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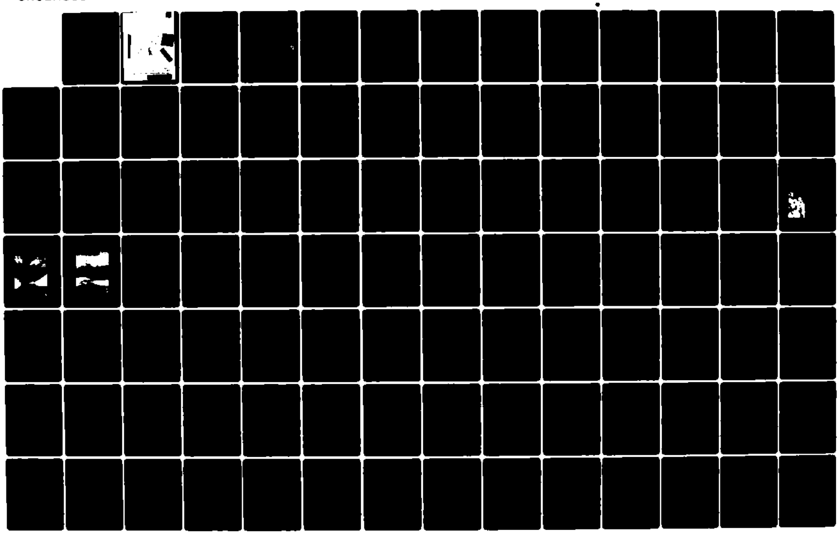

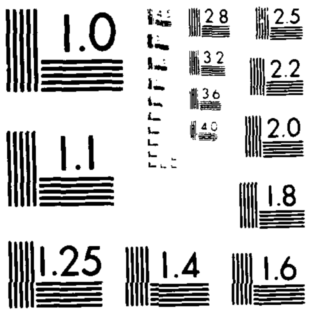

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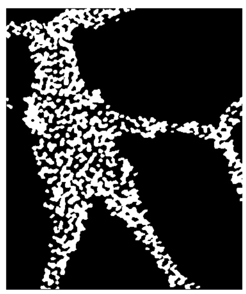

ARCHEOLOGICAL INVESTIGATIONS IN COCHITI RESERVOIR, NEW MEXICO
VOLUME 4: ADAPTIVE CHANGE IN THE NORTHERN RIO GRANDE VALLEY

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ARCHEOLOGICAL INVESTIGATIONS IN COCHITI RESERVOIR, NEW MEXICO
VOLUME 4: ADAPTIVE CHANGE IN THE NORTHERN RIO GRANDE VALLEY

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and
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Submitted by

Frank J. Broilo
Principal Investigator

to

National Park Service

funded by

U.S. Army Corps of Engineers
Albuquerque District

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Office of Contract Archeology
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University of New Mexico

1979

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ABSTRACT

This volume is the final report concerning a five year long archeological project which was undertaken to recover information about cultural resources within the present area of Cochiti Reservoir in the northern Rio Grande Valley of New Mexico. Three previous volumes have summarized data recovered from intensive surveys and two seasons of excavation within the reservoir boundaries. These reports have served as basic documentation required by Federal law to mitigate the destruction of archeological remains caused by flooding. This volume serves as an interpretive and analytical synthesis of those data.

In 21 chapters, the contributors to this report provide detailed analyses of settlement, subsistence and adaptive changes which characterize the human occupation of the northern Rio Grande Valley over the last four millenia. Papers are grouped according to broad cultural and temporal periods of adaptation—Archiac, prehistoric Pueblo and Historic Spanish—and emphasize analysis of residential size, subsistence pursuits and economic articulation of the occupants within the region during each period of adaptation. Particular emphasis is placed upon developing and evaluating a number of models proposed to account for settlement dynamics and adaptive change through time.

A diverse assortment of methodological studies are included as well. Specific topics range from techniques to identify properties of social structure and organization in the archeological record, to experiments evaluating the effect current field and laboratory processing procedures may have on lithic wear patterns. New data concerning the modern vegetative make-up of the reservoir locale and a quantitative assessment of the availability of lithic source materials are also presented.

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PREFACE

This volume is the fourth and last in a publication series concerning an archeological research program in Cochiti Reservoir, New Mexico, performed by personnel from the Office of Contract Archeology, Department of Anthropology, University of New Mexico. This research has been implemented under the auspices of Federal and State legislation which establishes a policy of preservation and conservation of cultural resources with recognition that cultural resources are limited and nonrenewable phenomena which require protection to insure their long-term productivity to benefit the American public and professional archeological community.

The multiphase research program has been conducted over a five year period and encompasses a cultural resource assessment, two intensive archeological surveys within the reservoir boundaries, and two mitigative phases involving excavation. The results of the assessment and two survey stages have been summarized in the first report in the current publication series entitled *Archeological Investigations in Cochiti Reservoir, New Mexico Volume 1: A Survey of Regional Variability*, edited by Jan V. Biella and Richard C. Chapman. This report, published in 1977, synthesizes previous archeological, historical and ecological literature available for the general reservoir locality within a cultural ecological framework. In all, 327 sites spanning Archaic, Anasazi and Historic periods of adaptation were described and their scientific significance was assessed.

The second report, *Archeological Investigations in Cochiti Reservoir, New Mexico Volume 2: Excavation and Analysis 1975 Season* (Chapman and Biella 1977), presented the results of a research program designed to mitigate, to the greatest possible extent, the adverse impacts upon those resources situated in the permanent pool of the reservoir. Thirty-two sites in all spanning each of the different cultural periods represented within the reservoir were summarized in this volume. In addition to presenting reports describing the character of each excavated site, a detailed set of chapters which outlined the rationale underlying the methodological approach adopted in the mitigation program was presented.

The third report, *Archeological Investigations in Cochiti Reservoir, New Mexico Volume 3: 1976-1977 Field Seasons* (Biella 1979), presented the results of a mitigation program developed for those sites situated in the flood control pool of the reservoir. Overall, this mitigation program was designed to augment the 1975 sample and paralleled the approach outlined in the second volume. Twenty sites were examined during the 1976 and 1977 field seasons spanning late Archaic, Anasazi (Pueblo III, IV), and Historic (Spanish Colonial and Territorial) phases.

One overriding concern affecting the structure and organization of each of these reports was a desire to present the data collected during the project in a manner which would aid future researchers. It is our opinion that one important factor to insure long-term productivity of the cultural resources in the reservoir is dependent upon an explicit statement of the methods of analysis and presentation of basic data in a format which facilitates easy data retrieval. Thus, each of the first three volumes is highly tabular in format and includes intentionally descriptive sections in the body of each report.

This fourth volume has been designed as a final interpretive report which uses information presented in the first three volumes as a basis for analytical treatment of each period of prehistoric and historic adaptation. The present report thus emphasizes analysis and synthesis of data gathered not only throughout the course of the Cochiti Reservoir Project but, in addition, treats data gathered by other researchers in the northern Rio Grande Valley.

Our intent in this volume is to present a series of papers which address a diverse set of topics concerning aspects of man's use of the locality encompassed by the present Cochiti Reservoir. The opportunity to devote an entire volume toward this kind of analytical summary of a contract research project is unusual and we would like to extend our thanks to Donna Roxey of the Army Corps of Engineers, Albuquerque District; and Cal Cummings, Bruce Anderson and Ron Ice of the National Park Service, Southwest Division. These individuals were instrumental in permitting this volume to be completed.

With this volume, the Cochiti Reservoir Project is concluded. It is our hope that the results of the project, when judged from the perspective of future research, will have served two major purposes. We hope the research will provide a lasting contribution to future understanding of man's past in the northern Rio Grande Valley as a comprehensive and usable data set; and we hope that it will provide at least a short-term contribution toward contemporary research through presentation of the models, tests, summaries, and methodological studies which are found in the volume at hand.

ARCHEOLOGICAL INVESTIGATIONS IN COCHITI RESERVOIR, NEW MEXICO
VOLUME 4: ADAPTIVE CHANGE IN THE NORTHERN RIO GRANDE VALLEY

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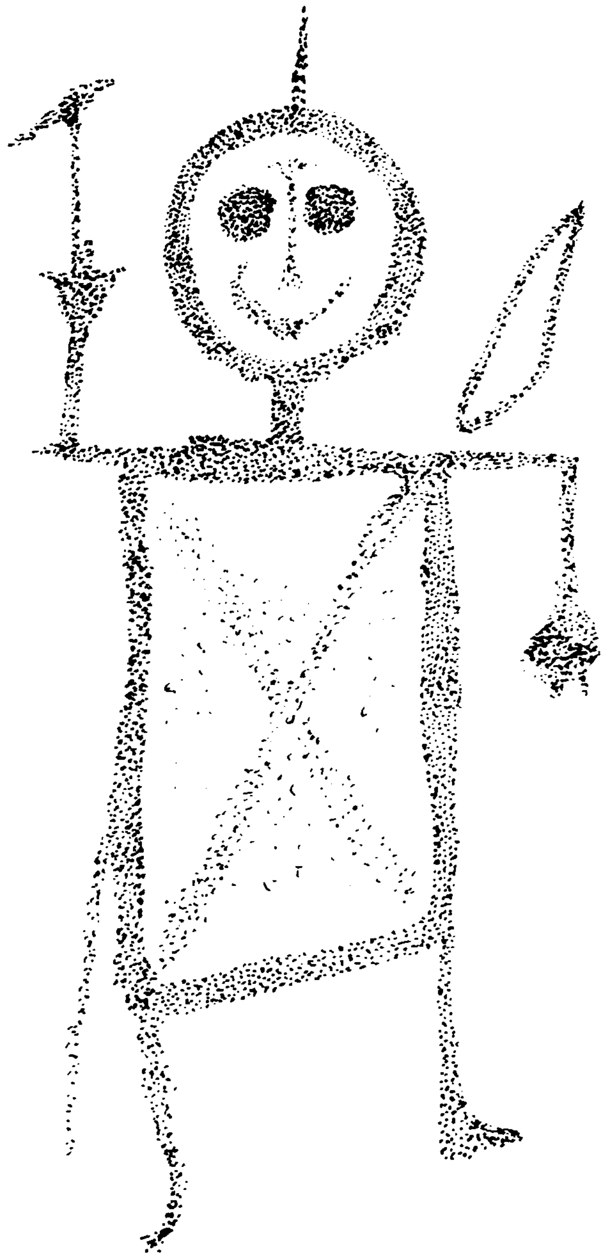
PART ONE: RESEARCH PERSPECTIVE



Chapter 1
AN ARCHEOLOGICAL APPROACH TO THE STUDY OF CULTURAL EVOLUTION

Jan V. Biella and Richard C. Chapman

INTRODUCTION

At the outset of the Cochiti Reservoir project, we adopted an explicit cultural ecological approach for analyzing archeological data. This is reflected at all stages of analysis from the literature review assessment to the survey and excavation phases (Biella and Chapman 1975, 1977a; Chapman and Biella 1977a; Biella 1979). There are many advantages in adopting a cultural ecological approach for conducting an archeological research program. The approach provides a clear focus to the research and offers considerable potential for describing properties of man-environment relationships directly observable in the archeological record.

A cultural ecological approach as currently adopted has, however, a principal deficiency as well. It is purely descriptive. At best, it serves to explicate particular events, how human populations cope with specific environmental problems. Thus, while a cultural ecological approach offers an extremely powerful means of delineating variation in cultural behavior in particularistic cases, it has, as yet, not offered an explanation of that variation or why people in the past did what they did and why they did not do something else.

Cultural evolution, on the other hand, is a theoretical approach which attempts to explain why cultural systems have developed in the way they have, and why many cultural groups around the world share similar structures and adaptive strategies in dramatically different environmental situations. Cultural evolution explicitly attempts to examine the structural properties of cultural systems and their operation, and ultimately to explain changes from one system state or adaptive strategy to another.

While the major anthropological treaties on cultural evolutionary theory have been written by social anthropologists, it is clear that the archeological record is the only anthropological data base with sufficient time depth to study cultural change on a broad scale. Further, it is the only substantial documentation of culture change in which change can be demonstrated rather than proposed.

The Cochiti Reservoir project was basically conceived within a cultural evolutionary theoretical framework. Unlike the cultural ecological part of the approach, concern for cultural evolutionary problems was implicit rather than explicit. As the research progressed, we became increasingly aware of major deficiencies in current model-building to link archeological data with cultural evolution. The greatest problem seemed to stem from the fact that nearly all modeling of cultural behavior from a cultural evolutionary standpoint employed concepts of social structure, social organization, and economic behavior which are not directly observable in the archeological record. Basic archeological data are instead comprised of such things as settlement variation, technological behavior, subsistence related activities and the like.

Given this problem, one research objective during the course of the project was that of continually assessing how properties of cultural behavior could be translated into archeologically relevant categories. That is, how could we conceptualize social properties of ongoing systems and translate those into archeologically recognizable entities?

We felt that previous attempts to draw analogies between social anthropological phenomena and archeological data were problematical at best. It became increasingly apparent that a new methodology needed to be developed to use archeological data to examine cultural evolutionary problems.

We were unable to develop a holistic methodology during the course of the project such that a particular model of cultural evolutionary process could be tested. We do feel, however, that we made some progress toward such a methodology and we wish to present the results of that progress to date. In this chapter, we outline a taxonomic procedure whereby archeological data may be used to examine cultural behavior in the past such that it may be related to the social anthropological evolutionary literature. We recognize that this is an incomplete attempt to redefine social behavioral concepts from an archeological perspective. The approach does, nevertheless, offer a means whereby archeological data may be used in the study of cultural evolutionary problems.

FUNDAMENTAL THEORETICAL CONCEPTS

Anthropologists have traditionally attempted to describe the totality of human behavior as a set of cultures. While the concept of culture has provided the context for an examination of variability exhibited among human populations, it has never been satisfactorily defined. *Culture* has variously been seen as:

> the integrated sum total of learned behavior traits characteristic of the members of a society (Hoebel 1966:561).

> What culture is can be better understood from knowledge of what forms it takes and how it works than by a definition. Culture is in this respect like life or matter; it is the total of their varied phenomena that is more significant than a concentrated phrase about them (Kroeber 1968: 13, originally published 1923).

> Culture consists of learned modes of behavior that are socially transmitted from one society of individuals to another (Steward 1955:44).

> Culture is human and only human. It depends on an as yet inadequately defined mental capacity of human beings to think imaginatively in ways that apparently no other animal can (Service 1962:35).

> What is called *culture* is a fragment of humanity which, from the points of view of the research at hand and the scale on which the latter is carried out, presents significant discontinuities in relation to the rest of humanity (Levi-Strauss 1967:288).

> *Culture* may be defined as the totality of conventional behavioral responses acquired primarily by symbolic learning (Fried 1967:7).

> Culture is man's most important instrument of adaptation. A culture is made up of the energy systems, the objective and specific artifacts, the organizations of social relations, the modes of thought, the ideologies, and the total range of customary behavior that are transmitted from one generation to another by a social group and that enables it to maintain life in a particular habitat (Cohen 1968:1).

Despite this diversity in definition of culture, the use of the concept has been productive in that it has resulted in documentation of a great degree of variation in social, political, economic, and ritualistic behavior in a variety of environmental contexts throughout the world. More importantly, however, it has served as a basis from which we may posit (1) that there are redundancies, or patterns, in the variation of human cultural behavior; (2) that these patterns are recurrent and reflect directional change from simple to complex when viewed through time; and (3) that this directional change is inherently predictable and worthy of scientific examination.

If variation in the character of human behavior is redundant and reflects directional change, it may be proposed that behavioral or cultural patterns can be explained as results of two interactive processes, general evolutionary processes, which govern the gross character of demographic, social, economic, and technological behavior exhibited among human populations, and specific adaptive processes, which govern the particular character of settlement behavior and activity specific pursuits undertaken by individual members of those human populations.

Anthropological debate concerning the first of these processes, general evolution, has focused upon developing taxonomies of stage-like, progressive sequences through which human populations can be expected to pass in a more or less step-by-step fashion (White 1959; Service 1962, Fried 1967; Morgan 1969). In developing these taxonomies, discussion has centered upon isolating key cultural features or variables which serve to differentiate each stage in an evolutionary sequence. Although the specific taxonomies and key variables differ from one study to another, there is a similarity in the approach to the concept of evolutionary change or process. Change is seen as the result of internal interactions among the components of the cultural system itself; that is, changes in one internal behavioral realm determines change in the others. For example, social organization (Service 1962), technology (White 1959) and socio-political behavior (Fried 1967) have variously been referred to as the primary processes which have precipitated general evolutionary change. Another commonality to the general evolutionary approaches is an agreement that environmental factors cannot account for general evolutionary change because similar adaptive strategies occur in different environments and different strategies occur in similar environments.

Specific adaptation, on the other hand, has been treated by anthropologists as a concept through which a wide range of human behavior can be partially accounted for as adaptive responses to specific environmental conditions such as climate, soils, abundance and predictability of food resources, and so on. In this sense, particular settlement or subsistence behavior is seen as the result of selective processes. Thus anthropologists have applied the concept of natural selection to the behavior of cultural systems in much the same way as biologists have applied that concept to genetic variation among populations comprising a species.

Although a degree of consensus exists among anthropologists that cultural behavior is both evolutionary and adaptive in character, anthropological theory has thus far failed to specify how processes of general evolution and specific adaptation can be posited or differentiated through observation and be employed in a *predictive* fashion to account for variation in forms of cultural behavior.

In spite of this, some specific areas of inquiry have been suggested which are worthy of further examination: (1) that the nature of general evolutionary processes underlying variation in forms of cultural behavior seems most readily applicable to relatively gross characteristics of demographic, technological, social and economic variation among human populations against long temporal frames and against a world-wide spatial referent; (2) that the nature of specific adaptive processes underlying such variation seems most readily applicable to aspects of subsistence and settlement variation among human populations against relatively short temporal frames and against a regional or subregional spatial referent; and (3) that the present inability of anthropologists to employ these constructs to predict variation in forms of cultural behavior can be attributed, in great part, to ambiguity in the application of *either* theoretical concept to observed variation and to the imprecise manner in which *culture* has been conceptually defined.

Thus a major problem facing anthropologists today is one of specifying the nature of general evolutionary processes and specific adaptive processes in such a fashion that permits the relationship between the two to be used in formulating a predictive theory of human behavior — a theory which explains *how* and under *what* conditions cultural evolution, or culture change, occurs. To this end, certain aspects of general and specific evolution are addressed in the following sections.

GENERAL EVOLUTION

A Review

General evolutionary approaches have been directed toward the explication of the operation of internal cultural mechanisms and have focused, not so much upon change, but upon demonstrating redundancies or patterns in human behavior which seem to characterize different cultural systems. The net result of those demonstrations has been the postulation of taxonomies of cultural evolutionary complexity. These taxonomies have been directed primarily toward documenting what are perceived to be recurrent patterns of cultural behavior in different portions of the world and establishing criteria through which these patterns can be ordered from simple to complex.

Attempts to posit explanatory models of process underlying change from one cultural evolutionary state of behavior to another more complex state of cultural behavior have been rudimentary at best. They have generally taken the form of emphasizing a few critical variables felt to be central to an understanding of major structural and organizational differences between those states of evolutionary complexity.

Service (1962), for example, emphasized the character of social and economic organization among individuals and groups of individuals as a taxonomy of bands, tribes, chiefdoms and (implicitly) states. Fried (1967) places a greater emphasis upon what he terms the political aspects of social organization and arrives at a tripartite classification of evolutionary stages which he terms egalitarian, ranked and stratified sociopolitical stances. White (1959) adopted a somewhat different view through classifying cultural evolutionary stages in terms of the energy capture capabilities of different cultural systems. He posited that the most critical variable serving to differentiate states of cultural behavior was that of technological effectiveenss in controlling and harnessing energy from the environment, and proposed (implicitly) a tripartate classification of preagricultural, agricultural and industrial stages of cultural evolutionary behavior.

For purposes of our present discussion, one important commonality of approach pervades all of these different cultural evolutionary schemes; their primary emphasis is upon developing taxonomic criteria through which different extant cultural systems might be arrayed or scaled from relatively more simple to relatively more complex. Attempts to address the question of change from one stage of evolutionary behavior to another have constituted a secondary interest of the cultural evolutionists.

In a sense, then, the major investment made into defining the nature of cultural evolution can be seen as a clear outgrowth of the structural-functionalist school of anthropological analysis which has, as its primary objective, the *explication* of the operation of a cultural system from a distinctly synchronic perspective, rather than the *explanation* of processes of change in the operation of a cultural system from a long term diachronic perspective.

The primary investment into this latter goal, the explanation of cultural evolutionary change, is found predominantly as hints or allusions to possible mechanisms or processes which might underly such change from one level of sociocultural or energetic stage to another. Thus a close reading of Service (1962), for example, reveals that the most critical and fundamental differences between a band-organized cultural system and a tribe-organized cultural system are variables of sedentism, subsistence base and population density—tribes are characterized by sedentary rather than mobile settlement, by agricultural rather than hunter-gatherer subsistence, and by substantially higher population densities than are bands.

Service is reluctant, however, to suggest a processual model which might account for evolutionary change from band to tribal organization which employs these variables of settlement, subsistence, and population density. He instead argues that the ultimate variable conditioning evolutionary change must be some undefined social process, because of the fact that both bands and tribes are presently found in essentially similar environmental settings.

In the same sense White (1959), while employing the amount of energy harnessed by cultural systems as the sole criterion to differentiate between extant stages of cultural evolutionary behavior, is basically unable to develop a model which accounts for directional change from smaller to greater amounts of energy captured. The only process White is able to posit in this regard is the invention or diffusion of ideas which might lead, in and of themselves, to the employment of technologies which would result in greater efficiency or economy of energy capture.

In summary, there are two basic points we feel should be made concerning past anthropological attempts to explicate general evolutionary processes as they might be pursued from an archeological standpoint. First, the cultural evolutionary approach to the study of human behavior has resulted in the identification of several fundamental features of human behavior which seem to be recurrently, or redundantly, apparent among the totality of cultural systems the world over. Second, these patterns in settlement, technology, subsistence, and social behavior, may be classified taxonomically, employing a variety of scales, into a finite (3 or 4) number of evolutionary stages of cultural behavior.

It is our opinion that a primary goal of anthropological research should be that of explaining *why* these recurrent states of cultural behavior occur. We feel it is reasonable to assume that the world-wide redundancy apparent in these different states of cultural structure and organization reflects a commonality in adaptation, a finite set of human adaptive responses which is the result of human physiological and social evolution.

The important question facing anthropologists, then, is specifying *under what conditions do particular cultural states or stages of evolutionary behavior develop?*

We feel that, at present, the most productive way to pursue answers to this question is through an examination of the character of processes of change from one adaptive state to another by whatever means available. The archeological record offers one such means. In order to use it productively, however, the nature of settlement, subsistence, social and technological behavior to be studied must be phrased in a fashion which permits that material record of past cultural behavior to be used as information bearing upon the questions asked of it.

Archeological Implications

The makeup or composition of social groupings of individuals comprising a culturally-organized population has emerged as a critical variable in the development of several evolutionary taxonomies, notably Sahlins (1958), Service (1962), and Fried (1967). The character of social groupings has been analyzed principally from two perspectives—structural and organizational. Many different definitions of social structure and social organization have been offered by anthropologists over the years, and considerable debate has been waged concerning the appropriateness of one kind of definition over another for purposes of cultural evolutionary taxonomy.

The structure of human social behavior can be viewed as the number, size and composition of groups of individuals who routinely interact cooperatively with other members of the same group in the performance of subsistence-related activities. It should be emphasized that definition of such groups, or structural components of social behavior, is in part hierarchical. By this we mean that some groups are made up of social components which are themselves similar groups.

Organization of human social behavior can be viewed as a scale of complexity in the interaction of individuals comprising a group, or as a scale of complexity in the interaction between groups comprising a hierarchically larger structural grouping.

Because these two properties of social behavior, structure and organization, are critical to continued examination of cultural evolutionary process but are not necessarily simple in their definition, we will outline how we have proposed to translate them into potentially archeologically recognizable variation.

Social Structure

For purposes of archeological analysis, three basic units of social structural variation may be proposed: the commensal group, the local group, and the regional group. Each will be defined and discussed below.

The *commensal group* can be defined as the smallest basic food-sharing group of individuals. From a socioeconomic standpoint, this group can be proposed as the smallest grouping of individuals who routinely, usually on a daily basis, share the combined results of each member's work in procurement and processing of food resources. The commensal unit thus constitutes the basic building block of all human societies. Although the use of the term here has no strict ethnographic correlate, it is generally similar to groupings termed families or households in the anthropological literature.

It should be noted that in our definition we deliberately avoid any reference to the actual kin relationships which may pertain between individuals comprising the commensal group. This is done for two reasons. First, we feel such kin relationships cannot be routinely ascertained in the archeological record and thus constitute a realm of speculation rather than description from an archeological standpoint. Second, ethnographic observation indicates that the actual kin relationships pertaining among individuals constituting commensal units are quite variable, at times on even a day-to-day basis. The basic structural group which survives over the short term and over the long term is not the family but the cooperative food-sharing group, which may fluctuate in its size and composition of individual membership.

The *local group* is comprised of several commensal groups and will be defined as the maximum number of commensal groups who share a finite spatial locality for purposes of resource procurement on a routine, annual basis. The local group is thus comprised of individuals who share an effective territory or home range and share in the daily consumption of food resources procured from that territory. Ethnographically-observed correlates to local groups include such entities as a pueblo village.

An important point to make concerning the local group is the variation in residential behavior among commensal groups comprising it throughout an annual cycle. In some cases, most notably among foragers or hunter-gatherers, residential occupation of the local group territory will fluctuate during an annual cycle from relatively widely dispersed settlements characterized by one or two commensal groups to aggregated settlements comprising all members of the local group. In other cases, as in those characterized by much greater dependence upon agricultural subsistence, the primary residence for the entire local group might be a relatively permanent village center from which production and procurement activities are undertaken by commensal groups as short term task exercises.

As with commensal groups, the exact personnel composition of the local group may fluctuate over the short term and long term with respect to kin relationships and individual membership. What we are interested in archeologically is the size of the local group in terms of the number of commensal units it encompasses relative to the location and extent of the territory it operates within.

The *regional group* may be defined as that range of possible ways in which different local groups may be articulated on either a periodic or nonperiodic basis. Of critical interest in this regard is the kind and amount of interlocal group interaction which characterizes the regional behavior of local groups. Social articulation can be seen as ranging from predominately ceremonial functions, which may involve minimal exchange of foodstuffs or services (although serving to maintain supportive alliance networks); to those economic in nature, which involve regular exchange in goods and services between local groups as a necessary aspect of subsistence. Amount of articulation can be posited as varying along a temporal scale from occasional multiannual cycles, to very regular on an annual, semiannual, or even more frequent basis.

Examples of this variation in the character of interlocal group behavior observed ethnographically include occasional aggregations of foraging groups in central and western Australia for elaborate initiation and increase ceremonies, which serve primarily ritual and social functions (such as search for marriage partners) and which are characterized by very limited and informal exchange of goods.

At the other end of the scale, the character of interlocal group exchange can be posited as classic market economies wherein the fundamental subsistence needs of local group populations are predicated upon a degree of specialization in the production of foodstuffs and goods. These are then exchanged for other foodstuffs and goods on a regular, often weekly basis at a central market.

The necessity for positing the character of articulation between local groups, from an archeological standpoint, can be seen clearly as providing information concerning critical variables of the particular adaptive system. Much of the cultural evolutionary literature has, in fact, focused primarily upon the nature of interlocal group articulation to develop taxonomies of evolutionary stages such as bands, tribes, chiefdoms, and the like.

One problem in developing these taxonomies, however, has been that of defining the boundaries of the cultural system to be classified. Sahlins (1968) proposes that reciprocal exchange versus redistributive exchange strategies constitute one major criterion in differentiating between bands and tribes on the one hand, and chiefdoms and states on the other hand. This distinction is ambiguous because it fails to specify whether the kind or amount of exchange should be characteristic of *intra*local group behavior or *inter*local group behavior.

In a similar sense, one criterion distinguishing more complex evolutionary stages such as chiefdoms or primitive states is generally phrased as greater complexity in the social, political and economic interaction between communities of individuals. However, explicit scales against which such complexity might be measured are rarely offered (such as frequency of interaction or volume of goods and resources exchanged).

Given these current problems in cultural evolutionary taxonomies with respect to the definition of regional groups, we prefer not to offer a rigid set of criteria through which all such structural entities might be conceptually differentiated. Instead, we suggest that the regional group, as a structural component of social behavior, may in many ways be viewed as congruent with what the majority of anthropologists term a culture or cultural system. Thus a culture or cultural system consists of interacting local groups, each of which is in turn comprised of individuals who share access to food and technological resources within a definable spatial territory, and whose basic individual socioeconomic behavior can be potentially recognized in the archeological record as commensal groups at the site specific level.

We can suggest, from an archeological referent, that a productive way of describing the regional group can be pursued through examining the interaction of local groups along the following dimensions: defining the kind of such interaction (whether predominantly ceremonial, political, social or economic in nature); the frequency of such interaction (whether less than annual, annual or multiannual in occurrence); and finally the volume or amount of such interaction (for example, the amount of goods being circulated).

Social Organization

As discussed earlier, anthropologists have generally defined social organization as those dynamic interrelationships which pertain between structural components of a system of social behavior. There exists, however, relatively little agreement among anthropologists concerning exact definitions of such organizational mechanisms. This is to be expected simply because particular definitions of structure and organization are analytical constructs rather than descriptions of empirical realities.

Some commonalities do exist among structural and organizational scenarios developed by cultural evolutionists, however, which offer some potential for visibility in the archeological record. Nearly all evolutionary taxonomies are similar in proposing that the complexity of organization characterizing different evolutionary stages increases as higher stages of cultural evolution are achieved.

Basically, the argument is made that as the number of social components which are integrated into a single behavioral system increase, so do the number and complexity of *organizational mechanisms which serve to integrate* those components. In essence, the entire cultural evolutionary scenario can be reduced to a single equation employing variables of population size, number of structural components, and number of integrative mechanisms. The equation can be stated, simplistically, as follows:

As the absolute number of individuals articulated in a functioning system of social behavior increases, so will the number of social groupings of individuals (or structural components). Similarly, the number and kinds of organizational mechanisms which serve to integrate individuals and groups of individuals will increase.

Evolutionary changes in this systems-growth process have been posited almost as threshold points at which changes in the character of organizational mechanisms must occur, if the increased number of individuals are to be effectively accommodated within a functioning system of behavior.

Many of the key variables related to such changes in organizational mechanisms proposed by cultural evolutionary studies are those which facilitate continued effective flow of information throughout the system.

Evolutionary simple systems, which must integrate relatively few individuals, are capable of maintaining an essentially egalitarian-based strategy of information flow, wherein individual status is achieved through personal endeavor rather than through ascription at birth. Exchange of goods and services is undertaken at a personal, reciprocal level rather than through politically or legally defined redistributive mechanisms. Hence administrative decision making entities are not necessitated.

When the number of individuals increases to some (as yet undefined) threshold size, the character of information flow throughout the social system must undergo significant changes in order to continue integrating individuals into a functioning system of behavior. Initial changes of this sort take the form of creating a set of social groupings and functionary positions within the society which serve as rudimentary decision making and administrative entities. Common groupings of this sort (generally termed sodalities by anthropologists) include clans, age-grades, and secret societies, among others.

Specific positions or leadership roles fulfilled by individuals, which carry a degree of political power when needed in specific circumstances, also characterize these initial evolutionary developments toward more complex stages. Common among these are positions equivalent to military leaders, judges, and internal police—all of which are achieved rather than ascribed and which carry power only under special circumstances warranting its exercise. An essential feature of these organizational strategies can be seen as the development of rudimentary mechanisms to channelize the flow of information throughout the entire system of social behavior. The kind of organizational changes characterizing the highest stages of cultural evolutionary taxonomies (chiefdoms and states) are those of codifying social groupings of individuals in hierarchical fashion, establishing routes of information flow through those hierarchies, and enforcing behavior of individuals comprising the different groupings through political power.

In contrast to evolutionarily simple systems, the more complex systems of behavior are characterized by hierarchical rather than egalitarian-based strategies of information flow. Individual status is ascribed at birth rather than achieved through personal endeavor, and in many cases the potential for an individual to achieve positions of functionary power of membership in particular sodalities is restricted entirely by rigidly defined class or caste membership which has been accrued at birth.

Exchange of goods and services in highly complex evolutionary systems is characterized by economic specialization in which entire segments of the population engage in focal production of goods or offer particular services which they exchange with other such focally engaged population segments for basic subsistence needs. Above all, evolutionarily complex systems are characterized by well developed decision making and administrative hierarchies through which activities of the general populace are governed and which are maintained and enforced through legal codes and, ultimately, quasi-military organizations responsive to those holding positions of political power.

In summary, a review of the cultural evolutionary literature indicates that a single fundamental variable seems to underly significant variation among integrative mechanisms which constitute the organizational properties of human social behavior: the absolute number of individuals who comprise the effective population of that system.

This fact, in and of iteself, suggests to the archeologist that the relative size of effectively interacting local groups or regional groups must constitute a primary objective of analysis if the character of past evolutionary process is to be evaluated.

Defining the properties of the integrative mechanisms themselves is a much more difficult task from an archeological standpoint. Cultural evolutionary studies have tended to focus upon integrative mechanisms in their taxonomies which in most cases have no direct archeological correlate. In this sense, it is difficult to posit how one might go about isolating a particular functionary position (such as age-grade) through archeological analysis.

If, however, such integrative mechanisms are viewed as social strategies through which individuals and groups of individuals are articulated, some relevant archeological manifestations of those strategies might be offered. We suggest that identifying strategies of social behavior which might constitute such organizational properties can be pursued through examining basic tenets of specific adaptation.

SPECIFIC ADAPTATION

A Review

A degree of ambiguity and confusion presently exists in differentiating the concepts of general evolution and specific adaptation as they are used to explicate cultural variation in particular cases. Anthropological debate concerning this issue has focused upon argument whether observed variation is due to unique environmental settings, or primarily due to processes of general evolutionary response dictated by the overall demographic, social and technological character of a cultural system. One major attempt to formalize the nature of this theoretical debate has been made by Steward (1955)

Steward suggested that the general evolutionists were overly concerned with searching for taxonomic criteria which might be employed to define covariant regularities among forms of cultural behavior which in turn were used to define evolutionary stages; and criticized the attempt to posit evolutionary process per se as the cause of those observed regularities.

Steward (1955) suggested instead that if particular histories of cultural change through time within different regions of the world were examined, much of the seeming similarity in forms of cultural behavior could be accounted for as the result of specific adaptation to essentially unique characteristics of regional environmental settings, and unique historical interaction between one cultural system and another through time. He thus proposed that observed variation in cultural behavior at any point in time within a particular region could be accounted for as a largely adaptive and historical process he termed multilinear evolution. He attempted to demonstrate that the seeming regularities in sociocultural integration (or the interaction among forms of social organization, economy and technology) could be accounted for not as the result of general evolutionary processes alone, but as expected expressions of fundamental and necessary specific adaptive responses by a human population, given basic core needs of any cultural organization.

In essence, Steward's argument can be seen at its basic level as a suggestion that change through time in the structure and organization of human cultural behavior is best accounted for in terms of specific historical and adaptive processes. Steward does not deny that regularities in forms of sociocultural integration are observed throughout the world, but he does suggest that such regularities are best explained in historical and adaptive terms. Critical law-like processes underlying cultural evolution in general, as posited by Steward, are processes of specific adaptation by a human population to its environmental setting and are not culturalogical processes operating independently of environment.

The effect of Steward's research upon subsequent anthropological investigation was profound, although it was not to be realized in any substantial manner until the mid-1960s. At that time a number of ethnographers and archeologists began to undertake research directed explicitly toward examining the character of human behavioral variation as it related to features of environment and have been termed themselves, after Steward's suggestion, as culture ecologists.

Especially notable among these cultural ecological studies were those which offered means of accounting for essentially strange kinds of human behavior which had been previously referred to by anthropologists as classic examples of the ultimate inexplicable properties of *Culture* itself. Harris (1966) conducted an analysis of sacred cows in India which examined the manner in which cattle served as a resource in subsistence terms. His work demonstrated that sacred cows, rather than constituting an unnecessary drain upon the resources of local populations, served several critical and useful subsistence needs—providing fuel and fertilizer (as dung); food resources (as milk and ultimately meat); and technological resources (as hides and bone).

Piddock (1965) approached the institution of the Northwest Coast potlatch for a similar perspective. His analysis of social structure and subsistence economy of the Kwakiutl suggested that the seemingly wasteful potlatch ceremony functions in a positive fashion as a periodic reaffirmation of social relationships which constituted the fundamental structure of basic subsistence pursuits undertaken by individuals and households comprising a local group.

These studies among others (cf. Vayda 1961; Rappaport 1967, 1968; Ford 1972) served as exemplary illustrations of the potential utility of Steward's cultural ecological approach to the anlaysis of human behavior in a synchronic sense. At the same time, other studies which offered some import concerning processes underlying man-environment relationships were being conducted. Lee (1968) pursued the energetic properties of !Kung San Bushmen subsistence in the Kalahari Desert of Africa, and he suggested that previous anthropological concepts of cultural evolution based upon premises that more primitive cultures involved greater labor investment by individuals than did more complex cultures, were not substantiated by his data.

This documentation, in and of itself, constituted revelation of insight among some anthropologists. As a consequence, a slightly earlier study of agriculturally based systems of economic behavior by Boserup (1965) became a kind of bible which documented the relationship between energetic input into a system of food production and the energetic output of that system. Boserup's study illustrated very concisely, from a cross-cultural frame of ethnographic and historical reference, that variation in volume of agriculturally produced foodstuffs was entirely dependent upon the amount of labor that was inputed into that production.

The combination of Lee's energetic analysis of hunter-gatherer subsistence and Boserup's energetic analysis of differential intensities of agriculturally based subsistence, essentially constituted a major breakthrough in anthropological theory-building.

In essence, then, the primary expression of Steward's approach to understanding cultural evolutionary process has been documentation of a set of synchronic cultural ecological case studies. These studies are, in many ways, very similar to more traditional structural-functionalist analyses of cultural systems (cf. Radcliffe-Brown 1952), with the important difference that cultural ecological analysis has expanded the boundaries of the system under investigation to include features of environmental variation.

Cultural ecological case studies thus have provided, and will continue to provide, very useful information insofar as they explicate the operation of the structural and organizational properties of human cultural systems as they articulate with variables of environment. Such studies thus bear out Steward's (1955) contention that much specific variation in forms of human behavior can be accounted for as specific adaptive responses to particular environmental settings. In this context, cultural ecological analysis offers a concerted means of explicating particular adaptive strategies.

Such studies do not, however, directly approach the problem of adaptive process itself because they are synchronic rather than diachronic in nature. At present questions of adaptive process have been approached by relatively few researchers.

Archeological Implications

A major feature of the specific adaptive concept, as it relates to archeological analysis, is the postulation that variation in the structural and organizational properties of human adaptive behavior reflect variation among effective environmental phenomena. In this sense, the operation of a cultural system as an adaptive mechanism can be viewed as a system of behavior through which the human population satisfies its essential nutritive needs through extracting energy from a particular environmental setting. For purposes of archeological analysis of the operation of such systems in the past, then, the structural and organizational properties of specific adaptive systems must be defined in a fashion offering archeological recognizability.

An argument was offered at the initial stages of the

Cochiti Reservoir project that suggested a line of inquiry through which some kinds of variability in material, or archeological, evidence of human behavior might be conceptualized in this respect (Biella and Chapman 1975: 7-17; Chapman and Biella 1977b:7-12). This argument was simple, or perhaps even simplistic, in nature. It stated that activities might be construed as the components, or building blocks, of the structure of a specific adaptive system of behavior. The argument further suggested that the interrelationships among those activity pursuits might be treated as the organization of that adaptive system. Specific interrelationships were defined as strategies through which activity performance was undertaken against a spatial and/or temporal referent.

An organizational strategy can be viewed as a schedule of activity performance(s) through time and across space. For example, if an individual is doing one task during one period of time during the day, that individual cannot be doing another kind of task at the same time period. If two tasks must be performed, a choice is involved; one task must be done first and another afterwards. This scheduling is a dynamic, organizational property of activity performance through which different activities are articulated as sequential events against a temporal referent.

In a similar sense, if two tasks must be, because of their nature, undertaken at different places within the same general time frames, the individual must again make a choice; one task must be performed first at one place and the other task must be performed second at another place. Depending upon the time involved to move from one place to the other, the selection of a particular order of task performance becomes a problem in strategy, not only in scheduling (against a temporal referent) but as well in positioning (against a spatial referent).

Strategic decision making in terms of temporal scheduling and spatial positioning of activity performance by an individual can thus be seen in the abstract as the organizational property of that individual's activity structure (with structure reflecting the different activity performance episodes actually undertaken by the individual throughout a period of time across space).

Archeologically, the material evidence of that decision making process will be evident, predominantly, as nonperishable by-products of the activity performance itself; the only direct evidence we will have available concerning the organizational properties of that strategic decision making will be the spatial segregation of activity events.

An individual thus performs a variety of different kinds of activities throughout each 24 hour period, some of which may result in production of a material record directly observable by future archeologists, and many of which do not result in such a directly observable record.

The structure of a specific adaptive system of human behavior, then, following this line of argument, might be defined as variability in the kinds of activities undertaken by individuals as arrayed against a spatial referent. For purposes of analysis from an archeological standpoint, the entire range of activities must (of necessity) be reduced to classes of activity performance which potentially are recognizable in the material record, on the one hand, and which offer a potential for understanding basic and fundamental relationships between the overall human population and environmental variation, on the other hand.

A finite set of activity classes might be defined which offer not only archeological visibility but, as well, a degree of adaptive significance, such that the behavior of human individuals at different site locations might be treated as primary information concerning the interaction of the human population as a whole.

Activity classes felt best meeting these criteria may be posited as subsistence-related activities; that is, activities directly performed to procure (or produce), process, store, and consume various resources. Resources are defined as food resources (including water) which constitute the biological energetic underpinnings of a human population; and as technological resources, or those living or nonliving materials which the human population employs or transforms into tools, facilities, clothing, fire, and so on in order to maintain its reproductive viability over the long term.

The intent of this conceptual definition of activity classes is to provide a simple and understandable means of classifying the material, archeological record of human activity performance such that different site locations across any regional landscape might be examined and analyzed for the information they provide about the structural properties of the specific adaptive systems resulting in their deposition.

ARCHEOLOGICAL APPLICATIONS

Ultimately the utility of the evolutionary approach presented in this chapter is to be found in its application to the archeological record at an empirical level. The archeological record is, above all, a *material* record of objects which have survived mechanical and chemical transformations over the long term. The empirical phenomena constituting archeological data thus range from microscopic pollen grains to habitation structures and exhibit a wide range of physical properties from chemical compounds or variation in soil structures to materials such as bone, wood, metal or plastic.

In order to employ these phenomena as information bearing upon properties of human behavior which resulted in their deposition, archeologists must draw upon entire realms of previous analytical research of an archeological nature (and from other scientific disciplines) to make even descriptive statements which can be employed as data underlying their analysis. The following discussion will make no attempt to trace the analytical underpinnings of these descriptive categories of data and thus assumes a familiarity on the part of the reader with fundamental kinds of data constituting the record itself.

In terms of differentiating classes of activity performance represented at particular site locations, however, a basic phenomenological categorization of the remains was initially defined and is listed below.

Evidence of facilities: The category of facilities was defined to include essentially nonportable features such as hearths, rooms, cists, bins, corrals, agricultural terraces, trails, and the like. The use of the term in our analysis is somewhat more narrow in scope than its use in some other analyses which have differentiated facilities (as objects which retard or restrict flow of energy or matter) from implements (which have been defined as objects which concentrate or channelize the flow of energy or matter). This latter definition, while appropriate for some kinds of analytical objectives, was not employed. We have preferred to restrict out use of the term to designate essentially architectural features.

Artifacts: The category of artifacts has been defined to include phenomena other than facilities which exhibit evidence of physical alteration of their natural state through the action of a human agent. The term generally includes objects which have been manufactured (such as cores, flakes, ceramic pots, bone awls, buttons, barbed wire, etc.) and objects which have undergone alteration solely through usage as tools (such as hammerstones, or grinding slabs).

Direct evidence of food resources: This category includes surviving parts of food species which occur at a site including bone, shell, seeds, husks, corn cobs and the like.

The intent of this categorization of material remains is clearly not that of postulating a taxonomy of all possible material phenomena which might constitute a site-specific record of human occupation. It is intended to serve as a general guideline to an examination of the archeological record such that classes of empirical data might be used to inform upon variation in activities which occurred at site locations.

Definition of Activity Classes

We will begin with basic material evidence constituting the archeological record of past human behavior. It has been proposed that a primary kind of information which should be derived initially from these materials are the kinds of subsistence-related activities which resulted in their deposition. Activity classes which have been proposed as relevant to the research are essentially those which involve procurement or production of resources, processing or manufacture of resources, consumption of resources, storage of resources, and the maintenance of the technological inventory necessitated in the performance of the first four activity realms. It should be emphasized that resources refer to both food (including water) and technological resources. Each of these activity realms will be discussed below.

Procurement activities: These refer to activities involved in the actual acquisition of food or technological resources, including the hunting or harvesting of food resources and the selection or quarrying of technological resources. All activities related to agricultural production, field preparation, planting, pest and weed control would be included in this class.

Processing activities: These refer to a range of activities involved in transforming resources from their initial acquired state into a form suitable for cooking or consumption (if food resources) or for utilization (if technological resources). Some of the more common kinds of processing activities would thus be field dressing, skinning and butchering of faunal resources; winnowing, parching and milling seeds; or stages of manufacture involved in producing tools suitable for utilization.

Consumption activities: These include activities which are related to cooking and eating food resources. Included in this general class would be the use of hearths, ceramic vessels, heat retainers and the like for cooking purposes. In a sense, technological items might be viewed as essentially consumed through their utilization for tasks; but since we are more concerned with the kinds of tasks performed through use of such items, we prefer to restrict the consumption category rather narrowly to cooking and eating.

Storage activities: Storage is not precisely an activity insofar as it does not require expenditure of human energy while it is happening; but it is nevertheless, a very critical component of subsistence-related behavior and can be recognized archeologically. Storage refers to either short term or long term protection of goods or resources for future consumption. Actual activities involved in storage fall under the processing class.

Maintenance activities: Maintenance activities involve the refurbishing or repair of tools or facilities. These kinds of activities are differentiated from initial manufacture or construction and may be identified archeologically, for example, as remodeling floors or hearths, or resharpening flakes on a siliceous tool to maintain a sharp edge.

The following discussion will outline procedures through which archeological data might be analyzed to provide information bearing upon variation in activities performed. For this discussion, food resource activity classes will be examined separately from technological resource activity classes.

Activity Classes and Food Resources

Procurement activities: One underlying observation concerning the spatial logistics of human cultural behavior which can be drawn from the ethnographic literature is the fact that actual activities of hunting, gathering, or agricultural production of food resources are generally undertaken at locations away from residential sites or locations at which those resources are processed and consumed. With few exceptions (discussed below), archeologically visible sites are not those where food resources are procured, but are rather locations where they undergo stages of processing for consumption or storage.

Given this expectation, the primary analytical investment made into the character of food resource procurement or production activities from the site-specific perspective is simply that of identifying what kinds of food resources have been processed and consumed at the site itself. Two kinds of evidence may be examined toward this end:

Direct, material evidence of food resource species processed and consumed at each site location may be sought through recovery and identification of faunal and vegetal remains. In addition to remains recovered through standard excavation procedures, soil samples from the interiors of cists, hearths, and other stratigraphic contexts as deemed appropriate can be subjected to flotation. Faunal elements which have been transformed into tools may be treated as information bearing upon procurement strategies as well.

From a site-specific level, indirect evidence of variation in foodstuffs procured may be undertaken largely through examination of the character of tool assemblages. For example, identification of implements which might be attributed to functionally specific processing procedures for classes of foodstuffs can be sought. Artifacts such as bone implements which indicate their use for fleshing hides; projectile points, gunflints or cartridge cases indicating hunting activities; and milling implements such as manos and metates indicating processing of seeds all constitute such indirect evidence of the general kinds of food resources which were procured by inhabitants of a particular site location.

