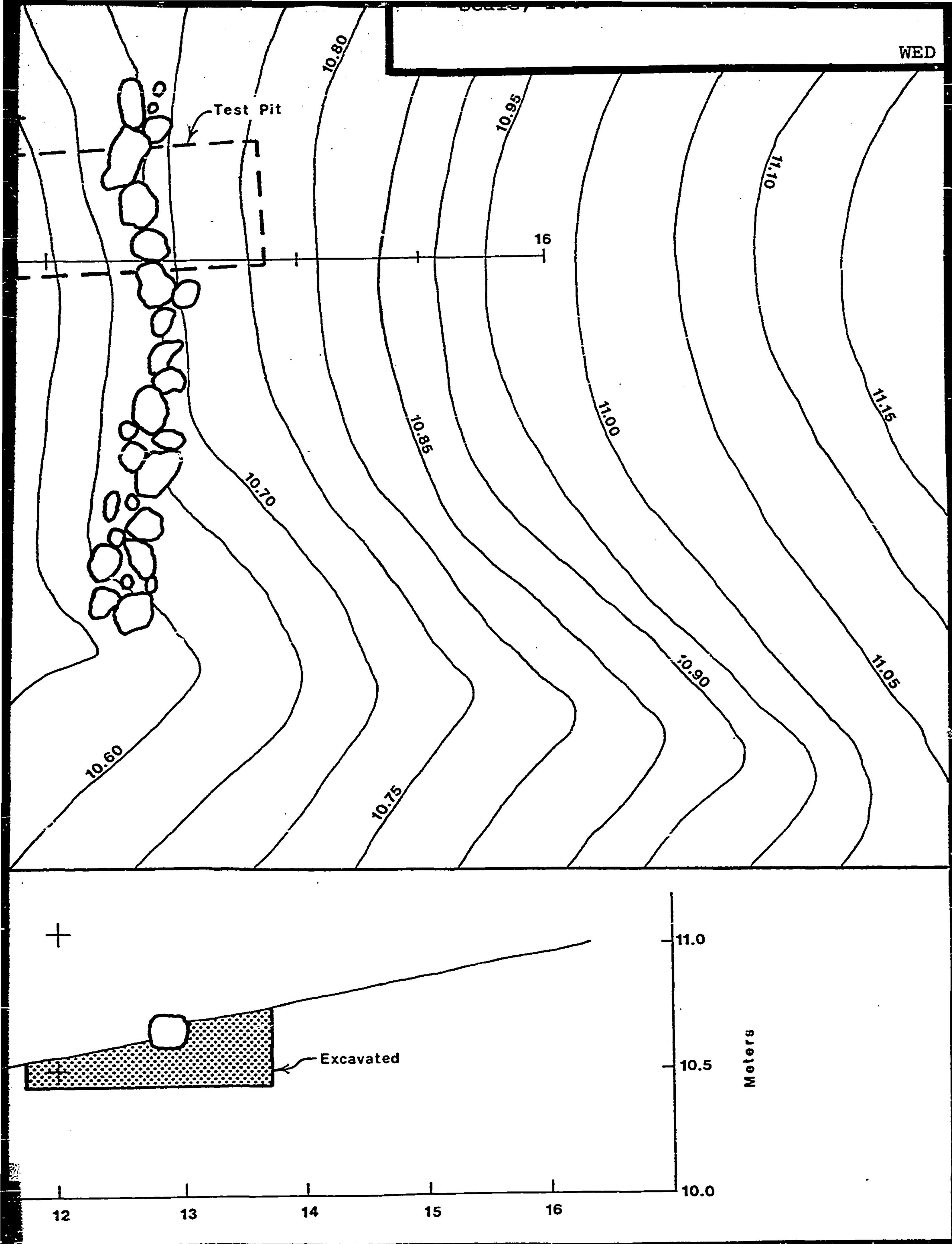

10.05
Test Pit
0
5
10.25
10.35
N
Excavated
0
1
2
3
4
5
6
7
8
Met



Test Pit
5
10
10.55
10.40
10.50
10.60
N
Excavated
5
6
7
8
9
10
11
12
Meters



Test Pit
10
16
10.40
10.50
10.55
10.60
10.70
10.75
10.80
10.85
10.95
Excavated
9
10
11
12
13
14
15
16
ers


WED
Test Pit
10.80
10.95
11.10
16
11.15
11.00
10.85
10.70
10.90
11.05
10.60
10.75
11.0
Excavated
10.5
Meters
10.0
12
13
14
15
16