Processing activities: Variation in food resource processing can be monitored from a number of perspectives. Of critical importance are the kinds of species which were treated. Since direct evidence of species is often not available, analysis can be directed toward gathering information pertinent to the general class of resources (floral or faunal) and variation within that class (such as large mammal small mammal; or seed parts versus leaf or root parts of vegetative species). Of equal importance is gathering information concerning the stage of an entire processing trajectory represented at a site location. In this sense, it is desirable to ascertain whether processing has been undertaken for immediate consumption at the site, for storage, or transportation elsewhere.

Remnants of floral or faunal species constitute the best direct evidence of kinds of species processed and stages of processing they have undergone. Techniques of butchering constitute useful information in this regard, and variation in the parts of vegetal species can provide insight into stages of processing as well. Variation in the kinds of tools at a site location constitute a primary indirect realm of data concerning food processing activities. Both classes of implements and their spatial association with other artifacts or facilities provide potential information in this regard. There is, however, a serious problem in assigning functionally specific meaning to particular kinds of artifacts. In general, there are relatively few classes of tools which can be warranted to reflect specific (unambiguous) task usages. The following discussion outlines the kind of strategy which might be employed to ascertain food resource processing activities at archeological sites from variation in the tool assemblages found at site locations.

A distinction must first be made between faunal parts which are subject to processing as food resources. In terms of their overall subsistence utility, faunal species offer not only potential food parts (muscle tissue, marrow, organs) but as well technological resources (hide, sinew, bone, antler). In addition, variation in size of faunal species dictates, in many ways, basic strategies of processing. Smaller body sizes (mice, gopher, rabbits) are most effectively processed through a minimum investment into skinning and perhaps evisceration, to be cooked through direct broiling, baking, roasting or stewing. Ethnographically, the smaller sized fauna are quite often prepared for consumption without processing, through direct baking in coals. Evidence of tool use in these cases would be minimal.

Larger body sized fauna (antelope, sheep, goat, deer or larger) require more investment into skinning, evisceration, dismemberment, and often marrow extraction to be effectively processed for consumption.

Basic kinds of tools which would be necessitated in a full cycle of processing might include a knife (cutting tool) for skinning, evisceration, dismemberment and, if the muscle tissue was being processed for storage, for slicing. A massive chopping implement may be employed as well for dismemberment.

As with faunal species, the kinds of edible parts of vegetal species must be considered in isolating artifactual evidence of their processing. Such parts include seeds, leaves, fruits, roots and occasionally stalks or stems. In general, the majority of these parts are processed directly through cooking procedures such as roasting, baking, or stewing. Parts which require a degree of processing prior to consumption are generally seeds or nuts. Seeds, in particular, often necessitate stages as winnowing, parching and grinding before they can be consumed. The most readily observable artifact evidence of such processing includes classes of milling implements (manos and metates) and various containers (baskets, trays, ceramic pots).

Consumption activities: Consumption activities have been defined as those involved in the cooking and eating of food resources. It is clear that a considerable amount of food is eaten without prior cooking, but this kind of consumption offers no systematically recognizable material record. Several kinds of cooking practices, however, can be defined which offer a degree of archeological visibility as hearth facilities. These include broiling (in which the food is suspended or held above the heat source), roasting (in which the food is laid directly upon live coals), baking (in which the food is buried within coals or covered with heated stones and buried for a period of time), toasting (in which food is placed directly upon a heated surface such as a piki stone, pan or flat rock), and boiling or stewing. Two kinds of boiling techniques can be identified. In direct boiling the food is placed in a metal or ceramic container with water and boiled directly upon the heat source. The stone boiling technique involves stones heated in the hearth facility which are successively dropped into the container and removed until the cooking process is completed. Stone boiling is used for containers made from flammable materials such as basketry, wood or hides.

The best direct evidence of variation in the kinds of food resources consumed can be seen as the remnants of the species themselves. Because different kinds of species and their edible parts require different cooking procedures, we will outline evidence of consumption for faunal and vegetative species separately.

Variation in consumption techniques employed for faunal species must be examined through analyzing the assemblage of faunal parts as the outcome of consumption activities. In this sense, the character of processing activities can be assumed to have resulted in a pattern of dismemberment and extraction of edible parts which is related to, or governed by, the mode of cooking and eating of those parts. Variation in cooking procedures can be partially isolated through examination of the structural properties of hearth facilities and by-products of hearth usage (such as firecracked rock). Variation in the actual empirical record of faunal element distribution must take into account, as well as possible, post-consumption activities such as clean-up and trash disposal.

We can thus basically examine three properties of faunal remains which constitute information concerning consumption activities. First, the manner in which they have been processed for consumption; second, the manner in which the consumption techniques have further transformed them physically; and third, the manner of their disposal after having been consumed. Two illustrations of the manner in which dismemberment, consumption, and subsequent disposal are related can be offered.

Broiling or roasting consumption necessitates no dismemberment of small fauna, but does require dismemberment of larger fauna. Bones remaining after consumption should exhibit articulator ends and may well be distributed over broad areas of the site because of a toss disposal strategy. If larger fauna are being processed for marrow extraction and soup making, dismemberment is much more intensive. Considerable volumes of bone fragments are generated during marrow extraction which may be disposed of in more or less systematic dump locales. Soup making may involve smashing articulator ends and stone boiling which will produce firecracked rock piles as well.

Vegetal parts, because they do not have the same long term survival properties as bones, offer much less routine information on consumption on a site by site basis. Further, the majority of volume of vegetal resources transported to a site for further processing are, in fact, consumed at the site. Direct evidence of the consumption of such resources is thus generally not available, although charred remains may be found on the interiors of cooking pots or be evidenced as by-products such as nut shells, corn cobs and the like.

A primary indirect monitor of consumption activities can be seen in hearth facilities and by-products of hearth usage (such as firecracked rock). Hearth facilities may be relatively shallow in depth and thus designed for heat radiation upward; or deep, such that heat absorbed by surrounding surfaces is radiated back into the cavity where the fire originally existed. Surficial hearths offer a wide range of possible cooking strategies including broiling, roasting, toasting (when ancillary artifacts are employed), coal-baking, and boiling (either through direct heating of vessels containing foods, or through heating rocks which can be transferred to vessels containing foods). Subsurface hearths (or deep hearths) offer the potential for all of the above cooking practices, but also can be used for pit-baking.

Potential variation in cooking practices exhibited among different hearth facilities can thus be examined through variables of depth, surface extent, ancillary features associated with them (such as emplaced rocks which might support cooking vessels) and by-products of their use such as firecracked rock accumulations.

Other indirect monitors of consumptions activities can be sought, where appropriate, in the technological inventory of items which are employed directly in cooking activities or serving activities. These are generally apparent as ceramic or metal containers, although other items such as ceramic or stone griddles may be expected to occur as well.

Activity Classes and Technological Resources

Technological resources include all materials from which tools and facilities are manufactured by a human population. These include both inorganic raw materials such as stone, clay, or minerals; and organic raw materials such as bone, hide, wood or fiber.

Procurement activities: Information about procurement activities is derived from two levels of analysis. One concerns the availability and abundance of those resources in space, and the other concerns the actual selection or procurement of individual resources at the site-specific level for tool or facility manufacture.

Identification of technological resources as they occur in the environment is best accomplished through areal surveys. Specific sources of different rock, clay, temper and mineral resources can be isolated, time permitting, through geological surveys; if sources cannot be located, the general availability may be inferred from the geologic history of an area.

Similarly, botanical and faunal surveys can provide information on the availability of possible floral and faunal resources. Unlike geologic resources, the availability and abundance of floral and faunal resources are much more variable both temporally and spatially. Evaluation of the actual procurement of technological resources at particularly site locations is dependent upon descriptive techniques through which materials can be unambiguously identified. Ideally, inorganic raw materials should be identified by known source location whenever possible, while floral and faunal species should be identified to species. Once this level of identification is achieved, strategies of procurement can be reconstructed.

Processing activities: For technological resources, processing activities can be defined as stages in manufacture through which materials are transformed from their natural state into usable implements or facilities. Central to an understanding of the manufacturing process is identification of stages involved in different manufacturing trajectories. This is achieved through analyzing morphological attributes of finished tools or facilities and through analyzing by-products of the manufacturing process.

Manufacture of lithic artifacts offers the best illustration of how these stage-like trajectories of manufacture can be identified archeologically. Stone tool manufacture is a subtractive process in which pieces of debitage are successively detached from a piece of raw material. Stages in the manufacturing process can be identified through analysis of morphology, platform characteristics, and presence or absence of cortex characterizing each piece of debitage within an archeological assemblage.

These observations alone can be employed to define whether an assemblage reflects primary or secondary stages of core reduction, or whether it reflects tertiary stages of preform manufacture and thinning to produce bifacial artifacts such as projectile points.

Analogous observations can be made upon cores, large angular debris, or utilized tools occurring within those assemblages. When taken in conjunction with variation in debitage attributes, basic trajectories of stages involved from initial core preparation through tool manufacture can be identified for different kinds of raw material. Further, variation among different site locations can be delineated in terms of which stages of the manufacturing trajectory are evident.

It must be emphasized that different kinds of implements or facilities constituting the end-products of the manufacturing trajectory will leave different kinds of evidence of their manufacture in the archeological record.

In general, the most voluminous evidence of this sort is debitage resultant from stone tool manufacture. Direct evidence of manufacturing stages characterizing other kinds of items such as ceramic vessels or architectural facilities is less abundant and much less obvious archeologically although the final products themselves are highly visible.

Perishable items manufactured from organic materials may leave no direct evidence whatsoever of manufacturing trajectories involved in their manufacture and may not be visible themselves in the majority of archeological cases. Identifying which stages of manufacture of items such as nets, bags, clothing, and arrow shafts may have occurred at different site locations must be pursued through analysis of wear patterns and morphological attributes of preserved stone and bone implements involved in such manufacture.

The importance of identifying techniques of manufacture and stages in the manufacturing process such that site-specific evidence of both technique and stage can be defined, is critical toward analysis of organizational properties of behavior. Once these characteristics of manufacturing trajectories can be identified at the site-specific level, logistical strategies through which temporal scheduling and spatial positioning of activity performance involved in the overall cycling of materials can be outlined. This information constitutes very important data when used comparatively to evaluate organizational complexity among different systems of cultural behavior.

Consumption activities: Consumption of implements and facilities refers to their use. From a strictly conceptual viewpoint, the importance of identifying kinds of artifact or facility use has already been discussed. If basic activities involved in procuring, processing, and consuming food resources; or procuring and manufacturing many technological raw materials are to be identified, information concerning the functional usages of tools and facilities involved in those activities is needed.

From the standpoint of analytical investment required to provide that information, however, analysis of tool and facility function constitutes a distinctly separate research concern. Specialized analyses drawing upon interdisciplinary studies, experiments, and varying amounts of technological hardware are quite often routinely employed to identify basic functional uses of artifacts and facilities. Such analytical strategies may treat microscopic examination of lithic artifacts for evidence of microfracture and abrasion resultant from their use as tools, or might involve analysis of heat radiation properties of hearths.

It is important to emphasize that specialized analyses of implement and facility function, while involving experiment, interdisciplinary comparison, or types of technological hardware which are not found in archeological laboratories, nevertheless, constitute an extremely important and dynamic part of ongoing archeological research.

Storage activities: Storage can be defined as both short term and long term preservation of materials for future consumption. As a subsistence strategy, it may be identified at the site-specific level through examination of processing activities related to the preparation of foods for storage, and as the construction or use of facilities wherein foods are stored. The amount of storage indicated at a site and the dependence upon short term and or long term storage can provide critical information about the character of the subsistence strategy or strategies employed by the people who occupied a specific site.

Maintenance activities: Maintenance activities may be defined as repair and upkeep of tools or facilities. Maintenance thus is differentiated from initial manufacture or construction, and includes clothing repair, implement repair, ceramic vessel repair, house replastering and so on. Facility maintenance, for example, may be recognized by remodeling episodes such as new floors, hearth alteration, or sequences of cist or bin remodeling and usage.

Recognizing implement maintenance activities is dependent in great part upon the ability to define functionally specific usage of tools. This is a difficult task archeologically in that tools used in primary manufacture of items are the same as those used in repair and upkeep.

IDENTIFYING SOCIAL GROUPINGS IN THE ARCHEOLOGICAL RECORD

Commensal Groups

Commensal groups have been defined as the basic food-sharing groups which constitute the smallest social components of a cultural system. Such social components are best identified at residential site locations through analysis of site space configuration. From an archeological standpoint, evidence of a single commensal group of residence can be seen principally as the presence of a hearth facility, generally in association with other structural and artifactual remains.

Of primary importance in the archeological analysis of such residential locations is defining the size of the residential group who inhabited the site (the number of commensal groups who occupied the site location contemporaneously); and any information pertaining to the character of articulation among them.

In residential sites exhibiting house structures, considerable information of this sort can be gained through examining the size and spatial arrangement of rooms enclosing hearth structures vis-a-vis other rooms. In site locations not exhibiting room features, similar information must be sought through examining the spatial distribution of artifactual debris in the vicinity of hearths.

Major analytical problems incurred when attempting to define the number of commensal units which occupied a particular site location are those of isolating the nature of discrete occupational events versus multiple occupational events that may have resulted in the deposition of a site. Sorting out a sequence of contemporaneous occupations making up site locations exhibiting architectural facilities such as rooms is often not as difficult. Sequences of construction and usage can often be employed to define multiple occupational events in these cases.

A more difficult analytical pursuit is that of sorting out different occupational events which characterize the occupational history of sites which do not exhibit room facilities, or those which consist entirely of hearths, fire-cracked rock and artifactual debris. Two basic approaches which may be proposed: (1) analysis of relative frequencies or volume of artifactual debris characterizing different sites; and (2) evaluating the degree of spatial integrity in patterning of artifact distribution with respect to hearth facilities.

Local Groups

The local group has been defined as the maximum number of commensal groups and individuals who share access to resources within a definable spatial territory. In many cases, local group subsistence within an effective territory involves seasonal variation in dispersal and aggregation of commensal group residences throughout each year so as to maximize food resource procurement. In other cases, residential variation may reflect essentially sedentary primary residences with logistical or task group dispersal on a seasonal basis for procurement or production purposes.

A fundamental concept underlying attempts to examine the character of local group interaction, as a structural component of cultural behavior, is that the local group constitutes an interactive socioeconomic entity of human behavior within certain spatial boundaries or territories. We have suggested that effective social components of the local group structure can be defined as commensal groups. We have further suggested that the subsistence-related behavior engaged in by members of commensal groups can be defined according to structural and organizational properties of such behavior. Structural properties consist of kinds of behavior undertaken at specific spatial locations (including procurement, processing, consumption, storage and maintenance); organizational properties consist of the manner in which each of those activities (as performed in one spatial location at one time during an annual cycle) functionally comprise parts of a system of activities performed at other spatial locations at other times during the annual cycle.

The character of interaction between activities performed at different site locations thus constitutes a focus of analysis underlying examination of local group interaction as a component of cultural systems.

Comprehensive definition of local group interaction among commensal units from an archeological standpoint is an extremely difficult and challenging task. A truly elegant archeological documentation of such interaction within a single phase or period of adaptation would require data from a large number of site locations including:

(1) the season of year during which each particular site was occupied;

(2) the number of commensal groups which comprised the residence unit of the site;

(3) the kinds of food and technological resources which were procured, processed and consumed during that seasonal term of residence; and

(4) the stages of processing of such resources which were undertaken.

Once this kind of information was explicitly documented for a great number of site locations over a relatively broad regional space, analysis could be directed toward ascertaining the relationships of activity performance which pertained between different residential locations. These relationships can be examined against two basic referent dimensions.

The first of these is a spatial referent, wherein the variation in kinds of resources procured and stages of processing they have been subjected to at different residential locales inhabited during the same seasons of year, are examined for information they provide concerning the character of contemporaneous interaction among residential units of the local group during that season. Objectives of this kind of analysis would be that of defining whether each residential unit was essentially operating as a self-contained economic entity or whether the different residential units were behaving more as subsistence specialists as segments of a local group structure.

The second referent against which intersite activity relationships might be examined is a temporal referent. This analysis would be directed toward isolating the annual patterning in resource procurement, processing, storage and consumption undertaken by commensal groups comprising a local group. Critical information desired through such analysis would be variation in size and composition of residence vis-a-vis spatial location of food and technological resources at different seasons of the year; and the degree to which different resources may have undergone stagelike temporal sequences of processing and consumption at different spatial locations throughout the annual cycle.

It can be seen, then, that analyses directed toward isolating salient properties of local group interaction among commensal groups employ, at their basic level, the same classes of archeological data which have been previously discussed as necessary in the identification of activities and commensal groups at the site specific level. The difference in analysis is simply that of perspective or goals. In the former case, the focus of interest is upon the *intrasite* frame of reference; while in the present case, it is upon the *intersite* frame of reference.

It is clear that archeological recognition of local groups, their social composition, and territorial frames of operation is predicated ultimately upon identifying the spatial and temporal strategies through which specific activities of resource procurement, processing, storage, consumption and maintenance are undertaken by commensal groups at particular sites. It should be equally clear th explicit and unequivocable delineation of exact territorial boundaries of different local groups through archeological analysis requires an opportunity to examine, intensively, a very broad study area.

Regional Groups

We have previously defined a regional group as a set of socially and economically interacting local group structures. The kind and intensity of local group interaction is expected to vary dependent upon the structural and organizational complexity of cultural behavior governing the regional group. Identification of regional group structure and the character of local group participation in that structure thus constitutes an important aspect of archeological analysis.

Analyses directed at isolating the character of regional group articulation are predicated upon defining the organization or interaction of local groups. This organization may have a social or ceremonial referent in providing, for example, mechanisms for operationalizing exogamous marriage practices; or it may have an economic or trade referent as trading partners or market systems through which goods and services are exchanged; or it may have a political referent, through administrative hierarchies or informal organization of war parties, for example.

We may define two kinds of data realms which are critical to an identification of regional group interaction. One concerns the kind of articulation (as above in social, economic or political terms). The other concerns the intensity of interaction which could be measured in terms of frequency of interaction or volume of goods and services exchanged. Together kind and intensity of local group interaction as regional groups constitute a primary kind of information bearing upon cultural evolutionary complexity.

From an archeological viewpoint, the most readily observable evidence of regional group interaction is that of the exchange or trade of material items. In this sense, political interaction or exogamous marriage exchange cannot be expected routinely to result in a highly visible archeological record.

Archeological analysis of local group interaction as a larger regional group must focus upon techniques to identify, on an empirical basis, items which are manufactured of materials that do not exist within the effective exploitive spatial territory of the local group segment.

Most readily identifiable items of this sort include lithic materials such as certain kinds of obsidians, cherts, ceramic vessel tempering agents, clays, turquoises, fibrolites, and the like. Occasionally other more perishable kinds of evidence may be employed in this regard, such as evidence of extra-local faunal species.

The context of occurrence at site locations of such extra-local material items is of extreme importance in defining the kind of interaction between local groups which resulted in their exchange. Particular attention must be paid to their use and deposition, so as to isolate whether they functioned predominantly as utilitarian items, whether they functioned predominantly in status enhancement contexts, or whether they represented basically decorative trinkets of no particular status or utilitarian meaning.

A second and equally important level of analysis is that of evaluating the intensity of nonlocal item occurrence throughout residential site locations occupied by local group segments. Of particular interest is the degree of redundancy in kinds of items recovered at each site location and the relative frequency or volume of their occurrence. Thus a pattern of redundancy of occurrence of certain items in certain contexts (such as shell pendants in association with adult male burials) might reflect a predominantly social, individual-based interaction between local groups. Such cases might be those wherein individuals of a given local group achieved local status through their ability to demonstrate prowess in periodic fashion in terms of their personal interaction with other local groups (through establishing trading partners, marriage alliances, or as warriors, for example).

A pattern of redundant deposition of bowls and ollas tempered with extra-local minerals at all residential sites within a local group territory, however, might reflect a much more routine social or economic exchange relationship which pertained between the local group which used those items, and the local group (or groups) who manufactured the vessels.

Like analysis of local group articulation, analysis directed toward isolating the kind and intensity of regional group interaction of local groups, from the perspective of a specific study area, is a partial process.

Primary data constituting the basis of such analysis are of two kinds. Site specific data can provide information bearing upon the character of local or nonlocal origins of items deposited, and a degree of information concerning their contexts of usage and deposition within the local group territory. A second realm of information critical to analysis of interlocal group articulation is simply that of spatial extent over which data concerning settlement variation exists. Spatial frames which characterize effective areas of regional group articulation are large in size, and generally much larger than specific study areas, or project areas within which archeological analyses are conducted. Because of this, the role of previous archeological, historical, and ethnographic research becomes critical in determining the extent to which problems of regional group structure and organization characterizing particular adaptive periods can be pursued.

SUMMARY

In this chapter we have presented a set of theoretical concepts which might be used as guidelines for studying the character of evolutionary change in human behavior. These concepts were derived in part from cultural evolutionary literature, in part from cultural ecological literature, and in part from observations about the structure of the archeological record itself. Salient points of that discussion are reviewed here.

Anthropologists have employed two basic processes for understanding variation and change in human cultural behavior. These have been termed general evolutionary processes and specific adaptive processes. It is our opinion that the general evolutionary literature has demonstrated the existence of basic redundancies in structure and organization of cultural systems throughout different parts of the world and has further demonstrated that variation among these can be ordered from simple to complex in a finite series of taxonomic schemes.

For purposes of archeological study, we proposed that structural properties of human social behavior relevant for study of cultural evolution might be defined hierarchically from smallest to largest as commensal groups, local groups, and regional groups. We further suggested that organizational properties of human social behavior relevant toward cultural evolutionary studies might be defined as scales of interaction pertaining between these social groupings at each level in the hierarchy. Properties of interaction which might be scaled include frequency of interaction, volume of interaction (if involving exchange of goods), and the number of social groupings which were articulated through those interactions.

In order to identify how these kinds of interaction might be recognized archeologically, we turned to a review of anthropological literature concerning specific adaptation and cultural ecology. These studies emphasize a fundamental relationship between cultural behavior and effective environmental settings in terms of activities through which resources are acquired and consumed by a human population. We suggested that this concept of activity performance offered considerable potential as a means of defining interaction among social components simply because activities must be sequentially performed one after the other through time and many must be performed at different places in space.

We thus proposed that basic properties of organization among social groupings might be defined as the relative temporal scheduling and spatial positioning of activity performance related to food and technological resources.

For purposes of archeological recognizability, we suggested these activities might be classified according to stages in the cycling of resources including procurement, processing, transportation, storage, and consumption. A variety of ways in which direct and indirect evidence of different stages of resource cycling might be identified for different species of food resources or different types of technological resources were discussed.

As a final point, we summarized how the concepts of social components (commensal groups, local groups, and regional groups) and the concepts of organizational properties (activity classes and stages in resource cycling) might be employed to describe past cultural systems in a fashion relevant for studying cultural evolutionary process.

What we have outlined thus constitutes a general conceptual scenario that reflects the manner in which we believe two fundamental theoretical concerns underlying much past anthropological research might be operationalized in a fashion permitting the archeological record to be used as new information bearing upon those theoretical and explanatory concerns.

We believe that the investment of anthropological research into modeling cultural evolutionary process has resulted, to date, only in identification of redundancies or patterns in cultural behavior which are *felt* to represent stages or levels in a hierarchy of change, but which exist at present only as taxonomies of variation among different cultural systems. The cultural evolutionists, as theory-builders, have only laid the foundations for a true processual, explanatory theory of cultural evolution. The character of the processes themselves, or the postulated conditions under which those processes can be predicted to result in evolutionary change from one stage to another, have not been developed in any satisfactory fashion.

As it exists now, cultural evolution is not a theory of human behavior; *it is a concept which offers potential for* theory-building. In order to pursue that theory-building process, means must be sought to examine diachronic cases which exhibit evidence of historical links between more simple stages and more complex stages of evolutionary behavior. We feel the archeological record offers the only worldwide document of a great variety of such empirical cases.

In order to use that document, however, the language in which it is written must first be deciphered. To that end we proposed that a second fundamental concept underlying much anthropological research, specific adaptation, offered (and offers) considerable potential as one such means of deciphering the archeological document.

The concept of adaptation suggests that variation in the behavior of a species, a population of individuals, or a single individual, can be potentially accounted for through the basic energetic articulation of organism and environment. From an archeological standpoint, the concept seems quite productive as a potential grammar through which the material document of human behavior might be assigned meaning, at least concerning the synchronic structure and organization of basic subsistence engaged in by past human populations.

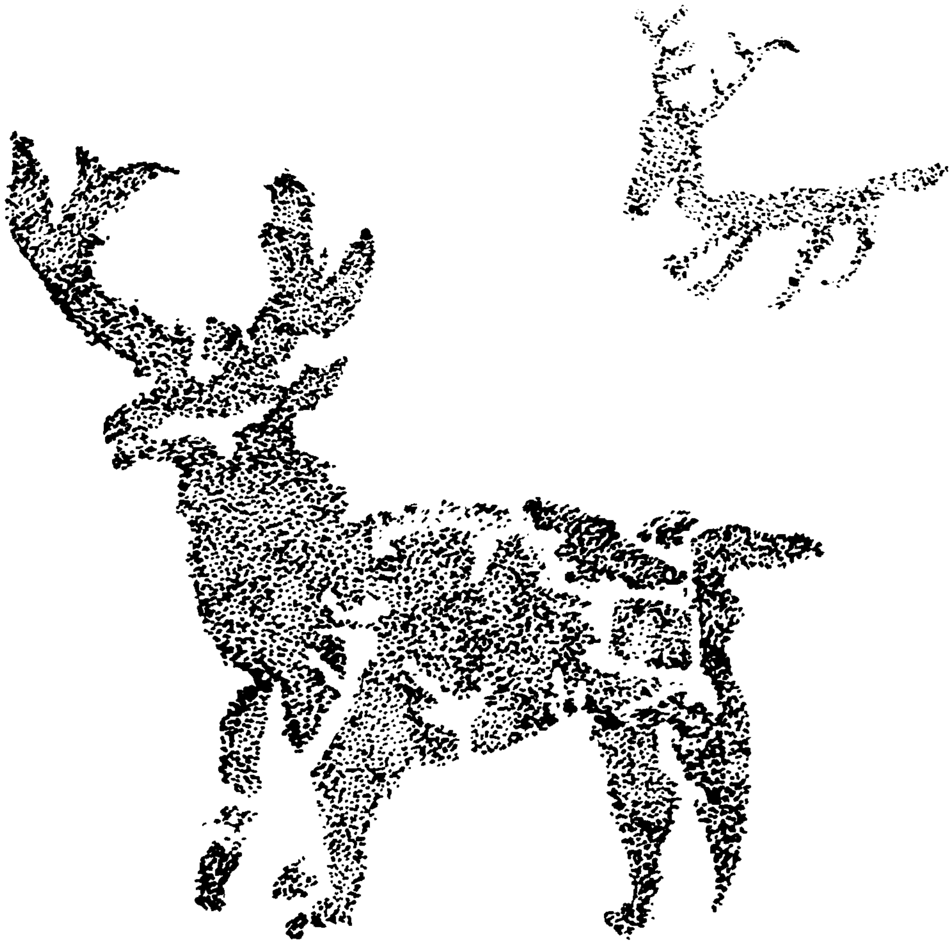
To this end we have suggested a strategy wherein particular material manifestations of past human activities might be construed as phonemic components, and wherein the spatial positioning of those activities (and temporal scheduling of those activities, when ascertainable) might be contrued as the syntax of that grammar, in behavioral terms. Given tools which we have available now to delineate the character of environmental variation within which adaptive systems operated in the past, we can outline a basic

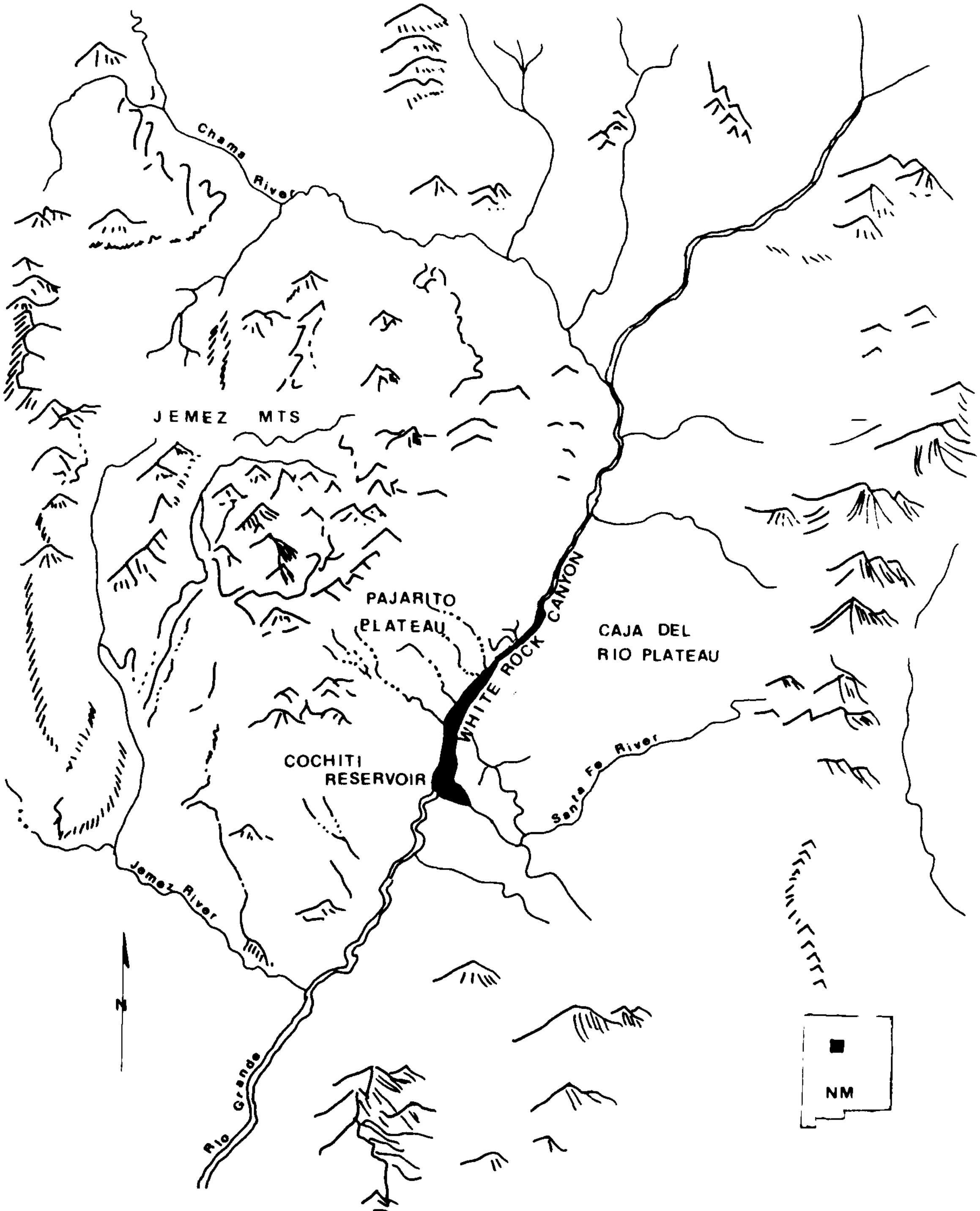
structure of the behavioral system itself. We can thus examine variation in the character of human behavior through time as different grammatical expressions of fitness to selected features of environmental phenomena.

In this chapter, we have attempted to articulate the manner in which two fundamental theoretical concepts that pervade past anthropological research, general evolution and specific adaptation, might be employed in complementary fashion to define features of archeological visibility such that those features can be used as information in building a predictive theory of human cultural behavior.

We by no means suffer the pretension that we have defined the outlines of such a theory; we have rather attempted to isolate what we feel are productive avenues of investigation in that regard. Our prospectus is decidedly rudimentary, but nevertheless offers, in our opinion, a potentially useful approach toward employing the archeological record as new information concerning the processes underlying cultural evolutionary change.

PART TWO: THE EFFECTIVE ENVIRONMENT

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PREFACE TO PART TWO

Cochiti Reservoir is located in the Rio Grande basin of north-central New Mexico. It lies at the base of the eastern flank of the Jemez Mountains in a narrow, deep canyon -- White Rock Canyon. Prominent features in the immediate area include the digitated mesas and narrow erosional canyons of the Pajarito Plateau, which lie directly to the west of the reservoir; the lava mesas of the Caja (or Cerros) del Rio Plateau, to the east of the reservoir; the basalt cliffs of La Bajada fault scarp, to the southeast of the Caja; and the gently sloping hills which flank the broad flood plain of the Santo Domingo Basin of the upper Middle Rio Grande Valley.

Cochiti Dam is situated directly across the Rio Grande, the major perennial river in the general area. The flood pool of the reservoir extends from the Santa Fe River in the upper Middle Rio Grande Valley (in the south) approximately 32 km upstream into White Rock Canyon encompassing an estimated 9060 surface-acres. The main portion of the reservoir or permanent pool however, is 0.8 kilometers wide with 1240 surface-acres.

Elevations within the reservoir range only from 5280 to 5460 ft, but peaks of the Jemez Mountains, to the west, rise to over 11,200 ft. The climate is semiarid with annual precipitation ranging from 8 to 16 inches with the heaviest rainfall during July and August (Tuan et al. 1969). Precipitation generally increases with elevation and is greatest on the Pajarito Plateau and lowest in the Rio Grande trough. Catchment runoff for the Pajarito Plateau drainages is higher in the spring than in the fall; the reverse is the case for drainages originating on the Caja del Rio Plateau (Brakenridge 1977). Although the growing season for the upper elevations of the Pajarito Plateau is as low as 120 frost-free days, most of the reservoir and surrounding environs exhibit between 160 and 180 frost-free days (Tuan et al. 1969).

Twelve vegetative communities within three life zones (Upper Sonoran, Transition and Canadian) have been documented for the general area, although the reservoir itself is situated entirely within three communities in the Upper Sonoran zone (Drager and Loose 1977). Differences in slope, exposure, soil matrix, as well as general elevation condition the extent and distribution of the vegetative communities. The Pajarito Plateau and White Rock Canyon areas, with their marked physiographic relief, are characterized by numerous small patchy habitats which support a wide variety of different species (both floral and faunal). The Caja del Rio Plateau and upper Middle Rio Grande Valley areas exhibit much more subdued physiographic relief and, as a result, larger more homogeneous habitats and less diverse complement of species. Cochiti Reservoir is thus situated in a complex physiographic and biotic province.

During the initial stages of the Cochiti Reservoir project, we began compiling information about the biotic and abiotic variability in the reservoir and surrounding areas. Whenever possible specialists were funded to conduct additional fieldwork to complement the literature on a particular environmental topic. The combined results of this research have been presented in the first volume of the present research series (Biella and Chapman 1977c) and include a review of the geologic history and lithic mineral resources of the Cochiti area (Warren 1977); an aerial stratification of the general area into life zones and vegetative communities (Drager and Loose 1977); a series of vegetative transects within White Rock Canyon coupled with a review of the ethnobotanical literature (Tierney 1977); a review of faunal diversity, availability and productivity (Marchiando 1977); a study which attempted to characterize the arable potential of the Cochiti area based upon differences in slope and exposure (Ramage 1977); a stratification of catchment flow estimates (seasonally and annually) for 40 lateral drainages within the general Cochiti area (Brakenridge 1977); and a review of paleoclimatic data (Cully 1977).

In this report we present two studies which should be considered a continuation of the previous environmental research. In Chapter 2, Tierney provides additional data on the vegetative makeup of the general Cochiti area. In addition to presenting information from new vegetative transects which were located outside the confines of White Rock Canyon, she summarizes the results of a study concerning the seasonal availability and productivity of different edible plants growing in the vicinity of the reservoir. In Chapter 3, Warren presents the results of a study concerning the distribution and availability of lithic and mineral resources within the general Cochiti area, in particular White Rock Canyon.

Together these studies provide a comprehensive review of environmental variability which might be expected to affect the character of human adaptation in Cochiti Reservoir and provide a framework for the analytical studies which follow in the next section of this report.

Chapter 2

NATIVE EDIBLE PLANT RESOURCES NEAR COCHITI RESERVOIR, NEW MEXICO

Gail D. Tierney

INTRODUCTION

A study of the variety and distribution of native, edible plant resources that exist in the vicinity of Cochiti Reservoir was begun in early April of 1977 under the sponsorship of the Office of Contract Archeology, University of New Mexico. The primary goals of the study were to identify the diversity of edible plant species existing in the Cochiti Reservoir study area; to observe and record the seasonal development of edible species in the environmental context of the study area; and to delineate potential resource areas in which those edible plants most important for human subsistence would occur.

Another goal not entirely realized during the study's term was an assessment of the caloric and protein intake potential of the native, edible species for supplying energy to prehistoric human populations. Though the latter goal has not yet been achieved, it is hoped that the results of the present study may provide baseline data for interpretations of archeobotanical materials retrieved in the excavations of the sites near the reservoir. Some of the results may also prove useful in broader studies of subsistence and adaptation within the Cochiti Reservoir study area.

Twenty days of useful fieldwork were accomplished during the term between April 6, 1977 and October 12, 1977. An additional four days were spent in the field in April 1978, for the purpose of confirming or revising certain observations made during the previous spring field session.

The methods used to present and interpret the data collected during the present study are unusual and require explanation. These methods emphasize the variations observed in the *diversity*, *seasonality* and *ubiquity* of the native edible plants that grow in each of the terrain types, or subregions, contained in the study area. Little emphasis is placed on measurements of the modern *density* of native edible species for reasons discussed below.

For purposes of this study, *diversity* is measured by the number of edible species recorded in each subregion. A plant species contributes equal weight to the measure of diversity even if only one individual of that species is found in a subregion. *Seasonality* is the same thing as seasonal diversity. It is measured by the number of different species that develop edible plant parts within a given interval of the growth season (early spring, late summer, etc.) and occur within a given subregion. As defined here, diversity and seasonality are measures assigned to each subregion. *Ubiquity*, on the other hand, is a measure assigned to each species by counting the number of subregions in which the species appears. Ideally, all three of these variables, diversity, seasonality and ubiquity, could easily be inferred from measurements of the *density* of the plant species. Density is usually estimated by counting the number of individuals, or weighing the biomass, representing a species that occur in a series of randomly chosen plots of standard size. The sample densities so obtained may then be used to estimate the absolute abundance (in number of individuals or biomass) of the species in a given subregion of the study area.

Given sufficient time and resources, density is clearly the variable that should be measured since one gains information that is useful in assessing the absolute food value potential of the subregion in question in addition to the information on vegetative patterns that is implicit in the diversity—seasonality—ubiquity variables. But if time and resources are limited (as they necessarily were during the present study), one must carefully balance the extra effort required to measure density with the benefits to be derived from having estimates of the *modern*, absolute food value potential for the study area. In the author's opinion, the connection between the modern absolute food value potential of the Cochiti Reservoir study area and its prehistoric carrying capacity for human gatherers is weak, owing mainly to the prolonged and locally intense disturbance by grazing and land development activities. The problem of disturbance in confounding assessments of prehistoric plant resources is a major one. For an example in the context of the overgrazed Rio Puerco valley, see Adams (1977). The problem has also been addressed by Vorsila Bohrer, who is developing nonpalynological methods for reconstructing the potential prehistoric vegetation patterns in overgrazed landscapes (Bohrer 1978).

The diversity—seasonality—ubiquity variables used in the present study have the advantage that they are relatively easy to measure. Subject to the validity of certain assumptions, these variables may prove useful indicators of resource and resource area importance in prehistoric time. The use of these variables in the present work is predicated on the following assumptions:

(1) The diversity of native plants has remained relatively stable since prehistoric times, though densities of the individual species may have been selectively altered by climatic or anthropogenic disturbance;

(2) Native food gatherers tend to settle and work within or near to, those subregions of a settlement area that exhibit the maximum resource diversity (as opposed to areas with a predominance of a few resources);

(3) The frequency of references to the specific, economic use of a plant species in the ethnographic and ethnobotanical literature is a good measure of the probability that the species was similarly used in prehistoric times.

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Granting the validity of these assumptions, it is easy to see how the diversity--seasonality--ubiquity variables might be used to indicate the resource and resource areas preferred by prehistoric populations. As examples: a subregion showing a high, modern diversity of native edible plants would be a potential resource area in prehistoric times according to assumptions (1) to (3); a subregion that contains a high diversity of developed plant foods in early April would be a potential spring resource area; and the most ubiquitous native edible plants appearing in a study area would also be the plant foods most familiar to native populations who formerly resided in the area. The most ubiquitous native edible plants are also the ones whose remains should turn up most frequently in demonstrable associations with archeological remains of fire pits, cooking ware and storage vessels.

AREAS SELECTED FOR STUDY

Selections of specific topographic areas for botanical observations were made primarily on the basis of previous experience of vegetative patterns near the Cochiti Reservoir (Tierney 1977:39-67). Another factor that determined the choice of study areas was the need to find accessible vegetation plots that would be free of disturbance (herbivore grazing and construction activities) throughout the season of vegetative growth. The eight areas that proved relatively stable throughout the study term are named below:

(A) A West Side Mesa Top (above Rio En Medio);
(B) A West Side Tributary Canyon (Cochiti Canyon, Rio Chiquito);
(C) The West Rim of White Rock Canyon;
(D) An East Side Talus Slope, White Rock Canyon;
(E) An East Side Terrace, White Rock Canyon;
(F) The East Rim, White Rock Canyon;
(G) An East Side Pebble Terrace, Canada de Cochiti;
(H) An East Side Flood Plain, Santa Fe River.

Some limited observations were also made in a ninth area:
(J) Riparian River Bottom (Rio Grande below Cochiti Dam).

The locations of the major centers of survey activity for each of the named areas are marked by capital letters (A, B, C,...) on Fig. 2.1. Observations were not, however, confined to small sites at the selected survey centers: the names of the study areas should also be interpreted as names of similar terrain types (i.e. topographically defined habitats that have roughly the same elevation, exposure and substrate) that lay between 300 to 1000 m of the marked centers. The nine specific study areas, and the adjacent patches of similar type of terrain, should be regarded as a biased sample of the set of all terrain types that would be accessible to a person traveling by foot from any point within 5 km of the present Cochiti Dam. The 5 km radius was dictated by limitations of accessibility and time; however, see the comments on radii of subsistence activities in Flannery (1976).

As is shown in Table 2.1, each of the composite study areas is usually adjacent to two of the fourteen ecological communities defined by Drager and Loose (1977:33) in a study of aerial photographs of the southern Pajarito Plateau. The ecological communities characteristic of elevations above 1829 m (6000 ft) on the southern Pajarito Plateau are not represented in the present sample of terrain types. Also missing are representations of river bottomlands in the trough of White Rock Canyon below 1615 m (5300 ft) elevations. The vegetation of the trough of White Rock Canyon was surveyed in the spring of 1975 (Tierney 1977) prior to the filling of the reservoir. A comparison of plant lists from this earlier study and ones obtained in the present work shows that with only a few exceptions, the vegetation in the bottom of White Rock Canyon (below 1615 m) is composed of species that appear in the presently defined study areas B (Cochiti Canyon) and D (East Side Talus).

Table 2.1

Ecological Zones Adjacent to Botanical Study Areas

Vegetative Community[1]	Study Area A	B	C	D	E	F	G	H	J
Upper Sonoran Juniper Grassland	—	—	—	—	X	X	X	X	—
Upper Sonoran Coniferous – Undifferentiated	X	X	X	—	—	—	X	—	—
Upper Sonoran Coniferous (Juniper)	—	—	—	—	—	—	—	—	—
Upper Sonoran Coniferous (Pinyon and Juniper)	—	—	—	—	—	—	—	—	—
Upper Sonoran Deciduous (Scrub Oak)	—	—	—	—	—	—	—	—	—
Upper Sonoran Arid (Yucca, etc.)	X	—	—	X	X	—	—	X	—
Canyon Riparian	—	—	—	X		—		—	—
Agricultural Fields	—	X	—	—		—	—	—	X

[1] cf: Drager and Loose 1977:31-37

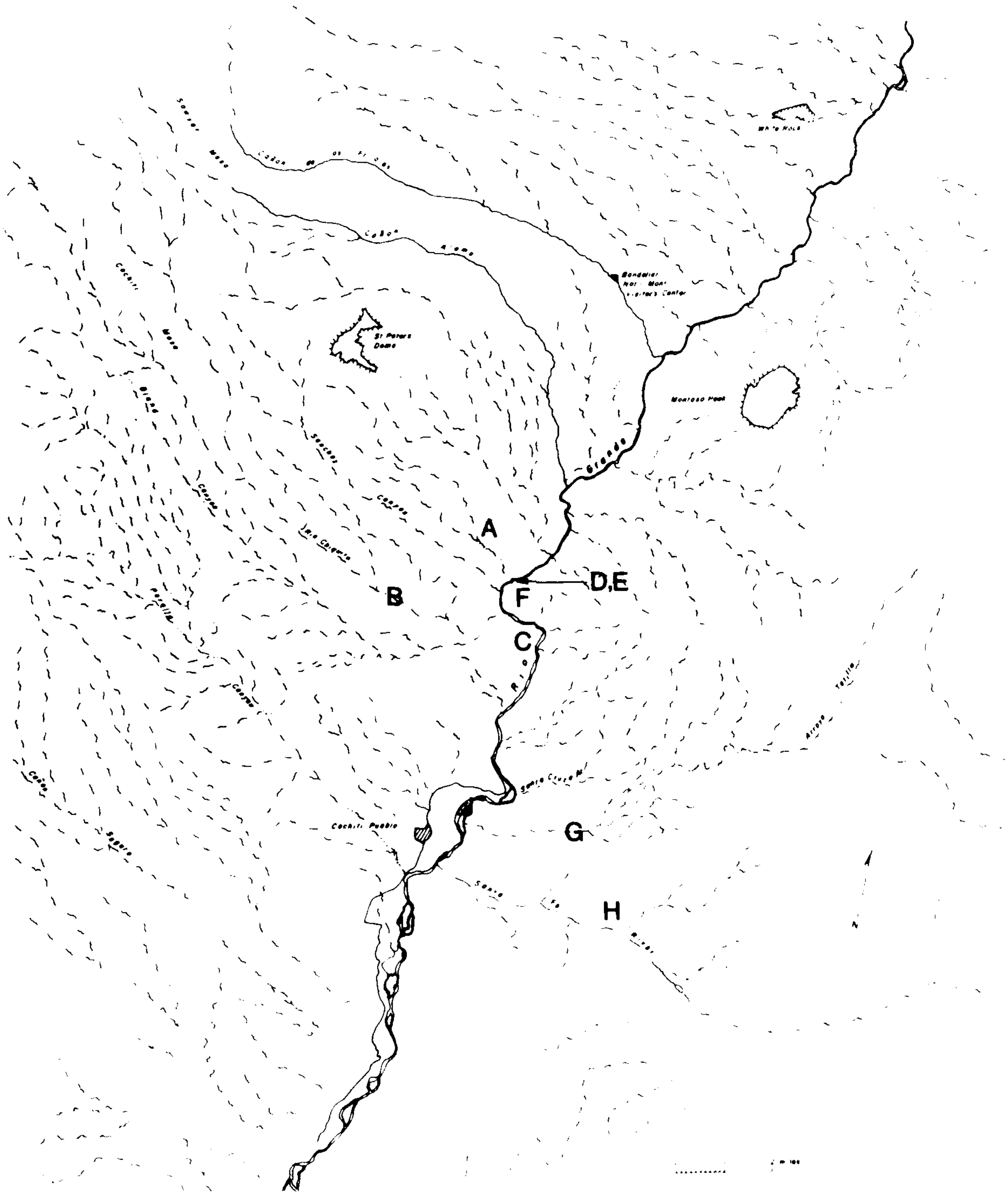


Fig. 2.1 Location of the study areas.

FIELD METHODS

The sites suitable for botanical observations were identified by May 1977. At each of these, a pattern of wooden or metal stakes was set out near a route of access to permit identification later in the season (areas F and J were not marked). Nearly all of the nine areas and their associated, contiguous terrains were then visited at least once in every month of the seasons that followed through October 1977. Some sites were missed in the month of July because of inclement weather. During each visit, the terrain was surveyed on foot and notes were taken on (1) any plant species missed on previous visits, including newly appearing annuals; and (2) the stage of development of certain stands of native, edible plants. New plant species were collected and pressed for later reference only if they could not be identified in the field.

The strategy for identifying new species in each terrain type was probably adequate to catch 95% of the number of different species of vascular plants. In general, the number of new species found per site per visit was nearly constant in April and May, began to decline in June, and was virtually nil in August and September.

When persistent stands of economically interesting native plants were identified in a study area, they were marked with wooden stakes and their coverage was noted by counting the number of units in a quadrat of appropriate size, usually 10 m by 10 m square. A limited number of experiments directed toward harvesting edible plant parts was also conducted at these sites at the appropriate season. The methods and results of the experiments are mentioned later in this chapter in sections that discuss selected, important edible plants.

Certain exceptions to the general field methods outlined above deserve mention. The botanical observations of the East Rim of White Rock Canyon, study area F, were mainly confined to a large prehistoric ruin and parts of an associated agricultural area. A natural fence of cholla (*Opuntia imbricata*) encircling the ruin provides protection from herbivores to open regions within the fence having a total area of about 0.8 hectares (8000 m^2). Agricultural areas outside this cholla stand were practically devoid of vegetation. The diversity of vegetation growing in these protected niches is (as will be seen later) sufficient to bring the overall floral diversity of the East Rim area up to the level of diversity measured for the West Rim, study area C. One should expect the composition of vegetative types on each side of White Rock Canyon to be nearly the same in the absence of differential grazing pressure. The present field observations have partially confirmed this expectation.

Observations of the Riparian River Bottom habitat, study area J, were limited by access to terrain no further than 30 m from public roads or cultivated lands. The composition of native plant species determined for this site is likely to be an unnatural one, particularly in measures of the diversity of annual herbs and grasses.

Figures 2.3 through 2.6 provide photograph examples of typical vegetative associations encountered in the study area(s).

Further description of the composite study areas, their topography, and other factors determining plant habitat variation is presented in the following section.

Fig. 2.2 Sego lily, a spring resource

Fig. 2.3 View from En Medio Mesa, looking east

Fig. 2.4 View of old agricultural area within Toreva block formation

Fig. 2.5 View of cholla forest surrounding ruin on Caja del Rio Plateau

Fig. 2.6 View of grassland looking toward La Bajada fault scarp

DESCRIPTION OF STUDY AREAS

Study Area A – A West Side Mesa Top

The center of the study area is near the southeastern edge of a mesa top above Rio En Medio canyon. The approximate UTM coordinates are: ^{3}81000mE ^{39}51000mN. Elevation at the site is about 1798 m (5900 ft) and the exposure is full. The soil is a mixture of weathered volcanic tuff and basaltic pebbles covered in places with a layer of stabilized aeolian sand.

The mesa top is typical of others that lie immediately to the north (above Capulin Canyon) and to the south (above Sanchez Canyon) at elevations 1768-1829 m (5800-6000 ft). Ecological communities on these mesa tops are a mixture of Upper Sonoran Coniferous and Upper Sonoran Arid (yucca, etc.) components (Drager and Loose 1977: Fig. II.2.1). As one moves off the mesa tops toward a tributary canyon, the biotic community shifts to a deciduous zone: near mesa rims and on terraces just below the rims, several species of oak (*Quercus* spp.) and saltbush (*Atriplex canescens*) are common where there are northeastern exposures and substrates of aeolian sands or colluvium. Some relicts of former *Pinus ponderosa* populations can be seen near the mesa rim on the northern face of Capulin Canyon. The steep parts of the canyon sides below the mesa show little vegetation since the substrate is a loose talus of blocks of tuff and coarse pumice pebbles. Some of the plant species characteristic of tributary canyon bottoms will colonize the lower talus where soils are established.

Study Area B – West Side Tributary Canyon

Botanical stations were set up and maintained throughout the season in Cochiti Canyon (Rio Chiquito) at the approximate UTM coordinates: Zone 13 ^{3}77000mE ^{39}49000mN. Elevations of the study area are between 1737 and 1783 m (5700-5850 ft). Exposure is nearly full everywhere, owing to the broadness of the canyon (800 m at this point), and the low relief of canyon sides. The soil of the canyon is variable. Deep, sandy colluvium mixed with pumice pebbles and angular blocks of basalt occurs frequently and furnishes the matrix for vegetative patterns.

A permanent stream, the Rio Chiquito, occupies the bottom of Cochiti Canyon at the center of the study area, and forms a 10 m wide strip of the Canyon Riparian zone. Outside of this narrow strip, the canyon exhibits a mixture of the Upper Sonoran Coniferous and Upper Sonoran Deciduous communities. Contemporary agricultural fields are seen on the western edge of the area; and this part of the canyon is otherwise disturbed by numerous roads, prehistoric ruins, and fences. There is evidence of persistent grazing by cattle and other herbivores.

Cochiti Canyon is not typical of other tributary canyons located on the west side of White Rock Canyon above its juncture with Bland Canyon. Most neighboring west side tributary canyons carry only intermittent streams and are continuously semiarid. The waters of the Rio Chiquito flow continuously until about a mile above the Rio Grande. East of that point the water disappears into the sand and the mouth of this canyon is like any other in this area.

Study Area C – The West Rim of White Rock Canyon

A survey of vegetation of the west rim of White Rock Canyon was mentioned in an earlier report (Tierney 1977: 58). To obtain new and seasonal information, observations were made during 1977 within areas of the west rim centered roughly at the UTM coordinates: Zone 13 ^{3}82000mE ^{39}47000mN.

Away from the mouths of tributary canyons, the western rim of White Rock Canyon is a series of gently sloping hills dissected by drainage channels that empty to the Canyon below. The slopes vary from 5^{0} to 30^{0} and exposure is full but slightly to the east. Elevations along a 300 m wide strip of the rim near the area's center may vary from 1707-1722 m (5600-5650 ft). The soil horizon near the rim is comprised of a layer of aeolian sand or colluvium mixed with pumice pebbles and averaging 20 cm in depth. The bedrock appears to be white pumice. Surficial organic layers have developed where leaves and plant remains have accumulated.

The biotic community is a mixture of Upper Sonoran Coniferous and Deciduous communities. Stands of the scrub oaks, *Quercus grisea* and *Quercus turbinella*, grow along the eastern margin of the rim; and stands of yucca (mainly *Yucca angustissima*) mark the western margin at a distance of about 200 m from the edge of the Canyon. The area is disturbed by roads, trails and property markers on its western margins. Vegetation in these disturbed areas is noticeably different from that which grows nearer to the canyon, mainly in the number of weeds and introduced species that are present.

Study Area D – An East Side Talus, White Rock Canyon

The talus slope surveyed during the 1977 season is located just below the center of area E (see below) which has the same approximate UTM coordinates: Zone 13 ^{3}82000mE ^{39}50000mN. The talus slants to the northwest with slopes of 25^{0}to32^{0} and elevations are between 1661-1676 m (5450-5500 ft). The sparse vegetation on these slopes is established in pockets of sandy colluvium between the tumbled boulders of basalt. Netleaf hackberry (*Celtis reticulata*), *Philadelphus microphyllus* and *Artemesia cana* are the most visually dominant species. Grasses are sparse near the center of the site which is typical of contiguous talus slopes and cones on the east side of the canyon.

Study Area E – An East Side Terrace, White Rock Canyon

The terrace referred to here is one that is formed by a Toreva block slide – a landslide of a single large block of material paralleling the cliff face. Between the basalt block and the cliff face pockets of windblown sand have formed in natural basins having areas from 10 to 6000 m^{2}. The vegetation is confined mainly to these basins at elevations within 1676 ± 5 m (5500 ft). Exposure may be limited on the margins of the terrace because of the Toreva block on the western side and a cliff face on the eastern side. Nevertheless, there is evidence that these terraces were used as prehistoric garden plots. Historically, some were modified as animal enclosures. The native plant communities are typical of a cline between the canyon riparian zones on lower talus slopes of White Rock Canyon and the Upper Sonoran Grassland zones that dominate the eastern canyon rim. The rim region begins 15-20 m above the terrace.

Study Area F – The East Rim, White Rock Canyon

The center of the study area lies near LA 5137 on the eastern rim of White Rock Canyon. The mouth of Sanchez Canyon lies almost directly west from the site. Approximate UTM coordinates are the same as those given for areas D and E.

The elevation at this part of the east rim is 1737 m (5700 ft) and the terrain is of low relief with nearly full exposure in every direction. The study area is mesa-like and arid, unlike the opposite western rim, though the composition of the substrate and the exposure are not substantially different. An Upper Sonoran Grassland is the dominant ecological zone at the site's center; coniferous trees such as juniper and pinyon are widely spaced and the understory vegetation growing outside of certain natural protected areas is sparse. Within protected areas though, the understory of small shrubs, perennial forbs and annual herbs is remarkably diverse. This suggests that the poor vegetative coverage of this part of the eastern rim is a consequence of overgrazing and resource exploitation, rather than due to major differences in habitat variables (when compared to the western rim).

Study Area G – An East Side Pebbled Terrace (Canada de Cochiti)

The study area is actually a composite of two specific patches of terrain that have very similar elevations, soil type and exposure. The first of these patches lies within the borrow area of the Cochiti Reservoir Flood Control Pool on the southeastern side of the Canada de Cochiti (Tetilla Arroyo) drainage. Approximate UTM coordinates are Zone 13 ^{3}83000mE ^{39}41000mN. The second patch is located outside the southern boundary of the borrow area 3 km due south of the first one: approximate UTM coordinates are ^{3}83000mE ^{39}38000mN. Though both areas are near Cochiti Dam and construction roads, they appear relatively undisturbed.

The elevations of these similar terrains are 1652-1661 m (5420-5450 ft). Exposure is nearly full and trees are sparse. The substrate varies from sandy colluvium and clay near the high points to clays and buff colored sands well mixed with rounded, river-washed pebbles and cobbles near the drainage channels. The substrate of these sites marks the principal difference between them and study area H (see below). The variation in soil type within these patches and the presence of shallow drainage channels have allowed the maintenance of a small coniferous (juniper) component within what is mainly a grassland community. The predominant grasses here are the gramas (*Bouteloua* spp.).

Study Area H – An East Side Flood Plain, Santa Fe River

This study area is made up of open grasslands on an old flood plain with stabilized dunes. The site is located on the eastern side of the Santa Fe River drainage below the La Bajada escarpment and about 2 km north of La Bajada village. The approximate UTM coordinates are Zone 13 ^{3}85000mE ^{39}37000mN. The terrain is rolling dunes on the east and a more level area on the north with evidence of old irrigation ditches dissecting it. The elevation at this site is 1681 m (5515 ft). The soils are deep, wind-blown sand that is mixed with small pebbles near the drainage slopes.

The dominant biotic community may be called Upper Sonoran Grassland although there are a few juniper trees in the area (roughly two per km^2). The flood plain and companion dunes have been sporadically grazed and cultivated in historic times. At present the main vegetative components for this area are sand dropseed (*Sporobulus aeriodes*), rice grass (*Oryzopsis hymenoides*), canaigre (*Rumex hymenosepalus*), narrow leaf yucca (*Yucca elata*), and chenopods (*Chenopodium* spp.).

DATA SUMMARIES AND COMMENTS

Introduction

The data on variety, distribution, and seasonality of vascular plant species obtained during the study's term is presented in Table 2.2 in the form of an annotated plant list for Cochiti Reservoir and its immediate environs. The list names all plant species that were observed in the study areas during the term, states the parts of the plant (if any) that are eaten by humans and gives the observed times of development of edible plant parts in the environmental context of the 1977 growth season at the reservoir. In addition, the presence or absence of each plant species at the nine study sites is indicated in the list by the presence or absence of an *x* in the column under each site label (A-H, J).

In naming the plants, an attempt was made to identify all edible specimens at the species level. The occasional appearance of *sp.* or *spp.* following the genus name in Table 2.2 shows that the attempt was not always successful. However, in those instances where only the genus name appears, the importance of the plants as a food (with the exception of *Portulaca* sp.) was either negligible for the purposes of this study or unknown. There is thus about 10% uncertainty in the total number of species identified in Table 2.2 in addition to the 5% sampling uncertainty. I did not attempt to exclude introduced species (non-native). These plants frequently indicate the degree of disturbance to which an area has been exposed and to some extent whether the disturbance is recent or historic. Most of the common plant names are taken from Kearney and Peebles (1964).

A plant appearing in the table is called edible only if there are references to the use of some part of it as a food in ethnographies or the ethnobotanical literature. References for the edibility of most of the native plants recorded in Table 2.2 can be found in an earlier report on the vegetation of White Rock Canyon (see Tierney 1977:62-67).

The dates of the month that appear in the column of Table 2.2 labeled *season* are those days during the 1977 season on which the stated plant part was *first* observed to be fully developed. A range of dates of the month (e.g., April 6--May 18) indicates the earliest and latest times of first, full development of the plant parts that were observed among populations of the stated species growing within the study area. In general, plant populations in different topographic habitats will form shoots, leaves, blossoms and fruits at different times, owing to geographic variations in exposure, substrate and precipitation patterns.

The appearance of annual grasses and herbs in a semi-arid landscape is especially sensitive to the precipitation during current and preceding seasons (Daubenmire 1968). A plant list compiled for a given region and year, and intended for use in resource availability studies, should therefore be qualified and accompanied by records of regional precipiation if possible. Figure 2.7 shows such precipitation records for Cochiti Dam during 1976 and the spring and summer of 1977 (Dept. of Commerce 1976, 1977). The curve for the average of cumulative precipitation near Cochiti Dam is constructed from data in Tuan et al. (1973). It is apparent that though precipitation was nearly normal during the first seven months of 1977, the moisture base supplied in 1976 (particularly, in the fall and early winter) fell 22% short of the average annual amount. The cold and dry winter of 1976 may account for the author's subjective impression that fruits and berries of many perennials — for example those of *Lycium pallidum* — developed poorly or not at all during the following growing season. On the other hand, the representation of annuals in the plant lists of Table 2.2 is probably a *normal* one, given the nearly normal pattern of precipitation during the spring and summer of 1977.

Table 2.2

List of Botanical Species

Binomial	Common Name	Edible Parts	Season	Present at Habitats: A	B	C	D	E	F	G	H	J
A. List of Trees												
Acer negundo L.	box elder	inner bark	All year	–	X	–			–	–		
Celtis reticulata Torr.	netleaf hackberry	fruits	Sept. 30	–	–	–	X	–	–		–	
Elaeagnus angustifolia L.	Russian olive	(introduced)	–	–	–	–	–	–		–		X
Juniperus monosperma (Engelm) Sarg.	one seeded juniper	fruit	Sept. 21–winter	X	X	X	X	X	X		X	
Juniperus scopulorum Sarg.	Rocky Mountain juniper	fruit	May 15–early spring	–	X	–		–				
Pinus edulis Engelm.	pinyon pine	nuts	alternate seasons after Sept. 15	X	X	–	–		X	–		
Pinus ponderosa Engelm.	ponderosa pine	inner bark	year round	–	X							
Populus angustifolia	narrowleaf cottonwood	seed pods	(not observed)	–	X		–	–	–	–		
Populus fremontii Wats.	cottonwood	seed pods	May 27		–				–			X
B. List of Shrubs												
Amorpha sp.	false Indigo	–										X
Artemisia bigelovii A. Gray	bigelow sagebrush	seeds	Sept. 22		–		X					
Artemisia filiafolia Torr.	sand sagebrush	seeds	Aug 22-Sept 22	X				X		X		
Artemisia tridentata Nutt.	big sagebrush	seeds	–			X						
Atriplex canescen (Pursh.) Nutt.	Four-wing saltbush	leaves: seeds:	after April 6 Sept 13-Oct 12	X					X	X	X	

Table 2.2 (Continued)

Binomial	Common Name	Edible Parts	Season	A	B	C	D	E	F	G	H	J
				Present at Habitats:								
				B. List of Shrubs (Continued)								
Brickellia californica (Torr. Gray) Gray	brickel bush	–	–	–	–	–	X	–	–	–		
Cerocarpus montanus Raf.	mountain mahogany	–	–	X	–	–	–	–	–	–	–	–
Chilopsis linearis (Cav.) Sweet	desert willow	–	–	–	–	–	–	–	–	X	–	–
Chrysothamnus greenei (Gray) Greene	rabbit brush	–	–	–	X	–		–	–	–		
Chrysothamnus nauseosus (Pall.) Britton	rabbit brush	–	–	X	X	–		X	X	X	X	
Clematis ligusticifolia Nutt.	western virgins bower	–	–	–	X	–	–	–	–	–		X
Dalea formosa Torr.	feather indigo	–	–	–	–	–	–	–	–		X	–
Dalea scoparia Gray	false Indigo bush	seeds?	Oct. 12	–	–	–	–	–	–	X	–	–
Ephedra sp.	Mormon tea	–	–	–	–	–	–	–	X	–	X	–
Eupatorium herbaceum (Gray) Greene	white thoroughwort	–	–	–	–	–	X	–	–	–	–	
Eurotia lanata (Pursh) Mog.	winter fat	–	–	–	–	–	–	–	–	X	X	
Fallugia paradoxa (D. Don.) Endl.	Apache plume	–	–	X	X	–	–	X	X	–	X	–
Forestierra neomexicana Gray	mountain privet	–	–	–	X	–	X	–	–	–	–	–
Gutierrezia microcephala D. C. Gray	snakeweed	–	–	X	X	X		X	X	X	X	–
Hoffmenseggia jamesii Torr. & Gray	hog potato	–	–	–	–	–	–	–	–		X	–
Lycium pallidum Miers.	wolf berry	fruits	(none observed)	–	–	–		X	X	X	X	
Parthenocissus inserta (Kerner) k. Fritsch	Virginia creeper	fruit	after Sept.	–	X	–						
Pericome caudata Gray		–	–	–	–		X	–	–	–	–	
Philadelphia microphyllus Gray	mock orange	fruits	June 24-persistent	–		–	X	–	–		–	
Ptelea angustifolia	hops tree	–	–	–	X	–	–	–	–		–	
Quercus gambellii Nutt.	Gambel's oak	leaves acorns	June 9	X	–	–	–	–	–	–		

Table 2.2 (Continued)

Binomial	Common Name	Edible Parts	Season	Present at Habitat: A	B	C	D	E	F	G	H	J
B. List of Shrubs (Continued)												
Quercus grisea Liebm.	gray oak	young leaves: acorns:	May 27 Aug 22-Sept	X	—	X	—	—	—	—	—	—
Quercus turbinella Greene	shrub live oak	young leaves: acorns:	May 27 Aug 22-Sept	—	—	X	—	—	—	—	—	—
Robinia neomexicana Gray	New Mexican locust	flowers	May 18	—	—	—	—	—	—	—	—	X
Rhus trilobata Nutt.	squawbush	fruit	June 9, persistent	X	X	—	X	—	—	—	—	—
Salix amygdaloides Anderss.	peachleaf willow	catkins	early April	—	—	—	—	—	—	—	—	X
Salix spp.	willow	catkins	early April	—	X	—	—	—	—	—	—	X
Tamarix pentandra Pall.	salt cedar	—	—	—	—	—	—	—	—	—		X
Vitis arizonica Engel.	wild grape	fruit	Aug 21	—	X	—	—	—	—	—	—	—
Yucca angustissima Engel.	soapweed or narrow leaf yucca	stipe: buds: fruits:	May 5 May 27 after June 15	X	—	X	—	X	X	X	X	—
Yucca baccata Torr.	banana yucca or broad leaf yucca	flowers: fruits:	May 17 June 24	—	—	—	—	—	X	—	—	—
C. List of Ferns, Herbs and Forbs												
Adiantum sp.	maiden hair fern	—	—	—	—	—	X	—	—	—	—	—
Aletes acaulis (Torr.) Coult. & Rose		—		—	—	—	X	—	—	—	—	
Allium macropetalum Rydb.	wild onion	bulb	May 5-May 27	—	—	—	—	—	—	—	X	—
Allium sp.	wild onion	bulb	May 27	—	—	X		—	—			—
Amaranthus albus L.	pigweed	greens: seeds:	— Sept 13	—		—		—	X		—	
Amaranthus retroflexus L.	red root amaranth	greens: seeds:	— Sept 13	—	X	—	—		—	—	—	
Ambrosia acanthicarpa Hook.	annual bursage	—	—	—	—	—	—	—	—	X		
Ambrosia psilostachya D.C.	western ragweed	—	—	—	X	—	—	—	—			X
Anemopsis californica (Nutt.) Hook. & Arn.	yerba mansa		—	—	—	—	—	—	—			X

Table 2.2 (Continued)

Binomial	Common Name	Edible Parts	Season	Present at Habitat: A	B	C	D	E	F	G	H	J
C. List of Ferns, Herbs and Forbs (Continued)												
Antennaria sp.	pussey toes	–	–	–	–	–	X	–	–	–	–	–
Argemone platycerus Link. & Otto	prickly poppy	–	–	–	–	X	–	–	–	–	–	–
Artemesia dracunculoides Pursh.	false tarragon	leaves	April 6 thru summer	–	X	X	X	–	X	–	–	–
Artemesia frigida Willd.	Estafiata	seeds	Sept 22	–	–	–	X	–	–	–	–	–
Artemesia ludoviciana Nutt.	sagebrush	seeds	Sept 22	–	–	–	X	–	–	–	–	–
Artemesia cana Pursh.	silver sage	seeds	Sept 12	–	X	–	X	–		–	–	–
Asclepias capricornu Woodson	immortal	–	–	–	–	–	–	X	–	–		–
Asclepias latifolia Torr. Raf.	milkweed	seeds	July-Aug	–	X	–	–	–	–	–	–	
Asclepias sp.		–	–	X	–	–	–	–	–	–	–	–
Asparagus officinalis L.	asparagus	(introduced)	–	–	–	–	–	–	–	–	–	X
Aster arenosus (Heller) Blake	baby aster	–	–	–	–	X	–	–	–	–	–	–
Astragalus gracilia Nutt.	milkvetch	–	–	–	–	–	–	X	–	–	–	–
Astragalus lentigenosus Dougl.	milkvetch	fruits	May 17-June 9	X	–	–	–	X	–	–	–	
A. lentigenosus Dougl. Var. diphysus (Gray) Jones	blue loco	fruits?	June 9	–	X	–	–		–	–	–	–
Astragalus nothoxys Gray	sheep loco	–	–	–	–			X	–	–		
Astragalus sp.		–	–	–		–	–	–	–	–	X	–
Bahia dissecta (Gray) Britt.	yellow ragweed	–	–	–	–	X		X	–	–	–	–
Berlandiera lyrata Benth.		flower heads and leaves	May 5	–	–	X	–			–	X	
Bidens bipinnata L.	beggar's tick	–	–	–	–	–	–					X
Calochortus nuttallii Torr. & Gray	sego lily	bulb	May 27	–	–	X		–				
Castilleja integra Gray	paint brush	flowers	June 24-Aug 15	X	–	X		X	X	–		

Table 2.2 (Continued)

Binomial	Common Name	Edible Parts	Season	Present at Habitat: A	B	C	D	E	F	G	H	J
C. List of Ferns, Herbs and Forbes (Continued)												
Cheilanthes sp.	lip fern	–	–	–	–	–	X	–	–	–	–	–
Chenopodium fremontii Wats.	Fremont goosefoot	greens & seeds	Aug 25-Sept 13	–	–	X	–	–	X	–	X	–
Chenopodium graveolens Willd.	goosefoot	seeds	Sept 13	–	–	–	–	–	X	–	–	–
Chenopodium leptophyllum Nutt.	goosefoot	leaves & seeds	Aug 25-Sept 21	–	–	–	–	–	–	–	X	–
Chenopodium incanum Heller	goosefoot	greens: seeds:	Apr 26-May 27 Aug 22-Oct 12	–	–	X	–	X	X	X	X	–
Chrysopsis foliosa Nutt.	golden aster	–	–	–	–	X	–		–	–	X	–
Circium neomexicana Gray	thistle	roots: stems: seeds:	– May 27-June 6 Aug 22-Sept 21	–	X	X	–	–	–	–	X	X
Cleome serrulata Pursh.	Rocky Mountain bee plant	leaves: seeds:	Apr 26-May 27 late June-Aug 15	–	X	X	–	X	–	–	–	X
Coreopsis cardaminifolia (DC) Torr. & Gray	tickseed	–	–	–	X	–	–	X	–	–	–	–
Croton texensis (Klotzsch.) Muell. Arg.	doveweed, spurge	–	–	–	X	X	–	X	–	X	–	–
Cryptantha jamesii (Torr.) Payson	Jame's cryptantha	–	–	–	–	–	–	X	–	–	–	–
Cryptantha fendlerii (Gray) Greene	Fendler's cryptantha	–	–	X	X		–	–	–	–		
Cucurbita foetidissima H.B.K.	buffalo gourd, calabazilla	fruit: seed:	August 22 Sept 22	–	X	X	–	–	–	–	–	
Cymopterus fendlerii Gray	chimaya	leaves & roots	April 5-June 9	X	–	X	–	X	X	–	X	–
Cymopterus montanus (Nutt.) Torr. & Gray	wafer parsnip	roots & leaves	April 5-May 5	–	–	–	–		–	–	X	
Datura metaloides D.C.	Indian apple	–	–	–	X	–	–			–	–	
Descurainia pinnata (Walt.) Britton	tansy	greens: seeds:	May 27 late June	–	–	–	–	X	–		–	
Dithyrea wislizenii Engelm.	spectacle pod	–	–	X	X	–	–	–	X	X		
Epilobium sp.	willow weed	greens	June	–	–	–	–	–	–			X
Erigeron canadensis L.	horseweed	–	–	–	–	–		X				
Erigeron divergens Torr. & Gray	spreading fleabane	–	–	X	–	X	–		X		X	–

Table 2.2 (Continued)

Binomial	Common Name	Edible Parts	Season	Present at Habitat: A	B	C	D	E	F	G	H	J
C. List of Ferns, Herbs and Forbes (Continued)												
Erigeron sp.	daisy	--	-	--		--				X		-
Eriogonum deflexum Small.	skeleton weed	seeds & stems	August	–	-	–		–		X	-	--
Eriogonum effusum Nutt.	buck wheat	seed & stems	August 25	·	--	–	·	--	–	–	X	–
Eriogonum leptocladon Torr. & Gray	buck wheat	seed & stems	August 25	–	--	--	--	·	·	·	X	
Eriogonum sp.	(sulphur flower type)	stems	May 17	X	-	–	--	·	X	–	·	
Eriogonum sp.	(buckwheat type)	seed & stems	May 17	X	--	-	·		X	X	-	–
Euphorbia albomarginata Torr. & Gray	spurge	–	–	--	–	X		X	X		–	·
Gaillardia pinnatifidia Torr.	blanket flower	--	–	–	·	X	–	--	·	·		–
Gaillardia sp.		–	–	X	–	–	–	·	–		X	–
Gaura coccinea Nutt.	velvet flower butterfly weed	–	–	–	X	X	–	–	–	·	–	·
Gilia longiflora (Torr.) D. Don	blue gilia	–	–	X	X	X	·	X	X	–	·	–
Glycyrrhiza lepidota (Nutt.) Pursh.	licorice	roots	–	–	–	–	–	–	·	–	–	X
Grindelia aphanactis Rydb.	gum weed	–	–	–	–	–	–	–	X	X	·	
Haplopappus gracilis (Nutt.) Gray		–	–	X	–	–	–	·	·	·	–	
Haplopappus spinulosus Nutt.	spiny aster	–	–	X	–	–	–	–	–	-		
Hedeoma drummondii Benth.	false pennyroyal	--	--	–	X	·	–	X	–	--		
Helianthus annus L.	sunflower	seeds	Sept 5-Sept 22	·		·	·	-	·	X	–	--
Hymenopappus filiofolia Hook.	white ragweed	--	·	·	X	X	·	X	X	–	–	·
Hymenoxys acaulis (Pursh.) K. F. Parker	bitterweed	-		X	·	X	·		X	-		
Hymenoxys argentea (Gray) K.F. Parker	bitterweed, perky sue		·		·	X	–		X	·	X	·
Hymenoxys sp.		·	·		X			·				
Kochia scoparia (L.) Schrad.	summer cypress	(introduced)			·					X		

Table 2.2 (Continued)

Binomial	Common Name	Edible Parts	Season	Present at Habitat: A	B	C	D	E	F	G	H	J
				C. List of Ferns, Herbs and Forbes (Continued)								
Lappula redowski (Hornem.) Greene	stickseed	—	—	X	—	–		—	X	—	—	–
Lesquerella fendleri (Gray) Wats.	bladder pod	—	—	—	–	—	—	X	—	—	—	—
Lesquerella intermedia (Wats.) Heller	bladder pod	greens: seeds:	May 5 May 27	—	—	X	—	X	–	X	—	–
Lesquerella sp.	bladder pod	seeds:	June 9	X	—	—	—	–		—	—	X
Leucampyx newberryi Gray	wild cosmos	—	—	—	—	—	—	—	—	—	X	—
Lotus wrightii (Gray) Greene	deer vetch	—	—	X	—	–	—	—	—		–	
Lupinus caudatus Kellogg	lupine	—	—	—	–	—	—	X	—	—		
Lupinus kingii Wats.	blue bonnet	—	—	—	X	—	—	—	–	–		
Machaeranthera bigelovii Gray	Bigelow's aster	—	—	—		—		—	—	—	X	—
Melilotus albus Desr.	white sweet clover	(introduced)	—	–	—	—	—	X	—			
Melilotus officinalis L.	yellow clover	(introduced)	—	—	X	—	—	—	—			—
Melampodium leucanthum Torr. & Gray	plains blackfoot	—	—	X	—	—		—	–	–		
Mentha arvensis L.	mint		–	—	X	–	–	—	—	–	–	—
Mentzelia pumila (Nutt.) Greene	stick leaf	seeds	June 24	–	—	—	–	X	—		—	–
Mentzelia sp.	stick leaf	seeds	August 15	X	—	—	–	–	X	X	—	–
Mirabilis oxybaphoides Gray	four o'clock	?	Sept 13	—	—	—	—	—	X	—	–	—
Mirabilis multiflora (Torr.) Gray	four o'clock	root	all year	X	—	X	—	—	X	—		
Nama hispidum Gray	water leaf	—	–	—	X	—	—	—		–	–	
Oenothera caespitosa Nutt.	evening primrose	root	May 27	—	—	X	—	—		–	–	
Oenothera sp.	evening primrose	root	May 17	—	X	—	—	X	—		–	
Pectis papposa Harv. & Gray	fetid marigold	seasoning?	May 5	—	X	—			–	X		
Pellaea limitanea (Maxon) Morton	cliff-brake fern	—	–	—	—		X					

Table 2.2 (Continued)

Binomial	Common Name	Edible Parts	Season	Present at Habitat: A	B	C	D	E	F	G	H	J
C. List of Ferns, Herbs and Forbes (Continued)												
Penstemon sp.		—	—	—	—	—	—	X	—	—	X	—
Petalostemon candidum (Willd.) Michx.	prairie clover	—	—	X	X	—	—	—	—	—		—
Phacelia corrugata A. Nels.	scorpion weed	—	—	X	—	X	—	—	—	—	—	—
Phacelia sp.	scorpion weed	—	—	X	—	—	—	—	X	—	—	—
Phaseolus angustissimus Gray	wild bean	seed	Sept 22	X	X	—	—	—	—	—	—	
Phlox longifolia Nutt.	phlox	—	—	—	—	—	—	X	—	—	—	—
Physalis fendlerii Gray	ground cherry	berries	June 6	—	—	X	—	—	X	—	—	—
Plantago purshii Roem. & Schutt.	Indian wheat	seeds	May 27	—	—	—	—	—	X	—	—	—
Polanisia trachysperma Torr. & Gray	clammy weed	greens: seeds:	June 9 Sept 21	X	X	X	—	—	—	—	X	
Portulaca sp.	purslane	greens: seeds:	June 9-Aug 22 Sept 5-Sept 21	—	—	X	—	—	X	X	X	—
Potentilla sp.	cinque foil	roots	May 27	—	—	—	—	—	—	—	—	X
Psilostrophe tagetina (Nutt.) Greene	paper daisy	—	—	—	—	X	—	—	—	—	—	—
Ranunculus inamoenus Greene	buttercup	roots, seeds	May 18	—	—	—	—	—	—	—	—	X
Rorripa sp.	watercress	greens	April-Sept	—	X	—	—	—	—	—	—	—
Rumex crispus L.	curly dock	greens	April-May	—	X	—	—	—	—	—	—	X
Rumex hymenosepalus Torr.	canaigre	greens: stems: seeds:	April 5 April 26 June 9	—	—	—	—	—	—	X	X	—
Salsola kali L.	Russian thistle	(introduced)		—	—	X	—	—	X	X	X	—
Salvia reflexa Hornem.	Rocky Mountain sage, chia	seeds	August 15	—	—	—	—	X	—	—		
Senecio longilobus Benth.	groundsel	—	—		X	X	—		X	X	X	—
Solanum elaegnifolium Cav.	silver horsenettle	—		—	—	X	—		X	X		—
Solidago sp.	goldenrod	leaves	May-Sept	—	X	—		—				—
Sphaeralcea coccinea	globe mallow	buds	June 24	—	—	—	—	X	—	—		
Sphaeralcea sp.	mallow	buds	August 22	—	—	—	—		X	X	X	

Table 2.2 (Continued)

Binomial	Common Name	Edible Parts	Season	Present at Habitat: A	B	C	D	E	F	G	H	J
C. List of Ferns, Herbs and Forbes (Continued)												
Stephanomeria sp.	wire lettuce	—	—	—	—	—	—	X	—	—	X	—
Thelesperma megapotamicum (Spreng) Kuntz.	Indian tea	tea	—	—	X	—	—	—	—	—	X	—
Thelesperma sp.	cota	(used as tea)	—	X	—	—	—	X	—		—	—
Tidestromia lanuginosa (Nutt.) Standl.	wooly tidestromia	seeds	Sept 13	—	—	—	—	—	X	—	—	—
Townsendia annua Bedman.	easter daisy	—	—	—	—	—	—	—	X	—	—	—
Townsendia exscapa (Richards) Porter		—	—	—	—	X	—	—	—	—	—	—
Trifolium sp.	clover	greens, seeds	May	—	X	—	—	—	—	—	—	—
Verbascum thapsus L.	mullein	—	—	—	X	—	—	—	—	—		
Verbena wrightii Gray	verbena	—	—	X	—	—	—	—	X	—	—	—
Verbena sp.		—	—	—		X	—	—	—	—	—	—
Verbescina encelioides (Cav.) Benth & Hook	crown beard	—	—	—	—	—	—	—	—	X	X	—
Xanthium strumarium L.	cockleburr	—	—	—	—	—	—	—	—	X	—	
D. List of Grasses and Grasslike Plants												
Agropyron sp.	wheat grass	—	—	—	—	—		—	—	—	—	X
Agrostis sp.	bent grass	—	—	—	—	X	—		—			
Andropogon barbinoides Lag.	blue stem	—	—	—	—	—			—	—	X	—
Andropogon sp.		—	—	X	—	—	—	—	—		—	—
Aristida arizonica Vasey	Arizona 3-awn	—	—	—	—	—	—	—	X	—		—
Aristida divaricata Hump. & Bompl.	Poverty 3-awn	—	—	—	—	X	—	X	X	X	—	
Aristida longiseta Steud.	red 3-awn	—		X	X	—	—	—	—	—	—	—
Aristida sp.	3-awn	—	—		—			—			X	
Bouteloua curtipendula (Mich.) Torr.	side oats grama	—	—	X		X	—	X	X		X	
Bouteloua eriopoda Torr.	black grama	—				X				X	X	
Bouteloua gracilis (H.B.K.)Lag	curly grama	seeds	after Sept 22	X	X	X			X	X	X	

Table 2.2 (Continued)

Binomial	Common Name	Edible Parts	Season	Present at Habitats: A	B	C	D	E	F	G	H	J
D. List of Grasses and Grasslike Plants (Continued)												
Bouteloua hirsuta Lag.	hairy grama	—	—	—	—	X	—	—	—	X	—	—
Cenchrus sp.	sand burr	—	—	—	—	—	—	X	—	—	—	—
Cyperus esculentus L.	nut sedge	tubers	all seasons	—	X	—	—	—	—	—	—	X
Elymus canadensis L.	wild rye	seed	August	—	—	—	—	—	—		—	X
Equisetum sp.	horsetail	cones	June	—	—	—	—	—	—	—	—	X
Hilaria jamesii (Torr.) Benth.	galleta	—	—	—	—	—	—	—	—	X	—	—
Hilaria mutica (Buckl.) Benth.	tobosa grass	—	—	—	—	—	—	—	X	—	X	—
Hilaria sp.		—	—	X	—	—	—	—	—	—	—	—
Juncus balticus Willd.	wire rush	—	—	—	—	—	—	—	—	—	—	X
Juncus sp.	rush	—	—	—	X	—	—	—	—	—	—	—
Muhlenbergia montana (Nutt.) Hitchc.	mountain muhley	—	—	—	—	—	—	—	X	—	—	—
Muhlenbergia porterii Schribn.	bush muhley	—	—	X	—	—	—	—	—	—	X	—
Muhlenbergia torreyii (Kunth) Hitch	ring muhley	—	—	—	—	X	—	—	—	X	X	—
Oryzopsis hymenoides (Roem & Schultz) Ricker	rice grass	seed	June 9	X	—	—	—	—	—	X	X	—
Panicum obtusum H.B.K.	vine mesquite	—	—	—	—	—	—	—	—	—	X	—
Scirpus sp.	bulrush	roots pollen seeds	year round — September	—	—	—	—	—	—	—		X
Scleropogon brevifolius Phil.	burrow grass	—	—	—	—	—	—	X	—	—	—	—
Setaria sp.	bristle grass	seeds	August	—	—	—	—	—	—	—	—	X
Sporobolus airodes Torr.	alkali saccaton	seeds	Sept 22	—	—	—	—	—	—	X	X	—
Sporobolus cryptantha (Torr.) Gray	sand dropseed	seeds	Aug 22- Sept 5	—	—	X	—	—	—	—	X	—
Sporobolus sp.	dropseed	seeds	—	—	—	—	—	X	—		—	—
Stipa comata Trin. & Rupir.	needle and thread grass	—	—	X	—	X	—	—	—	—	—	—
Stipa robusta (Vasey) Scribn.	sleepy grass	—	—	—	—	—	—	—	—	—	—	X

Table 2.2 (Continued)

Binomial	Common Name	Edible Parts	Season	A	B	C	D	E	F	G	H	J
				Present at Habitat								
D. List of Grasses and Grasslike Plants (Continued)												
Typhus sp.	cattail	almost all parts in season	Spring-Fall	—	—	—	—		—	—	—	X
E. List of Cacti												
Coryphantha vivipora Nutt.	pincushion cactus	—	—	—	—	—	—	—	—		X	—
Echinocereus spp.	hedgehog cactus	—	—	X	—	—		—	X	—	—	—
Opuntia clavata Engelm.	club cholla	joints & fruits	Aug 28 thru winter	—	—	X	—	—	X	X	X	
Opuntia erinaceae Engelm.	grizzly bear cactus	—	—	X	—	—	X	—	—	—		—
Opuntia imbricata (Haw.) DC	cholla	joints & fruits	June 9-24 Aug 15-Sept 15		X	—	—	X	X	X	—	—
Opuntia phaeacantha Engelm.	plains prickly pear	joints & fruits	Sept 13	X	—	—	—		X	X	X	—
Opuntia polycantha Haw.	prickly pear	joints & fruits	Aug 28 thru winter	—	X	X	—	X	X	—	—	—
Pediocactus sp.		—	—	X	—	—	—	—	—	—	—	—

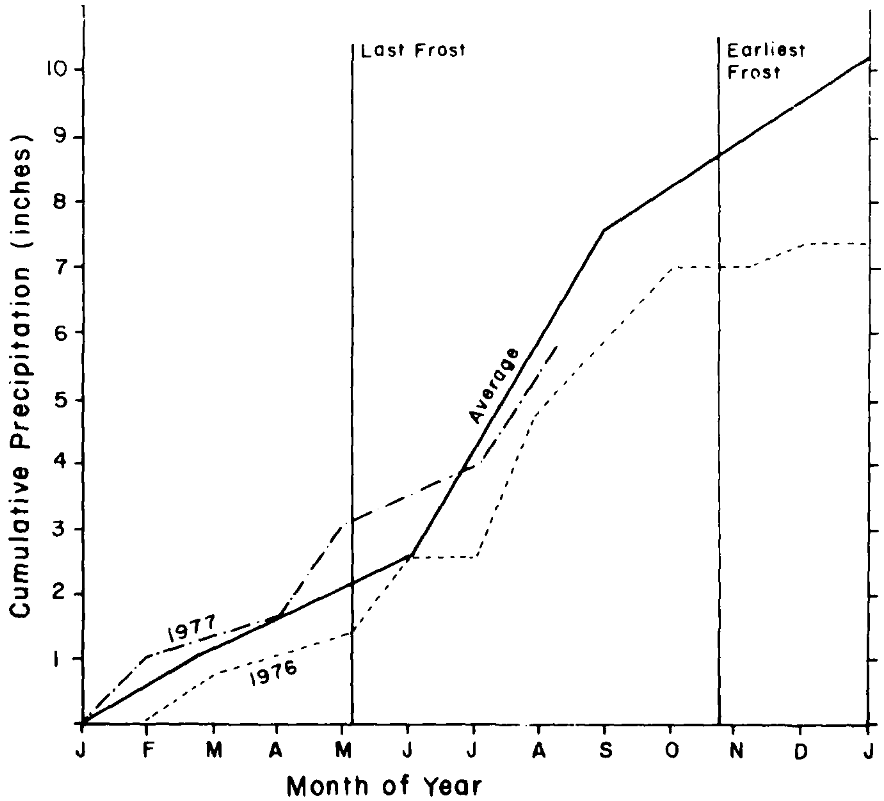


Fig. 2.7 Cumulative precipitation record for Cochiti Dam, 1976 and 1977

The Number and Distribution of Native Edible Species

Two hundred and eighteen (218) plant species were observed in the nine combined study areas. Of these, 96 (44%) are native and have plant parts that are potential food for humans. All eight species of native trees have either edible inner bark, berries or nuts. Seventeen (47%) of the 36 perennial shrubs and 56 (43%) of the 130 herbs forbs seen in the combined areas have edible greens, shoots, flowers or seeds. Eleven (31%) of the 35 species of grasses grasslike plants have nourishing seeds or flowering parts. Finally, four of the eight species of cacti (mostly *Opuntia* spp.) possess edible joints and fruits.

The number of native edibles observed within each of the nine study areas is given in Table 2.3. Areas B, F, C and H exhibit the highest diversity of native edible plants among all of the nine study areas. The differences in numbers of edible species among these four areas are all comparable to the assumed 15% error in the listing of species in Table 2.2.Hence all four areas rank as equals on the basis of high diversity of edible species. A similar ranking can be made on the basis of the five assumed life forms (trees, shrubs, herbs forbs, grasses and cacti). Area B has the largest number (6) of native trees with edible parts; areas A and G tie for the highest diversity of native shrubs with edible parts (five species in each area). Within the limits of sampling error, the variety of edible herbs and forbs is highest and equal in area C (17 species), areas B and F (16 species in each) and area H (15 species). The riparian river bottom, area J, exhibits the most species (6) of edible native grasses and grasslike plants; this fact is a consequence of the presence of many riparian monocots with edible roots and stems. Finally, area F exhibits the most species (4) of edible cacti, all of which are in the genus *Opuntia*.

Table 2.3
Distribution of Native Edible Plants

	Botanical Study Area	No. of All Species	No. of Edible Spec.
A	(En Medio Mesa)	51	20
B	(Cochiti Canyon)	58	30
C	(West Rim - WRC)	54	26
D	(East Talus - WRC)	19	10
E	(East Terrace - WRC)	44	18
F	(East Rim - WRC)	53	27
G	(East Flood Plain)	41	20
H	(La Majada Mesa)	54	25
J	(Riparian River Bottom, Cochiti Dam)	28	18

If one extends these rankings of study areas to the analogous terrain types that exist in the Cochiti Reservoir Study Area, then the tributary canyons represented by area B and the rims of White Rock Canyon represented respectively by areas C and F would appear to have a significant advantage over other terrain types as potential resource areas for native edible plants. The actual advantage during any period of time would of course also depend on the density achieved in the biomass of native edibles. The now submerged trough of White Rock Canyon would share much of the advantage attributed to area B, since the composition of vegetation is nearly identical within the two areas. Open grasslands of the piedmont terraces such as the ones on La Majada Mesa (area H) offer about the same diversity, and possibly a higher density, of native, edible herbs and forbs as are found in the tributary canyons and along the rims of White Rock Canyon.

The Ubiquity of the Native Edible Species

Information from the plant lists, Table 2.2, concerning frequency of appearance of common plants in the nine study areas is condensed in Table 2.4. Each plant is ranked by the number of study areas in which it was observed, and only those species appearing in four or more areas are included. The assigned ranks would be a direct measure of each species' ubiquity within the surveyed parts of the Cochiti Reservoir district only if each of the study areas had been randomly chosen (they were not). In spite of this, there is good agreement between the impression of dominant vegetation supplied by Table 2.4 and the subjective, visual impression of dominant vegetation.

Table 2.4
Ranking Plant Species by Ubiquity

Species represented in fewer than four study areas are not shown. Rank indicates number of areas in which species were observed. A check (X) to the right of binomical indicates edibility.

Life Form	Name		Rank
Trees:	*J. monosperma*	X	7
Shrubs:	*G. microcephala*		7
	C. nauseosus		6
	Y. angustissima	X	6
	E. paradoxa		5
	A. canescens	X	4
	L. pallidum	X	4
Herbs & Forbs:	*C. glaucum*	X	5
	C. fendlerii	X	5
	G. longiflora		5
	S. longilobus		5
	A. dracunculoides	X	4
	C. integra	X	4
	C. neomexicana	X	4
	C. serrulata	X	4
	C. texensis		4
	D. wislizeni		4
	E. divergens		4
	H. filiofolia		4
	P. trachysperma	X	4
	Portulaca spp.	X	4
Grasses.	*B. gracilis*	X	6
	B. curtipendula		6
	A. divaricata		4
Cacti:	*O. clavata*	X	4
	O. imbricata	X	4
	O. phaeacantha	X	4
	O. polycantha	X	4

The scores assigned to certain plants in Table 2.4 illustrate reasons for calling the general biotic zone of the souther Pajarito Plateau a Juniper-Grama grass community. The one seed juniper, *J. monosperma*, and curly grama, *B. gracilis*, are respectively the highest ranking tree and grass: both of these have an edible part. Other, high ranking native edibles are also familiar objects in the landscape of the southern Pajarito Plateau: the narrow leaf yucca, *Y. angustissima*; the several species of cylindrical and pad-like *Opuntia*; and the four-wing saltbush, *A. canescens*. The wolfberry, *L. pallidum*, is a slightly less familiar shrub that is often found in association with former habitation and agricultural sites (Yarnell 1958).

Because of their size and erratic patterns of appearance, herbs and annual forbs tend to be less well defined as objects in a subjectively recalled landscape. The two highest scoring herbs, goosefoot (*C. incanum*) and chimaya (*C. fendlerii*), are unobtrusive but important resource plants that warrant further discussion. Chimaya is still gathered and used by members of the Cochiti Pueblo in the early spring (personal observation).

Seasonality of Ubiquitous Edible Plants

The most ubiquitous native plants with edible parts are summarized in Table 2.4. These provide potential food resources of different kinds at different periods of the growing season. Greens, young leaves, buds and roots first appear in the early spring (roughly March 15–April 30) with the early development of foilage on the saltbush (*A. canescens*) and the sprouting of certain herbs: *Chenopodium* spp., *C. fendlerii*, *A. dracunculoides*; and the bee plant (*C. serrulata*). Resources developing in the late spring (roughly May 1–June 15) are the stipes and buds of the narrow leaf yucca (*Y. angustissima*); the young joints of the cholla (*O. imbricata*); and the greens and stems of certain late appearing herbs and forbs such as *C. neomexicana*, *P. trachysperma* and the purslanes (*Portulaca* spp.). In the early summer (June 16–July 31) the types of plant food begin to change from greens and immature buds to fruits (probably *L. pallidum*), flowers and some seeds. The transition continues through late summer (August 1–September 15) and is completed in the early fall (after September 15) when fruits and seeds are fully mature and the edible biomass is maximized. These late summer and early fall plant foods include fruits from the ubiquitous *J. monosperma*; the fruits of cholla and prickly pear; seeds of the saltbush (*A. canescens*); the seeds of *Chenopodium* spp., *Portulaca* spp., and many other herbs and forbs; and the seeds of the most ubiquitous grasses (*B. gracilis* and *Sporobolus* spp.).

This assessment of seasonality is highly dependent upon the precipitation patterns and also upon the resolution that is obtained by the particular timing of visits to the study areas. The patterns of plant food resources development during the terms of the 1977 growing season may have overlapped one another as much as three weeks.

Seasonality within Study Areas

The value of each study area's contribution to seasonal food resources may be roughly assessed by noting, for each area, the number of species that produce edible parts in each of the six categories: roots (bulbs, tubers, etc.), stems, greens (leaves), flowers, fruits (fleshy or nut-like), and seeds. With only a few but important exceptions, roots, stems and greens are the dominant, ethnobotanically important, plant foods in the context of Cochiti Reservoir during spring and early summer. Exceptions are mentioned below. Similarly, flowers, fruits and seeds usually dominate in the late summer and early fall seasons.

The distribution of species among the six categories of plant foods is condensed from Table 2.2 and shown for each of the nine study areas in Table 2.5. An order of ranking of the areas is established by summing the entries of the first columns for spring and early summer resources: the last three columns for late summer and early fall resources. For spring and early summer, it is seen that area C with 21 species is first, followed by area H with 19 species, followed by areas B and F with 16 species each. The order is somewhat inverted in ranking potential food resources characteristic of the late summer and fall: area F is first with 24 species; area H follows with 23 species; and areas A, B, C, G and E are last and nearly equal in rank with 19-21 species in each of them. The small spread in these *ranks* for late summer and fall resources is just a reflection of the fact that seed producing plants are nearly uniformly distributed over the entire study area. The high and roughly equal scores achieved by area H for both early and late-season resources are noteworthy.

Not all nutritious seeds are developed in the late summer and early fall. In the reservoir study area the seeds of rice grass (*O. hymenoides*), the buckwheat types of *Eriogonum*, and the canaigre (*R. hymenosepalus*), are ripe by early June *if* precipitation is normal. Rice grass in particular deserves further discussion because of its exceptionally early production of seeds and its probable large density in the absence of grazing pressure.

Table 2.5

***Distribution of Seasonal Plant Foods within the Study Areas**

Species with different edible parts are counted more than once but under the appropriate category. (a) *stems* includes edible joints of cacti and inner bark of trees; (b) *flowers* includes edible buds and catkins; (c) *seeds* includes edible acorns and the grass caryopsis.

Area		roots	(a) stems	greens	(b) flowers	fruits	(c) seeds
A	(En Medio Mesa)	2	4	5	2	6	12
B	(Cochiti Canyon)	3	6	7	1	10	10
C	(West Rim - WRC)	5	4	12	3	6	12
D	(East Talus - WRC)	0	0	1	0	4	4
E	(East Terrace - WRC)	2	3	6	4	8	7
F	(East Rim - WRC)	2	7	7	4	9	11
G	(East Flood Plain)	0	7	5	2	5	14
H	(La Majada Mesa)	3	7	9	3	5	15
J	(Riparian River Bottom, Cochiti Dam)	9	1	3	6	0	8

*Number of species in area having the edible parts

NOTES OF SELECTED RESOURCE PLANTS

Early Spring Greens and Roots

Chimaya (*C. fenderii*) is an ubiquitous and perhaps the most palatable early spring green growing in the Cochiti study area. The author collected chimaya with friends at Cochiti Pueblo in early May of 1968: the greens were washed and placed in a bowl, then dipped in a bowl of lightly salted water and eaten as a salad along with the meal. The plant has the texture and taste of commercially grown celery leaves but is more pungent. During the present study, *C. fenderii* was gathered in area H where, under suitable conditions, the plant may grow to a density of 0.6 individuals m^2. By prying out the roots (also edible) with a dull knife, one can harvest about 20 g of chimaya including roots from a 36 m^2 plot in ten minutes.

Both chimaya and a sister species, the wafer parsnip (*C. montanus*), are sprouted usually by the first week of April in the Cochiti area. Lange (1959) mentions the use of *C. montanus* at Cochiti Pueblo. The wafer parsnip has a more limited habitat than chimaya since it seems to prefer pebbled soil at the base of steep hills. However, it has a large, edible root that is palatable if not tasty. In the proper habitat, one finds wafer parsnip and chimaya growing together although the wafer parsnip is an earlier bloomer than chimaya and prefers northern exposures. The former shows a density of about 0.8 individuals/m^2 and yields 60 g of root and greens for 15 minutes effort on a 35 m^2 plot. Both plants have a deeply placed, *double* root; that is, an upper tap root at 3-5 cm depth is connected to a lower root at about 8-10 cm depth. Harvesting these roots with a stick or knife usually yields only the upper portion and leaves a conical depression through which the plant may be renewed from the remaining root system in the following spring. These features are perhaps the reason why *Cymopterus* is so ubiquitous in the study area in spite of centuries of exploitation.

The most ubiquitous goosefoot species in the Cochiti study area, *C. incanum*, also produces greens that are edible and the seedlings appear by late spring or early May. This goosefoot is known to be an acceptable potherb or salad green (Harrington 1967:71). However, all of the species of *Chenopodium* (excepting perhaps *C. graveolens*) observed in the study area produce an edible seed that is more nutritous than the greens. The seeds are developed in the late summer and early fall.

The sego lilly (*C. nuttallii*) is a spring root food that was found only on the west rim of White Rock Canyon. The whole plant of most species of *Calochortus* are edible (Harrington 1967:159) but the bulbs are the most massive part and taste like raw potatoes. Some bulbs of sego lily were harvested in late May on study area C: using a rock hammer to extract the bulb clusters, about three minutes were required to extract 10 g of material (two large bulbs approximately 2 cm long and 1 cm in diameter). The main bulb of each sego lily has several smaller bulblets semi-attached and one seldom is able to extract all the bulblets (nor does their size warrant the effort) with simple tools. As with the *Cymopterus* spp. some vegetatively reproducing portion is always left to take advantage of the extra water and sunlight trapped by the excavation.

Other sources of early greens are found in the young leaves of the scrub oaks (*Quercus* spp.), of the salt bush (*A. canescens*), false tarragon (*A. dracunculoides*), and the bee plant (*C. serrulata*). However, these young leaves are not likely to have been eaten in any large quantity since they are rather bitter and their use as a food is problematic when other more palatable greens would be available.

Other Spring and Early Summer Resources

The stipes and buds of the narrow leaf yucca (*Y. angustissima*) are usually well developed in the Cochiti Reservoir district by late May and could therefore provide an early, natural source of carbohydrate. Narrow leaf yucca has many economic uses that are recorded in the ethnographies (for example, see Whiting 1966) but little is said concerning use of its parts as food. Nevertheless, Swank (1932) asserts that the young flower stalks of a closely related species, *Y. glauca* (sometimes considered to be one and the same as *Y. angustissima*) were roasted and eaten by the people of Laguna and Acoma Pueblos in time of famine. The author has tried eating the yucca stipes and buds raw: the buds are satisfactory and have a similar taste and texture to domesticated lettuce but the stipes, while having a similar texture to asparagus, are bitter and must be cooked before eating.

The narrow leaf yucca is most ubiquitous among the study areas but it achieves its highest density on area A, the west rim of White Rock Canyon, where the plants grow in *colonies* 3-10 m in diameter, with a mean density of 0.6 plants/m^2 within each patch. The habit of growing in colonies or patches is typical of a plant species that propogates mainly by its root systems. In area A, patches of *Y. angustissima* were scattered at a density of 5-6 ha, while on La Majada Mesa the average patch density was less than one per hectare. In general, only 20-25% of the individuals in each colony forms blossoms during the growth season. Some experiments with harvesting of the edible yucca parts were conducted in area A. In mid April, about 62 g of yucca stipe was obtained in one minute by separating the sharp leaves with a gloved hand and cutting the stipe base with a dull knife. In late May, I was able to harvest 105 g of yucca buds in one minute by simply plucking them from the stipe. The fruits of *Y. angustissima* were not harvested because the stands under observation (and most of the others in the study area) were either grazed by late June or did not set fruit.

Rice grass (*O. hymenoides*), though not presently abundant among the areas surveyed, is potentially the major spring resource for subsistence in the Cochiti Reservoir district. Before the introduction of cattle, rice grass should have been prolific on those soils composed of stabilized, aeolian sands that are common throughout the district. Rice grass seeds are relatively large, high in protein, and ripen by early June—a time when protein might be lacking in prehistoric diets. Numerous references to *Oryzopsis* in the ethnographic and archeological literature (see for example, Wetterstrom 1976; Whiting 1966) attest to its use as a food in the Southwest.

Stands of rice grass can presently be found in protected pockets of sandy soil on the west side mesa tops where access by herbivores is somehow precluded by rock walls, ledges or encirclement by dense vegetation. However, some stands of *Oryzopsis* inexplicably remain on the open sandy terraces northeast of the Santa Fe River drainage (area H). One such population remained stable throughout the study season, allowing the author to make estimates of density and seed yield of the rice grass. The seeds were harvested in early June by cutting off a handful of stems close to the ground and thrusting the heads into a cloth sack which was then kneaded and shaken for 5-15 seconds. In this way, I was able to extract, from the bottom of the sack, about 3 g of seed and attached chaff in one minute's effort while working in a patch of grass with mean density of 0.2 clumps/m^2. Chaff (glumes, palea, lemnas, etc.) account for at least 15-18% of the freshly gathered material. There are probably more efficient methods of harvesting rice grass in the field that allow the chaff to be separated from seed. However, all archeobotanical specimens of *Oryzopsis* seed that the author has seen have considerable chaff attached. Regarding the nutritional values of the rice grass caryopsis, the caloric and crude protein contents have been most recently analyzed and quoted by Wetterstrom (1976: 255). For clean but undried seed, there are 3.0 calories per gram and 15.19% crude protein by weight. An earlier analysis (Earle and Jones 1962) gave 11.9% crude protein for clean, dry seed.

In addition to the resource plants mentioned above, there are fruits of certain flowering shrubs that are ripe in the study area by early summer. The squawbush (*R. trilobata*) occurs mainly on the west side of White Rock Canyon and on talus slopes within the canyon. On the talus slopes, squawbush may occur at a density of one bush every 10 m^2 and one can gather about 60 g of the small (3 mm) red berries in five minutes. The fruits are wholly edible, but they contain tannin: the Hopis have used them to flavor a lemonade-like beverage and as a dye mordant (Whiting 1966). The fruit of the mock orange (*P. microphyllus*) which also grows on talus slopes is mentioned by V. Jones (1930) as being eaten by the Isleta Indians. The author collected some fruits of the mock orange in late June and found them difficult to eat. The woody calyx that adheres to the fruit must first be broken away and what is left is a tiny morsel of the same taste and texture as leather.

Late Summer and Fall Resources

1. Stems and Fruits of the Opuntia

The new joints and the fruits of two species of cylindropuntia, *O. clavata* and *O. imbricata*, and two species of pad-like cactus, *O. phaeccntha* and *O. polycantha*, are ripe in the Cochiti Reservoir area usually by mid-August. One or more of the *Opuntia* species were observed at every study area mentioned in this report except the riparian river bottom below Cochiti Dam. The greatest density of these cacti occurs on the eastern rim of White Rock Canyon in the form of thick stands of *O. imbricata*, often in association with ruins and old agricultural fields.

In early ethnobotanical studies, the stems and fruits of *O. imbricata* were not considered edible, since the stems were found to have high mineral and malic acid content and the fruits had a higher proportion of seed than any other *Opuntia* except *O. phaecantha* (Hare and Griffiths 1907). However, more recent studies show that the cholla, while perhaps not a preferred food, was nevertheless eaten frequently in the Southwest (Jones 1930; Castetter 1930; Castetter and Underhill 1935; Whiting 1966). Coprolites from early prehistoric cave sites in northeastern Mexico show that *Opuntia* stems were once a principal foodstuff (Callen 1973). (The *Opuntia* eaten in Mexico was probably of the prickly pear type; but the young stems of the cylindropuntias have similar taste and mucillagenous interior texture.) In any case, the fruits or stems of cholla could be used in stews to provide flavor, bulk and trace element nutrition.

The use of *O. imbricata* as a food in the Cochiti Reservoir district during prehistoric times is plausible, but the species may have been utilized in other ways that overshadowed its nutritional value. Housley (1974) has observed *O. imbricata* growing out of its normal range on late prehistoric ruins in Jemez, just west of the Pajarito Plateau. She postulates that cholla was brought there by prehistoric inhabitants for the purposes of fortification and protection of agricultural fields from predators. It is possible that this species may have been similarly used by former inhabitants of the east rim of White Rock Canyon. On the other hand, there is evidence that cholla increases on grasslands not protected from cattle and rabbits in the southern parts of New Mexico (Pieper, Rea and Fraser 1974) and a similar habit could account for its density on the overgrazed east rim and terraces of White Rock Canyon.

The fruits of the several *Opuntia* are so similar that the subject of edibility remains a matter of opinion until more careful nutritional studies are performed. The author prefers the purple tunas of the plains prickly pear (*O. phaecantha*) which were ripe by mid-September during the study's term. In a particularly dense and undisturbed stand of *O. phaecantha* located on a ruin (LA 5173), I was able to collect 30 tunas, or about 450 g of fruit, in one minute without the aid of gloves. The glochids do not adhere to the fingers and fruits growing on the edge of the pads are easily removed. The fruit of the pad-like *Opuntia* sp. is approximately 25% water and the energy content of the dried flesh (minus seeds) is 3.6 calories per gram (Wetterstrom 1976:256).

2. Seeds of Herbs and Grasses

As can be seen from the plant lists in Table 2.2, the seeds of many herbs and the caryopsis of curly grama are not ripe and edible until late September in the Cochiti study area. Of the numerous annual herbs producing an edible and nutritious seed, the *Chenopodium* species are the most abundant and one of the most important as a potential source of protein and calories.

The species of chenopods that occur in the study area are usually inconspicuous until after the mid-summer rains when their stems may grow 20-30 cm in length. The seeds begin to mature at this time but are not easily harvested until the plant is either dried or nipped by frost (usually in October). For most of the species, a red stem will indicate that seeds can be easily stripped from the fruits. In an experiment to measure the potential harvesting rate of chenopod seeds, I held a basin under the plant and stripped the seeds from the stems with a cupped hand. I was able to obtain about 6 g of seed and calyx for one minute's effort (the density of mature plants in this area was around one individual/m^2 and each plant yielded 2 g of material on the average). I estimate the calyx represents at least 40% of the undried material by weight.

The chenopodium seed has roughly the same nutritive values in terms of crude protein and caloric content as the rice grass (*O. hymenoides*) caryopsis on a gram-for-gram basis, according to assays given for an unnamed *Chenopodium* species in Wetterstrom (1976:255). Harrington (1967:71) asserts that the seeds of goosefoot were used as a source of meal for bread or gruel: *The flour is dark colored from the blackish seed coats, but bakes up into a nice tasting and surely a nutritious product.*

It is also worth noting that a seed of the Family Chenopodiaceae is apparently present among the limited archeobotanical materials retrieved in definite association with a late P-III site located in the Cochiti Reservoir district (Sudar-Murphy and Laumbach 1977:27).

In contrast with the chenopods, little can be said concerning utilization of the seeds of *B. gracilis* as prehistoric food: they are certainly edible, but ethnobotanical connections with utilization by native societies are slim, perhaps because these seeds are so tiny that they are difficult to accumulate in amounts that provide more than a snack. However, another grass growing in the study area, the sand dropseed (*S. cryptandrus*) has equally minute seeds and is known to have been used by the Navajo and Hopi as a grain food (Castetter 1930).

3. The One-Seeded Juniper and the Pinyon Pine

These most ubiquitous trees produce, respectively, new berries and nuts in the fall, usually in late September and October. The potential yield of berries from *J. monosperma* in the study area is enormous, as is the yield of the nuts of *P. edulis*. The latter species, however, only produces fruit every other year as it takes two years for a cone containing nuts to mature. Furthermore, abundant crops of pinyon nuts occur irregularly.

The fruit of the one seeded juniper should be considered a staple only in times of need. Swank (1932:14) mentions that among the Acomas and Lagunas the berries were often used in seasoning meat and were eaten . . . *in considerable quantities in the fall of the year or when food becomes scarce.* Whether the seed within the berry was consumed along with the flesh is not stated. The seed is like the hard, stony endocarp of a plum or cherry and must account for 40-50% of the mass of the berry. Modern cooks who use the berries of *J. monosperma* in stews invariably remove the seeds from the mixture before serving it (Hughes 1978). The nutritive values of either flesh or seed are not known.

The most edible berry among the *Juniperus* species is probably the fruit of *J. scopulorum*, the Rocky Mountain juniper. This tree occurs rarely in the study area below 1676 m (5,500 ft) elevations and even then, only in the west side tributary canyons. The author tried eating some immature berries of *J. scopulorum* in late April of 1978 and found them to be quite palatable and without the strong terpenic taste of the immature berry of *J. monosperma*. The immature berries can be stripped and eaten whole since the seeds are very soft. The nearby Jemez Indians are said to have eaten the mature (fall) berries of *J. scopulorum* in this way, or to have stewed them for food (Cook 1930).

Uses of the nut of the pinyon pine, *P. edulis*, as a concentrated source of protein and oil are well known and too numerous to quote here (see Harrington 1967:323). The most recent assay of the pinyon nut nutrient content gives: 6.5 calories/g of dry weight; 60.31% lipids (oils); and 16.14% crude protein (Wetterstrom 1976:255). It is easily inferred that the pinyon nut would be a dietary staple among prehistoric populations if its appearance were not so sporadic. No nuts developed in the study area in 1977.

SUMMARY AND CONCLUSIONS

Nine areas typifying terrain types that lie within 5 km of Cochiti Dam were selected for botanical studies in April to mid-October of 1977. Of the 218 species observed in the nine areas, 44% are native and edible by the criteria of reference to use of one or more of the plant parts as a food in an ethnographic or ethnobotanical context.

The number of native, edible plant species is maximum in the following areas: Cochiti Canyon (B), the west rim of White Rock Canyon (C); the flood plain terraces along the Santa Fe River below La Bajada scarp (H); and, under certain conditions described in the text, the east rim of White Rock Canyon (F). The edible vegetation in these areas is represented by 25-30 species which, within an assumed 15% observational error, is significantly higher than the other five areas studied. The four areas just mentioned are the potential resource areas.

The general distribution of vegetative types that have seasonally appearing, edible plant parts indicates that the west rim of White Rock Canyon and the flood plain terraces along the Santa Fe River are significant resource areas for food plants appearing in the spring and early summer. The flood plain terraces are also significant resource areas for late summer and fall plant foods. The east rim area would also be a significant fall resource area under undisturbed conditions. Though it contains the largest number of *native edible plant species in the study area*, Cochiti Canyon's resources are largely confined (in the study area) to a short, narrow, riparian zone.

Notable among the spring and early summer vegetative foods are the greens and roots of *C. fendlerii*, greens of *Portulaca* and the caryopsis of rice grass, *O. hymenoides*. Supplements to these foods could include the stipes and buds of *Y. angustissma*, the stems and buds of cacti, the roots of *C. montanus* and roots and bulbs of other herbs. The more palatable late summer and fall vegetative foods are: the fruits of the *Opuntia* spp.; the seeds of the *Chenopodium* spp.; and the nut meats of *P. edulis* and *Quercus* spp. Supplements to a fall diet might include numerous other fruits and seeds that are locally abundant.

At the present only one general area, the sandy flood plain and dunes of the Santa Fe River, is capable of producing native, edible, high protein grains in abundance under stable conditions in both spring (*O. hymenoides*) and fall (*C. leptophyllum*). These grains may have supplied the principal vegetable feature of an adequate human diet in prehistoric times.

The limited evidence from this study suggests that a minimum subsistence diet might be gathered from among the native edible plant species growing near the Cochiti Reservoir, but that diet would necessarily be a highly varied one.

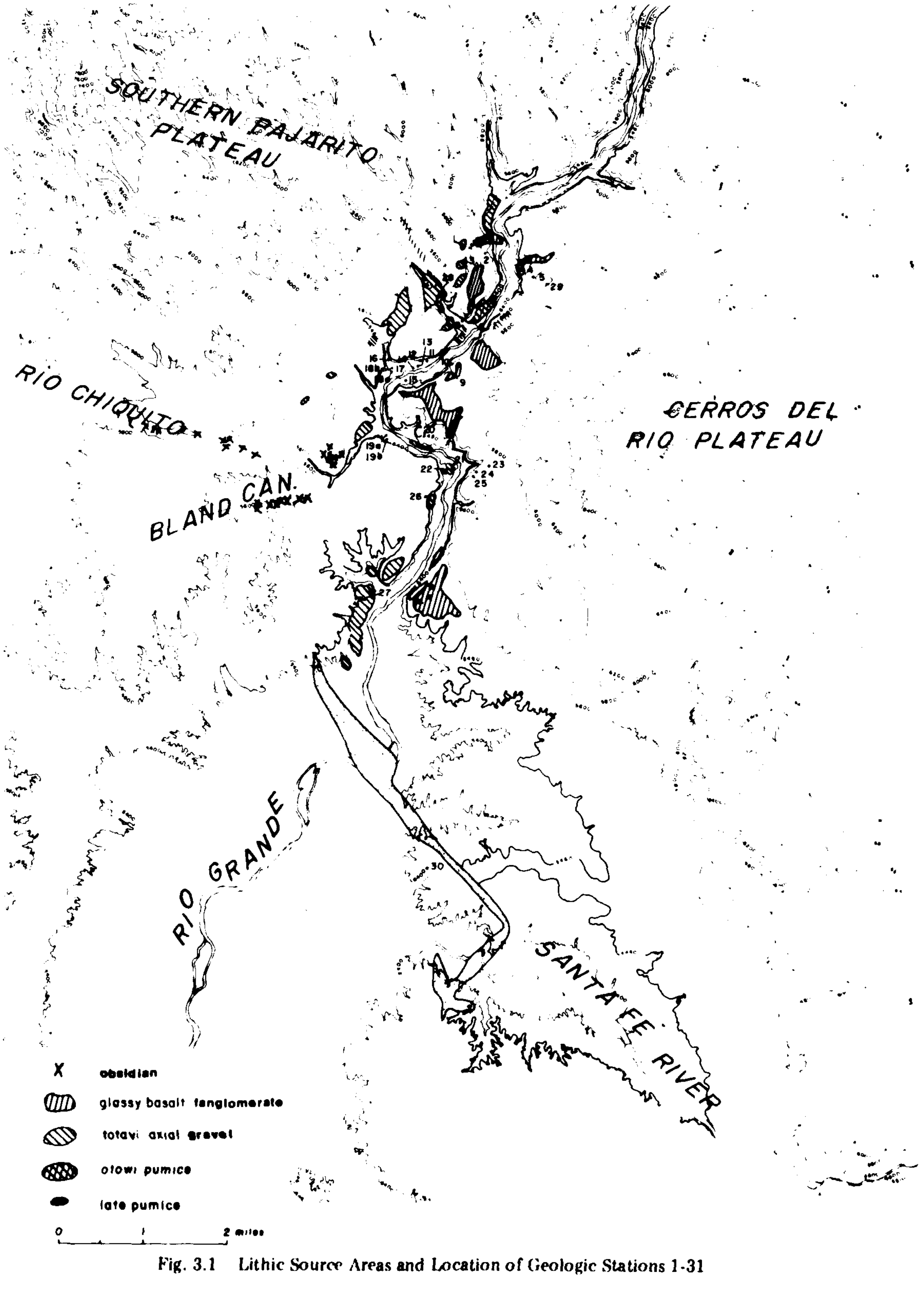


Fig. 3.1 Lithic Source Areas and Location of Geologic Stations 1-31

Chapter 3

GEOLOGICAL AND MINERAL RESOURCES OF THE COCHITI RESERVOIR AREA

A. H. Warren

INTRODUCTION

This report on the prehistoric mineral resources of the Cochiti Reservoir area is one of a series that have been prepared during the twelve years in connection with various archeological surveys and excavation projects. Field reconnaissance was carried out during and following the 1976-1977 excavations in White Rock Canyon, by the Office of Contract Archeology, University of New Mexico. The primary purpose was to determine the extent of mineral resources available to early prehistoric and historic occupants and to establish patterns of utilization if possible.

Early studies had established the nature of the geologic materials and their utilization in the Cochiti Reservoir District (Warren 1966, 1974a). The 1976-1977 investigations were limited in time and scope, but were basically a continuation of previous work in the area. The latter included the analysis and classification of lithic artifact material, identification of ceramic source materials including temper and paints, and limited field studies at nine sites excavated by the Museum of New Mexico, within the Cochiti Dam site (Warren 1966, 1974a). Lithic materials from 39 sites within the Cochiti Development Survey were also classified in 1969. These studies resulted in the identification and description of approximately 75 lithic material classes, the location of geologic sources of many of the types, and the major uses by early inhabitants of the various classes. Subsequent studies in the Cochiti Reservoir District between 1975 and 1978, increased the identified material types to about 100 classes.

The source area studies indicate that virtually all of the lithic materials from both excavated and survey sites could be found within a 15 mile radius, and usually within a mile or two, of an archeological site. Exotic minerals or lithic materials were rarely found at the Cochiti sites, although even turquoise could be obtained in the Cerrillos District, less than 20 miles distant. The pattern of indigenous use of lithic material contrasts with evidence of extensive trade or importation of ceramics in the area (see Warren, Chapter 10, this volume).

METHOD OF STUDY

No single approach to the investigation of geologic source materials can be suggested for different archeological problems. However, various methods that were used in the Cochiti Reservoir District are listed here, along with preliminary assessment of their effectiveness.

1) Familiarity with the artifact materials from the archeological sites under investigations is essential. Specimens that had been collected and brought into the laboratory for study were examined prior to field reconnaissance whenever possible. Knowledge of the distribution of specific classes can be helpful in locating sources in the field.

2) Examination of lithic and artifact materials was made at site locations; in particular, unmodified fragments that could not be classed as artifacts were noted. These include possible tempering materials, building materials, abrasives, or other mineral resources that might have been used in production processes.

3) Stream gravels, alluvial fans, and rock or landslide areas in the vicinity of sites were examined for transported materials from possible outcrops within drainage or source areas. Although these are not primary sources, they can give clues to the provenience of many materials in geologic outcrops.

4) Geologic publications and maps of the area were studied to identify rock units present, and to note any unusual or isolated exposures of geologic formations. Frequently small outcrops of importance to the prehistoric Indian have been overlooked by the field geologist mapping an area; these can be located by field reconnaissance. In White Rock Canyon, numerous exposures of obsidian in the Bandelier Tuff units were located, but were not extensive enough to be included on a geologic map.

5) Type specimens were collected for laboratory study and permanent records; materials of new lithic types recognized were placed on file at the Laboratory of Anthropology, Santa Fe.

6) During the 1976-1978 studies, pebble or cobble counts were made of outcrops of river gravel of the ancestral Rio Grande. The gravel units occur in different stratigraphic context throughout White Rock Canyon, and are interbedded with basalt flows and other depositional units. The uppermost deposits were located on top of basalt flows in some areas and included volcanic rocks of Bandelier time.

Specimens were selected randomly from outcrops, which were limited by exposures available and accessibility. In some cases, specimens were made of successive vertical strata, where these were exposed. Rock types and frequencies from a 2 m diameter area were recorded; pebbles smaller than 2 cm were not usually counted. Lithic code numbers for material classes were used in the field to order the data from each sample area. For the purpose of resource interpretation, however, many classes not used widely for artifacts were grouped. Table 3.1 provides a brief description with known sources for each lithic code number utilized in the present study. Major source material areas have been depicted on a map of the Cochiti Reservoir area (Fig. 3.1), and Table 3.2 provides counts of pebbles and cobbles for the 31 geologic stations investigated during the 1976-1978 seasons.

Additional data concerning resource areas are included in this report and a synthesis of previous work is given.

Table 3.1

Minerals and Rocks of White Rock Canyon and the Cochiti Area, Revised 1978

Code No.	Classification	Source
1011	Chert, cream colored, dull to waxy luster, small circular and crescentic fossils	As cobbles in the axial gravel, Rio Grande
1030	Chert, black	Axial gravel, Rio Grande and elsewhere
1040	Chert, green, cream	Brushy Basin Formation, San Juan County
1050-51	Chert, white, dull luster (1050); black mossy inclusions (1051)	Axial gravel, Rio Grande
1052-53	Chalcedony, clear, colorless, waxy luster (1052); black dendritic inclusions (1053)	Chalcedonic variation of 1050-51
1055	Chert, white, quartz inclusions	Undetermined
1060	Chert, dark red (jasper)	Axial gravel, Rio Grande; and elsewhere
1070	Chert, yellow brown (jasper)	Axial gravel, Rio Grande; and elsewhere
1071	Chert, yellow brown, oolitic	Undetermined
1072-73	Chert, yellow brown to olive brown (1073); dendritic inclusions (1072)	Axial gravel, Rio Grande; derived from Pennsylvania limestones
1075	Chert and chalcedony	Laguna, New Mexico
1090-91	Chert, white, red, black and/or yellow inclusions (1090); chalcedonic (1091)	Axial gravel, Rio Grande; also Cerro Pedernal
1098	Chert, chalcedonic — similar to 1091	Undetermined
1100	Silicified wood, yellow brown	Axial gravel, Rio Grande (sparse); Jemez and Galisteo River Valleys
1110	Silicified wood, dark colors	Same as 1100
1112-13	Silicified wood, waxy luster, dark colors (1112); light colors (1113)	Jemez and Galisteo Valleys; and elsewhere
1140	Silicified wood, light colors, chalcedonic	Same as 1112-13
1210	Chalcedony, mossy inclusions	Undetermined
1212	Chalcedony, abundant red and yellow mossy inclusions (moss jasper)	Axial gravel, Rio Grande
1213	Chalcedony, banded, clear white, plae buff, black dendrites in fracture	Undetermined; Cochiti area, possibly Bland Canyon
1214-15	Chalcedony, clear, colorless, may grade to pink, milky white inclusions (1214); black inclusions (1215)	Axial gravel, Rio Grande; Tertiary fan gravel, Jemez River; Llano de Albuquerque (Ceja Mesa).

Table 3.1 (Continued)

Code No.	Classification	Source
1221	Chalcedony with abundant mossy yellow inclusions (moss jasper)	Axial gravel, Rio Grande; or Tertiary alluvial fan gravel
1230	Chalcedony, clear with sparse red inclusions	Undetermined
1233	Chalcedony, clear with abundant yellow and red inclusions (moss jasper)	Undetermined
1310	Chalcedony, clear uniform shade of yellow	Axial gravel, Rio Grande
1340	Chalcedony, clear uniform shades of light brown	Same as 1310
1391	Opal, blue hyalite, botryoidal crusts	Cochiti or Jemez Sulfur mining district
1400	Chert, undifferentiated	Undetermined
1430	Chert and chalcedony, mossy red to colorless, light gray	Laguna, New Mexico
1433	Chert, red and gray, undifferentiated	Undetermined
1500	Chert, jasperoids and porcellanites, volcanic associations	Undetermined
1501	Chert (jasperoid), cream, reddish brown, gray, banded or mottled, brittle, waxy luster	In rhyolite tuffs, Jemez Mountains
1502	Jasperoid (metarhyolite?), gray porcelanoid, sparse phenocrysts	Axial gravel, Rio Grande
1600	Light gray chert, misc.	Undetermined
1630	Chert, cream colored	Undetermined
2000	Sandstone, undifferentiated	Undetermined
2010	Sandstone, undifferentiated, fine-grained, indurated, massive	Undetermined
2015	Sandstone, very fine-grained (less than 0.125), undifferentiated	Undetermined
2020	Sandstone, fine-grained, well indurated, slabby	Undetermined
2030	Sandstone, fine-grained, indurated, tan	Axial gravel, Rio Grande
2040	Sandstone, fine-grained, subangular grains, undifferentiated, friable	Undetermined
2050	Sandstone medium to coarse grained, indurated, massive	Axial gravel, Rio Grande
2065	Sandstone, medium to coarse grained, undifferentiated	Undetermined
2090	Sandstone, hematitic, friable	At base of basalt flows in Axial gravel, Rio Grande
2091	Sandstone, limonitic, undifferentiated	Undetermined
2200	Sandstone, quartzitic, undifferentiated	Undetermined
2203	Sandstone, quartzitic, brown, red, red purple	Tertiary fan gravel, Jemez River
2205	Quartzite sandstone, white-buff, orange, to red, or Morrison Formation fine-grained, even, conchoidal fracture	Northeastern New Mexico

Table 3.1 (Continued)

Minerals and Rocks of White Rock Canyon and the Cochiti Area Revised, 1978

Code No.	Classification	Source
2250	Siltstone, indurated	Undetermined
2300	Conglomerate, quartzite cobbles	Axial gravels, Rio Grande
2554	Claystones, red, yellow, gray, burned and hardened by heat	East wall, White Rock Canyon, near LA 12463 in axial gravels
2710	Limestone, fossiliferous	Axial gravels, Rio Grande (?)
2810	Diatomite, white, powdery	White Rock Canyon, across from Alamo Canyon
2850	Fossils, limestone	Axial gravels, Rio Grande
2911	Concretion, limonitic	Undetermined
3000	Granitic rock, undifferentiated	Axial gravels, Rio Grande
3010	Felsite, aphanitic (rhyolite); light colored volcanic rock	Undetermined
3015	Felsophyre, aphanitic groundmass with phenocrysts (rhyolite, etc.), also 3165, 3166	Undetermined
3020-30	Intermediate igneous, phaneric (3020); aphanite (3030)	Undetermined
3035	Intermediate, syenitic rocks, felsophyre	Undetermined
3050	Basalt, very fine-grained (*trap*)	Basalt flows, Cerros del Rio
3055	Melaphyre, aphanitic with phenocrysts	Undetermined
3100	Granite, undifferentiated	Undetermined
3101	Granite, pink-orange inclusions	Axial gravels, Rio Grande; Sangre de Cristos, Nacimiento Mountains
3150	Rhyolite, undifferentiated	Undetermined
3170	Syenite, undifferentiated	Undetermined
3262	Augite latite	Cieneguilla, Los Cerrillos, fan gravel at La Bajada
3300	Andesite, undifferentiated	Undetermined
3350	Gabbro	Undetermined
3400	Basalt, very fine-grained, sparse phenocrysts	Basalt flows, Cerros del Rio
3401	Basalt, fine-grained, tabular	Basalt flows, Cerros del Rio
3404	Basalt, finely crystalline	Undetermined
3410	Basalt, very fine-grained (*trap*), conchoidal fracture	Basalt flows, Cerros del Rio
3430-31	Basalt, vesicular to scoriaceous, gray (3430); low density, highly vesicular (3431)	Basalt flows, Cerros del Rio

Table 3.1 (Continued)

Code No.	Classification	Source
3432	Basalt, scoria, low density	Cochiti area
3451	Basalt, olivine vesicular	Undetermined
3500	Obsidian, undifferentiated	Undetermined
3510	Obsidian, black, waxy luster, opaque	Grants area
3520	Obsidian, clear, brownish tinges, translucent, homogeneous	Jemez Mts.; high surfaces, White Rock, Borrego and Bland Canyons; elsewhere
3521	Obsidian, reddish brown tinges, swirls and bands	Same as 3520
3523	Obsidian, brown, opaque	Same as 3520
3524	Obsidian, brown, bands, streaks or flows, translucent	Same as 3520
3525	Obsidian, white inclusions	Valle Grande, Jemez Mts.
3526	Obsidian, green or greenish-black bands, opaque	High surfaces, White Rock Canyon
3530	Obsidian, light smokey gray, may be banded, small white to black inclusions	Polvadera Peak area, Jemez Mts.
3550	Obsidian	Red Hill area, New Mexico
3651	Pumice, cellular with obsidian Jemez (151F), burned obsidian?	Undetermined
3652	Perlite, (welded pumice), white, etc.	Peralta Canyon? Jemez Mts.
3653	Pumice, popcorn, white, with crystals	El Cajete(?) Member
3655	Pumice, chunk, white, weathers, tan	Otowi Member, Bandelier Tuff
3700	Vitrophyre, black, dense, conchoidal fracture, undifferentiated	Undetermined
3701	Vitrophyre, basaltic (glassy basalt), vitreous luster, brittle: grades to fine-grained (*trap*), conchoidal fracture	Pyroclastic fragments, high surfaces, White Rock Canyon
3730-31	Vitrophyre, rhyolitic, glassy, welded, red, gray, white (3730); banded (3731)	Ash flow tuffs, Jemez Mts.; Axial gravels, Rio Grande
3740	Vitrophyre, intermediate glassy	Undetermined
3810	Tuff, welded, rhyolitic or ash flow	Undetermined
3811	Rhyolite, ash flow tuff, partially welded	Bandelier Tuff; Jemez Mts., Pajarito Plateau
3812	Rhyolite, ash flow tuff, platy, welded	Pajarito Plateau; fan gravel; channel gravel
3813	Rhyolite, lapilli, welded	Same as 3812
3820	Andesite, ash flow tuff, moderately well indurated	Same as 3812
3821	Tuff, welded, altered andesitic, crystals, (tempered material)	Undetermined

Table 3.1 (Continued)

Minerals and Rocks of White Rock Canyon and the Cochiti Area Revised, 1978

Code No.	Classification	Source
4000	Quartz, white, opaque; rounded rocks	Axial gravels, Rio Grande
4005	Quartzite, misc. cobbles	Undetermined
4301	Phyllite, satiny gray to black; flattened pebbles	Axial gravels, Rio Grande
4370	Metarhyolite	Undetermined
4375	Metasyenite	Undetermined
4380	Metabasalt (melaphyre)	Undetermined
4510	Schist, hornblende (schistose)	Undetermined
4515	Amphibolite (or hornblende gneiss) (see 4750)	Undetermined
4520	Schist, green, schistose, misc.	Undetermined
4525	Greenstone, massive	Undetermined
4530	Schist, sillimanite (and gneiss), fibrolite	Undetermined
4531	Sillimanite quartz schist (fibrolite); cobbles	Axial gravels, Rio Grande
4550	Schist, quartz mica	Axial gravels, Rio Grande
4560	Schist, quartz muscovite	Undetermined
4700	Gneiss, undifferentiated	Undetermined
4710	Gneiss, quartz feldspar (Granite)	Undetermined
5010	Quartz, rock, colorless	Undetermined
5020	Quartz, crystals, misc.	Undetermined
5030	Feldspar crystals	Undetermined
5040	Gypsum rock	Rosario (La Bajada)
5041	Gypsum selenite	Rosario (La Bajada)
5110	Limonite, earthy, yellow brown	East wall, White Rock Canyon, near LA 12463; and elsewhere
5211	Hematite, hexagonal, silvery crystals	Undetermined
5220	Hematite, earthy, ochre	Same as 5110
5290	Jarosite, yellow to dark brown ochre	In sandstone, Cochiti Dam Site
5300	Turquoise	Cerrillos, Santa Fe County; & elsewhere
5321	Malachite, in sandstone	La Bajada, Cerrillos, Nacimiento mining district; and elsewhere
5340	Epidote	Axial gravels, Rio Grande
9999	Unknown material	Undetermined

Table 3.2

Lithic Counts from Geologic Stations (1978)

TAXA	1	2	3	4	5	6	7	8	9	10a	10b	11	12a	12b	13	14	15a	15b	16	17	18	19a	19b	20	21	22	23	24	25	26	27	28	29	30	31
?el Fm																																			
3520	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-
3523	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Basalt																																			
3740	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
3701	-	-	-	-	-	1	-	1	-	1	11	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	1	-	-	-
3400	1	10	2	-	-	14	2	21	5	-	-	-	-	-	-	-	-	-	-	-	-	13	6												
3401	-	-	-	-	-	1	-	1	-	3	-	-	-	-	-	-	-	1	-	-	-	6	4	-	1	1	-	-	-	-	-	-	-	-	-
3404	-	-	-	-	-	-	-	-	-	32	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3410	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	1	-	-	22	17	-	-	-	-	-	-	-	-	-
3431	-	-	-	-	-	1	-	1	-	10	-	-	-	-	-	-	-	-	--	-	-	-	10	-	-	2	-	-	-	-	-	-	-	-	-
3451	-	-	-	-	-	5	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	-	-	-	-	-	-	-	-	-	-	-	-
3010	-	-	-	-	-	-	-	-	-	20	-	-	32	-	-	-	-	63	-	-	-	-	-	-	19	1	-	-	-	-	-	-	-	-	-
3430	-	-	-	-	-	-	-	-	-	21	-	-	-	-	-	-	-	2	-	-	-	-	-	-	4	11	-	-	-	-	-	-	-	-	-
[illegible]																																			
1050	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1051	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
1052	-	-	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
1053	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	3	-	1	1	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-
1054	-	-	-	-	-	-	-	-	-	-	-	6	-	2	-	-	-	13	-	-	1	-	30	-		2	-	-	-	-		-		-	-
1098	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-
1214	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-		-
1215	3	-	2	-	-	-	2	-	-	-	-	-	-	-	-	-	1	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]																																			
1010	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
1011	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-		-	-		-	-	-	-		-		-	-	-	-	-	-	-	-	-

Table 3.2 (Continued)

Lithic Counts from Geologic Stations (1978)

GEOLOGIC STATIONS

TAXA	1	2	3	4	5	6	7	8	9	10a	10b	11	12a	12b	13	14	15a	15b	16	17	18	19a	19b	20	21	22	23	24	25	26	27	28	29	30	31
1060	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1070	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1073	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1433	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
1630	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Chalcedony 1213	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1221	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1230	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1233	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quartzite																																			
4000 Gray	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-
4000 Tan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	5	-	-	-	-	-	-	-	-	-	-	-	-
4001	1	-	1	2	-	2	1	1	-	-	-	-	5	-	6	5	5	19	2	6	-	1	-	-	-	4	-	-	-	-	-	3	-	2	2
4005 Red	-	-	-	-	5	1	-	-	1	-	-	-	-	-	1	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yellow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	-	-	-	-	-	-	-	-	-
Gray	20	3	24	26	14	20	21	10	14	6	-	-	13	-	3	21	26	34	14	24	50	-	-	-	57	2	-	-	-	-	-	24	-	21	13
Pebble	2	1	2	10	3	-	1	1	8	6	-	-	21	-	7	8	14	4	3	12	17	-	-	-	5	1	-	-	-	-	-	7	-	3	5
Black	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White	6	2	5	15	5	-	1	4	6	2	-	-	12	-	4	8	15	6	7	6	7	-	-	-	5	-	-	-	-	-	-	8	-	7	8
Tan	4	15	6	26	24	3	5	3	23	22	-	-	53	-	20	15	40	37	13	24	34	-	-	-	2	-	-	-	-	-	-	34	-	18	35
Grey-red	7	3	8	14	3	7	3	2	12	9	-	-	11	-	1	7	7	8	-	9	12	-	-	-	10	4	-	-	-	-	-	8	-	6	5
Andesite/Granite 3100	4	2	7	-	1	10	8	2	2	8	-	-	-	-	2	1	9	-	-	6	-	-	1	-	-	18	-	-	-	-	-	2	-	2	-

Table 3.2 (Continued)

Lithic Counts from Geologic Stations (1978)

TAXA	GEOLOGIC STATIONS																																		
	1	2	3	4	5	6	7	8	9	10a	10b	11	12a	12b	13	14	15a	15b	16	17	18	19a	19b	20	21	22	23	24	25	26	27	28	29	30	31
3101	12	8	7	-	11	14	19	9	6	-	-	-	17	-	4	16	23	32	-	12	9	13	9	-	9	-	-	-	-	-	-	-	-	7	9
3150	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	1	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
3170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-
3015	8	3	3	-	3	20	10	10	1	-	-	-	-	-	2	3	7	-	1	4	3	7	6	-	-	-	-	-	-	-	-	-	-	-	3
3035	19	7	9	7	25	-	6	11	13	-	-	-	-	-	11	12	40	-	1	16	23	-	-	-	-	-	-	-	-	-	-	26	-	3	12
3055	-	-	8	-	-	-	5	24	5	-	-	-	-	-	3	2	5	-	5	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	8
3300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	16	-	-	-	-	-	-	-	1	-
3010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metamorphic																																			
4370	-	-	-	2	3	-	-	-	5	-	-	-	11	-	2	-	9	-	7	-	-	-	-	-	-	4	-	-	-	-	-	-	-	5	6
4372	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4375	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4380	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
4301	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	3	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1
4530	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4520	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4510	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4515	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
4525	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
4526	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4531	-	-	2	3	2	-	1	2	3	-	-	-	-	-	1	-	5	-	-	4	-	-	-	-	-	-	-	-	-	-	-	4	-	1	7
4560	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
4700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4710	-	1	3	-	-	2	1	-	-	-	-	-	2	-	-	2	7	6	2	3	2	-	1	-	-	10	-	-	-	-	-	-	-	-	1

Table 3.2 (Continued)

Lithic Counts from Geologic Stations (1978)

	GEOLOGIC STATIONS																																		
TAXA	1	2	3	4	5	6	7	8	9	10a	10b	11	12a	12b	13	14	15a	15b	16	17	18	19a	19b	20	21	22	23	24	25	26	27	28	29	30	31
Meta Rhy. (Tusas)	2	2	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
Mica Schist	1	2	-	-	-	1	1	-	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Granite mica schist Sandstone																																			
2015	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
2040	1	1	-	-	-	-	1	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
2065	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
2091	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
2205	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Igneous																																			
3651	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
3652	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
3810	1	-	3	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	11	3	-	-	-	-	-	-	-	-	1	-	-	-
3811	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	-	-	-	-	-	-	-	-	-	-	-	-
3813	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-
3820	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	9	1	-	-	-	-	-	-	-	-	-	-	-	-
3821	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	--	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Other minerals																																			
5010	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	3	-	-	-	-	-	-	-	-	-	-	1	-
5020	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5015	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
5030	1	1	-	-	1	-	2	2	-	-	-	-	-	-	1	-	2	-	2	3	-	2	2	-	-	1	-	-	-	-	-	-	-	1	-
5340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-

OBSIDIAN

Obsidian suitable for production of flaked artifacts is abundant on the Pajarito Plateau and can be found in scattered surface deposits and gravel as far south as Zia Pueblo. Outcrops in ancestral Rio Grande gravel beds of early Pleistocene(?) time have been found as far south as Las Cruces, New Mexico. Obsidian of the Plateau (3520 series) can be distinguished from another source of obsidian (3530) west of Polvadera Peak, by its pale to dark brown tinges and by the absence of minute white inclusions, which give the Polvadera obsidian a smokey cast.

The primary obsidian source in the Cochiti Reservoir District is in an ashflow deposit from Rabbit Mountain (Robert L. Smith, written communication), and is part of the Toledo Tuff sequence of the Bandelier Tuff. The best known outcrop is on Obsidian Ridge, or Mesa del Rito. Here clasts of volcanic glass have been extensively exploited in prehistoric and possibly historic times. Ridges and mesa tops in the area of the outcrops are littered with discarded flakes and debris from gathering and refining activities. The tuff includes fragments of pumice, perlite, scoria, and vesicular glass as well as transparent to opaque brown and green nodules of obsidian.

Some of the obsidian clasts are vesicular; other specimens have white spherical inclusions up to 0.5 m in diameter. Obsidian fragments up to 10 or 12 cm are common and one boulder 45 cm in diameter was noted on Obsidian Ridge. Similar outcrops of the Toledo Tuff with obsidian fragments, but not as abundant as the Obsidian Ridge deposit, occur along the road east of Rabbit Mountain and along the Lookout road to the south. Scattered lag deposits have been noted near St. Peter's Dome trail where it enters St. Peter's Dome road.

An in situ outcrop of obsidian-bearing volcanic tuff breccia, probably the Toledo Tuff, is located on the north side of Bland Canyon. Obsidian nodules up to 10 cm or more in diameter occur in a partially consolidated lapilli tuff above the Otowi Member of the Bandelier Tuff, but below the cliff-forming Tsirege Member. Along White Rock Canyon on high digitate mesas to the west and on the basalt mesas to the east are scattered deposits of obsidian, usually at the top of Otowi Pumice outcrops. The latter are not all marked on the geologic map of the area and more occurrences than indicated in Fig. 3.1 may be present in the canyon area.

Less conspicuous are outcrops of Canovas Canyon Rhyolite at the base of the Otowi Pumice (Smith, Bailey and Ross 1970). At one exposure at the base of the Potrero Viejo (Horn Mesa) obsidian was apparently gathered by occupants of a nearby pueblo of the Santa Fe period, judging from the amount of debris left at the site. Outcrops of the Canovas Canyon obsidian are also reported in the Bear Springs area. Artifact grade obsidian also occurs in the older gravel deposits along the Rio Chiquito, on Borrego Mesa, and on high surfaces bordering White Rock Canyon.

On the northern Pajarito Plateau, an important deposit of obsidian occurs west of Polvadera Peak. Pebbles and cobbles of obsidians can also be found in the stream gravel along the Jemez River and its tributaries of the Valle Grande. A volcanic glass flow, the Banco Bonito, which crops out in the Valle Grande is not of artifact quality.

GLASSY BASALT (Basalt vitrophyre 3701)

Source area distribution of basalt vitrophyre was mapped along the Rio Grande in White Rock Canyon. Some of the outcrops were in stratified units and exposed along the canyon walls; others appeared to be either lag deposits on mesa surfaces or alluvial and talus deposits. Most of the basalt occurs as clasts in partly consolidated volcanic breccia above the Otowi Pumice unit; obsidian occurs in some of the outcrops of this breccia. An outcrop of the glassy basalt occurs as a flow on a ridge overlooking the Rio Grande, north of the mouth of Capulin Canyon. A volcanic breccia exposed along the St. Peter's Dome trail to Medio Canyon also contains large fragments of the glassy basalt. Boulders measuring 1.5 m or greater have been noted at several outcrops. Probably the most abundant and ubiquitous artifact source material in the Cochiti Reservoir area, glassy basalt was extensively utilized by prehistoric inhabitants. Discarded refining debris can be found in the vicinity of outcrops throughout the district.

MINERALS

Malachite (5321), a green copper mineral was used prehistorically as a pigment and for ground stone ornaments. Malachite in sandstone was found in the channel gravel in Capulin Canyon, suggesting a possible source in the headwaters.

Limonite (5110) and hematite (5221) in sandstone and in earthy nodules have been found in Capulin Canyon above the Painted Cave. The probable source is an outcrop of sandstone near Ha'atse (LA 370).

Quartz crystals (5020) occur in mineralized zones in the Cochiti Mining District. Amethyst crystals were noted along the road between Bland and Colle Canyons.

CHERT AND CHALCEDONY (1054 Series)

Cobbles of chert, predominantly chalcedonic, occur in many of the outcrops of axial river gravel of the ancestral Rio Grande, but are absent from some (Table 2.2). Color variations are numerous and include white to clear (1050, 1052); with black dendrites (1051, 1053); with milky white inclusions (1214) and milky white with black (1215); yellowish to brown shades (1213); and red inclusions (1230). The chalcedonic varieties resemble those of the Pedernal Chert, of the northern Jemez Mountains; however, the white chert (1090) with fine red and yellow inclusions, which is distinctive of the Cerro Pedernal area is not present in White Rock Canyon. For tabulation purposes, the code number 1054 was used to include chalcedony with any of the above color combinations.

The 1054 series chalcedony occurs in most of the units of axial gravel in White Rock Canyon. These units are interbedded with basalt flows of the Cerros del Rio. Two of these flows have been dated about 2.5 m.y., which places a minimum date on the original source of the chalcedony (Bachman and Mehnert 1978). Elsewhere, the chalcedony has been found on the surface of Ceja Mesa

(Bryan's 1937 Llano de Albuquerque), in ancient fan gravel deposits north and west of San Pedro Mountain, and on high surface remnants north of Chaco Canyon. Chalcedony from the high surface remnants is associated with cherty limestone, oolitic and fossiliferous cherts, quartzitic sandstone, and in the Chaco area, with light colored silicified wood. The present conjecture is that these materials were formed by silicification of surface materials by excess silica following volcanic ash falls. It cannot be determined at this time if the various occurrences are contemporary, or whether several geologic time periods or episodes are involved.

JASPER

Numerous fragments of yellow brown jasper (1221) were found in the vicinity of Ha'atse (LA 370) and in Capulin and Medio Canyons. The jasper ranges from a glossy yellow chalcedony to mottled yellow and may be from a mineralized zone.

OPAL

Blue hyaline opal (1391), a possible turquoise substitute, is found in fractures in the rhyolite which forms the wall of the narrow canyon of the Rio Chiquito upstream from Dixon's apple ranch. The opal has been noted at archeological sites.

White opal (1390) was found in the vicinity of Ha'atse (LA 370) and probably has a source nearby.

SANDSTONES

Sandstones may be commonplace rocks, but they are not abundant in the Cochiti Reservoir District. Fine-grained sandstones (2010) have been found in the axial river gravel along Medio Canyon; these are well indurated. An outcrop of well indurated sandstone (2011) occurs on the old road from Bland Canyon to Albemarie, in Colle Canyon.

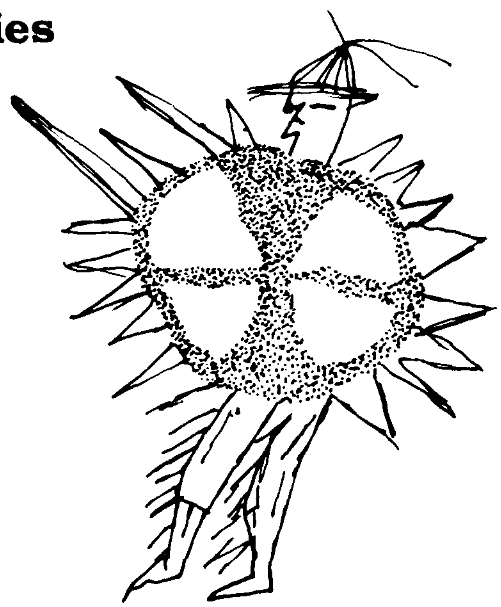
During the historic period, coarse-grained sandstone was a common tempering material, particularly in utility wares. The source of a local volcanic sandstone (2471) is found above the Otowi Pumice, a lower unit of the Bandelier Tuff, but below the cliff-forming welded rhyolite unit. Slides of the temper material were examined by Dale Rugge (written communication 1978) and were found to include subrounded grains of colorless and brown glass, plagioclase, sericitized plagioclase, quartz grains, basalt or andesite fragments, rhyolite fragments, and opaque material. The volcanic glass contained feldspar microlites and sparse phenocrysts of biotite.

PART THREE:
ADAPTIVE CHANGE IN COCHITI RESERVOIR

The Archaic Strategies

The Anasazi Strategies

The Historic Strategies



Cross-Cultural Studies

Chapter 4

THE ARCHAIC OCCUPATION OF WHITE ROCK CANYON

Richard C. Chapman

WHAT IS THE ARCHAIC?

The term Archaic and the kind of meaning assigned to the term by students of Southwestern prehistory can be seen, in an historical sense, as a developmental process which had its origins in the discovery of Folsom remains in association with extinct Pleistocene bison. This discovery established without doubt the archeological reality of a long term of human adaptation within the New World which preceded the more spectacular adaptive periods which had previously constituted a focus of investigation (such as the Anasazi ruins in the Mesa Verde and Chaco Canyon regions). As a consequence, the Folsom discovery initiated a concerted search for evidence of other Paleo-Indian remains, and a search for evidence for ways of understanding the changes in climate which had occurred since the Pleistocene. One by-product of this general search for ancient remains was the documentation of entire sets of archeological manifestations within the Southwest which could not be attributed to either the earlier Paleo-Indian Clovis, Folsom or Cody Complex artifactual inventory or to the later Anasazi, Mogollon or Hohokam artifactual or architectural manifestations.

Thus an entire adaptive period or stage, falling between the late Pleistocene and the earliest manifestations of essentially house-building, pottery-making peoples was documented as an archeological fact by the early 1940s (Sayles and Antevs 1941). The existence of such a cultural stage then stimulated a period of data gathering and speculation concerning the nature of adaptation these data represented, exactly what their antiquity was, and how the prehistoric people themselves were related, either culturally or genetically, to the earlier PaleoIndian populations and the later sedentary villagers.

A major thrust of this research was directed initially, and continues to be directed, toward outlining the culture-history of the Archaic period for different regions within the Southwest. Emphasis was initially placed upon excavation of stratified cave or shelter deposits (Haury 1950; Jennings 1957; Dick 1965; Irwin-Williams and Tomkins 1968) and, from these excavations, a series of regional chronological sequences began to be developed. Although radiocarbon dating has been employed to define the broad outlines of regional sequences, artifact typologies (especially projectile point morphology) still serve as the primary basis for classifying Archaic period manifestations to temporal phase and cultural affiliation.

At present, research emphasis has shifted toward broad areal surveys in response to government agency and industry needs. Concurrent with this kind of research has been an ongoing attempt to define the outlines of general climatological variation which occurred between the terminal Pleistocene and the present.

In addition to this kind of cultural-historical research emphasis, a second major thrust of inquiry into the Archaic period has been directed toward attempting to explicate the character of adaptation engaged in by human populations throughout the period.

This effort has been pursued increasingly through use of ethnographic analogues derived from extant band-organized groups in arid environmental settings, most notably from populations inhabiting the Kalahari desert of Africa, the central and western deserts of interior Australia, and the Great Basin region of the American Southwest. Specific attention has been paid to variation in subsistence, technology, local group composition, social organization and settlement behavior among such foraging groups; and a variety of attempts have been made in drawing parallels between observations of living behavior and certain aspects of the archeological record of the Southwestern Archaic.

These procedures have tended to take the form of listing, in almost structural-functionalist fashion, behavioral properties which are *assumed* to characterize Archaic adaptation. Many of these properties of social, demographic, subsistence and settlement behavior have been accepted by now almost as empirical facts concerning the prehistoric Archaic. Among these are assumptions that local groups were relatively small in size (up to 25-30 individuals); that social behavior was essentially egalitarian in character and family based; that subsistence emphasis was upon a broad range of vegetative and faunal species rather than focal in nature; and that settlement was relatively mobile, involving residential relocation through each year to a number of campsites within relatively large territories as dictated by food and water availability.

These kinds of behavioral properties are by now so routinely referred to in almost all archeological reports dealing with Archaic archeological manifestations, that they might be construed as a *generalized hunter-gatherer model* which is being employed to explain the character of behavior underlying variation observed in the archeological record itself.

To a certain extent, however, the recent investment into ethnoarcheology among foraging groups might be seen as a recognition that this generalized behavioral model does not, in fact, offer much explanatory utility with respect to understanding the archeological record of hunter-gatherer behavior. The model is too general to be of any substantive use in accounting for variation in the archeological record of the Archaic, at least in its present formulation. Ethnoarcheological research conducted among arid

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foraging groups (Gould 1969; Gould et al. 1971; Yellen and Harpending 1972; Yellen 1976, 1977) has been undertaken in part as an attempt to document the relationship between ongoing behavior and the character of the material record of that behavior, given this problem.

To summarize, then, the question *What is the Archaic?* has many answers. The Archaic is, on one hand, an archeological fact — a period of human adaptation within many regions of the Southwest which falls historically between the end of the Pleistocene and the beginning of regional adaptations characterized by a considerable dependence upon agricultural production. On the other hand, the Archaic constitutes a kind of unknown phenomenon in terms of the actual character of cultural behavior exhibited by human populations throughout that time frame. Data exist which indicate that essential properties of Archaic adaptation seem to be those of a very diversified subsistence base, relatively small residential group size and local group size, and a relatively great degree of seasonal residential mobility throughout each year within large territorial frames. The particulars of Archaic adaptation within any given region, however, remain at present very sketchy or unknown and have been filled in through recourse to ethnographic analogy.

The Cochiti Reservoir project has provided an opportunity for examination of Archaic period archeological remains in some detail for a small portion of the northern Rio Grande Valley. Previous research directed explicitly toward describing and understanding Archaic period adaptation within this region has been disparate for a variety of reasons, and relatively little information has been disseminated through publication. For this reason, an attempt was made throughout the course of the Cochiti Reservoir project to provide a substantive descriptive documentation of Archaic period site locations within the project boundaries, at both the survey and excavation stages of analysis (Biella and Chapman 1977c; Chapman et al. 1977; Hunter-Anderson 1979a, 1979b, 1979c; Eck 1979).

The objectives of this chapter are two-fold: first, to summarize where the archeological evidence of Archaic adaptation within the project boundaries fit with respect to current scenarios which have been offered concerning the absolute and relative temporal sequences of adaptive phases possibly characterizing the region; and second, to review some features of ethnographic and archeological research directed toward understanding properties of these adaptive phases. This review will hopefully offer some guidelines for future research which might prove productive as opportunities for continued examination of the Archaic period within the northern Rio Grande Valley become available.

REGIONAL ARCHAIC CHRONOLOGY

One attempt to provide a general overview of the Archaic period of adaptation across northern New Mexico has been undertaken by Irwin-Williams (1967, 1973, n.d.). Her work on the Oshara Tradition serves, at present, as the primary referent for assigning chronological position to Archaic manifestations within the northern Rio Grande Valley. It should be noted, however, that artifacts diagnostic of the northern Mexico, southern New Mexico and Arizona based Cochise Tradition have occasionally been found on sites in the northern Rio Grande Valley (Lang 1977: Traylor et al. 1977). Despite the presence of Cochise Tradition materials, the Oshara Tradition manifestation as outlined by Irwin-Williams is best representative of the Archaic materials present in the northern Rio Grande Valley.

Drawing in part upon previous documentation and in part upon survey and excavation data from the Arroyo Cuervo Valley in the Rio Puerco (of the east) drainage basin of northwestern New Mexico, Irwin-Williams (1973, n.d.) has posited a chronological sequence of five temporal phases within the Oshara Tradition of Archaic period adaptation. These temporal phases date roughly between 5500 B.C. and A.D. 400. Although differences in settlement, subsistence and local group size are noted for the various phases, it is suggested that Archaic adaptation overall reflects small populations engaged in a mixed foraging subsistence strategy.

Irwin-Williams distinguishes between *early* and *late* Archaic manifestations. The Early Archaic is seen to develop in the context of significant climatic changes during the post-Pleistocene period characterized by conditions of fluctuating desiccation (Antevs' Altithermal) between ca. 5000 and 3000 B.C. From ca. 3500 and 2500 B.C. there was a trend toward increased effective moisture which coincided with behavioral changes that marked the beginning of the Late Archaic. These climatic changes, which were pan-Southwestern in extent, coincided with variation in cultural adaptation pertaining to settlement, subsistence base and overall population which reflected different phases of Archaic period adaptation.

In the following section each of the Archaic temporal phases for northern New Mexico will be reviewed. Salient properties of behavioral adaptation and accompanying artifactual assemblages which have been posited to reflect different phases of Archaic period occupation will be summarized.

Early Archaic

Jay Phase (ca. 5500-4800 B.C.) Irwin-Williams (n.d.) divides Jay Phase sites into base camps and small specialized activity sites. Base camps are generally small in areal extent and reflect multiple reoccupations. Tool kits and faunal evidence, in particular, suggest a mixed foraging subsistence strategy. Hunting, generalized foraging and quarrying activities are characteristic of the small specialized activity sites.

Distinctive projectile points (Jay points) are defined as *"large slightly shouldered projectile points (reminiscent of those termed Lake Mohave in California and Arizona"* (Irwin-Williams 1973:5). Other distinguishable criteria include an absence of basal thinning, an absence of basal indentation, and contracting stems. Jay phase assemblages include *"well-made lanceolate bifacial knives and numerous very well-made side scrapers"* as well as an absence of milling implements (Irwin-Williams 1973:5). Criteria for affixing dates to the Jay phase are not explicitly stated, although the earlier date of ca. 5500 B.C. seems to be suggested based on radiocarbon dating of terminal PaleoIndian Cody Complex assemblages.

Bajada Phase (4800-3300 B.C.) According to Irwin-Williams (n.d.) Bajada phase sites reflect a continuity in adaptation from the Jay phase in terms of site type (base camps and special activity sites) and settlement distribution, although the regional population may have increased during the Bajada phase. Certain changes in the basic tool kit (including an increasing number of large chopping tools—presumably plant processing implements) may reflect a more effective adaptation to a broad-spectrum localized resource procurement strategy (Irwin-Williams n.d.:26).

Distinctive projectile points (Bajada points) range "*from an early variety, distinguished from those of the Jay phase principally aby the presence of basal indentation and basal thinning, to a later variety with increasingly well defined shoulders and decreasing over-all length*" (Irwin-Williams 1973:7). From specimens illustrated (Irwin-Williams 1973:Fig. 3), stems were thinned through lateral retouch, while basal thinning was achieved through proximal rather than lateral retouch, which generally resulted in a single broad negative scar on both surfaces of the artifact originating from the base itself. Stems are parallel rather than contracting, and shoulders, while *well-defined*, are rounded. Lateral edges above shoulders range from straight to slightly convex in outline, and are generally smooth rather than serrate.

Bajada phase assemblages include "*well-made side scrapers,*" "*rare bifacial knives*" and "*increasing numbers of large chopping tools and poorly made side scrapers on thin irregular flakes*" (Irwin-Williams 1973:7). Presence or absence of milling implements is not noted, but "*small cracked-cobble filled hearths and earth ovens*" are described as occurring on Bajada phase sites (Irwin-Williams 1973:6-7).

Criteria for affixing bracketing dates to the Bajada phase are not stated by Irwin-Williams (1973) or Irwin-Williams and Haynes (1970); but in her most recent article, Irwin-Williams (n.d.:25) states "*the next phase of Oshara development in the Arroyo Cuervo region was termed Bajada and was Radiocarbon-dated between 4800 B.C. and about 3300 B.C.*" The statement is not, however, further elaborated upon in that article.

Late Archaic

San Jose Phase (3300-1800 B.C.) During the San Jose phase the total number of sites increases, the size of campsites increases areally (two to three-fold), and the general amount of artifactual debris increases as well. In the Arroyo Cuervo region posthole patterns suggest the presence of simple habitation structures. Extensive earthen ovens are common. Specialized gathering and quarrying sites continue, but relatively few hunting stands have been noted. The tool kits reflect increased numbers of large chopping tools. The San Jose phase is seen as an increasingly effective localized foraging subsistence adaptation.

Distinctive projectile points (San Jose points) are defined as similar to Bajada points, "*the principle shifts being in the increasing use of serration along the blade and relatively shorter stem to blade ratio. Through time a trend develops toward decreased overall length, increasingly expanded stems and increasingly marked serration*" (Irwin-Williams 1973:8). Again through reference to illustrations (Irwin-Williams 1973:Fig. 4), stem and basal morphology of San Jose points is essentially identical to that of Bajada points, but stems are decidedly shorter in *absolute* length, which is mentioned in a later article by Irwin-Williams (n.d.:36). San Jose points are thus morphologically similar to *Pinto* points documented from southeastern California and by Haury (1950) in the Ventana Cave deposits.

Other characteristics of San Jose phase assemblages are defined as "*increasing numbers of poorly made side scrapers on thin flakes, and large heavy chopping tools. The earlier well-made side scrapers are rare and bifacial knives, very rare or absent*" (Irwin-Williams 1973:8). It should be noted that the *increasing numbers* of poorly made side scrapers, large chopping tools, and rarity of bifacial knives are posited to characterize Bajada phase assemblages as well (Irwin-Williams 1973:7), and thus do not in effect constitute distinguishing criteria of San Jose phase sites.

Shallow-basined grinding slabs are noted as "*important additions*" to the San Jose phase assemblages, as are large subsurface or surface ovens "*usually filled with cobbles*" (Irwin-Williams 1973:8). These latter are presumably distinguishable from the small cracked-cobble filled hearths and earth ovens previously defined as characteristic of Bajada phase sites on the basis of dimensions.

Criteria for affixing dates to the San Jose phase are not specified in Irwin-Williams and Haynes (1970), or by Irwin-Williams (1973, n.d.), but Irwin-Williams and Tompkins (1968:5-7) document three radiocarbon dates of 1440 ± 120 B.C., 1530 ± 95 B.C., and 1660 ± 130 B.C. from levels D and F of En Medio Shelter which they provisionally assign in deposition to the late San Jose phase.

Armijo Phase (1800-800 B.C.) The Armijo phase marked the first significant change in Archaic adaptation from small residences to larger seasonally aggregated encampments during fall-winter. Evidence of primitive maize is noted and Irwin-Williams (n.d.) suggests that maize may have provided a critical temporary seasonal surplus, complimented by nondomesticated resources, which may have permitted the larger population aggregations. Residential sites were situated in settings similar to the preceding San Jose phase, although specialized activity sites expanded into new zones. Tool kits remained similar but the proportion of ground stone increased.

Armijo phase projectile points are defined as exhibiting a much greater range in morphological variability than the Jay, Bajada or San Jose types. Irwin-Williams (1973:1) defines an *early* variety characterized by serrated lateral edges, "*short widely expanding stems and concave or (later) straight bases*", and *late* types characterized by "*a number of variations on a shallow corner notched or narrow stemmed node.*" Illustrated specimens (Irwin-Williams 1973:Fig. 5) with one exception are stemless. Bases range from concave to slightly convex in outline, and exhibit slight tangs produced through lateral retouching directly above the base. In some cases this retouching has resulted in distinct although shallow lateral notches. No specimens characterized by corner notching or narrow stems are illustrated, and Irwin-Williams' statement may refer to En Medio phase projectile points which do exhibit such variability.

Other characteristics of Armijo phase sites include *"large firecracked cobble heaps," "irregular post hole patterns," "large cobble filled ovens," "objects which are probably of a magic-religious or ideological significance"* and a greater *"proportion"* of ground stone tools (Irwin-Williams 1973:10). Criteria for affixing dates to the Armijo phase are not discussed.

En Medio Phase (800 B.C.–A.D. 400) During the En Medio phase there is evidence of an increase in regional population. The fall-winter base camps noted in the Armijo phase continue and are accompanied by small specialized residential gathering sites. These latter are characterized by possible simple shelters, large shallow storage pits, fire-cracked cobble concentrations and sparse artifactual debris. While the tool kit at the winter base camps remains similar and diversified, the artifactual compliment of the gathering sites is dominated by ground stone tools and flake cutting tools and may indicate a more marked seasonal annual cycle.

Irwin-Williams essentially describes the En Medio phase as a local manifestation of the Basketmaker II phase of the Anasazi period recognized over broad areas of northern New Mexico. Projectile points *"are variations of stemmed corner notched forms which trend through time toward the use of increasingly long barbs"* (Irwin-Williams 1973:13). Illustrated specimens (Irwin-Williams 1973:Fig. 6) reflect considerable variability in size and placement of notches and stem width. Two specimens are stemless and exhibit shallow side notches directly above the base, however, and could be classified as Armijo points.

The only other distinguishing criteria characterizing En Medio phase site locations cited are an *"increasing emphasis on ground stone tools"* and *"the development and growing importance of storage pits"* (Irwin-Williams 1973:12). Criteria for affixing absolute dates to the En Medio phase are not discussed in Irwin-Williams (1973), but a radiocarbon date of 10 ± 85 B.C. is reported from Zone B-1 of En Medio Shelter which was attributed in deposition to the Basketmaker II phase by Irwin-Williams and Tompkins (1968:5, 8).

ARCHAIC CHRONOLOGY IN COCHITI RESERVOIR

Radiocarbon Dates

Although carbon samples were taken from hearths on several of the lithic sites in Cochiti Reservoir, the samples were insufficient for radiocarbon dates to be assigned. Thus, absolute dates for the Archaic occupation could not be obtained.

One shelter with an Archaic period occupation, LA 12566, which was excavated during the National Park Service's Cochiti Reservoir project, however, yielded four radiocarbon dates of 3100 ± 70 B.P.; 2620 ± 145 B.P.; 2540 ± 75 B.P.; and 1390 ± 95 B.P. or occupations between 1750 B.C., 670 B.C., 590 B.C., and A.D. 560, respectively (Traylor et al. 1977). Thus dates from LA 12566, indicated that Archaic populations inhabited at least portions of the Cochiti Reservoir area during the Late Archaic Armijo and En Medio phases.

Projectile Point Morphologies

Few projectile points were recovered from either the excavated or surveyed sites in Cochiti Reservoir. Whole projectile points or fragments which exhibited basal modification characteristic of either Jay, Bajada or San Jose types were absent from sites in the reservoir with the exception of two basal fragments, perhaps indicative of Bajada or San Jose types, which were documented as isolated occurrences during the survey phase. The remaining identifiable points were characterized by considerable diversity in basal modification, although predominantly exhibiting corner or side notching. These latter forms are indicative of Armijo and En Medio phase variation discussed by Irwin-Williams (1973).

The overall paucity of *diagnostic* projectile point forms recovered tends to obviate any rigorous attempt to assign phase affiliation to any of the sites on a site-by-site basis. Characteristics of the population of point fragments recovered from all of the Archaic sites in the reservoir, and the diversity of essentially unstemmed hafting modification characterizing the points which were described during survey or excavation, seems to indicate an Oshara Tradition Archaic period occupation during the Armijo-En Medio phases.

Obsidian Hydration

Obsidian hydration analysis was undertaken during both excavation phases of the Cochiti Reservoir project and is summarized in Haecker (1977) and Trembour (1979). Jemez obsidian materials were plentiful on most of the non-structural lithic sites in the reservoir, but unfortunately the sites were surficial in nature. Consequently, the obsidian was potentially subjected to a wide variety of temperature and moisture conditions which could affect the rate of hydration. Since the sites were in similar phsyiographic contexts, we hoped that the hydration rates would prove similar enough to permit a gross relative means of assigning a period of occupation to the lithic sites in the reservoir.

A total of 184 samples were analyzed. In addition to samples selected from the nonstructural lithic sites, samples were also taken from several structural Anasazi P-III to P-IV sites and Historic 18th century sites. Phases had been assigned to these latter sites based upon their ceramic assemblages.

Mean micron readings for the lithic sites were as follows:

Archaic point	9.80	1 sample
BM-II point	7.38	1 sample
LA 12442	6.97	10 samples
LA 12456	8.09	10 samples
LA 12494	10.00	10 samples
LA 12496	6.34	10 samples
LA 13350	3.71	2 samples
LA 13351	6.40	10 samples
LA 13352	3.77	2 samples
LA 13353	7.25	13 samples

Mean micron readings for surface samples from six Anasazi (P-III/P-IV) sites was 3.10 (13 samples), and two 18th century Historic sites had a mean reading of 5.09 (16 samples).

Although a curve for the Cochiti area has yet to be established, we can suggest that samples from the lithic sites, *in general, exhibit thicker* hydration rinds than samples from the Anasazi or Historic sites. It should be noted that the Historic readings were lower than the Anasazi readings (Haecker 1977; Trembour 1979). The differences in mean micron thickness suggest a Late Archaic occupation, but this is very tentative.

Summary

Although the evidence from radiocarbon, projectile points and obsidian hydration analyses taken collectively are limited in scope, they all indicate a *Late Archaic* occupation during the Armijo-En Medio phases.

ARCHAIC BEHAVIORAL VARIATION IN COCHITI RESERVOIR

Choice of Site Location

Site locations which have been provisionally assigned to the Archaic period of deposition are distributed throughout the Cochiti Reservoir survey boundaries. This distribution is not continuous, however, but takes the form of a set of clusters both within White Rock Canyon itself and below the mouth of White Rock Canyon east of the Rio Grande (see Fig. 5.1 in Chapter 5, *this volume*). In general, site locations within White Rock Canyon proper are situated on both the east and west sides of the Rio Grande near the mouths of lateral drainages and canyon systems. Within the canyon, there is a distinct tendency for site locations to be situated in aeolian dune deposits which have accumulated on alluvial fans at the mouths of lateral drainages. There exists as well a tendency for the sites to be situated in specific physiographic locales exhibiting southern and western exposures, despite the fact that other land surfaces otherwise amenable for occupation are available within the immediate vicinity.

Below the mouth of White Rock Canyon, terrain east of the Rio Grande becomes much less convoluted and takes the form of a series of terraces and benches of relatively broad extent bordering both the Rio Grande itself and lateral drainages. In these areas, Archaic site locations are generally situated in more open or flat physiographic situations, although the same tendency toward southern through western exposures can be observed.

The reader is referred to Chapter 5 in this volume for a discussion of some factors which may have influenced both the distribution and density of Archaic site locations in the Cochiti Reservoir locale.

Site Size

Estimates of site size, as defined by maximum distribution of artifactual debris, indicate that a great range of variation exists among Archaic site locations within the project boundaries. Areal estimates range from 8 up to 40,000 m^2 in extent. In general, those locations of greater than 500 m^2 are characterized by one or two spatially discrete proveniences which are each relatively small in area but which exhibit relatively greater artifactual densities and more hearth facilities, with the remainder of the site area being characterized by very low densities of artifacts.

To a certain extent, some of the variation in absolute site size can be seen strictly as a function of the areal extent of physiographic locales available for occupation, given physical parameters of slope and substrate, and apparent behavioral parameters dictating location upon particular exposures. Thus, site locations within White Rock Canyon tend to be smaller in areal extent simply because land surfaces of contiguous substrate, slope and exposure within any given spatial locality are quite restricted. In con*trast, such* land surfaces below the mouth of White Rock Canyon on the eastern side of the Rio Grande are much larger in spatial extent; and artifactual debris comprising Archaic sites in those locales tend to be substantially more broadly distributed, albeit in lower densities over much of the site surface.

No evidence exists to indicate that site size and density of artifactual remains is in any way correlated for the Archaic site locations within Cochiti Reservoir (Biella and Chapman 1977c:300). This fact may well indicate that different, and essentially unrelated kinds of behavior, underlie the character of site space utilization by Archaic populations with respect to the absolute areal extent of site space functionally occupied in the performance of activities on the one hand; and the intensity and kind of site space utilization, on the other hand.

Site Content

The content of Archaic period site locations within Cochiti Reservoir can be summarized with respect to three general kinds of information: variability in the construction and use of hearth facilities; variability in the manufacture and use of tools at those sites; and variability in the spatial distribution of hearths, tools, and tool manufacture byproducts which constitute the actual physical structure of the site locations themselves.

Hearth Variability

Over 50% of Archaic site locations within the Cochiti Reservoir project boundaries exhibited evidence of hearths. Two kinds of archeological data indicated hearth utilization: firecracked rock scatters; and actual hearth features themselves. In general, the major evidence of hearth utilization apparent from *survey observations was distributions* of firecracked rock, including firecrack quartzite cobbles and basalt clasts. In some cases, site locations were characterized by more or less discrete concentrations of firecracked rock, permitting estimates of the probable number of hearth facilities which were present at the site. In other cases, firecracked rock was distributed more ubiquitously over *the site and thus did not permit* such estimates.

Excavation procedures were directed toward discovery of any extant hearth features preserved at site locations and, in addition, involved weighing both firecracked rock and larger slab, cobble, or clast lining elements which might have represented constructional elements of now eroded hearth facilities. Through plotting firecracked rock weights for 1 x 1 m collection units and counts or weights of larger elements for each site location, hearth *epicenters* could be defined when intact hearth features were absent.

The vast majority of intact hearth facilities and hearth epicenters defined by relatively high densities of possible hearth constructional elements were directly associated with concentrations of firecracked rock. The intact hearth features themselves were generally shallow circular facilities ranging from 56 to 112 cm in diameter and no more than 25 cm deep. The shallow depth, and association of these features with firecracked rock indicates that one primary function they served was to heat quartzite cobbles and basalt clasts for use in stone boiling. Stone boiling involves dropping heated rocks into containers filled with foodstuffs and water. It is a common food preparation technique used by people whose technological inventory does not include fire-resistant ceramic or metal cooking vessels. Repeated use of stones as heat retainers inevitably results in their fracture and generation of a discard pile of heat-fractured or firecracked rock pieces.

Kinds of foodstuffs prepared through stone boiling include soups, stews, and mushes made from milled seeds. Examination of flotation residue from hearths and areas immediately adjacent to the hearths at Archaic sites in Cochiti Reservoir often revealed the presence of very small bone fragments. Although these fragments generally could not be identified as to part or species, their presence indicates that stews may have been prepared through stone boiling. In addition, slab and shallow basin metates or metate fragments were often recovered directly adjacent to hearth features or within hearth epicenter concentrations of firecracked rock and/or hearth elements. The association of these milling implements with hearth features may well indicate preparation of mushes made from ground seeds.

It is clear that hearth facilities within the project area could have served other cooking and heating functions in addition to their use as heat sources for stone-boiling, but no direct evidence of such usage was encountered. In general, the kinds of cooking practices directly and indirectly attributable to them were those involving stone-boiling. Rare exceptions include two or possibly three large rectangular slab-lined hearth features found in Proveniences 1 and 2 of LA 12456. One of these, Feature 2, was a rectangular basalt slab-lined structure apparently built into the original ground surface. It measured 210 cm long by 60 cm wide and was 20-25 cm deep. The structure was not associated with concentrations of firecracked rock and its fill contained microscopic bone, shell and seed fragments, none of which could be identified as to species. Another concentration of basalt slabs situated nearby in the same site may have represented the presence of a similar feature, but it was not intact. The weight of slab elements in this eroded feature was twice that of the intact feature. From this we may conclude that either it was a larger feature or that it represented two features of similar size to the intact feature.

It may be suggested that overall, little variation in either the structure or usage of hearth facilities was observed among Archaic period site locations within the project area. All seem to have been employed for immediate needs of consumption, which in the majority of cases involved stone boiling techniques of cooking for at least a portion of normal residential terms of site occupancy.

Stone Tool Assemblage Variability

Traditionally, only artifacts which have been *formally* modified have been considered as evidence of cultural or adaptational variation by archeologists. In this discussion we wish to treat three classes of artifactual remains: siliceous stone tools including those which have been formally modified (projectile points and bifaces) and essentially unmodified but utilized flakes and angular debris; milling implements (manos and metates); and by-products of the siliceous stone artifact manufacturing process (debitage, cores, large angular debris).

(1) Siliceous Stone Tools. *Formally* modified (and thus definable as types) artifacts are, by and large, generally absent from the Cochiti Reservoir assemblages. Fragments of substantially modified siliceous stone artifacts such as projectile points and other bifaces do occur occasionally, but much more often evidence of manufacture or utilization of larger artifacts of this kind are represented as either resharpening flakes or *bifacial trimming flakes* generated through their manufacture.

Two basic kinds of bifacial artifacts were represented. These were projectile points, characterized generally by corner notches and very short stems; and relatively larger triangular bifaces which exhibited rounded proximal-lateral corners and unmodified bases.

Siliceous tools which were essentially unmodified flakes, or flakes and angular debris characterized by a minimal amount of marginal retouch, comprised by far the greatest proportion of tools at every site location.

Two observations concerning these tools are in order. First, variation in tool usage is minimal across all Archaic site locations. In this sense, variability in utilized edge shape morphology and wear patterns is remarkably similar from assemblage to assemblage. Second, the range of variation in task specific tool utilization is relatively restricted throughout all Archaic assemblages. By far the greatest proportion of utilized tools are characterized by straight or slightly convex edges, which exhibit, in relatively equal proportions, wear patterns indicative of (1) cutting, (2) sawing, or (3) scraping utilization. Utilized edges indicative of somewhat more specialized use such as concave cutting or scraping edges, and projections employed for incising or drilling, are present in nearly all assemblages but occur in very low frequencies.

The degree of similarity in assemblage content, coupled with a lack of diversity in usage characterizing different assemblages, may well indicate that very similar kinds of activities were performed thoughout all Archaic period site locations within the project boundaries; and that those activities by and large reflect generalized food resource processing and artifact maintenance, rather than more specialized food resource processing or artifact manufacture.

(2) Ground Stone Tools. Variation among milling implements (manos and metates) associated with Archaic site locations was very similar in form. Nearly all were one-hand manos which were essentially circular in outline shape and lenticular to rectangular in cross section. Grinding surfaces were apparent on one or both sides of such artifacts and quite often two distinct grinding surfaces were apparent upon a single side. In all cases, striae upon grinding surfaces indicated that the manos were used in reciprocal rather than rotary fashion.

Nearly all metates were slabs or clasts of medium to fine-grained basalt which had been modified only through usage in grinding. Metate grinding surfaces were situated on only one side of the implement, and were apparent as elongate troughs or basins of about the same width as manos recovered from Archaic sites. Striae within metate grinding surfaces indicated as well that milling was undertaken in reciprocal rather than rotary fashion. The depth of grinding surfaces upon metates varied from extremely shallow to ca. 3 cm. This variation in depth might well indicate simply duration of usage in that no evidence existed to suggest that the grinding surfaces were in any way prepared or manufactured prior to first usage.

From the excavated sample, milling implements were observed at nearly all site locations which exhibited evidence of hearth utilization and, in addition, were observed at a substantial number of site locations for which no direct evidence of hearth utilization was encountered.

A major and unresolved problem concerning the use of milling implements is a lack of any good evidence indicating what kinds of food resources might have been processed by them. It seems most probable that such implements would be employed to reduce seeds into meal preparatory for cooking, although no macroscopic or microscopic evidence of such usage was obtained through examination of grinding surfaces themselves, or through examination of flotation samples taken in the vicinity of milling implements.

A distinct tendency for metates or metate fragments to be located in the immediate vicinity of hearth facilities was, however, apparent among site locations which were excavated. The redundancy of this spatial association might be taken as evidence to suggest that milling implements were used to process foodstuffs which were routinely prepared for consumption through cooking; and further, that such foodstuffs may have constituted a significant portion of the inhabitants' diet during given occupations of those sites.

(3) By-products of Tool Manufacture. Variation in by-products of siliceous stone tool manufacturing activities was monitored through survey and excavation with respect to the kinds of raw materials which were selected for manufacture at specific site locations relative to possible source locations of those materials, and with respect to procedures of manufacture and the stages of reduction in the manufacturing process reflected by each assemblage.

Predominant siliceous raw materials within the study area include basalt vitrophyre, Pedernal cherts and chalcedonies, and variants of Jemez obsidians. Basalt vitrophyre (or glassy basalt) occurs generally on the east side of the Rio Grande in White Rock Canyon as talus rubble or colluvially deposited clasts from higher outcrops; although it is found as well along recent beaches bordering the present river as waterworn slabs, and rarely in older Totavi Lentil formations on the western side of the Rio Grande in White Rock Canyon.

Pedernal cherts and chalcedonies occur as waterworn nodules within outcrops of the Totavi Lentil on either side of the Rio Grande both within and below White Rock Canyon. Jemez obsidians occur infrequently as very small nodules deposited sporadically upon higher surfaces as a function of volcanic eruptions responsible for tuff and pumice deposits which are occasionally found interbedded among basalt flows throughout the study area. The majority of obsidian materials recovered in artifactual form is presumed, however, to derive from obsidian flow deposits located some distance to the north of the project boundaries. (See Warren, Chapter 2, for a detailed treatment of documented material source areas.)

Selection of raw materials for manufacture, as evidenced among Archaic site locations within the project boundaries, was overwhelmingly local in nature with the possible exception of obsidians. Basalt vitrophyre was decidedly preferred for tool manufacture and use by Archaic populations. Relative proportions of such debitage are generally greater for site locations along the east side of the Rio Grande (where such materials are found in greater abundance). Examination of cortex variation indicates that the majority of glassy basalt raw materials selected for manufacture at site locations west of the Rio Grande were waterworn slabs which occur along recent riverside beach locales. Proportions of Pedernal chert and chalcedony materials occurring at different site locations seem to reflect, as well, relative proximity of site locations to areas where such materials occur.

An exception to this general tendency can be seen in the occurrence of obsidian. With the exception of the obsidian assemblage at LA 12442, which clearly reflects reduction of very small nodules that occur as airborne falls occasionally in the vicinity, obsidian materials at other Archaic sites seem to have derived primarily from nonlocal sources further north of the project boundaries. Thus, the vast majority of obsidian cortical surfaces are not waterworn, which would indicate that locally available nodules within the Totavi Lentil were not predominately selected for manufacture.

In terms of stone tool manufacture, an interesting commonality among Archaic site locations was a tendency for all stages of the manufacturing process to be represented at each site. Two basic manufacturing trajectories could be defined as characteristic of Archaic tool making technology. The first and more common of these might be termed a simple flake trajectory which involved only primary and secondary stages of core reduction into flakes that were selected at either stage for use as tools (either with or without subsequent edge modification) or that were marginally retouched prior to usage.

The second of these manufacturing trajectories might be termed a flake-biface trajectory in which flakes generated through the first strategy were transformed either directly into tools through bifacial retouch, or were transformed into bifacial preforms and thinned through bifacial retouch into such tools.

In general, evidence of all reduction stages of the simple flake manufacturing trajectory was evident at each Archaic site location for basalts, cherts and chalcedonies. Although some variation in relative proportions of cortical and noncortical debitage flakes per core ratios, and proportions of small angular debirs to flakes was observed, much of this variation could be accounted for as differences in *technique* of reduction necessitated by size and structural shape variability among available raw materials.

An intriguing situation exists, however, with respect to simple flake reduction trajectories characterizing obsidians. Debitage assemblages for these materials were comprised of proportions of cortical and noncortical debitage clearly indicative of both primary and secondary core reduction; but at the same time, cores and large angular debris were routinely absent from the assemblages. This kind of situation might be expected if the debitage was manufactured elsewhere and imported to site locations for use as tools, but wear pattern analysis indicated that only moderate numbers of obsidian flakes were in fact used as tools.

It is possible that this redundant kind of assemblage complex might reflect a *core preform* biface reduction strategy, in which cores themselves comprised bifacial preforms which are subsequently thinned through bifacial retouch into tools. Examination of taxonomic variation and platform morphology among obsidian debitage assemblages did not seem to substantiate this possibility, however.

Bifacial tools manufactured from other materials seem to have been produced through a flake-biface trajectory, although in general only emphemeral evidence existed to indicate that bifaces were routinely manufactured at site locations within the project boundaries. In general, core, large angular debris and debitage assemblages for all other materials overwhelmingly indicated that simple flake tool production constituted the dominant manufacturing strategy.

Site Space Use and Residential Configurations

Evidence bearing upon the size and composition of residential groups which occupied site locations within the Cochiti Reservoir locale may be derived from several kinds of data. This discussion will focus upon the number and distribution of hearth features and associated firecracked rock concentrations, and variation in the spatial distribution of certain kinds of artifactual remains relative to those hearth features.

One major problem in analysis of this sort is isolating the relative contemporaneity of site occupational episodes. Given the relatively long time span of Archaic occupation within the reservoir boundaries, ca. 1800 B.C. to A.D. 400, it may be expected that many site locations will represent cumulative evidence of several episodes of occupation and reoccupation; whereas, other site locations may represent very few such occupational episodes. Multiple occupation sites might be expected to exhibit greater numbers of hearth features, greater density of artifactual remains, and greater volumes of firecracked rock simply because they were revisited more frequently than other site locations. At the same time, these sites may have been occupied during any single event by residential groups of exactly the same size and composition as residential groups which occupied less frequently revisited sites.

It is clear that simple counts of hearths or simple scales of firecracked rock volume or artifact density alone cannot serve as adequate measures of residential group size. One possible strategy for sorting out this kind of multiple occupancy problem is an examination of patterning in site space use among features and artifact distributions. If each hearth facility is assumed to represent a locus of food preparation for members of a single commensal group, a search may be made for patterning in the distribution of firecracked rock, milling implements, other tools, and by-products of tool manufacture in the vicinity of these hearths. If a patterning emerges, we might be able to dissect, analytically, the occupational history of each site and thus propose the residential configuration(s) which characterize the Archaic occupation of Cochiti Reservoir.

In order to pursue this kind of analytical dissection, several excavated sites or proveniences within sites were examined for feature and artifact patterning: LA 12456, proveniences 3 and 4; LA 12463; LA 13352; and LA 13353, provenience 1. These sites or proveniences were selected because they were characterized by spatially discrete hearth loci and as such were felt to be the least likely to be distorted by multiple occupation noise.

Examination of features and artifactual assemblages from these sites revealed the following tendencies:

(1) maximum concentrations of firecracked rock occur adjacent to existing hearths;
(2) maximum concentrations of lithic debitage or tool manufacturing debris are distributed to one or either side of the hearth and generally form crescentic arcs extending from the hearth itself toward one side of the hearth;
(3) these arcs enclose areas which are relatively free of any debris;
(4) larger by-products of tool manufacture (cores and large angular debris) are generally distributed outside the debris-free areas and may well represent toss zones;
(5) metates or metate fragments are generally found adjacent to hearths;
(6) manos or mano fragments are sometimes found adjacent to hearths and sometimes found within the toss zones of expended cores and large angular debris.

The basic picture of commensal group occupation or the residential configuration of site locations within Cochiti Reservoir thus exhibits considerable similarity with the kind of commensal unit record documented by Yellen (1977) for the !Kung San of the Kalihari Desert of southern Africa. His campsite maps indicate a hearth area and more or less crescentic distribution of foodstuff and manufacturing detritus (bones, mongongo nut shells, melon rinds, ostrich eggshells, wood shavings, etc.) directly adjacent to hearth areas which begin to enclose *empty space* which exists to one side of the hearth area itself. The empty spaces associated with hearths documented by Yellen (although in different spatial arrangements and usages) constituted locations where members of the commensal groups sharing the hearth generally sat, rested, slept, or otherwise physically put themselves when spending time in the campsite. Parts of the empty spaces documented by Yellen were covered by temporary shelters. The important fact of the general distribution of material in relation to specific hearth facilities, however, is that each *complex* of hearth, material remains, and detritus-free areas represented the occupational locus of a single commensal group when taken in reference to the entire site location.

Given this scenario for single commensal group hearth-artifact configuration, a question still remains as to what multiple hearth proveniences or sites represent. They could represent contemporaneous occupations by relatively large residential groups (that is, groups of commensal units); or they could represent recurrent occupations by relatively small groups over a period of years.

One means of assessing this problem is to determine whether a covariant relationship exists between number of hearths, density of lithic debris, and volume of firecracked rock among multiple hearth site locations. The spatial configuration of these features and artifacts seems to indicate that each hearth served as a focal residential locus of a single commensal group. It can be proposed that a single occupational event by a commensal group using the hearth facility would result in generation or deposition of a certain amount of firecracked rock and a certain amount of lithic artifactual debris. If individual hearth facilities were used recurrently over a period of years, the volume of firecracked rock and lithic debris found in the vicinity of hearth facilities would be expected to increase accordingly as a function of the number of multiple occupational events.

Table 4.1 documents volume of firecracked rock in kilograms and density of lithic artifacts per m^2 associated with hearths and hearth epicenters encountered during excavation. These data are graphically represented in Fig. 4.1. Several observations can be made concerning the import of these data with respect to the problem of multiple occupational events and size of residential occupations.

First, there is a clear positive relationship between volume of firecracked rock and density of artifactual debris associated with each hearth. As volume of firecracked rock increases, a corresponding increase in lithic artifact density can be observed. Absolute values for both firecracked rock and artifact density vary in magnitude for hearths occurring at different sites, but the relationship between the two by-products of residence are similar. Firecracked rock is clearly generated at a significantly higher rate than lithic artifactual debris. The latter is primarily manufacturing debris.

Second, it can be seen that with the exception of two sites (LA 12494 and LA 12495) the same range in magnitude of absolute volumes of both firecracked rock and artifactual debris characterize the population of single-hearth

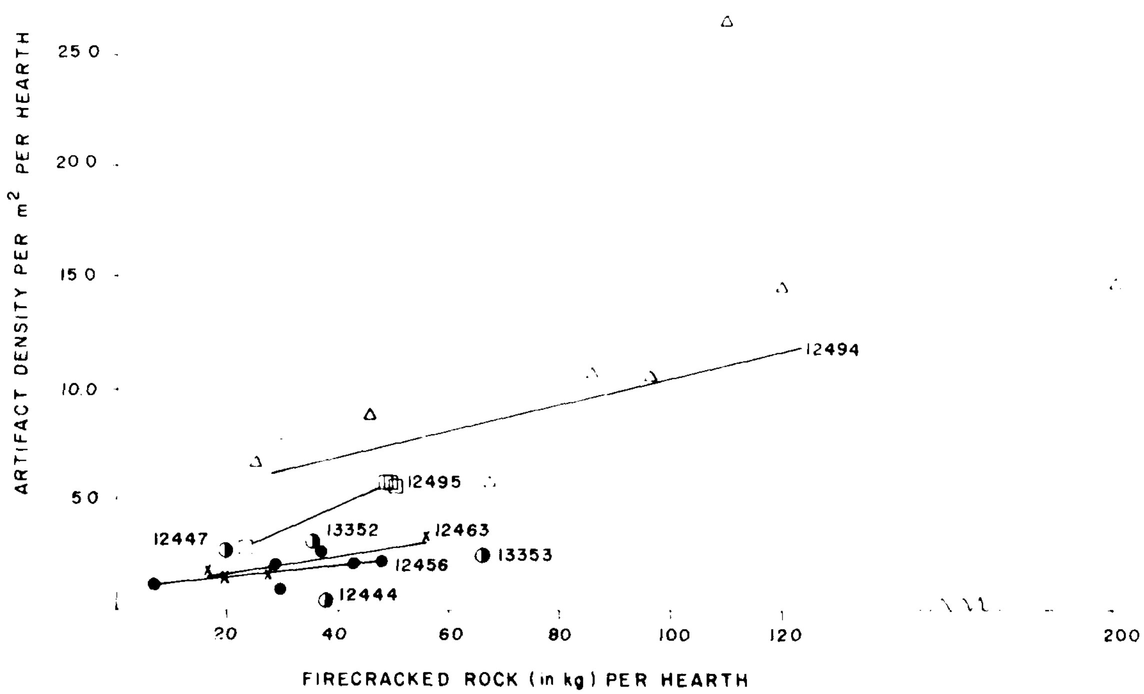

Fig. 4.1 Artifact density per hearth versus firecracked rock density per hearth for Archaic Period sites.

Table 4.1

Occupation Intensity Measures for Excavated Archaic Sites by Provenience

Site No.	Prov. No.	# Hearths or Epicenters	Total Volume Firecracked Rock (in kg)	Firecracked Rock/hearth	Artifact Density/m^2*	Artifact Density/m^2 per Hearth
LA 12444	2	1?**	38.5	38.5	0.26	0.26
LA 12447	Feat. 2	1	19.7	19.7	2.90	2.90
LA 12456	1	1-2	37.2	18.6 - 37.2	2.75	1.38 - 2.75
	2	1	7.2	7.2	1.46	1.46
	3	1	42.7	42.7	2.45	2.45
	4	27	97.0	48.5	5.32	2.66
	5	3	89.9	30.0	3.18	1.06
	8	1	28.7	28.7	2.10	2.10
LA 12463	1	1	20.3	20.3	1.60	1.60
	2	1	56.6	56.6	3.18	3.18
	3	1	27.5	27.5	1.31	1.31
	4	1?**	16.8	16.8	1.69	1.69
LA 12468	1	1?**	not weighed	n.d.	1.32	unknown
LA 12494	1	1	28.0	28.0	6.75	6.75
	2	1	67.8	67.8	5.86	5.86
	3	2	172.1	86.0	20.73	10.37
	4	1	200.6	200.6	14.60	14.60
	5	1	45.7	45.7	8.81	8.81
	6	1	97.1	97.1	10.59	10.59
	7	1	30.0	30.0	7.75	7.75
	8	1	113.7	113.7	26.28	26.28
LA 12495	1	1	24.0	24.0	2.8	2.8
	2	3	152.0	50.6	5.79	5.79
LA 13352	1	1	36.55	36.55	2.91	2.91
LA 13353	1	1	66.5		2.04	2.04

* calculated for grids exhibiting artifacts only
**no clear epicenter; at least one hearth represented

sites (LA 12447, LA 13352, LA 13353) and multiple-hearth sites (LA 12456 and LA 12463). This implies about the same range of occupational intensity or variation in number of reoccupational events may have occurred at both single and multiple hearth sites. Two exceptions to this (LA 12494, LA 12495) may represent two proveniences of a repetitively used residential locality which encompassed LA 12496 as well. All three of these sites are situated at the mouth of Medio Canyon (see Chapman et al. 1977).

Third, it is evident within multihearth sites that a considerable range in absolute amount of debris is associated with each hearth, regardless of the relative volume of firecracked rock and lithic artifact density characterizing the site in comparison with other sites. This would seem to indicate, rather conclusively, that not all hearths were used during each occupation of a site. This in turn implies that the size of the residential group as measured by number of commensal groups fluctuated from occupation to occupation.

In order to examine the question of whether sites with greater numbers of hearths reflect residential locations of larger groups of people or whether those sites represent more frequent revisitation by small residential groups through time, one final analysis may be suggested.

Variation in spacing of commensal group minicamps occurring at site locations may be examined. It may be suggested that contemporaneous occupation of a residential site by large numbers of commensal groups will result in a certain kind of spacing between commensal group habitation loci simply because of the need for social and physical space. Yellen (1977) has documented this kind of spacing behavior among Dobe !Kung San, and Tindale (1972) mentions similar behavior at Australian Aborigine residential camps.

Archeological sites reflecting recurrent occupation by several commensal groups should thus exhibit some minimum spacing distance between hearths. The exact distances involved and patterning in hearth distribution are not known but should be different from site locations recurrently used only by one or two commensal groups for the following reasons.

Site locations created through multiple reoccupations by only one or two commensal groups can be expected to reflect a degree of new hearth starts through time given the exigencies of occupation-specific factors such as wind, shade, or familiarity with the camping place. Spacing requirements for placement of new hearths relative to old hearths would be negligible in these cases. This is in contrast to the social and physical necessity to adopt a certain minimum spacing distance from immediate neighbors in a large residential group.

In light of these considerations, data from four excavated Archaic sites which exhibited more than two hearths are presented in Table 4.2. This table summarizes simple nearest neighbor distances between intact hearths or hearth epicenters defined through analysis. Distances were measured to the nearest 50 cm for purposes of calculation. In several cases reflexive pairs of hearths were defined as nearest neighbors in which each hearth of the pair was the nearest neighbor of the other. For purposes of calculating mean and standard deviation values characterizing hearth distributions at each site, these reflexive pair distances were entered only once.

Although only four site locations are represented in the sample, some interesting observations can be made concerning hearth spacing. First, the minimum distance between hearths among all four sites is 4 m. This distance is relatively large and even falls within limits of residential spacing observed among the Dobe group !Kung by Yellen (1976:61). The hearth spacing evident among the four sites thus does not clearly refute an expectation that several hearths were used simultaneously during each occupation of a site and that *new* hearths would have been constructed in the contexts of such residential spacing. In this regard, at least a few cases of closer spacing (ca. 2-3 m) might be expected if the basic history of residential reoccupation for the sites was by one or two commensal groups.

In summary, the preceding analyses have resulted in some provocative observations concerning basic social features of Archaic settlement within the Cochiti Reservoir locale. The data indicate rather conclusively that sites exhibiting hearths were residential campsites occupied by one or more commensal groups. Good evidence exists to suggest that all site locations were characterized by different degrees of occupation through time, regardless of the size of residential groups which occupied them at any single time. These data are important because they verify the assumption that Archaic settlement behavior involved cyclical reoccupation of sites within different parts of environmental settings over a period of years.

Differences in size of residential groups occupying different site locations can also be suggested although not as conclusively demonstrated. An interesting feature of regional settlement pattern seems to be reflected as an almost bimodal distribution of single-hearth sites and multiple-hearth sites characterized by four or more hearths. Given results of the present analysis, Archaic campsites characterized by several hearths may well reflect occupation by several commensal groups during each occupational event. Actual size of residential groups occupying such sites clearly varies from one occupational event to another.

The net results of analysis indicate that Archaic occupation of White Rock Canyon was of a recurrent nature involving very similar kinds of activities during each occupational event. The basic social structural properties of Archaic groups occupying the locale consisted of ca. 4 up to 9 commensal groups occupying larger campsites and single commensal groups occupying other campsites. From other evidence concerning variation in artifact type and function, it seems clear that a great degree of fundamental similarity in subsistence realted activities is apparent among all of the residential sites within the canyon.

Structural variation in artifact deposition among site locations which did not exhibit evidence of hearth usage is somewhat more difficult to summarize. From survey data, such site locations were often characterized by one or more relatively restricted locales of comparatively high densities of artifactual debris. Excavated nonhearth sites (such as LA 12442, LA 12444-provenience 1, LA 13350, LA 13351) reflect a variety of activities, very similar in range to sites with hearths and as such cannot be cursorily dismissed a loci of *limited* activity performance. In contrast to hearth sites, however, they reflect a different distributional pattern to the structure of debris in that the debris-free areas partially encircled by debitage concentrations are absent. The question of whether the nonhearth sites represent very

Table 4.2

Nearest Hearth Distances for Archaic Sites with Multiple Hearths*

Site No.	# Hearths or Epicenters	Minimum Distance	Maximum Distance	$\bar{x}$ Distance	Standard Deviation
LA 12456	8	4.0	6.0	5.1	0.74
LA 12463	4	8.0	14.5	11.25	4.60
LA 12494	9	4.0	9.0	7.25	1.89
LA 12495	4	5.0	8.5	7.15	1.58

***all distances are in meters**

short term residential camps or field locations where tool manufacture and usage activities were undertaken away from residential encampments remains unanswered at this point. The fact that spatial patterns are different between hearth and nonhearth sites indicates that there may be significant behavioral differences between the two worthy of more detailed examination.

SUMMARY

This chapter has served to summarize Archaic period site-specific archeological variability. What has emerged from this discussion is a picture of short term residential occupations by very small complements of commensal groups, which characterize the late Archaic adaptation within the Cochiti Reservoir locale. Considerable redundancy from site location to site location is evident in all aspects of subsistence-related behavior, including strategies of food resource processing and consumption; strategies of raw material selection for tool manufacture; reduction trajectories involved in tool manufacture; and the character of site space utilization.

Data derived through survey and excavation within the Cochiti Reservoir project boundaries have thus provided a substantial body of information concerning site-specific occupancy which was not available previously. Some questions concerning this behavior, however, could not be resolved in any definitive fashion with the Cochiti Reservoir data; but at the same time are very critical toward our increased understanding of Archaic adaptation within the region.

Two as yet unresolved kinds of information can be seen as especially critical in this regard. The first of these concerns exactly what kinds of vegetative and faunal species constituted staple food resources for residential units occupying site locations within the project boundaries. The second of these questions concerns whether Archaic settlement within the project boundaries represents essentially a recurrent *single-season* occupation by commensal units of one or more local groups whose effective, year-round exploitive territory was much larger; or whether the site locations within the project boundaries represent different residential camps occupied at different times during an annual cycle of settlement relocation by such local groups basically within the immediate subregional locale encompassing the project boundaries.

In terms of the first question, direct information derived through excavation in Cochiti Reservoir ranged from nonexistent to ephemeral because of the surficial nature of the site locations and correspondingly poor state of preservation of organic materials. Few macroscopic floral or faunal specimens were recovered through excavation and, as might be expected, microscopic examination of flotation samples resulted in documentation predominantly of unidentifiable bone fragments.

The totality of direct evidence of vegetative species use by Archaic populations within the project boundaries is represented by a single *Portulaca* seed recovered from LA 12494, and an unidentified seed fragment found at LA 12456.

Faunal species exploitation is comparatively more abundant, although again ephemeral in an absolute sense. Large mammals are represented as a bison hoof fragment at LA 13353, a deer antler fragment at LA 12494, unidentified large mammal teeth fragments at LA 13351, and small unidentified fragments of what may be large mammal long bones recovered from LA 12456 and LA 12494.

Other identifiable remains include cottontail rabbit maxillae fragments recovered from LA 12494, freshwater bivalve mollusk fragments from LA 12456 and LA 12494, and a terrestrial snail fragment from LA 12456 which may or may not indicate evidence of consumption given its context of deposition.

Remaining evidence of species exploited has been documented through microscopic examination of flotation samples as unidentifiable shell fragments from LA 12456, and unidentifiable bone fragments from LA 12442, LA 12456, LA 12463, and LA 12494.

When taken together, direct evidence of faunal species possibly exploited as food resources by Archaic populations within the project boundaries seems to indicate a relatively diverse subsistence economy. The character of such evidence, on a site-by-site basis, however, cannot in any way be seen as constituting data which empirically substantiates *any* broad statements summarizing the nature of subsistence behavior engaged in by those populations.

In a similar sense, direct evidence of vegetative species constituting local food resources procured by Archaic inhabitants of the project area is basically lacking. The redundant occurrence of milling implements and firecracked rock concentrations within the vicinity of hearth facilities may, however, reflect food processing and cooking activities involved in the consumption of seeds produced by a variety of grasses within the study area.

To summarize, future research directed toward ascertaining the kinds of food resources routinely procured, processed and consumed by Archaic populations within the study area might well be most profitably pursued through continued and concerted collection and analysis of flotation samples at *all* surficial site locations which might be made available for investigation in the future.

It can be suggested, in terms of future research, that such site locations might be examined very carefully from surficial evidence to ascertain their physical potential for preservation of floral and faunal remains. Those locations exhibiting evidence of greater preservation potential, given vagaries of their locations with respect to substrate, physiographic situation, integrity of facilities and structure of artifact distribution, should consititute, where feasible, *key* sites for continued investigation in this regard.

The second major unanswered question concerning Archaic adaptive behavior within the study area concerns the seasonality of occupation for sites within the project boundaries. It is unknown whether these sites reflect different seasonal residences which in their entirety represent a year-round occupation by one or more local groups; or whether these sites represent only seasonal residences for local groups whose effective territories were much larger in extent.

Information bearing upon this kind of regional behavior must ultimately be gathered through intensive survey and excavation within other portions of the northern Rio Grande and be analytically examined with reference to data documented within the Cochiti Reservoir project boundaries.

Although such comparative data do not exist at present, it is possible to employ the Cochiti Reservoir data in an analytical fashion so as to suggest avenues through which future research might be pursued profitably to shed light upon this general problem. In this respect, Cochiti Reservoir data can be analyzed so as to suggest the character of local group articulation of commensal groups occupying the project area; and as well to gain information concerning the overall regional articulation of Archaic local groups which operated within the northern Rio Grande Valley.

Toward this end the following chapter will examine several properties of Archaic period settlement within the project area from such a larger regional perspective. A specific line of investigation will be taken in this regard—that of evaluating whether variation in the location and intensity of settlement within the project area can be accounted for as a function of differential diversity of vegetative food resources characterizing the study area in general.

It is felt that the results of this analysis should contribute substantively toward an understanding of Archaic settlement behavior within the Cochiti Reservoir locale and, as well, should provide insight of a more general nature into overall properties of foraging-based adaptive behavior within essentially arid environmental settings.

Chapter 5
ARCHAIC SETTLEMENT AND THE VEGETATIVE DIVERSITY MODEL

Richard C. Chapman

INTRODUCTION

At present, the most substantive overview of Archaic period adaptation for northern New Mexico, southern Colorado, northeastern Arizona and southeastern Utah has been presented in a series of articles by Irwin-Williams (1967, 1973, n.d.; Irwin-Williams and Haynes 1970). Any attempt to assign a chronology to Archaic period sites in the northern Rio Grande is ultimately based upon her work. Using survey and excavation data within the Arroyo Cuervo region of northwestern New Mexico, to the west of the Rio Grande Valley, and previous research elsewhere, Irwin-Williams (1973) proposes five different temporal phases of adaptation for the Archaic which extend roughly from 5500 B.C. to A.D. 400. During the course of the Archaic period she suggests that human populations were engaged in a mixed foraging subsistence strategy with some variation in group size, composition and subsistence focus through time being recognized. Although broad outlines of Archaic adaptation are thus available in the literature, the Archaic period of adaptation in the northern Rio Grande remains, to date, poorly understood.

In Cochiti Reservoir we are, in part, severely hampered in the directions in which we may attempt to augment our knowledge of the Archaic period adaptation in the northern Rio Grande Valley. For example, sites in the reservoir cannot be employed to clarify the chronology or sequence of adaptation. Dating information was restricted to obsidian hydration samples, a relative rather than absolute method. Data permitting other more precise dating procedures (such as radiocarbon techniques) were, unfortunately, not present at any excavated sites. Similarly, diagnostic items, such as projectile points, were generally absent from Archaic sites in the reservoir.

Sites in the reservoir may, however, be employed to evaluate some commonly held ideas about ecological determinants of Archaic settlement behavior. It is frequently assumed that Archaic populations situated their residential campsites in areas which would maximize access to, and minimize energetic expenditure in procuring, food resources. A variant of this assumption which is appearing with increasing frequency in the Southwestern literature is what might be termed a *vegetative diversity model*. A basic tenet of this model is that Archaic residential locales will be located in areas of the highest ecological diversity.

Since Cochiti Reservoir is situated at the interface of one of the most ecologically diverse regions in North America (Emlen 1973), we feel that the Archaic sites in the reservoir are especially appropriate to evaluate a diversity model concerning Archaic settlement behavior. In the following sections we will outline a series of analyses which will help us evaluate the diversity model itself, a model which proposes to explain the distribution of Archaic period sites. In addition, this chapter will provide a detailed discussion of some variability in the Cochiti Reservoir Archaic sites. In this way the data base from the northern Rio Grande Valley can be employed to provide new information about Archaic adaptation which will help us refine aspects of current models and suggest new avenues of research.

THE VEGETATIVE DIVERSITY MODEL

One model which has been increasingly employed to account for Archaic period settlement patterns can be termed the *vegetative diversity model*. Stated simply, this model suggests that human populations engaged in a broad-spectrum foraging subsistence strategy will tend to locate their residential campsites in areas providing access to the greatest variety of floral food resources. The model is based upon two premises:

(1) that hunter gatherer-based subsistence in arid environments entails a *fine-grained* feeding strategy in which food resources are acquired more or less as encountered during diurnal foraging episodes away from a residential camp or site; and

(2) that more diverse areas of food resources offer a higher potential for caloric return versus investment, given a fine-grained feeding strategy. In this sense, it is assumed that the greater the number of food resources available within a foraging locale, the higher the probability that a food resource of some kind will be encountered.

One of the more explicit statements of the food resource diversity model as a control of Archaic settlement behavior has been made by Reher and Witter (1977). In their study they employed species diversity among vegetative associations as a measure of food resource diversity, and examined species diversity in the vicinity of a dense cluster of Archaic site locations along the lower Chaco drainage in the San Juan Basin of northwestern New Mexico. Although their analysis served to explicate the character of vegetative diversity in one locale of the Chaco drainage, it was not designed to test the diversity model itself.

Another study directed more explicitly toward evaluating the utility of the diversity model to account for variation in placement and density of Archaic sites was undertaken by Allan et al. (1975). This study was also located in the San Juan Basin some 15 km northeast of the study conducted by Reher and Witter. Food resource diversity was measured using plant counts from sample plots within 3 x 3 mile quadrats superimposed over Archaic site locations. Species diversity within these quadrats was then compared to diversity measures derived from randomly selected quadrats from the same general area which did not encompass Archaic sites. They noted that Archaic site locations did covary significantly with greater species diversity.

Although variants of the diversity model have been offered in other archeological case studies, there has been relatively little investment into testing the capability of the model to account for Archaic residential variability. Whether phrased explicitly, as in the two examples cited above, or implicitly, as in the vast majority of studies, it can be suggested that the food resource diversity model has assumed a quasiexplanatory status as a generally accepted tenet underlying man-environment relationships. It can also be suggested that it has not been rigorously evaluated for its predictive utility.

It is thus felt that because of the potential importance of the model as a predictive principle underlying settlement behavior resultant from broad-spectrum foraging subsistence strategies, the model warrants more intensive evaluation from an empirical standpoint than has been afforded. In the following section, we will discuss the Archaic period settlement data from the Cochiti Reservoir area in terms of their potential and liabilities for conducting such an evaluation.

COCHITI DATA BASE FOR THE ARCHAIC PERIOD

Limitations of the Survey Data

Since the diversity model requires information concerning the kind and spatial distribution of Archaic period site locations, we elected to focus upon survey rather than excavation data*. In this way we were able to incorporate a larger sample of Archaic period site locations in the analysis. The character of surveys conducted within the Cochiti area, however, presents some limitations upon the scope of analysis undertaken in this chapter; consequently, a brief review of the nature of the survey documentation will be presented below.

The largest intensive survey conducted within the area of study was restricted to the 9060 acre Cochiti Reservoir flood control pool limits, an area defined by the 5460.5 ft elevational gradient directly adjacent to the Rio Grande from slightly below the mouth of White Rock Canyon northward to the vicinity of Mortandad Canyon; and portions of the Santa Fe River drainage, the Canada de Cochiti drainage and Santa Cruz Arroyo below the mouth of White Rock Canyon. Eighty-three site locations exhibiting possible evidence of Archaic period occupation were recorded (Biella and Chapman 1977c).

Intensive archeological survey of the higher surfaces of the Caja del Rio Plateau, to the east of Cochiti Reservoir, *have not been conducted, with the following exceptions.* An area of land comprising the present Tetilla Park recreation area was surveyed by the Office of Contract Archeology prior to construction of the recreation facility (Stein 1975). This area is situated at the mouth of White Rock Canyon and encompasses portions of drainage basin numbers 1 and 2 (see Fig. 5.1). Two Archaic site locations were documented during this survey (Stein 1975).

More recently a series of 0.1 x 1.0 mile sample transects on the Caja del Rio Plateau have been surveyed as a part of the ongoing Pajarito Plateau Archeological Research Project conducted by James N. Hill of the University of California at Los Angeles. Data from this latter survey, which were generously provided by Dr. Hill and his staff, indicate the presence of probable Archaic period site locations throughout the Caja del Rio Plateau. Unfortunately, much of the area surveyed falls outside the boundaries of the vegetative stratification employed in the present analysis (Drager and Loose 1977) and thus this archeological sample could not be included in this chapter.

Considerably more archeological surveys have been conducted on the west side of White Rock Canyon, but the intensity of coverage has varied for different areas and, in many cases, only certain kinds of site locations (generally prehistoric Anasazi) were documented. An extensive review of the different archeological surveys which have been conducted within the southern Pajarito Plateau can be found in Biella (1977). As a general statement, only two of these previous surveys resulted in documentation of nonstructural site locations.

The first of these was conducted by Snow (1970) and involved an intensive survey of approximately 3850 acres which had been leased by the City of California Development Corporation for portions of a proposed residential development (the town of Cochiti Lake). The surveyed area on the west side of White Rock Canyon, roughly between Bland Canyon to the north and the present site of Cochiti Dam to the south. Of a total of 75 sites located during the survey, 46 were nonstructural lithic chipping areas.

A second survey was conducted in the eastern part of the Canada de Cochiti Grant, including portions of Rio Chiquito, Bland, Medio and Sanchez Canyons (Flynn and Judge 1973). The primary intent of the Canada de Cochiti survey was to provide an assessment of the general character of cultural resources within the boundaries of the Grant. Although portions of the Grant were intensively surveyed during the course of this assessment, additional survey work was recommended (Flynn and Judge 1973:43). Eight lithic scatters were recorded during this survey.

Neither of these surveys systematically documented certain kinds of information such as presence, absence or numbers of hearth facilities and artifact densities in their reports. As a consequence, these data are not employed in the present analysis, although they will be referred to, where appropriate, in evaluating implications of the analysis itself.

In summary, data which can be employed in the study are basically those generated solely through the Cochiti Reservoir project surveys, and, as such, may constitute a distinctly biased sample of evidence of Archaic period settlement within the region as a whole. Despite this, it will be argued that the data do constitute a sufficient sample for purposes of evaluating several aspects of the diversity model. The manner in which specific limitations of the data set

* As appropriate, excavation data are integrated into the analyses or concluding discussions in the sections which follow.

have been accounted for in terms of conducting the analysis will be discussed in subsequent sections of the chapter.

THE APPROACH

Inspection of Figs. 5.1 and 5.2 indicates that the distribution of Archaic site locations within the boundaries of the flood control pool (or below 5460 ft elevations) is not continuous in nature. The majority of site locations are distributed in discrete clusters of two or more sites, separated by expanses of landscape devoid of site locations.

Given premises of the food resource diversity model, such a discontinuous rather than continuous spatial distribution of sites should reflect variations in food diversity accessible to the occupants from those clustered locations, other things equal.

Definition of catchment areas through which this premise might be assessed was undertaken simply through inspection, in which an arbitrary radius of 1 km was chosen as a means of bounding the site clusters. Center points of the catchment areas were defined through positioning circles or circle segments with 1 km radii over each cluster such that the site locations comprising each cluster fell more or less centrally within the circle boundaries. Figures 5.1 and 5.2 illustrate the resultant definition of site clusters (residential locales) which were isolated in this fashion, and Table 5.1 lists each of these residential locales, and the LA numbers of site locations comprising each.

Table 5.1 – **Archaic Period Residential Localities**

Locality No.	Site No.	Prov. No.	No. of Hearths**
1 east	13342	1	1?
	13343	1	firecracked rock
	13344	1	2
	13345	1	1 + firecracked rock
2 east	13350*	1	none
	13351*	1	none
	13352*	1	1
	13353*	1	1
3 east	12893	1-3	16?
	13010	1	none
4 east	11592	1-2	2?
	12436	1	firecracked rock
	12439	1	6
	12445	1	2
	12446	1	1
	13016	1	none
	13017	1	1 + firecracked rock
	13019	1	3 + firecracked rock
	13022	1	5 + firecracked rock
	13023	1-2	1 + firecracked rock
	13025	1	3 + firecracked rock
	13026	1-4	4
	13027	1	4? + firecracked rock
	13028	1	2
	13029	1-3	4-5 + firecracked rock
	13035	1	1 + firecracked rock
	13036	1	none
	13037	1-2	none
	13038	1-2	8-10
	13040	1	1 + firecracked rock
	13041	1	none
	13043	1	none
	13348	1	3
	13393	1	1
	13394	1	none
	13395	1-2	none
	13400	2	firecracked rock
5 east	12459	1	firecracked rock
	12463*	1	firecracked rock (2 hearths defined during excavation)***
6 east	12447*	2	firecracked rock (1 probable hearth defined during excavation)***
	12448*	1-2	firecracked rock
	12450	1	none
	12455	1-2	firecracked rock
	12456*	1-4	2 + firecracked rock (hearths defined during excavation)***
	13056	1-2	none
	13062	1	firecracked rock
	13066	2	none
7 east	12460	1-5	2 + firecracked rock
	13300	3	firecracked rock
	13308	1-2	2 + firecracked rock
8 east	13321	1	firecracked rock
9 east	13354	1	2 + firecracked rock
10 east	13358	1	none
	13359	1	6
	13362	1	2 + firecracked rock
11 west	10111	2	none
	12517	2	none
	12521	1-2	firecracked rock
	13031	1	1
	13048	1	none
12 west	13061	1	none
	13063	1	1?
	13065	1	1 + firecracked rock
13 west	12503	1	1
14 west	12163	1	none
	12478	1	none
	12479	1	none
	12481	1-3	2 + firecracked rock
	12490	1	none
	12491	2	none
	12494*	1	firecracked rock (during excavation 3 intact hearths + 7 more probable hearth areas)***
	12495*	1	firecracked rock (4 probable hearth areas)***
	12496*	1	firecracked rock (6 probable hearth areas)***
15 west	12499	1-2	1
	12502	1	firecracked rock
	13052	3	none
	13053	1	none
16 west	13383	2	firecracked rock

* excavated or tested sites
** information taken from Biella and Chapman 1977c:224-238
*** see Chapman et al. 1977

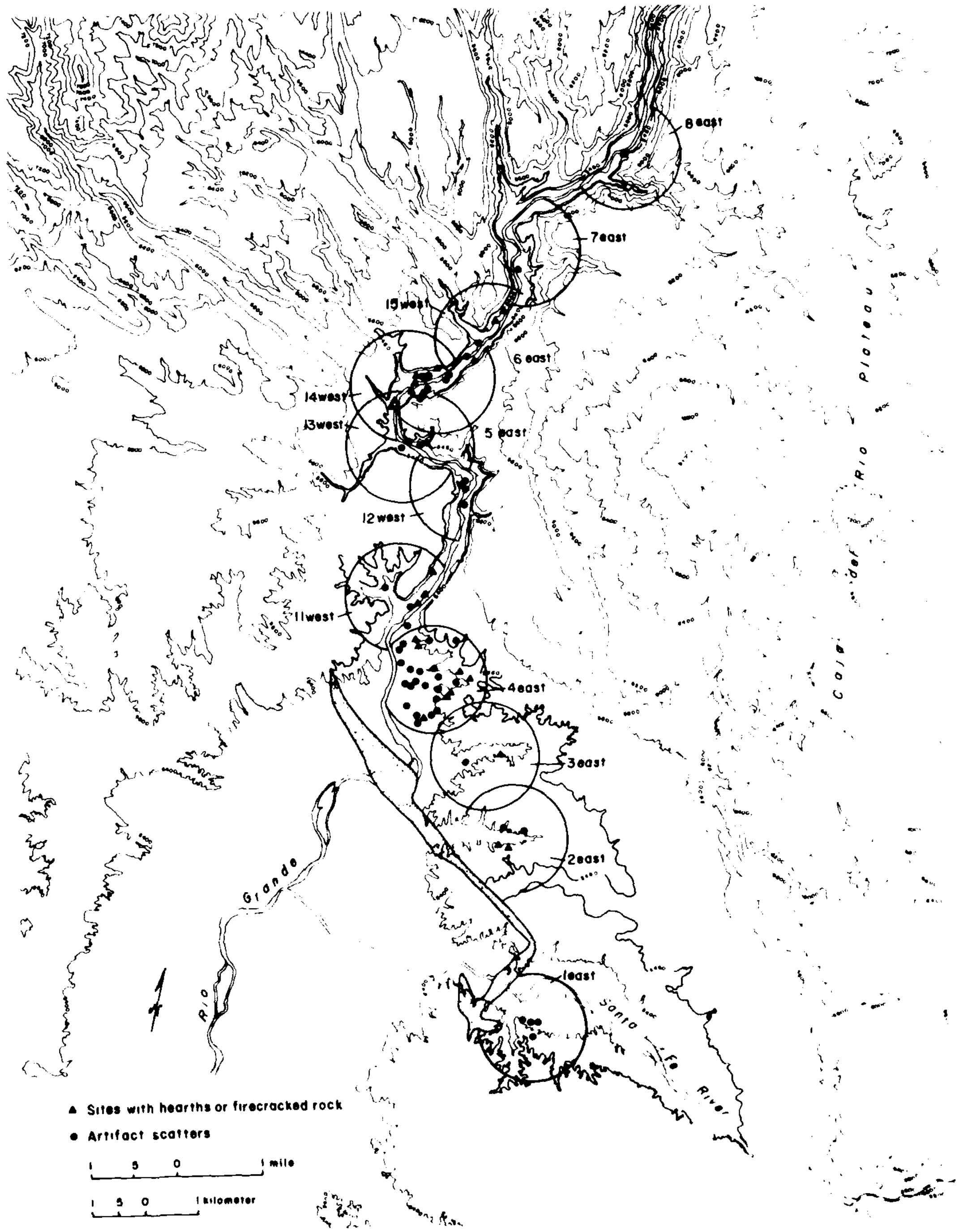

Fig. 5.1 Location of Archaic sites and residential clusters (1-8 east and 11-15 west) in the southern portion of Cochiti Reservoir.

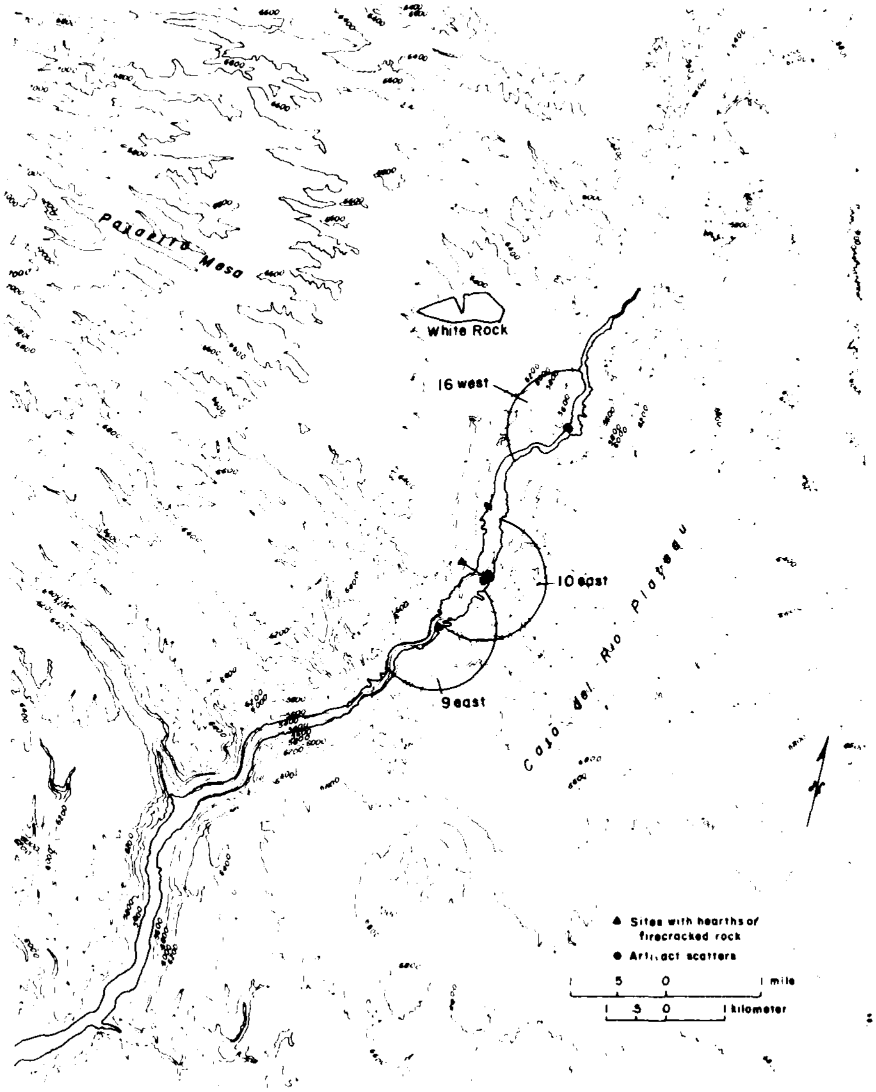

Fig. 5.2 Location of Archaic sites and residential clusters (9-10 east, 16 west) in the northern portion of Cochiti Reservoir

Two points concerning this definition of residential locales and catchment areas should be brought up at this time. First, an assumption has been made that routine daily or diurnal foraging behavior in the study area would *not* be expected to involve crossing the Rio Grande as it flows through White Rock Canyon. The river, although not excessively deep in this area, is wide and very fast flowing. It can be crossed by swimming, but it is extremely unlikely that it would be routinely crossed and recrossed on a daily basis in search of food—especially when such foraging and hunting activities necessitate carrying a certain amount of gear (digging sticks, bags, baskets, atlatls, etc.), and normally involves a degree of transportation of infants or small children, and any such foodstuffs which were acquired during the day's work. The catchment areas as defined are thus truncated by the river.

A second concern is that the definition of residential locales employing an arbitrary 1 km radius resulted in a distinctly ambiguous inclusion of site locations in some cases. A few clusters of two or three Archaic site locations could be inspectionally defined which were situated at some distance from other site locations in space; but when a center point was defined for the cluster, other site locations comprising the population of other residential locales were encompassed within the 1 km radius. Examples of this ambiquity in inclusion are residential locales 5 east and 15 west.

It can be seen, however, that this kind of inclusionary overlap was not mutual between any two residential locales: rather, one locale of the pair was characterized by a discrete inclusion of all sites comprising the cluster within the 1 km radius boundaries. The other locale of the pair, when its center point was defined, included some sites of the first locale within its 1 km radius.

To simplify possible interpretational complexity, residential locales such as this were dropped from the analysis. Reasons for this are found in the manner in which occupational intensity was measured for each residential locale, and will be discussed in those sections.

Measuring Vegetative Diversity

Data employed in measuring vegetative diversity within the vicinity of each locality were gathered through the following procedures.

(1) After center points for each of the residential locales selected for analysis were defined, a series of arcs with successive radii of 1, 2, 3, 4 and 5 km were drawn from these center pints to encompass all land areas about the center to the Rio Grande.

(2) Employing the vegetative stratification of the study area developed by Drager and Loose (1977:31-38), the amount of land area within each radius interval encompassed by each vegetative community was measured in hectares (ha).

(3) Once the amount of land area comprising different vegetative communities was calculated for the successive radius intervals for each residential locale, the measures were summed to arrive at the total number of hectares for each vegetative community within the 5 km radius from the center point, and the relative percentages of land encompassed by the different communities within that radius calculated.

Table 5.2 lists these basic data for each residential locale catchment as defined by a 5 km radius. It should be noted that selection of a 5 km radius as the maximum distance treated is basically a function of the amount of land surface for which vegetative community data were available. For one residential locality (10 east), the 5 km radius extended beyond the boundaries of the vegetative stratification, and the figures were based upon only those areas within the catchment.

(4) Diversity indices were then calculated for each catchment, employing the relative percentages of vegetative communities encompassed by each. The statistic chosen to calculate diversity has been termed the Shannon-Weaver formula (cf. Emlen 1973:385), or perhaps more correctly in a strictly historical sense, the Shannon-Weiner information function (MacArthur and MacArthur 1961) and is expressed as follows:

$$H = -\sum_{i=1}^{s} p_i \log_{p_i}$$

where H is the diversity index, s is the number of species (in this case, number of vegetative communities) within the area, and p_i is the probability of occurrence of the ith species within the area (or the relative percentage of occurrence of that species).

Table 5.2
Vegetative Diversity Data for Each 5 Kilometer Locality Catchment
(all areas are in hectares)

		UPPER SONORAN						TRANSIT.				
Locality No.	Riparian	Scrub Oak	Arid	Pinyon	Pinyon-Juniper	Juniper	Juniper Grassland	Ponderosa	Mt. Meadow	Modern fields	Total hectares	Diversity index
1 east	66	—	267	—	—	159	5943	—	—	190	6625	.4643
2 east	165	—	432	—	—	1297	4987	—	—	161	7042	.9015
3 east	162	1	332	—	—	1404	3665	—	3	125	5692	.9853
4 east	—	4	197	—	—	1880	2515	—	6	105	4707	.9335
5 east	—	4	304	17	—	2186	634	—	13	—	3158	.8618
6 east	—	5	285	16	—	2002	683	—	7	—	2998	.8830
7 east	—	3	610	16	—	2429	525	—	5	—	3588	.8857
8 east	—	—	752	14	—	2829	666	—		—	4261	.8870
9 east					(information inadequate)							
10 east*	—	—	196	—	—	1335	579	—	—	—	2110	.8652
11 west	7	11	13	—	90	3590	192	—		203	4106	.5382
12 west	3	36	142	—	262	2760	267	—	—	—	3470	.7589
13 west	16	109	269	—	349	3764	286	—	—		4793	.8152
14 west	41	114	426	—	506	3469	464	—	—	—	5020	1.0415
15 west	55	89	605	—	558	2306	565	—	—	—	4178	1.2864
16 west	12	69	316	2206	—	462	206	28	—	—	3299	1.0838

The term *pi* is calculated basically as *ni*/N, where *ni* is the number of species *i*, and N is the total number of species. By substituting *ni*/N for *pi* in the above formula, the Shannon-Weaver formula becomes the Shannon-Weiner information function, both of which do the same thing.

As generally used by plant ecologists, the formula is an expression of the relationship of the numbers of *species* within a sample space to the relative numbers of *individuals* of each species. As it is used in this analysis, the relationship is expressed as pertaining between the number of *vegetative communities* encompassed by the 5 km radius catchment and the relative *proportion of the total catchment area* encompassed by each of those communities.

As the number of vegetative communities within a sample area increases, and as the amount of area covered by each of those communities becomes more equal, the diversity of the sample area will increase. This is perhaps best illustrated by simple examples.

First, consider a case in which the entire sample area is characterized by a single vegetative community *i*. The probability of occurrence of *i* (*pi*) is 1.00, and the natural logarithm (log e) or the common logarithm ($\log_{10}$) of 1.00 is 0, with the result that the sample area data would yield a calculated diversity of 0.

Consider a second case in which four communities exist within a sample area, one of which encompasses three-fourths (or .75) of the area, and the other three of which equally encompass the remaining one-fourth of the area (or .0833 of the entire area for each). Employing a natural logarithm in the calculation, these data would yield a diversity index of .84.

Finally, consider a third case in which the same four communities exist within the sample area, but the areal coverage of each is equal (.25 of the total area). Again employing a natural logarithm in the calculation, the diversity index for this case would be 1.39.

It can be seen then that the index offers a convenient way to scale both the *number* of different communities represented, and their *relative proportion* of occurrence, along a single referent. Because plant ecologists seem to prefer employing natural logarithms (log e) over common logarithms ($\log_{10}$) in the calculation of diversity indices, that convention will be followed in this analysis.

Table 5.2 provides the diversity indices for each residential locale catchment, in addition to the basic data employed in their calculation.

Measuring Intensity of Occupation

The vegetative diversity model, in its simplist formulation, suggests that variation in the intensity of occupation of particular spatial locales is governed predominantly, or even entirely, by the degree to which those locales offer spatial accessibility to maximum diversity among kinds of vegetative resources. In order to assess, from an empirical standpoint, the utility of that model to account for Archaic settlement of the Cochiti Reservoir area, a set of measures of such occupational intensity must be defined.

Occupational intensity, as a concept, can be seen as referring to several possible dimensions of human behavior. Such dimensions include the *size of a residential population* during any given site or locale through time; and the temporal *duration of single occupational episodes* of a site or locality.

A major problem in defining measures of occupational intensity resides in correlating specific archeological measures with these different types of behavioral intensity. In light of this, four measures which can be derived from survey documentation of Archaic period site locations will be discussed below in terms of possible information they provide about these concepts of occupational intensity.

Number of Sites (site density)

One of the more common measures of occupational intensity employed by archeologists investigating settlement dynamics at a regional scale of analysis is the relative *density* of site locations per unit land area. Individual site locations can be warranted to reflect a circumscribed area of space within which activities were undertaken. Minimally, then, each site location should reflect at least one occupational event (for whatever purpose) which resulted in deposition of an archeologically recognizable case of that event. For purposes of the present analysis, variation in the relative density of sites per unit area of landscape characterizing residential locales offers one measure of occupational intensity.

Two problems exist, however, in assigning meaning to such density estimates, given the basic dimensions of behavior discussed above. The first of these resides in the question whether different site locations within a particular locality might represent different places where particular activities were undertaken by members of the same contemporaneous residential unit of individuals during a single term of occupation. The second resides in the question whether some site locations within a given locale may represent substantial reoccupation through a period of years, whereas others may represent single occupational events.

To a certain extent, arguments based upon ethnographic analogues can be offered as partial approximations toward answering both questions. Data from Australia and Africa indicate a general tendency on the part of arid foraging based populations to establish new residential camps in particular locales over the *short term* (i.e., 1-2 years), in cases where such camps are expected to be occupied for relatively extensive periods of time during each annual cycle. In localities being occupied recurrently over the short term annual frame by a relatively large residential unit (as the Dobe waterhole by the !Kung San, cf. Yellen 1977), primary reasons for such new site starts are smell, pests, etc. which attenuate as by-products of occupation.

In localities being occupied recurrently over a longer term multiannual frame, such residential new site starts may be conditioned (in addition to these above criteria) by the longer term productivity of food resource species within the locality itself (cf. Tindale 1972:241). In these

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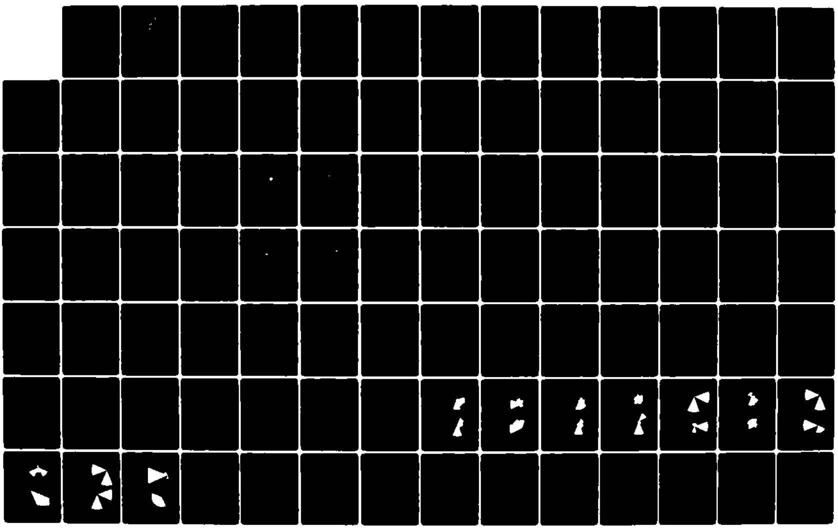

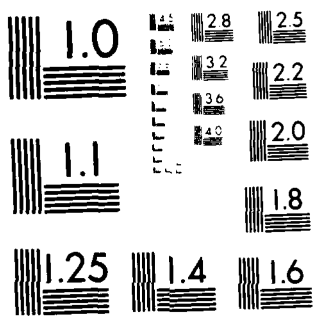

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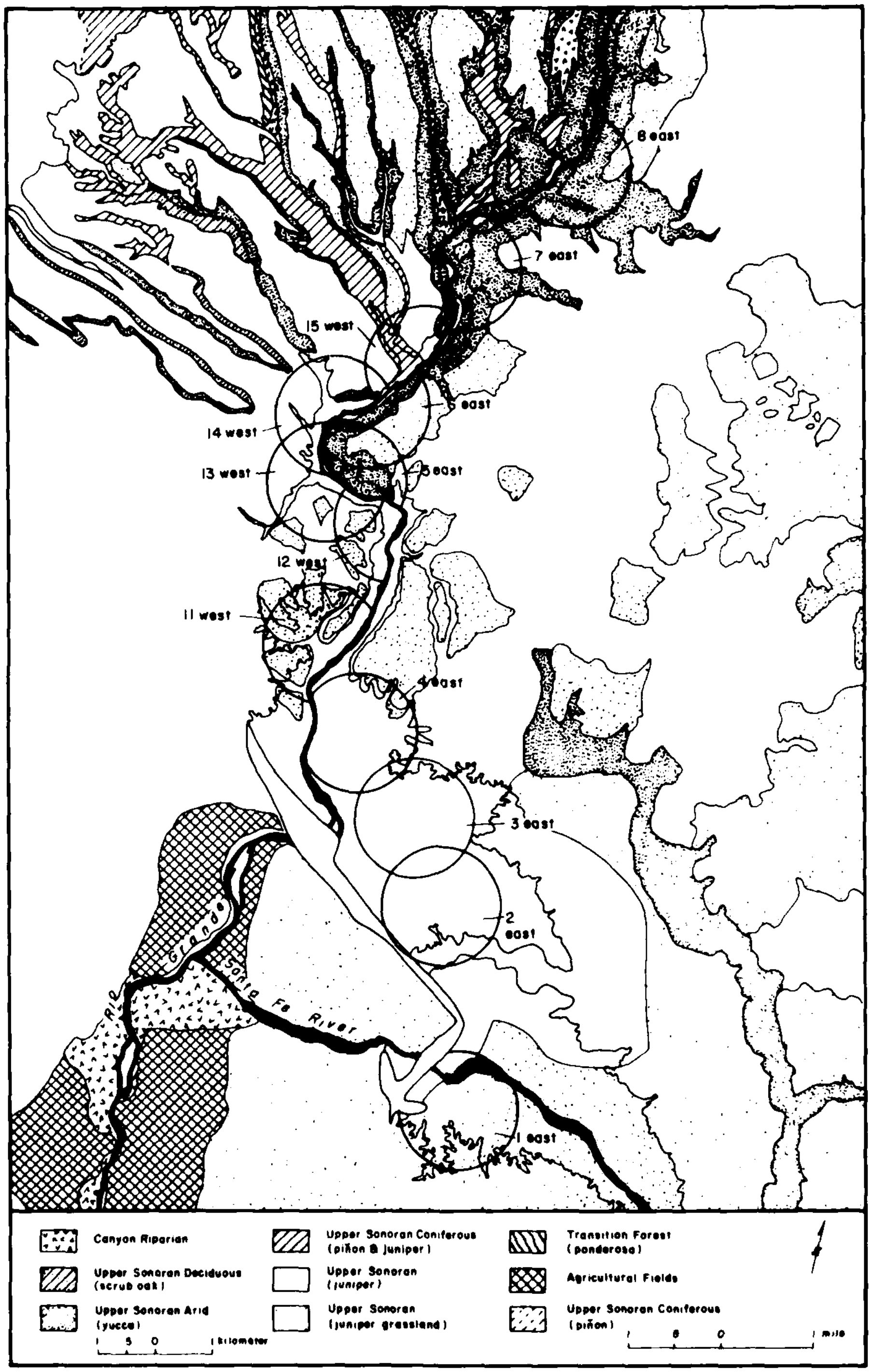


Fig. 5.3 Distribution of vegetative communities in the vicinity of Cochiti Reservoir, Santa Fe River to Arroyo Montoso (after Drager and Loose 1977:Fig.II.2.1).

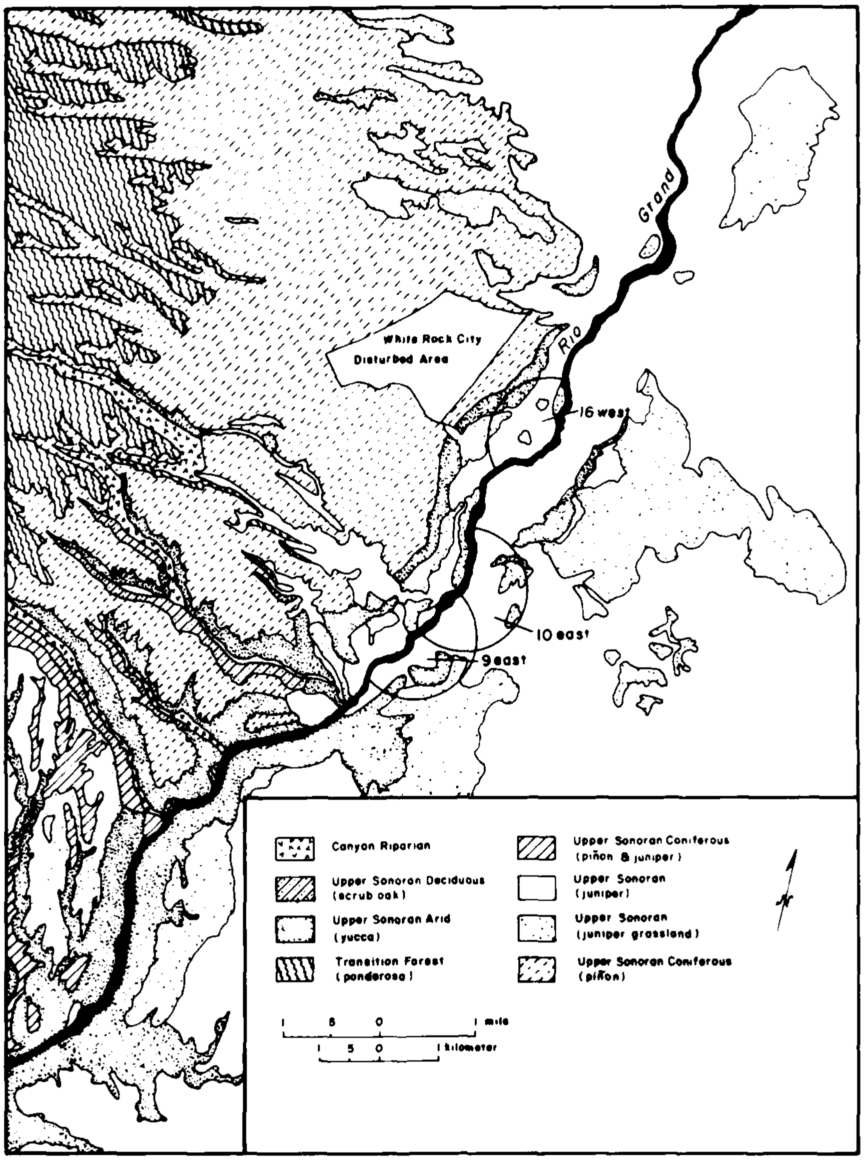


Fig. 5.4 Distribution of vegetative communities in the vicinity of Cochiti Reservoir, Frijoles Canyon to Pajarito Canyon (after Drager and Loose 1977:Fig.II.2.1).

circumstances a recurrently used residential camp is shifted over an area within a 3 to 4 km radius of a permanent water source in response to overexploitation of staple vegetative foodstuffs within the immediate vicinity of the camp.

Given these observations, it can be suggested that one contributing factor underlying the number of residential sites within a particular locale may well be the frequency within an annual cycle that locale is revisited, and the duration of occupation each such revisitation entails. Another contributing factor in this regard can be posited as the regularity with which the locale is reoccupied by residential groups over a long term multiannual cycle and the extent to which this results in over-exploitation of vegetal food resources in the immediate diurnal foraging radius of given campsites.

In terms of archeological visibility, *either* contributing variable should be expected to result in a relatively great density of sites indicative of large (ca. 10-20) encampments of commensal units per unit area.

For the question of whether different site locations might represent expressions of different activities undertaken by the same contemporaneous residential population, the ethnographic literature offers little help in the way of analogues.

It can be suggested food *procurement* activities are inevitably undertaken at some distance from a residential site location. Some kinds of technological procurement activities, especially stone resources, can be expected to result in archeologically visible evidence as debris generated through decortication to assess the qualitites of different pieces of material as part of the selection process. Gould et al. (1971:160) provide a brief description of selection areas exploited by the Australian aborigines in this regard.

In a similar sense, hunting stands may exhibit archeological recognizability, but predominately in the form of manufacturing or refurbishing (maintenance) of existing stone implements (Gould et al 1971:153).

Actual physical evidence of kills and field processing of fauna can be expected to be archeologically negligible over the long term with respect to arid foraging behavior (Yellen 1976:67). Other potentially recognizable processing activities such as hide preparation, seed winnowing, nut shelling, siliceous stone implement manufacture, wooden implement manufacture, and the like are all, from an ethnographic perspective, kinds of activities which are routinely performed within the confines or vicinity of residential encampments (Silberbauer 1972; Tindale 1972; Yellen 1976, 1977).

Each residential locality defined for purposes of this analysis contains site locations which do not exhibit evidence of hearth utilization. As discussed in the previous chapter, these sites exhibit a range of tool manufacture and usage activities quite similar to those found at residential encampments. At the same time, nonhearth sites are characterized by distinctly different patterning in artifact distributions.

The nonhearth sites thus represent an interesting anomaly which is not accounted for through reference to ethnographic analogues concerning special use sites or procurement stations. Further, they do not seem to represent merely little-used residential camps for which no evidence of hearth usage remains visible archeologically.

Given their relatively close spatial distribution in the vicinity of residential sites, it can be argued they may well represent loci of behavior undertaken in conjunction with occupation of the residential sites themselves, the specific nature of which overlaps in many respects activities performed at the latter.

Given this rudimentary attempt to assess how observable variation in the density of site locations per se might inform upon occupational intensity of a particular locality, it can be suggested that a ratio of site locations per hectare of landscape represents the combined effect of two possibly interacting variables: degree of recurrent occupation of site space within a short term annual cycle of commensal unit mobility; and degree of long term reoccupation of the locality as governed by overexploitation of staple vegetal resources within the diurnal foraging vicinity of particular site locations.

Measuring the density of archeological site locations comprising residential locales within the study area poses another kind of problem in a methodological sense. This is selection of an appropriate spatial scale through which numbers of archeological sites can be translated into density variation, and the degree of reliability in documentation of the existence of site locations within that spatial area.

Reliable documentation of presumed Archaic period site locations within the study area exists at present only within the confines of the 5460 ft contour to the river itself (see Biella 1977:105-150). The reader is referred to Chapman and Enloe (1977:173-200) for a description of survey technique employed within those areal constraints.

It is clear that only small portions of each catchment area encompassing the different residential locales have been intensively surveyed. For this reason a means of standardizing estimates of site density among the different locales was a necessary first step in analysis. In order to approach this, the spatial frame encompassed within the first 1 km radius about the center point of each residential locality was defined as the standard spatial referent for assessing variation in measures of occupational intensity among the different locales (see Figs. 5.1 and 5.2).

Computation of site densities was undertaken through counting the number of site locations within each radius and dividing by the number of hectares within those radii which had been surveyed.

It is felt that this ratio of sites per hectare, insofar as it is based upon the inspectional technique employed to define residential locale *catchment* centers in the first place, represents a reasonable means of standardizing estimates of site density for purposes of the analysis at hand.

In this sense, the objective of this analysis is to assess the degree to which variation in occupational intensity covaries positively with vegetative diversity within possible dirunal foraging radii of residential locales. Defining centers of such residential locales is biased toward *maximizing* the number of site locations encompassed for each such residential locale, given the technique employed. For this reason, ambiguous cases were excluded from the study. This was done because of an underlying concern that no particular residential locale might be defined which exhibited an artificially low measure of occupational intensity.

It might be offered that a more precise definition of variation in occupational intensity vis-a-vis vegetative catchments along the lines proposed in this analysis could be approached through arbitrarily defining a set of catchment center points from the mouth of White Rock Canyon northward on both the eastern and western sides of the Rio Grande at distances of perhaps 0.5 km or 0.25 km apart, and calculating diversity indices and indices of occupational intensity for each. In this fashion, a much more rigorous and precise scale of occupational intensity might be defined such that associated vegetative catchments could be examined in terms of their diversity. Conversely, a scale of catchment diversity might be defined against which indices of occupational intensity could be assessed.

Table 5.3

Measures of Vegetative Diversity and Occupational Intensity

Locality No.	Diversity Index	Sites per Hectare	Site area per ha.	Hearth Density per Hectare	Hearth Density per m^2 of site area	Artifact Density per m^2 (total)	Artifact Density per m^2 (adjusted)
1 east	.4643	.0157	.0006	.0197	.0031	1.4063	.7727
2 east	.9015	.0211	.0072	.0105	.0001	2.5333	1.8182
4 east	.9335	.0860	.0417	.1505	.0040	.1856	.1656
6 east	.8830	.2105	.0200	.2632	.0013	.3273	.2320
7 east	.8857	.0577	.0148	.1538	.0010	.5393	.1313
8 east	.8870	.0357	.0001	.0357	.0278	1.2222	1.2222
10 east	.8652	.1071	.0141	.2857	.0020	.4643	.4643
11 west	.5382	.0526	.0067	.0211	.0003	.1547	.1072
12 west	.7589	.0638	.0007	.0426	.0064	.0533	.0533
14 west	1.0415	.1343	.0146	.0746	.0005	.1548	.1202
15 west	1.2864	.0909	.0111	.0455	.0004	.0836	.0707
16 west	1.0838	.1250	.1709	.1250	.0001	.0343	.0343

The technique outlined in this analysis has maximized variation in occupational intensity under the assumption that such behavioral variation is of primary interest to archeologists. Other data concerning occupational intensity are found in Biella and Chapman (1977c:201-294).

Measures of site density (per hectare surveyed within 1 km radius of residential locale center) are provided in Table 5.3.

Size of Residential Unit – Site Area

One possible measure of relative size of residential populations occupying particular site locations is the spatial extent of those locations. There are a number of factors which might serve to condition variation in site area as observed archeologically, such as restrictions upon the amount of usable site space imposed by topography or vegetative cover at the time of occupancy. In general, however, the amount of site area offers at least a rudimentary estimate of resident population size. Ethnographic research by Yellen (1977) constitutes one of the few cases where an attempt was made to measure the spatial extent of debris generated through site occupation, and the actual size of the residential unit as numbers of individuals. His data indicate a relatively strong positive covariance between site area as defined by the limits of most scatter and residential size (Yellen 1977).

For this analysis, estimates of site area derived from survey were employed. Data used are presented in Volume 1 (Biella and Chapman 1977c:201-294).

In order to standardize site area with respect to the amount of land area actually surveyed, all site areas within the boundaries of the 1 km radius sample frame for each residential locale were summed, converted to hectares, and divided by the number of hectares within the sample frame which had been surveyed. Table 5.3 lists the combined site areas for each residential locale (in hectares), as a percentage of surveyed land area within each sample which was covered by sites (site area/hectare).

Hearth Density

Variation in the number or density of hearths provides a third way of estimating occupational intensity within a given locale. Hearth facilities and evidence of hearth utilization were recognized during survey as concentrations of firecracked rock, often in association with clasts or slabs which constituted either intact or eroded remnants of the facilities themselves. Occasionally, such facilities or remnants were encountered without evidence of associated firecracked rock.

It should be noted that, in the majority of cases, site locations exhibiting firecracked rock and larger slabs or clasts of this sort are situated upon substrate which are *not* characterized by such materials (such as sand dunes, or soil lenses). It is felt that the presence of such materials in those locational settings clearly indicates that they have been imported by human agents. Through comparison with the few *intact* hearth facilities which were preserved, they seem to represent evidence of constructed hearths and the by-products of hearth usage. The reader is referred to descriptive information presented for each site location in Chapman and Biella (1977) and Biella (1979) for more specific documentation on a case by case basis.

The presence of hearth facilities or evidence of hearth utilization is a very important kind of information to define archeologically when evaluating the character of Archaic period settlement and subsistence behavior within a region. Ethnographic information concerning hunter-gatherer groups in arid environments indicates that residential camps are nearly always characterized by hearth utilization for food preparation; and that in general, each socially defined household occupying a residential site uses one hearth for the duration of the group's stay at the site.

In a simplistic sense, then, the presence of hearth facilities at a site location can be taken generally to indicate that the site location served as a residential rather than logistical locus of activity; and the number of hearth facilities indicates the number of household units which occupied that site location.

It would be unwise to apply this kind of interpretation blindly to all archeological manifestations as an interpretative construct, of course. It is well documented ethnographically that hearths are used in nonresidential contexts as well as residential contexts of site occupancy, especially if logistical task groups (such as hunting parties) must travel distances away from the residential camp which require overnight stays in transit.

Despite these potential problems in assigning unambiguous meaning to the numbers of hearth facilities, it is felt that variation in the numbers of such facilities among different residential locales offers a kind of estimate of residential intensity of occupation.

Toward this end, survey estimates of the numbers of hearth facilities were summed for each residential locale. In the few cases where such numbers were expressed as a range (i.e., "3-4" or "8-10") the lower figure was employed in that summation. Cases in which only firecracked rock was observed during survey were counted as evidence of one hearth for each provenience where firecracked rock was noted.

The density of hearths was computed in two ways for purposes of analysis. First, the overall density of hearths per hectare of land surveyed within the 1 km sample frames was calculated; and second, the overall density of hearths per square meter of total site area within the sample frame was calculated.

Table 5.3 lists the density of hearths per hectare of surveyed landscape and their density per m^2 of site area within each residential locale.

Artifact Density

By far the vast majority of artifacts observed during survey on Archaic period site locations were unutilized and utilized flakes and pieces of angular debris of siliceous materials. Items such as manos, metate fragments, cores and facially retouched artifacts were encountered in very low frequencies as well.

All Archaic site locations exhibited evidence, in the form of cortical and noncortical manufacturing debris, that manufacturing activities had been undertaken. It can be suggested that variation in the density of such manufacturing debris, and in the density of utilized tools, offers another kind of information bearing upon relative intensity or duration of occupation of residential locales.

If it is assumed that there exists no significant interlocality variation in the basic manufacturing trajectories with respect to the kinds of artifacts being manufactured, variation in density of manufacturing debris can be warranted on at least a minimal basis as representing relative numbers of manufacturing episodes.

Similarly, variation in the density of utilized tools deposited among different site locations can be warranted to reflect some index of number of usage episodes.

Given these premises, an expedient relative measure of occupational intensity can be defined through calculating the density of all artifacts (by-products of manufacture and tools) among different residential locales.

Survey procedure in documenting artifactual variability was strongly oriented toward documentation of items within bounded sample frames as a control for density variation. Criteria for selecting size and placement of sample frames was less systematic, however, with the result that sample frames ranged from entire proveniences of 700 m^2 or more in extent (characterized by very low numbers of artifacts) to 1.0 m^2 sample frames placed over high concentrations of artifacts which were localized within single proveniences.

Given this variation in sampling strategy, assessing the comparative reliability of artifact density estimates among different residential locales is a somewhat difficult task. Two approaches were taken in this regard.

First, for each residential locale the total number of artifacts documented within sample frames was summed. A combined artifact density per m^2 for the locale was then calculated.

As a second exercise, artifact densities characterizing each sample frame monitored within particular localities were treated as a single population of measures, and the standard deviation of the entire population of density estimates for the locality was derived. Those samples which exhibited artifact densities greater than one standard deviation from the mean density, or less than one standard deviation from the mean density, were excluded from the analysis. New summative density values were then calculated for each residential locality following the procedure outlined earlier.

This second procedure basically resulted in excluding only estremely high density samples within some localities.

Mean artifact densities for each residential locality calculated from the total population of sample frames monitored during survey, and calculated from the adjusted population of sample frames derived through the above procedure, are presented in Table 5.3.

THE TEST

The previous sections have outlined the manner in which vegetative diversity has been measured with respect to different localities of Archaic period site locations in the study area. Four kinds of measures to assess variation in the *intensity* of occupation have been developed to scale variation in intensity of occupation among those residential localities. The vegetative diversity model essentially posits that both location and variation in occupational intensity by foraging based populations within a region will be fundamentally dictated by relative diversity in vegetative species which are accessible within a daily or diurnal range of those site locations.

Given the measures of occupational intensity which have been developed, we would thus expect that, if the model does account for this kind of behavior, a positive covariance between measures of occupational intensity and vegetative diversity should exist among the population of residential localities. As vegetative diversity increases, indices of occupational intensity should increase as well.

This expectation can be tested through employing a Pearson's correlation coefficient (r) between the population of diversity indices and each population of occupational intensities. This coefficient is an expression of the relationship between paired measures which expresses both the direction (+ or −) and strength of covariation between those measures. Given a population of paired measures (xi, yi) where $i = 1, 2, \ldots n$; a strong positive correlation reflects a situation in which values of y increase as values of x increase; and a strong negative correlation results from a situation in which values of y decrease as values of x increase.

It should be emphasized that the Pearson's r provides only an index of the strength and direction of the relationship between such paired observations and, as such, cannot be interpreted as a test of *significance* of that relationship. The square of the r statistic (r^2), however, can be seen as expressing the relative proportion of variance among one set of the paired measures which is accounted for by the other set of measures (Roscoe 1969:79).

The following section provides data summarizing the results of analysis directed toward describing the relationships between measures of vegetative diversity encompassed by 5 km radius catchments for each residential locality and different measures of occupations intensity for each locality. These data are presented graphically to illustrate the relationships and are expressed as correlation coefficients (r) and squared correlation coefficients (r^2) for each comparative measure. Figures 5.5 through 5.10 provide this information.

Vegetative Diversity and Site Density

Figure 5.5 graphically illustrates the relationship between vegetative diversity indices and measures of site density monitored as number of sites per ha. The overall correlation coefficient (r) among these measures for the 12 residential localities is +.44, or a relatively weak positive correlation. The value of r^2 for this correlation is .19, which indicates that slightly less than 20 percent of the variance among one set of the measures is accounted for by the other set of measures.

Inspection of Fig. 5.5 indicates that of the four localities which deviate the greatest from a projected regression line through the distribution, three are eastern localities and one is a western locality. In general, the western residential localities tend to conform slightly better to expectations of the diversity model than to the eastern localities. The correlation coefficient for diversity indices and site densities among the five western localities is +.70 (r^2 = .49); whereas it drops to +.36 (r^2 = .13) for the seven eastern residential localities.

The salient observation to be made is that in neither case is a substantially strong positive correlation between site density and vegetative diversity demonstrated.

Vegetative Diversity and Site Area Measures

A second way of estimating variation in occupational intensity for purposes of evaluating the diversity model was that of computing the percentage of surveyed landscape which was encompassed by total site area within each residential locality. Figure 5.6 illustrates the relationship between diversity indices and site area percentage estimates. Again it can be seen that, although a positive correlation exists between the two variables (r = +.36), the value of r^2 (.13) indicates that the strength of the relationship is very weak.

When the seven eastern residential localities are examined as a single population, the value of r increases slightly to +.49 (r^2 = .24). In contrast, the value of r decreases slightly when computed for the five western residential localities (r = +.31; r^2 = .10).

It is perhaps interesting to note that, if the extreme southernmost residential locality (1 east, diversity = .46; site area per ha = .0006) and the extreme northernmost locality (16 west, diversity = 1.08; site area per ha = .17) are excluded from the population, two distinctly different regression lines can be projected for the eastern and western populations of localities (see Fig. 5.6). The value of r for eastern residential localities exluding locality 1 east becomes +.66 (r^2 = .43); and for western residential localities, excluding locality 16 west, r becomes +.62 (r^2 = .38).

Despite these tendencies toward increasingly stronger positive correlation coefficients in each case, the most critical observation which might be made concerning the relationship between vegetative diversity measures and estimates of site area is that in no case is more than 44% of the variance among one set of measures accounted for by the other set of measures, even when *aberrant* localities are excluded from both populations.

It can be suggested, then, that data concerning vegetative diversity and estimates of site area define a kind of positively correlated *tendency* such as that suggested by the vegetative diversity model. These data in no way, however, demonstrate the magnitude or strength of positive correlation which might be expected given assumptions of the model itself; and are thus, at best, inconclusive.

Vegetative Diversity and Hearth Density (per hectare)

A third measure of occupational intensity developed to assess the vegetative diversity model accounting for settlement behavior is that of densities of hearth facilities per hectare of surveyed landscape within each residential locality. Figure 5.7 illustrates a scattergram of hearth densities versus vegetative diversity indices characterizing each of the 12 residential localities for which such measures could be defined.

The overall correlation coefficient for this distribution (r = +.19) *indicates, at best, an ephemerally positive relationship* between the two measures (r^2 = .04 or less than 4% of the variance in hearth density accounted for by vegetative diversity, or vice versa). Through stratifying the two populations of residential localities into eastern and western subsets, the correlation coefficients are increased slightly for each population (r = +.38 for eastern localities; and r = +.52 for western residential localities). Values of r^2 for each subset, however, are again very low (r^2 = .14 for eastern localities, and r^2 = .27 for western localities), which indicates that the strength of correlation between diversity indices and hearth density measures is relatively insignificant in terms of expectations of the diversity model itself.

Vegetative Diversity and Hearth Density (per square meter of site area)

A fourth measure of occupational intensity employed to evaluate the vegetative diversity model is an index of hearth facilities per m^2 of site area, derived through summing the total number of hearths within each residential locality, and dividing by the total m^2 of site space within that locality.

Figure 5.8 presents a scattergram of this index of occupational intensity. It can be noted that vegetative diversity and hearth density per m^2 of site area, across all 12 residential localities, exhibit an essentially *uncorrelated* distribution wherein r = —.17, and r^2 = .005.

Values of r^2 calculated independently for the eastern residential localities (r^2 = .004) and the western residential localities (r^2 = .09) indicate as well that less than 1% of the variance in hearth densities per m^2 of site area can be seen as accounted for by vegetative diversity measures, or vice versa.

Vegetative Diversity and Artifact Density (total sample area estimates)

The first set of artifact density estimates developed to evaluate the vegetative diversity model involved comulatively summing *all* areal sample frames established during survey for each site location in terms of the total area sampled per residential locality in m^2; and dividing by the total artifacts observed within those summed sample frames to arrive at a ratio of artifacts per m^2 overall for each residential locality.

These data are illustrated as a scattergram in Fig. 5.9. It can be seen very quickly that neither the eastern residential localities nor the western residential localities are characterized by variation in artifact densities which tend to support the expectations of the vegetative diversity model; and, further, that properties of the artifact density/vegetative diversity distributions for eastern and western localities are radically different.

Artifact densities for the western residential localities are uniformly low (between .03 and .15 per m^2); whereas artifact densities for the eastern residential localities exhibit a great range of variation (between .46 and 2.53 per m^2).

The correlation coefficient for this overall distribution is —.26, with an r^2 value of .07. The distribution clearly does not fit expectations of the diversity model as a control of occupational intensity.

Vegetative Diversity and Artifact Density (adjusted sample area estimate)

A final measure of artifact density was undertaken through calculating the mean and standard deviation of artifact sample densities monitored within each residential locale, and dropping from the analysis all sample frames which exceeded one standard deviation above or below the mean value.

This procedure in fact resulted in deletion of a few extremely high density sample frames which had been placed over unusually dense concentrations of manufacturing debris. Figure 5.10 is a scattergram of adjusted artifact density values against vegetative diversity indices for all residential localities. The value of r for this distribution is —.18, or very nearly uncorrelated (r^2 = .03). When correlation coefficients are calculated independently for eastern and western populations of residential localities, values of r and r^2 are not substantially changed. For eastern localities, r = —.06, and r^2 = .004; whereas for western localities, r = —.28, and r^2 = .08. In neither case are expected strong positive relationships between values of artifact densities and vegetative diversity demonstrated.

Summary of Test Results

The preceding analyses indicate very clearly that expectations of the vegetative diversity model are *not met* to any satisfactory degree by Archaic settlement data from the Cochiti Reservoir area. The expected relationship between diversity indices characterizing residential locality *catchments* and measures of occupational intensity within these catchments was one of a high, positive correlation. As summarized in the preceding discussion and on Table 5.4, it can be seen that correlation coefficients range from weakly positive (r = +.44 between site density and vegetative diversity) to weakly negative (r = —.26 between total artifact density and vegetative diversity). Perhaps more importantly, values of r^2 range between .002 and .19, indicating that very low proportions of variance in measuring of occupational intensity are essentially accounted for by measures of vegetative diversity.

Measures of site density and site area are most strongly correlated in positive fashion with vegetative diversity, whereas the different measures of hearth density resulted in a weak positive correlation in one case (hearths per hectare), and a weak negative correlation in the other case (hearths per m^2 of site area). It is perhaps interesting to note that both measures of artifact density (the *total* density per m^2 of site area, and the *adjusted* density per m^2 of site area) were negatively correlated with vegetative diversity.

In summary, then, the test results demonstrate rather conclusively that vegetative diversity cannot be demonstrated to operate in any way as a significant determinant of the intensity of Archaic period occupation within the Cochiti Reservoir flood control pool boundaries given the kind of analysis conducted.

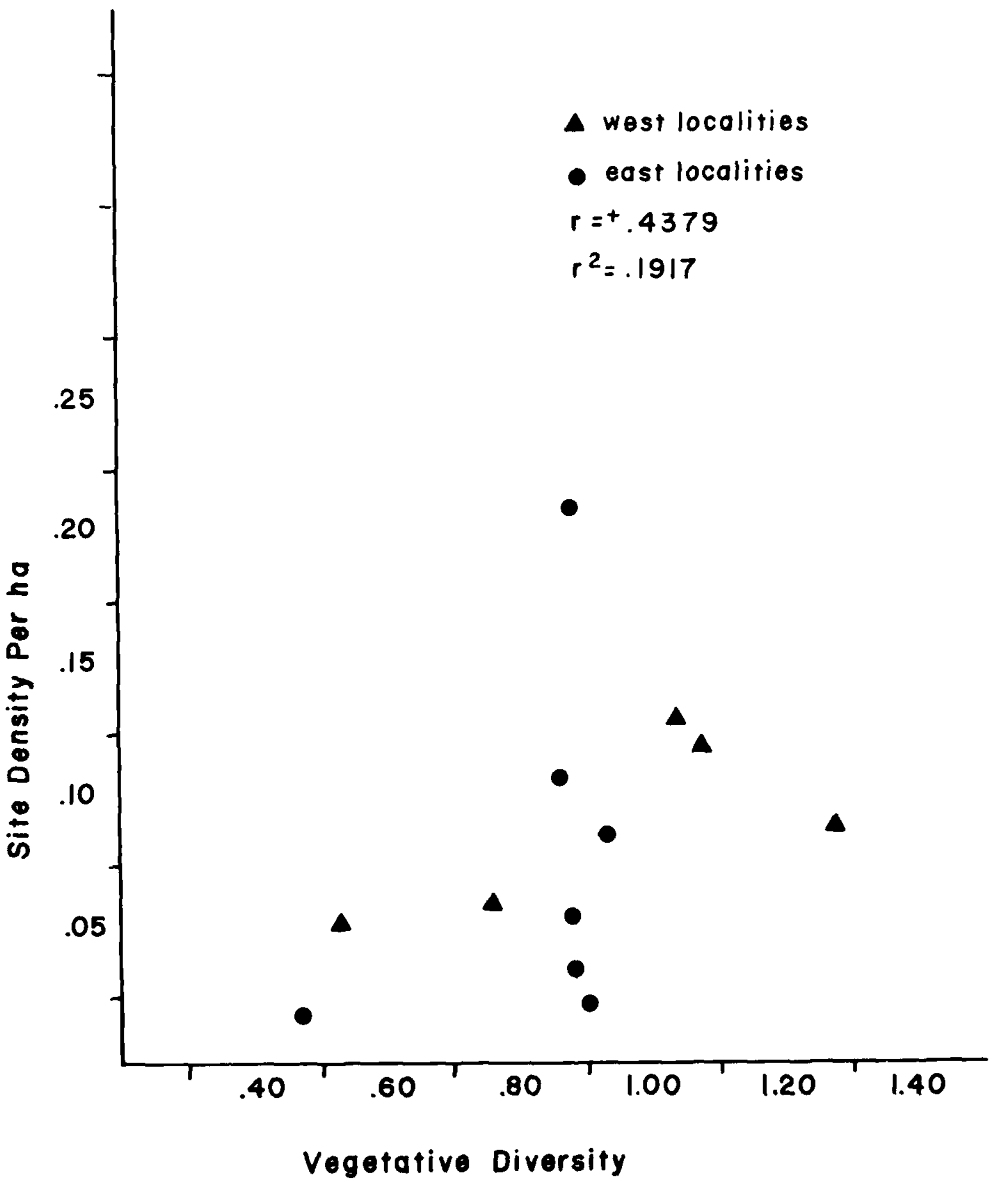


Fig. 5.5 Vegetative diversity and site density per hectare (ha)

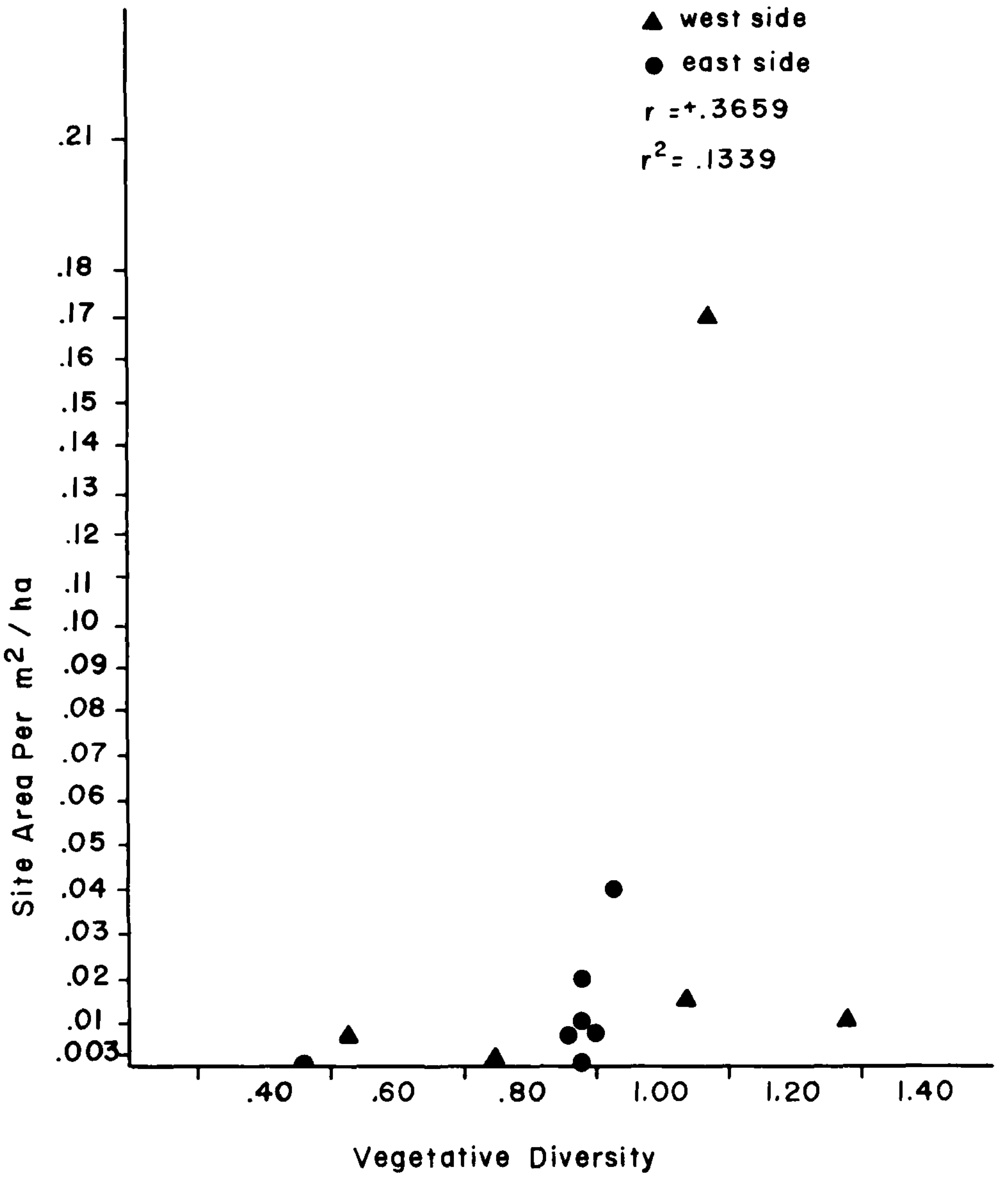


Fig. 5.6 Vegetative diversity and site area (m^2/ha)

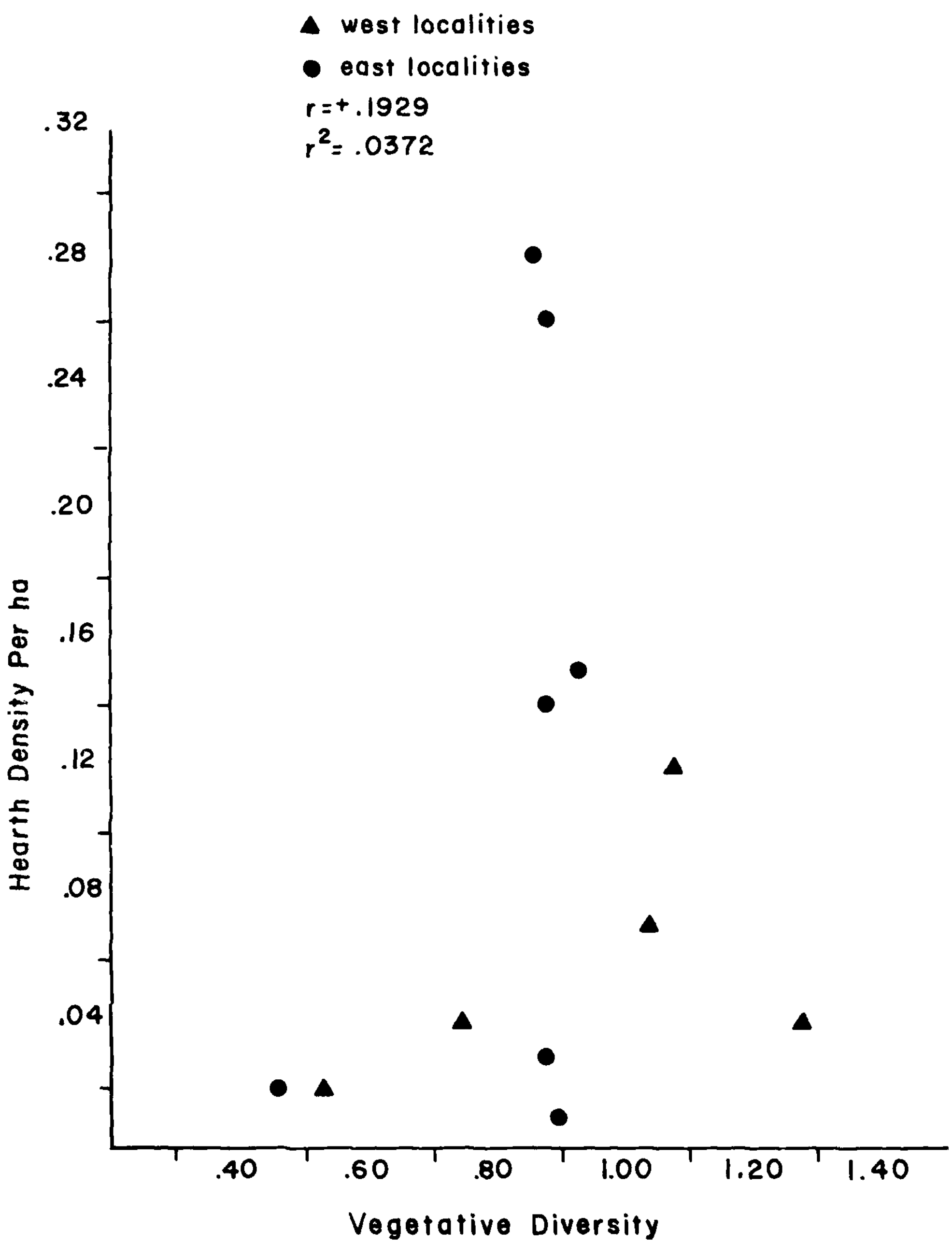


Fig. ' " Vegeta' diversity and hearth density per hectare (ha)

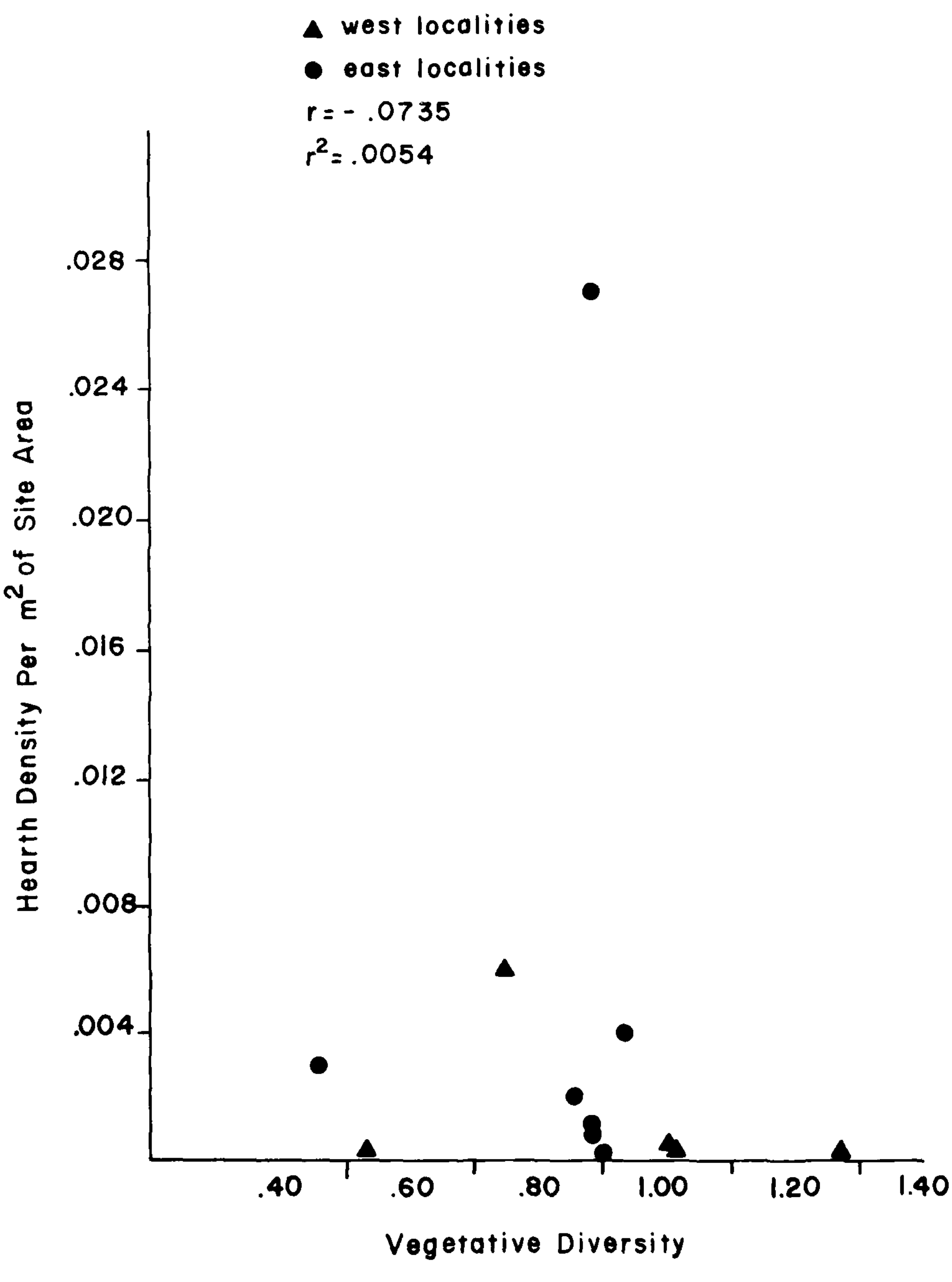


Fig. 5.8 Vegetative diversity and hearth density per m^2

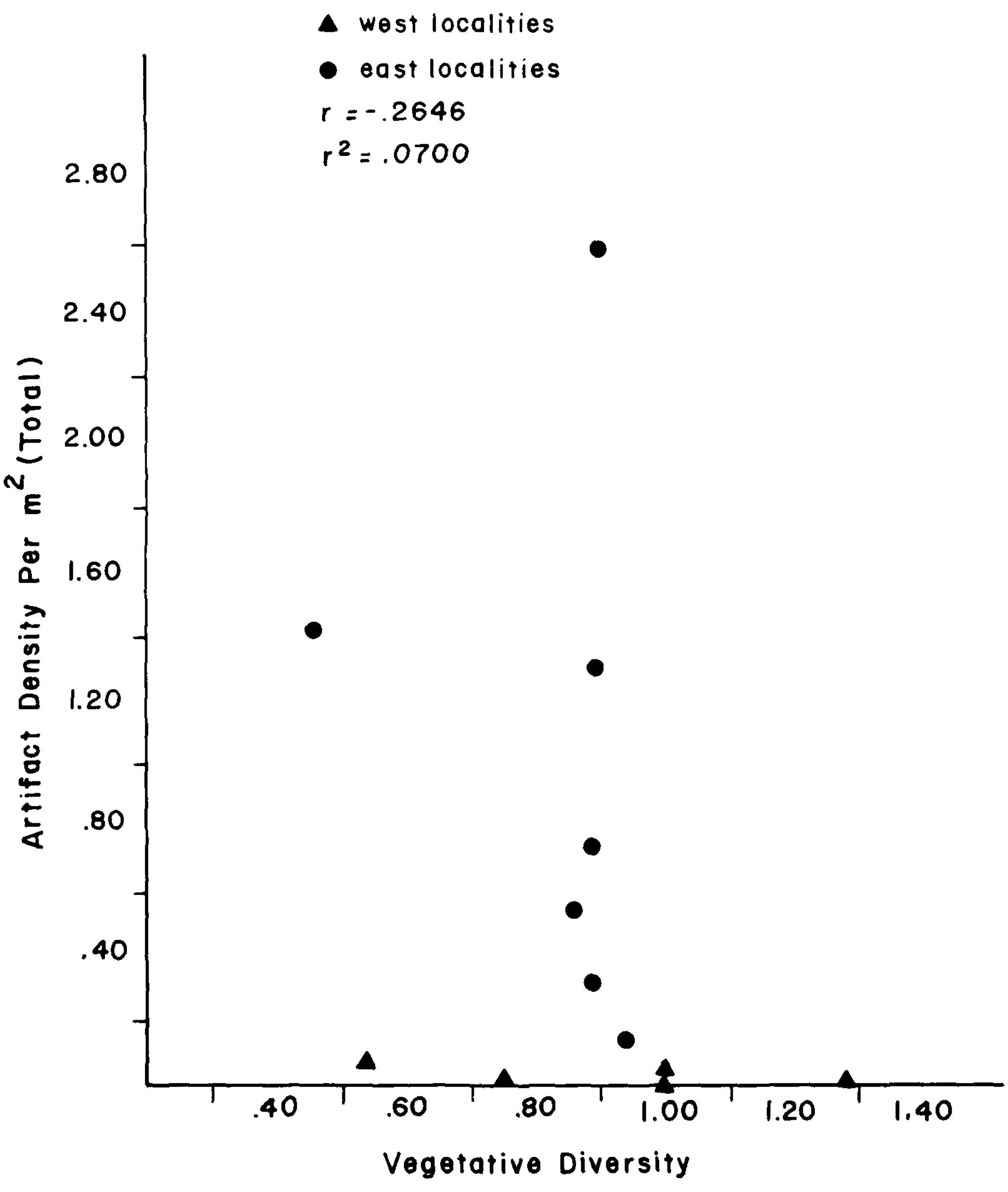


Fig. 5.9 Vegetative diversity and artifact density (total)

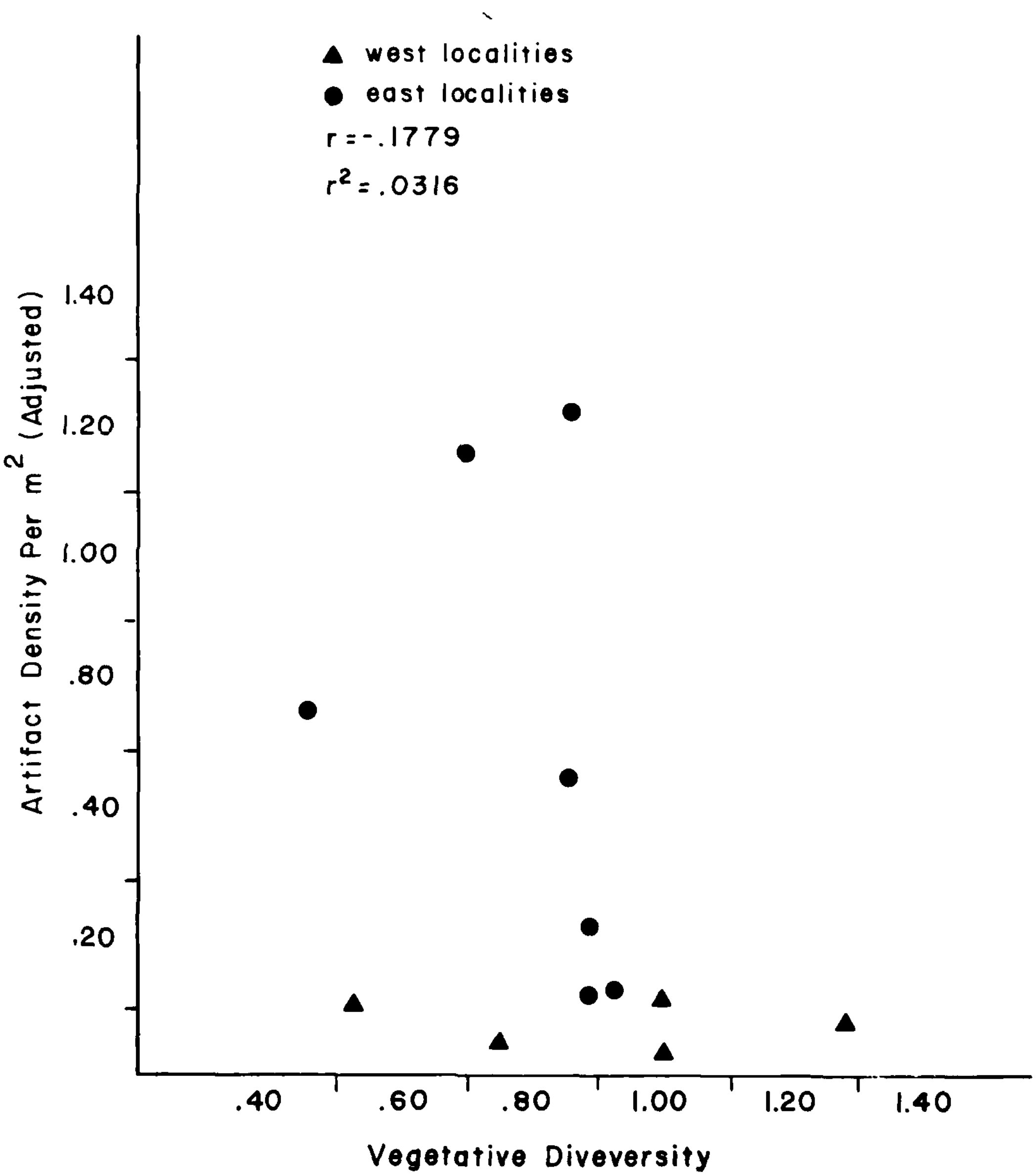


Fig. 5.10 Vegetative diversity and artifact density (adjusted)

Table 5.4

Correlation Coefficients (r) and Square Correlation Coefficients (r^2) between Vegetative Diversity Indices and Measures of Occupational Intensity

Variables	r	r^2
vegetative diversity: number of sites per ha	+0.4379	0.1917
vegetative diversity: site area per ha	+0.3659	0.1339
vegetative diversity: number of hearths per ha	+0.1929	0.0372
vegetative diversity: number of hearths per m^2 of site area	–0.0735	0.0054
vegetative diversity: number of artifacts per m^2 of summed sampled areas	–0.2646	0.0700
vegetative diversity: number of artifacts per m^2 adjusted sample (see text)	–0.1779	0.0316

EVALUATING RESULTS OF ANALYSIS

Before these results of the preceding analysis are taken as information to negate the vegetative diversity model, however, it would be useful to examine some of the properties of the analysis in more detail so as to offer alternative means of evaluating the model. Through this evaluation it may be possible as well to suggest a set of reasons why vegetative diversity may *not* have been a significa: ' factor conditioning Archaic period settlement within th study area.

Spatial Size of Vegetative Catchments

An initial question which can be addressed concerns whether the *size* of catchment areas defined might be either too small, or too large in scale for purposes of evaluating the diversity model. This question can be examined from two perspectives. First, ethnographic data concerning actual spatial extent of diurnal foraging behavior in the vicinity of campsites can be reviewed for their goodness of fit with distances used in the White Rock Canyon study. Second, the size of catchment areas used in the study can be manipulated in order to see whether vegetative diversity measures change as a function of area.

A cursory survey of ethnographic studies of arid foragers indicates that decisions to relocate residential camps are commonly made when distances between areas being exploited and the campsites begin to exceed two miles, or ca. 3.2 km (Lee 1968; Silberbauer 1972; Tindale 1972). When such distances reach four miles or ca. 6.4 km, residential campsties are inevitably relocated; and it is often stated that only under *extremely unique* circumstances is this maximum diurnal exploitive radius actually reached prior to camp relocation.

From this perspective, the 5 km radius employed in the analysis to define such exploitive catchments can be warranted as an appropriate scale for measuring diversity in vegetative resource availability—given the premise that Archaic period populations in the study area *were* engaged in an essentially residentially based foraging strategy for purposes of food acquisition.

The second part of this question, whether reducing or increasing the actual radii of catchment areas significantly alters diversity indices defining the 5 km radius catchments, can be examined, although not necessarily resolved, through evaluating differences in diversity measures describing successively larger catchment sizes for each residential locality. Because of limitations imposed by the absolute amount of land area which has been stratified into vegetative communities, this analysis will necessarily be restricted to variation in diversity measures describing successive 1, 2, 3, 4 and 5 km catchment radii.

Table 5.5 presents these successive diversity indices calculated for increasing radii defining each catchment area for each residential locality in the study area. For purposes of illustration, this variation has been graphically illustrated as two figures: Fig. 5.11, which illustrates the successively increasing catchment area diversity measures for residential *localities situated on the east side of the* Rio Grande (localities 1 through 8); and Fig. 5.12, which illustrates the same for residential localities situated on the west side of the Rio Grande (localities 11 through 16).

Through comparison, some interesting observations can be drawn between residential locality catchments situated on the east side versus the west side of the Rio Grande.

Table 5.5

Vegetative Diversity Measures for 1-5 kilometer Radii Diversity Indices

Locality #	1 km	2 km	3 km	4 km	5 km
1 east	.000	.000	.000	.012	.464
2 east	.000	.328	.504	.814	.902
3 east	.685	.691	.837	.880	.985
4 east	.215	.448	.724	.932	.934
5 east	1.311	1.183	1.037	.946	.862
6 east	.914	1.138	1.049	.979	.883
7 east	.652	1.073	.976	.926	.886
8 east	.540	.938	.976	.914	.887
9 east		(information inadequate)			
10 east		(information inadequate)			
11 west	.644	.491	.358	.415	.538
12 west	.669	.604	.725	.757	.759
13 west	.395	.644	.737	.732	.815
14 west	.645	.794	.865	.992	1.042
15 west	.782	.885	1.106	1.232	1.286
16 west	.964	1.322	1.282	1 200	1.084

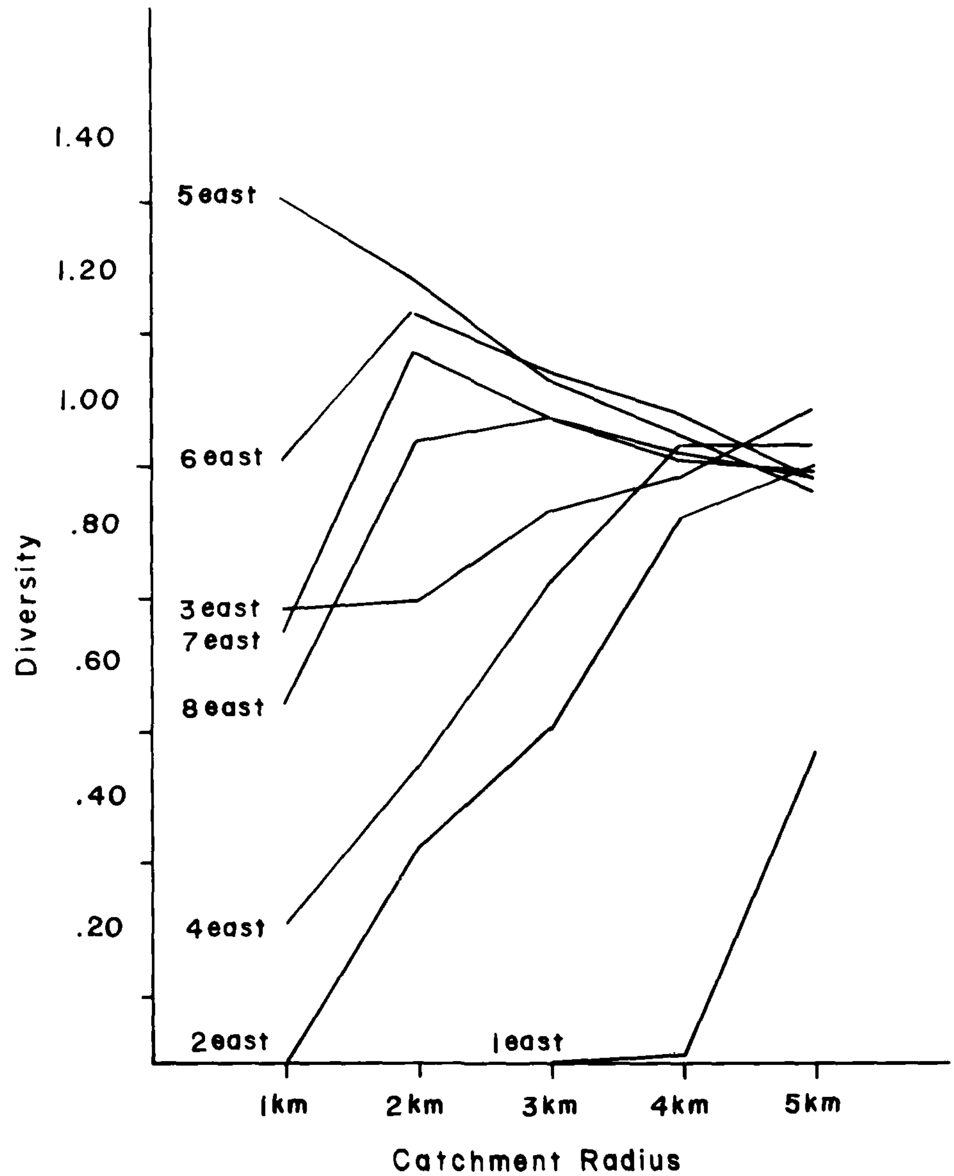


Fig. 5.11 Vegetative diversity and catchment radii for east side residential clusters.

First, the eastern catchments (Fig. 5.11) exhibit considerably more variation in diversity at 1 km and 2 km radii than do the western catchments (Fig. 5.12). Second, the eastern catchments (with the exception of locality 1 east) exhibit a distinct tendency toward convergence, or *similarity* in diversity measures as catchment radii increase; whereas the western catchments exhibit a slight tendency toward *increased variation* in diversity measures as catchment radii increase.

It can be suggested that this difference may well reflect a basic distinction in the spatial patterning of vegetative community distribution characterizing the Caja del Rio Plateau to the east of the river, and the Pajarito Plateau to the west.

Vegetative communities on the Caja del Rio occur predominantly as relatively large patches which are interspersed with one another in an irregular *mosaic* pattern.

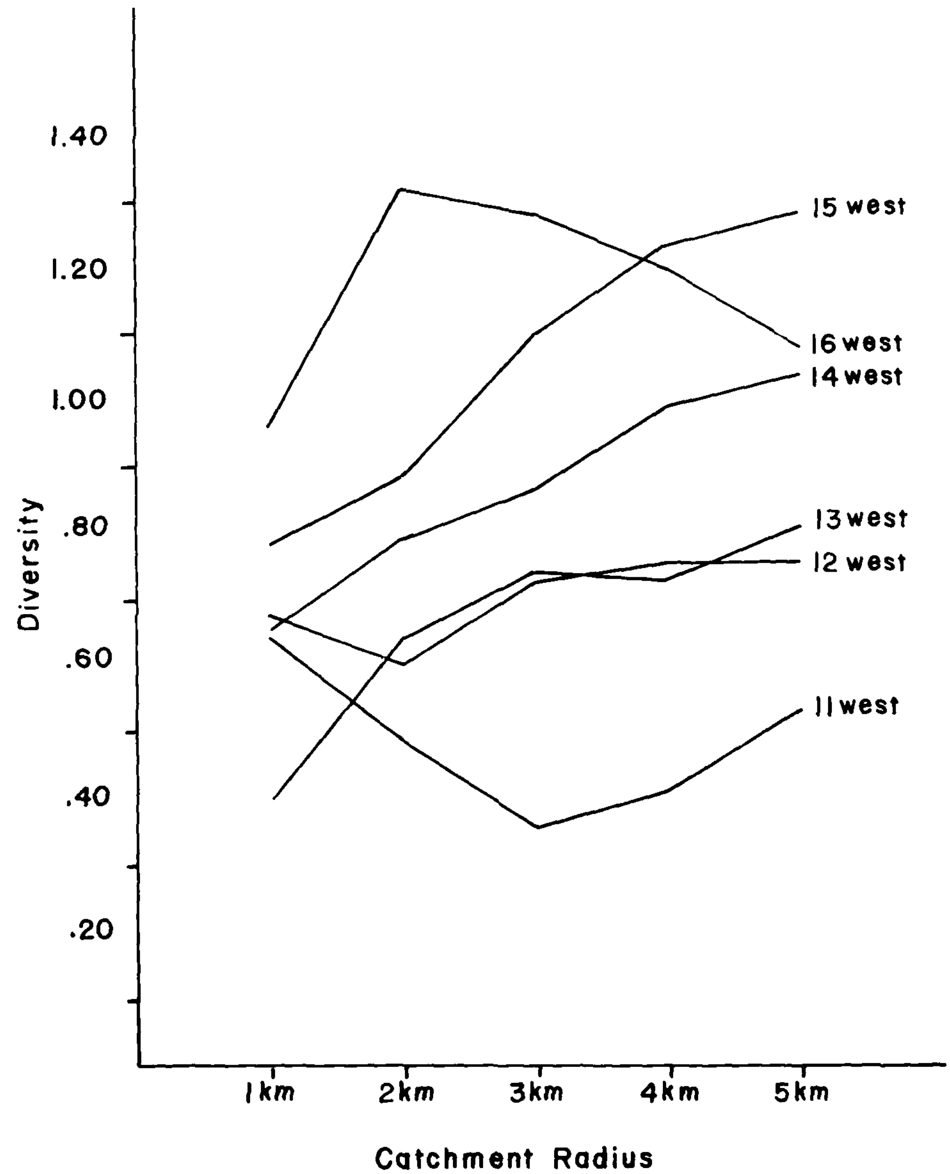


Fig. 5.12 Vegetative diversity and catchment radii for west side residential clusters.

Because the size of these vegetative patches is relatively large, the great range in variation of diversity measures defined by 1 km and 2 km catchment radii reflects basically whether catchment center points are falling, more or less, centrally within a single patch (such as localities 1, 2 and 4 east); or whether such center points fall near the intersection of several patches (such as localities 5 and 6 east).

As catchment radii are increased in length, however, successively larger land areas are encompassed within each catchment with the result that initially low catchment diversities become higher as greater numbers of communities become encompassed. Initially high catchment diversities become dampened as successively larger areas of particular communities are included.

The distinct tendency toward convergence of diversity measures reflected at the 4 km and 5 km radii sizes in all probability reflects a kind of maximum diversity value which would be maintained if the radii were extended even further within such a patchy community distribution.

The variation in diversity measures for the Pajarito Plateau catchments, on the other hand, seems to reflect a quite different patterning in vegetative community distribution (see Fig. 5.12). The Pajarito itself is an east sloping formation which is deeply dissected by easterly flowing canyon drainages with the result that vegetative communities tend to follow marked slope and exposure gradients. Thus, mesa tops between canyons, south facing canyon sides, north facing canyon sides and canyon bottoms all support different kinds of vegetative communities which are distributed in essentially linear fashion from east to west.

Radius defined catchment areas, centered as they are upon residential localities within White Rock Canyon itself at the eastern periphery of the plateau, encompass portions of this linear distribution at 1 km radii. As catchment radii are extended in length, they tend to encompass successively greater portions of essentially the same communities both up canyon from the particular locality center, and across adjacent canyon systems.

Unlike the Caja del Rio catchments, the Pajarito catchments seem to reflect a tendency toward increasing variation in diversity measures as catchment radii are lengthened. In addition, the absolute variation in diversity measures begins to become stratified at the 3 km radius length with lower diversities reflected for southernmost residential localities (11, 12 and 13 west) and high diversities reflected for northernmost residential localities (14, 15 and 16 west). This kind of patterning may well reflect variation in distances between canyon drainages which tend to be somewhat greater in the southern portion of Pajarito Plateau, and shorter to the north. This results in relatively broader zones of some mesa top vegetative communities in the southern area which tend to reduce diversity indices in those locales.

Summary observations which can be offered concerning the effect of catchment area size upon diversity indices within the study area are, then, as follows:

In the relatively more patchy Caja del Rio area east of the Rio Grande, vegetative diversity among residentially defined catchments along the Rio Grande itself is considerably greater in variation within shorter (ca. 1-2 km) possible foraging radii; and tends to become quite uniform as such radii reach 4-5 km. It can be suggested that further evaluation of vegetative diversity as a possible controlling factor over residential settlement behavior among Archaic period populations in such patchy environmental settings might profitably focus upon these smaller radius defined foraging catchments in the future.

In contrast, the Pajarito Plateau area west of the Rio Grande is characterized by vegetative community distributions which are distinctly more linear than patchy. Variation in vegetative diversity measures among different catchment locales is considerably less at the 1 km radius scale for western localities than for eastern localities, and tends to increase rather than decrease as catchment areas are increased in size. In addition, there is a distinct pattern of increasing diversity as one moves from south to north among catchment locales in the Pajarito which does not occur among locales on the Caja del Rio.

It seems clear from these differences that much of the variation in vegetative diversity measures among catchment areas is controlled by the *pattern* of community distributions in space. The Cochiti Reservoir data indicate that different scales of catchment area size result in distinctly different trends when scaled against patchy versus linear distributions. Future attempts to assess the role that vegetative diversity may play as a determinant of settlement behavior among foraging populations might well approach the problem through employing a *sliding* scale of catchment size to arrive at maximum values of diversity indices, rather than employing a single scale of catchment size.

Topographical Variation and Catchment Area Definition

A second question of methodological appropriateness concerns whether areas of potential food resources are best defined through employing *radii* as measures of distance from capsite locations. In this sense, the study area is characterized by extreme topographical variation, to the extent that straight line routes of travel from one place to another are either impossible, or at best highly difficult in terms of time and energy expenditure.

Although Archaic period site locations below the mouth of White Rock Canyon (within residential localities 1-4 east) are situated in topographic locales which permit relatively easy foot travel access to surrounding areas of landscape, the same is not true of the remaining east side and west side residential localities within White Rock Canyon itself. These latter locales are characterized by a variety of sheer cliff faces and extremely steep and rugged basalt talus slopes both adjacent to the Rio Grande in the canyon and adjacent to side canyons opening into White Rock Canyon.

The nature of this topography is such that straight line foot access from site locations (situated at lower elevations along the Rio Grande within White Rock Canyon) to higher surfaces is either impossible in some cases, or extremely difficult in most other cases. Daily travel to and from many portions of landscape encompassed by radius defined catchment areas surrounding these inner canyon residential localities would often require very circuitous routes. These may entail a kilometer or more of upcanyon or downcanyon travel, either along the Rio Grande or along bottoms of lateral drainages, before ready access to higher mesa surfaces could be attained.

In terms of some residential localities on the west side of the Rio Grande (especially localities 13-16), traveling to and from presumed food resource areas situated furthest from the residential camp would entail crossing as many as three canyon systems averaging some 300 ft in depth.

Given this kind of topographical complexity, it might be suggested that employing an essentially straight line radius kind of measure to encompass potential food resources is inappropriate.

A more appropriate means of bounding the spatial distribution of such resource areas might be proposed as an adjusted resource zone which took into account obvious topographical limitations of access.

One such measure can be offered in this regard. Many of the residential site localities are situated at or nearby the mouths of lateral drainagers opening into White Rock Canyon. The structure of vegetative community distribution generally follows elevational and exposure referents. Elevational variation from bottoms of drainages to mesa tops adjacent to drainages in the study area thus covaries with zonation in vegetative communities comprising the present cover within the study area in general.

It can be proposed that human travel from campsite locales situated near the mouths of such drainages to and from areas of vegetative food resource acquisition might best be maximized as essentially up drainage- -down drainage diurnal routes of movement. In this respect, a variety of north-slope and south-slope vegetative communities could be accessed at any given point in the foraging route; as could particular avenues of more efficient (or less tiring) access to higher mesa surfaces adjacent on either side of the drainage valley constituting the travel route itself.

In terms of methodologically defining boundaries of catchments potentially comprising spatial areas of resource exploitation by Archaic period populations, then, it can be offered that a drainage-based definition might constitute a more realistic approximation of areas in fact exploited by prehistoric foraging populations than would a radius-based definition of such catchments.

With respect to the diversity model, the alternative utility of this way of defining catchments can be somewhat crudely assessed through examining measures of vegetative community diversity characterizing particular drainage basins exhibiting Archaic residential locales at their mouths, and comparing these measures with diversity indices derived for the 5 km radius defined catchments for the same residential locales.

Data for developing indices for drainage basins are found in Drager and Loose (1977:Table II.2.2); and are summarized in Table 5.6 of this chapter. Data concerning diversity indices for both eastern and western residential localities have been included in Table 5.6.

It should be noted that in four cases Archaic site distributions are situated in locales which offer equal up canyon access to two canyon systems (localities 4 and 5 east; 13 and 14 west). In these cases, diversity indices for both canyon systems have been presented in the table. It should also be noted that six of the canyon system drainages extended beyond the limits of the vegetative stratification (Santa Fe, Bland, Rio Chiquito, Sanchez, Medio and Capulin). Diversity indices for these systems were calculated upon only those land areas they encompassed within the boundaries of the vegetative stratification. For this reason the total area in square kilometers which was monitored is included in the table. Finally, four of the Archaic residential

Table 5.6

Comparison of Drainage Basin and Catchment Area Diversity Indices

Locality	Basin	Basin Diversity	Basin Area (km²)	5 km Catchment Diversity	5 km Catchment Area (km²)
1 east	Santa Fe*	.476 (3)**	45.1	.464 (5)**	66.3
2 east	Canada de Cochiti	.927 (3)	35.7	.902 (5)	70.4
3 east	Santa Cruz	.991 (3)	8.1	.985 (7)	56.9
4 east	Basin No. 1	.525 (3)	8.7	.934 (6)	47.1
	Basin No. 2	.673 (2)	1.6		
5 east	White Rock Canyon				
6 east	White Rock Canyon				
7 east	Basin No. 8	.422 (3)	2.5	.886 (6)	35.9
	Basin No. 9	.781 (3)	9.6		
8 east	Arroyo Montoso	.565 (3)	25.1	.887 (4)	42.6
9 east		(information inadequate)			
10 east		(information inadequate)			
11 west	Basin No. 24	.627 (2)	4.5	.538 (7)	41.1
12 west	White Rock Canyon				
13 west	Bland*	1.203 (8)	53.6	.815 (6)	47.9
	Rio Chiquito*	1.452 (8)	35.3		
14 west	Sanchez*	1.357 (8)	19.4	1.042 (6)	50.2
	Medio*	1.338 (9)	16.0		
15 west	Capulin*	1.679 (9)	48.2	1.286 (6)	41.8
16 west	White Rock Canyon				

* measured only for area of basin within boundaries of areal stratification
** figures in parentheses represent number of vegetative communities within basin

locales were situated within land areas drained only by White Rock Canyon itself, or in areas essentially between major side drainages, such that no comparison of their drainage based catchments could be effectively undertaken.

Given the comparison of 5 km radius defined catchment area diversity measures, and the drainage basin defined catchment area diversity measures for those Archaic residential localities where such comparison can be made (see Table 5.6), two basic observations can be made.

First, for localities situated on the east side of the Rio Grande, radius defined catchment diversity measures are either relatively similar to drainage defined measures (in the cases of localities 1, 2 and 3 east) or slightly higher (in the cases of localities 4, 7 and 8 east). It can be seen that the amount of land area encompassed by the arbitrary 5 km radii is, in all cases, much greater than the land area encompassed by the drainages themselves. Given the essentially patchy character of vegetative communities comprising the Caja del Rio, this has resulted in a greater number of vegetative communities being encompassed by the arbitrarily defined catchments in all cases.

Second, for those localities situated on the west side of the Rio Grande, radius defined catchment diversity measures are uniformly lower than drainage basin defined catchment diversity measures. This pattern persists despite the fact that, in some cases, the amount of land area encompassed by 5 km radii catchments is less than encompassed by drainage defined catchments (localities 13 and 15 west).

With the exception of locality 11 west, however, drainage defined catchments west of the Rio Grande encompass two or three more vegetative communities than do the radius defined catchments which, in itself, accounts for the increase in diversity measures.

These additional vegetative communities are, in fact, situated at higher elevations in the Jemez mountains at distances greater than 5 km from the residential centers themselves.

Perhaps the most important observation to make concerning differences between radius and drainage basin defined catchment diversity indices is that, in both cases, diversity measures are lower at the southern end of the study area, and become higher toward the northern end of the study area.

In summary, then, it can be suggested that for residential localities along the Caja del Rio side of the Rio Grande, where topographical relief is more subdued, variation in vegetative diversity indices seems to be predominately controlled by absolute size of catchment areas rather than by *how* those catchments are defined (i.e. through radii, or as drainage basins). In the case example, these eastern catchment areas defined by drainage basin boundaries were smaller in extent, encompassed fewer vegetative communities, and hence exhibited slightly lower diversity indices than did catchment areas defined by 5 km radii.

For residential localities situated along the Pajarito Plateau side of the Rio Grande, where topographic relief is more pronounced, variation in vegetative diversity indices seems to be controlled not so much by absolute *size* of catchments or by the manner in which those catchments are defined but by whether the catchments are located toward the southern or northern ends of the study area and by the amount of land areas at higher elevations that are encompassed.

Drainage basin defined catchments thus tend to include land areas at higher elevations and at distances exceeding 5 km from residential centers and thus exhibit generally higher diversity indices than do radius defined catchments west of the Rio Grande. In general, however, diversity indices for catchment areas in the southern portion of the study area are lower, whereas diversity indices in the northern portion of the study are higher, *regardless* of the manner in which they are defined.

In conclusion, it can be suggested that the character of topographical relief, especially along the western side of White Rock Canyon at the base of the Pajarito Plateau, is of such a highly convoluted nature that the most appropriate definition of actual foraging areas attentuating to residential camps along the river might well be defined along drainage basin boundaries.

From the perspective of vegetative diversity measures, however, essentially little difference exists between drainage basin defined catchments and radius defined catchments which cannot be accounted for by either absolute size of catchment areas (along the eastern side of the Rio Grande) or by latitudinal placement and absolute elevations of land areas encompassed by catchment areas (along the western side of the Rio Grande).

It is offered, then, that for purposes of evaluating the vegetative diversity model as a control of Archaic settlement intensity within the study area, the use of radius defined catchment areas to assess variation in vegetative diversity is an appropriate strategy.

Resource Potential as Species, Community or Life Zone Diversity

Another kind of question which might be asked of the analysis concerns whether the manner in which estimates made of vegetative food resource diversity were appropriate to the goals of the analysis. In this sense, variation in diversity of *vegetative communities* encompassed by catchment areas was employed as the sole monitor of vegetative food resource diversity. It could be argued that variation in *species* diversity might be a more appropriate fine-grained measure in this regard; or conversely, that locational access to areally broader life-zones might be a more appropriate coarse-grained estimate of food resource potential in this regard.

These kinds of questions of specificity or generality in characterization of food resource availability ultimately center about a single question: assuming that diversity per se among vegetative food resources constitutes a control of settlement behavior, what is the exact *scale* of diversity which operates as such a control? In this sense, should effective diversity be assumed to be species composition within a catchment universe of hectare plots, community composition per km^2, or should it be considered as life zone composition within worldwide longitudinal and latitudinal referents?

Although this question cannot be rigorously evaluated with respect to the case at hand, some observations concerning spatial variation in food resource species composition in the study area can be made which provide a degree of insight into the problem.

Tierney's description of species composition of several sample plots within White Rock Canyon and immediate environs (Tierney 1977, this volume) indicates that some food resource species may be found in several vegetative communities within the study area. Tierney's research involved monitoring nine sample plots distributed across four of the vegetative communities defined by Drager and Loose (1977), including the Upper Sonoran Juniper, Upper Sonoran Arid, Juniper Grassland and Riparian communities.

One-hundred-one different edible species were identified throughout all nine sample plots (see Tierney, this volume, Table 2.1). Of these, 58% were unique in occurrence within particular vegetative communities; 31% occurred within two vegetative communities; and 11% were found in three communities (Table 5.7). It might be noted that two-thirds of the species occurring in two different communities were common to the Juniper and Juniper Grassland communities, which intergrade with one another over many portions of the study area.

Table 5.7
Frequency of Edible Species in Vegetative Communities

Community*	# Unique Edible Species**	Total # Edible Species**
Juniper only	21	62
Arid only	11	28
Juniper Grassland only	15	47
Riparian only	12	17
Juniper & Arid only	5	—
Juniper & Juniper Grassland only	21	—
Juniper & Riparian only	4	—
Arid & Juniper Grassland only	1	—
Juniper & Arid & Juniper Grassland	10	—
Juniper & Arid & Riparian	1	—

* after Drager and Loose 1977
** edible species calculated from Tierney, this volume

Given this rudimentary assessment of actual species distributions throughout the study area, it can be suggested that measuring diversity at the vegetative community scale of observation may account adequately for species diversity as well.

In order to refine these estimates, future investigation should probably focus upon evaluating relative volume productivity of edible parts among species common to two or more communities, versus those found only within single communities.

Whether a substantially larger spatial scale of vegetative diversity (such as life zone variation) might be a more appropriate means of investigating controls of foraging settlement, is more difficult to assess. The lower White Rock Canyon locale is situated more or less centrally at the interface of three relatively broad topographical and vegetative zones: the Caja del Rio Plateau and the La Majada Mesa to the east and southeast; the Pajarito Plateau and Jemez Mountains to the west; and the broad alluvial Rio Grande Valley to the south. Because of the Rio Grande, White Rock Canyon itself might be seen as a fourth such zone, although the character of vegetation within the canyon, although supporting a few riparian species, is not substantially different from that surrounding it to the east and west.

From this areally larger perspective, a reasonable consideration underlying settlement behavior might be the degree to which residential site locations within the White Rock Canyon vicinity may reflect relatively brief occupational episodes which constitute campsites essentially en route to or from surrounding topographic and vegetative zones. In this sense, it could be offered that *significant* differences in the kinds of both vegetative and faunal food resource species within the region are really reflected as variation among major elevationally and physiographically defined subregional life zones. Regional patterning in residential settlement by foraging groups might thus be seen as fundamentally controlled by (1) seasonal availability and abundance of food resources among these broader resource zones, such that variation in location and long term occupational intensity within any given single zone (such as the White Rock Canyon area) may be controlled to a much greater extent by regional patterns of transit among those subregional locales, and (2) particular features of water availability and topographical setting within such zones, rather than by vegetative diversity within the diurnal foraging radius of each site.

CONCLUSIONS

The preceding study has endeavored to undertake an explicit evaluation of what can be termed the *vegetative diversity model*. This model suggests that over a period of years Archaic hunter-gatherer populations will relocate their residential campsites more frequently in places which permit access to a significantly greater variety of vegetative food resources. If verified, the model offers potential for becoming a powerful predictive tool because it is derived from general ecological principles which underly the distribution of other species.

The present study employed several measures of settlement or occupational intensity charactertizing Archaic site locations in White Rock Canyon and evaluated whether significant correlations of occupational intensity and vegetative diversity within that study area pertained.

The results of this analysis were decidedly negative. Several avenues of investigation were then explored to assess whether those negative results were artifacts of analysis. It was concluded that the lack of correlation between settlement density and variation in vegetative diversity did, in fact, reflect the reality of past behavior in the study area.

These negative test results have several implications for future investigation into the relationship between properties of the effective environment and Archaic settlement and subsistence behavior. First, it can be suggested that the vegetative diversity model *in its present formulation* cannot be warranted as a general principle of man-environment relationships characterizing the Archaic period.

Since expectations of the models have been met for some case examples in other areas in the Southwest (Allan et al. 1975; Reher and Witter 1977), the more general question must be asked *What are the parameters which condition different settlement responses to different patterns of vegetative resources?*

Previous attempts to evaluate the model have held a great number of *things equal* in analysis, more often implicitly than explicitly. Results of the present test indicate that analytically defined variables such as shape and size of catchment areas and different measures of settlement intensity result in observably different values of correlation when using the same environmental data. Similarly, basically different structures of vegetative patterning characterizing the White Rock Canyon locale can be demonstrated to have an effect upon the outcome of correlative tests employing the same measures of settlement intensity.

Taken together, test results from the White Rock Canyon study area clearly indicate that future investigation of the relationship between vegetative diversity and Archaic settlement behavior must begin to treat certain features of both environment and human behavior as *variables* rather than as assumed *constants*.

These include shape and size of catchment areas used in analysis relative to shape and size of vegetative communities actually comprising the area of study, and kinds of archeological data which are ultimately used to measure settlement intensity. In this latter regard, a clear direction for future research can be identified as the need to model how particular aspects of observable material remains actually reflect particular properties of land use or settlement behavior.

When the actual character of settlement distribution and vegetative food resource availability parameters can be established using a set of archeological case examples of Archaic period settlement, we will be in a position to construct a truly explanatory model which accounts for variation in vegetative diversity as it relates to properties of settlement behavior.

Toward this goal, a final comment based upon what we have learned from Cochiti Reservoir can be offered. The reservoir locale, as noted in the analysis, is situated in one of the most vegetatively diverse areas of the North American continent. Given this knowledge, we must consider whether variation in relative diversity within such a highly diverse setting is significant as a control of Archaic settlement response, or if the values of intensity of occupation characterizing settlement within the reservoir are better used as comparative data for evaluating other patterns of settlement in other less diverse environmental settings.

Survey data are now available from a broad range of environmental settings throughout the Southwestern United States which can be used to continue this kind of investigation. It is hoped that the analyses documented here will stimulate productive use of that information in the future.

Chapter 6

CHANGING RESIDENTIAL PATTERNS AMONG THE ANASAZI, A.D. 750-1525

Jan V. Biella

INTRODUCTION

The Anasazi occupation of the Cochiti Reservoir locality has been one with dramatic shifts in character of settlement for some eight centuries of puebloan prehistory. These shifts often parallel changes documented in other regions in the northern Rio Grande and elsewhere in the Southwest (Wendorf and Reed 1955; McGregor 1974), although they tend to occur at slightly later times. There has been a tendency for archeologists to interpret these changes as a developmental sequence with demographic or climatic factors being proposed as causal factors. Often models employing these variables depend upon (or assume) a continuity in the occupation of a region or subregion and cite shifts in the occupation of one locality to another as behavioral responses by a single population to deteriorations of the environment, overcrowding or some similar approach. They do not, however, provide explanations for areas with discontinuous occupational sequences.

The Cochiti Reservoir archeological record for the Anasazi period appears to be one which stands in contrast to this assumption of continuity and one which may not easily depend upon a developmental approach. For this reason, an attempt will be made in this article to examine some properties of the changes in settlement which are not dependent upon linking the antecedents of one occupational population to another. Instead, the analysis will attempt to elucidate variation in the basic character of residence for the Anasazi populations of the Cochiti Reservoir area such that some fundamental aspects of the character of Anasazi adaptation might be identified. This analysis will begin with the earliest Anasazi occupation of the area in ca. A.D. 750 and will continue to its latest prehistoric occupation in ca. A.D. 1525.

Chronological Classifications

In the northern Rio Grande region two different typological schemes have been employed to categorize the prehistoric Anasazi sequence. One is the multiregional Pecos Classification (Basketmaker II and III; Pueblo I, II, III, IV and V) and the other is the Rio Grande Classification (Developmental, Coalition, Classic and Historic). The Pecos Classification was initially developed in 1927 and divided Anasazi prehistory into cultural stages which were ordered into a quasievolutionary sequence (Kidder 1927). Since that time the Pecos Classification has undergone numerous modifications which adjust it to specific regional sequences. The most significant change over the years has been an attempt to assign temporal periods to each stage in the classification (McGregor 1974). The exact dates for these periods vary from region to region, a fact which has contributed to problems in utilization of the classification, if not partial abandonment of the classification, in some regions. The northern Rio Grande is one such region.

In 1954 Wendorf (and subsequently Wendorf and Reed 1955) proposed an alternative classification for the northern Rio Grande. Although this scheme is generally more consistent with the archeological record in the Cochiti area than is the Pecos Classification, the Rio Grande Classification has glaring dissimilarities as well. For example, the characteristic site plan for the Developmental period is a small pueblo unit of 10-12 surface rooms and an associated kiva (Wendorf 1954:203). In the Cochiti area this kind of site plan is routinely associated with ceramic assemblages (Santa Fe B/W and Wiyo B/W) which are characteristic of the later Coalition period elsewhere in the Rio Grande.

It may be suggested that such inconsistencies are unavoidable in the application of any broad regional classification, especially in attempting to unite cultural stages with specific temporal periods. In fact, one might expect such apparent *inconsistencies*, insofar as they indicate a lack of uniformity in regionwide patterns of cultural behavior characterizing sequences of temporal phases. Such a lack of uniformity provides extremely important information bearing upon the character of social and economic behavior which might coexist at different places within the general northern Rio Grande region.

For this reason neither the Pecos nor Rio Grande Classifications are employed per se in this article. Rather, the terms are used more or less interchangeably as *temporal* referents, excluding other diagnostic features associated with either classification.

Data Sets

In the following discussion a general cultural historical sequence for the Cochiti area will be presented. This sequence differs, in part, from that proposed in either the Pecos or Rio Grande Classifications and is based upon data compiled from a 40 x 30 km study area situated between 35°32'30" and 35°52'30" north latitude and 106°30' and 107°7'15" east longitude and extending roughly from the Santa Fe River in the south to Los Alamos Canyon in the north, to the Jemez Caldera in the west to Tetilla Peak in the east. The permanent pool of Cochiti Reservoir is situated approximately in the center of this study area.

The more detailed site specific data are derived three different excavation projects conducted over a 15 year period: the Museum of New Mexico's Cochiti Dam Salvage Project (Peckham and Wells 1967; Lange 1968; Snow 1971, 1976); the National Park Service, Southwest Region's Bandelier National Monument Cochiti Lake Project (Traylor, et al. 1977); and the Office of Contract Archeology, University of New Mexico's Cochiti Reservoir Project (Chapman and Biella 1977a; Biella 1979). All of the excavation localities are situated within or adjacent to the flood pool of Cochiti Reservoir.

DEVELOPMENTAL OCCUPATION

Introduction

Elsewhere in the northern Rio Grande beginning dates for the Developmental range from ca. A.D. 500-700 (Cordell n.d.) to 600 (Wendorf and Reed 1955). In the Cochiti area, the earliest manifestations which may be attributed to the Developmental begin around A.D. 750 (Peckham and Wells 1967). These studies generally are in agreement that the Developmental continues until ca. A.D. 1175 or 1200. Dates and associated ceramic types suggested for phases within the Developmental period can be summarized as follows:

BM-III†	Lino gray and/or San Marcial B/W	A.D. 750-850	(Peckham and Wells 1967)
P-I	Piedra B/W	850-950	(Peckham and Wells 1967)
early P-II	Red Mesa B/W	950-1025 or 875-1050	(Peckham and Wells 1967) (Warren1977c)
late P-II	Kwahe'e B/W	1025-1175 or 950-1225*	(Peckham and Wells 1967) (Warren1977c)

† Neither Peckham and Wells (1967) nor Warren (1977c) link the nominal Pecos Classification headings with the ceramic types in their articles. Their articles strictly concern possible temporal ceramic sequences and dates. We have linked the ceramic groupings with Pecos *labels* for simplicity in referencing.

* Note that these dates for Kwahe'e B/W extend into the P-III period.

Evidence of an extensive occupation of the Cochiti study area during the entire Developmental period is lacking. Only 43 sites have been documented, 30 of which represent late P-II occupations. Developmental sites are generally small, consisting of 1-3 pithouse structures, and are occasionally associated with surface roomblocks and subsurface storage cists (Biella 1977:120-121). Pithouse villages have been noted outside the immediate area both to the south and to the northeast (Warren, personal communication).

Early Developmental sites (BM-III, P-I) are situated exclusively in the upper Middle Rio Grande Valley either near or adjacent to the modern Rio Grande floodplain or along the Santa Fe River near its confluence with the Rio Grande. The later Developmental sites are also situated in the upper Middle Rio Grande Valley but have been recorded as well along a few of the southernmost mesa tops and canyon bottoms in the Pajarito Plateau, especially from Frijoles Canyon south.

Three Developmental sites within the study area have been excavated. Table 6.1 summarizes available chronological information concerning their occupation.

Residential Patterns A.D. 750-950

Only one site (LA 272, Snow 1971) which may date toward the end of the early Developmental period, has been excavated. This site consists of three pithouses, two surface roomblocks (one of nine rooms arranged in a single linear row and the other of two contiguous rooms), another possible surface room or small eroded roomblock, one isolated storage pit, and a retaining or diversion wall. All of these structures are situated on a small mesa top with the pithouses situated roughly 12 m apart. Only one of the pithouses exhibited a central firepit. Another was poorly preserved but contained a burned area along its eastern wall. The third pithouse lacked any formal interior hearth

Table 6.1
Chronology for Excavated Developmental (P-I and P-II) Sites

Site by Occupation or Component	Archeomag.	Dendro.	Ceramic	Reference
Early Pueblo II:				
LA 272	—	—	850-950	Snow 1971
Late Pueblo II:				
LA 6461 unit I				
lst occupation (pithouse 1)	—	—	mid Kwahe'e	Bussey 1968a:10
2nd occupation (pithouse 2)	—	—	late Kwahe'e	Bussey 1968a:10
LA 6462 unit II (pithouses 1, 3)	—	—	late Kwahe'e	Bussey 1968b:19, 23
LA 6462 unit III	—	1119+vv (1 sample)	early Kwahe'e	Honea 1968:127; Bussey 1968b:23
LA 6462 unit IV	—	—	mid to late Kwahe'e	Bussey 1968b:38
LA 6462 unit V				
lst occupation (pithouse 1)	—	—	early Kwahe'e	Bussey 1968b:45
2nd occupation (pithouse 2 & storage pits)	—	1116+vv (4 samples)	mid Kwahe'e	Honea 1968:127; Bussey 1968b:50
LA 6462 unit VI	—	—	early to mid Kwahe'e	Bussey 1968b:53

although a small oval centrally located depression of unknown function was defined during excavation. Three of the rooms in the larger roomblock contained hearths as did one of the rooms in the other roomblock.

If all of the features from the site were occupied contemporaneously, six separate food sharing groups (cf. commensal groups, Chapter 1, this volume) would be represented. Whether this complex of features was occupied seasonally or annually is unclear. The presence of a subsurface storage pit and a minimum of seven possible bulk storage surface rooms would indicate a winter occupation. The presence of five *Zea mays* corncobs, all charred, from the fill of one of the pithouses (Ford 1971:Table 1) would be consistent with a winter occupation. The amount of artifactual debris recovered from LA 272 is suggestive of either a short term perennial occupation or a reoccupation, seasonally, over a period of years.

From survey records, LA 272 appears to reflect a typical early Developmental residential structure which centers around a pithouse complex. Although LA 272 was occupied during the late P-I into the early P-II phase (based upon the presence of Piedra and Red Mesa B/W ceramics) it is similar in configuration to BM-III and early P-I sites. Other types of residential sites documented on survey include small isolated roomblocks of 2-4 rooms and open campsites characterized by scatters of firecracked rock and artifactual debris. These latter presumably reflect warm weather residences, but could be logistical loci articulated with sites characterized by architectural residences.

Residential Patterns A.D. 950-1175

Two late Developmental sites (LA 6461 and 6462, Bussey 1968a, 1968b) have been excavated. Both are situated in the upper Middle Rio Grande below the mouth of White Rock Canyon (see Fig. 6.1). Four separate pithouse features were defined at LA 6461 but only two were completely excavated. One of the excavated pithouses was filled with trash during the occupation of the other. Most of the ceramics recovered from LA 6461 indicate a late Kwahe'e occupation for the second structure and probably a mid Kwahe'e occupation for the other.

LA 6462 is a large multicomponent (P-II/P-III) site which was excavated in spatially discrete proveniences, units I-VII (see Fig. 6.2). Each unit appears to reflect separate occupations and for purposes of this discussion will be considered as a separate analytical unit. Ten Kwahe'e pithouses were defined in all from LA 6462 and eight were excavated. They contained central hearths, often with a deflector and ash pit. Many contained small wall cists or an adjacent storage pit. Exterior pits were documented as well in association with some of the pithouses (see Table 6.1).

From ceramics in the fill of the pithouses early, mid and late Kwahe'e occupations are represented. Based upon a general lack in regularity in arrangement or orientation of the pithouses with respect to each other, coupled with the ceramic data, it seems apparent that the basic residential pattern represented at both LA 6462 and LA 6461 consisted of single households occupying isolated pithouses. The only possible indication of a larger residential cooperative group was recovered from unit II at LA 6462. This unit consisted of four pithouses which were roughly aligned (see Fig. 6.2). They thus could be interpreted as representing four cooperative households. It is important to note, however, that only two of these pithouses were ultimately occupied, both during the late Kwahe'e phase, and that the other two were never completed. If they did once indicate a possible relationship between four households, this relationship must have been of a rather fluid and impermanent nature.

Since all of the pithouse structures contained interior hearths, they appear to be suitable for cold weather, winter to early spring habitation. Bulk storage, another probable indicator of winter habitation, is well represented at most of the units at LA 6462 in the form of subsurface storage pits. These pits were irregular in shape and occasionally were directly joined to a pithouse (Table 6.2). The other pithouses generally contained defined compartments such as benches or cists suitable for some storage as well.

Surface roomblocks containing rooms lacking interior features which could serve as bulk storage repositories were completely absent at both LA 6461 and 6462. Although Bussey (1968a, 1968b) suggests that surface roomblocks associated with the Kwahe'e components may have been destroyed, it is important to note that numerous P-III roomblocks were preserved at LA 6462. One might also argue that with the presence of interior storage bins and exterior storage pits surface roomblocks might not necessarily be an expected storage strategy.

Direct evidence of storable resources was recovered in the form of corncobs and dried shanks of *Zea mays* at both LA 6461 and LA 6462 (see Table 6.3). The corn appears to have been stored in the husk with mature kernels (Ford 1968:240). Indirect evidence of stored resources is based upon the presence of considerable numbers of milling implements. For example, 23 manos and 10 grinding slabs were recovered from LA 6461 (Honea 1968:171). The presence of this quantity of milling implements indicates a considerable focus upon the grinding of grains, presumably including maize.

Nondomesticated flora including unidentified grass seeds, Amaranthus, and *Physalis* sp. (ground-cherry) were recovered from some of the pithouses and storage pits. The grass and Amaranthus would probably indicate procurement during the late summer or early fall (Tierney, this volume) although some grasses are available year-round. The Physalis is currently available in June in the Cochiti area (Tierney, this volume).

Evidence of occupation in other seasons is found in the presence of some fauna (see Table 6.3). An early spring or late fall occupation might be inferred from the presence of Canada goose at both LA 6461 and 6462 (Harris 1968: 199, 203) although these birds might be available nesting in the summer months (Lang, personal communication). In absence of data concerning ages of some of these animals, notably the large mammals, seasonality of procurement cannot be determined beyond the general availability of most of the species from spring through fall.

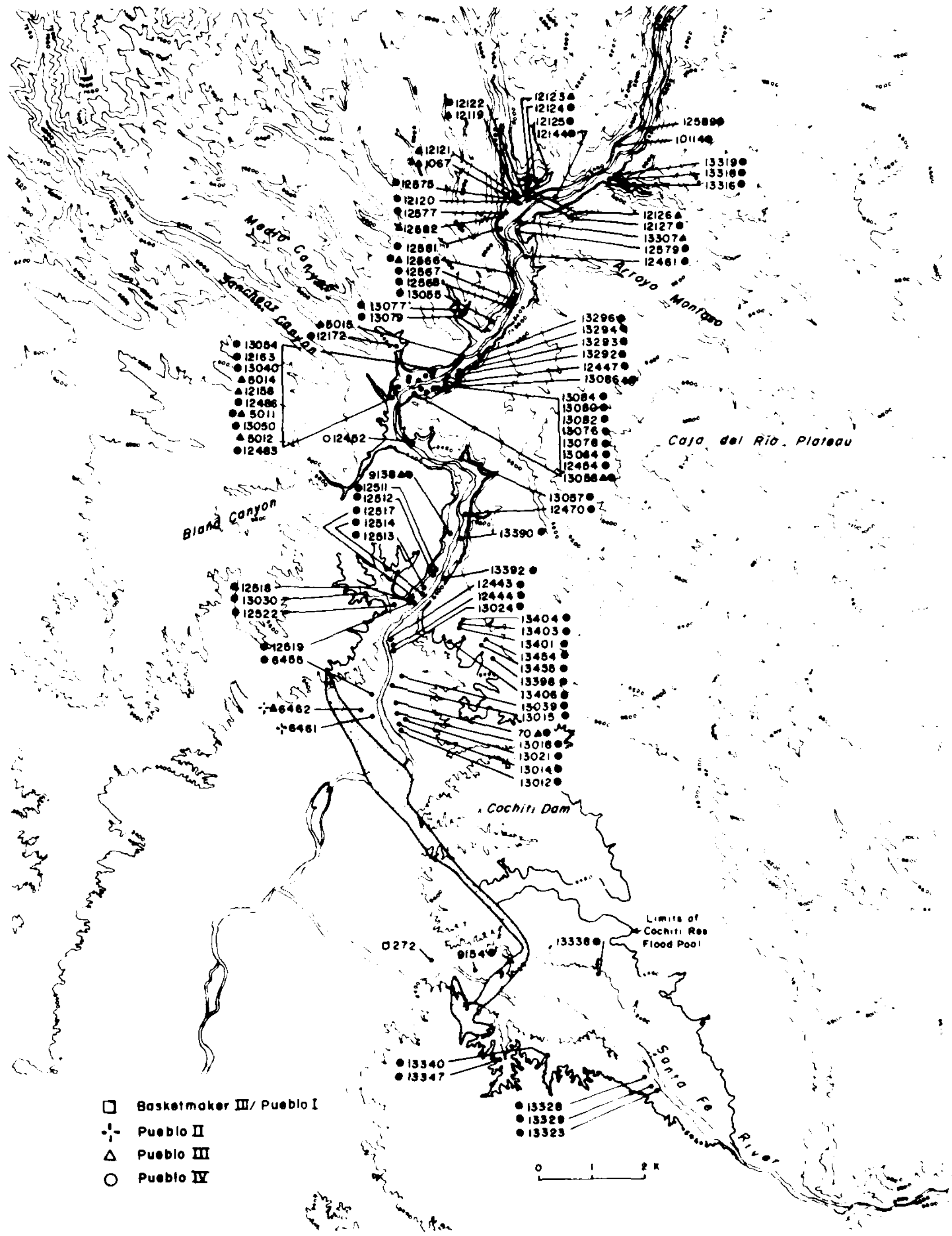


Fig. 6.1 Location of Anasazi sites from the Santa Fe River to Alamo Canyon

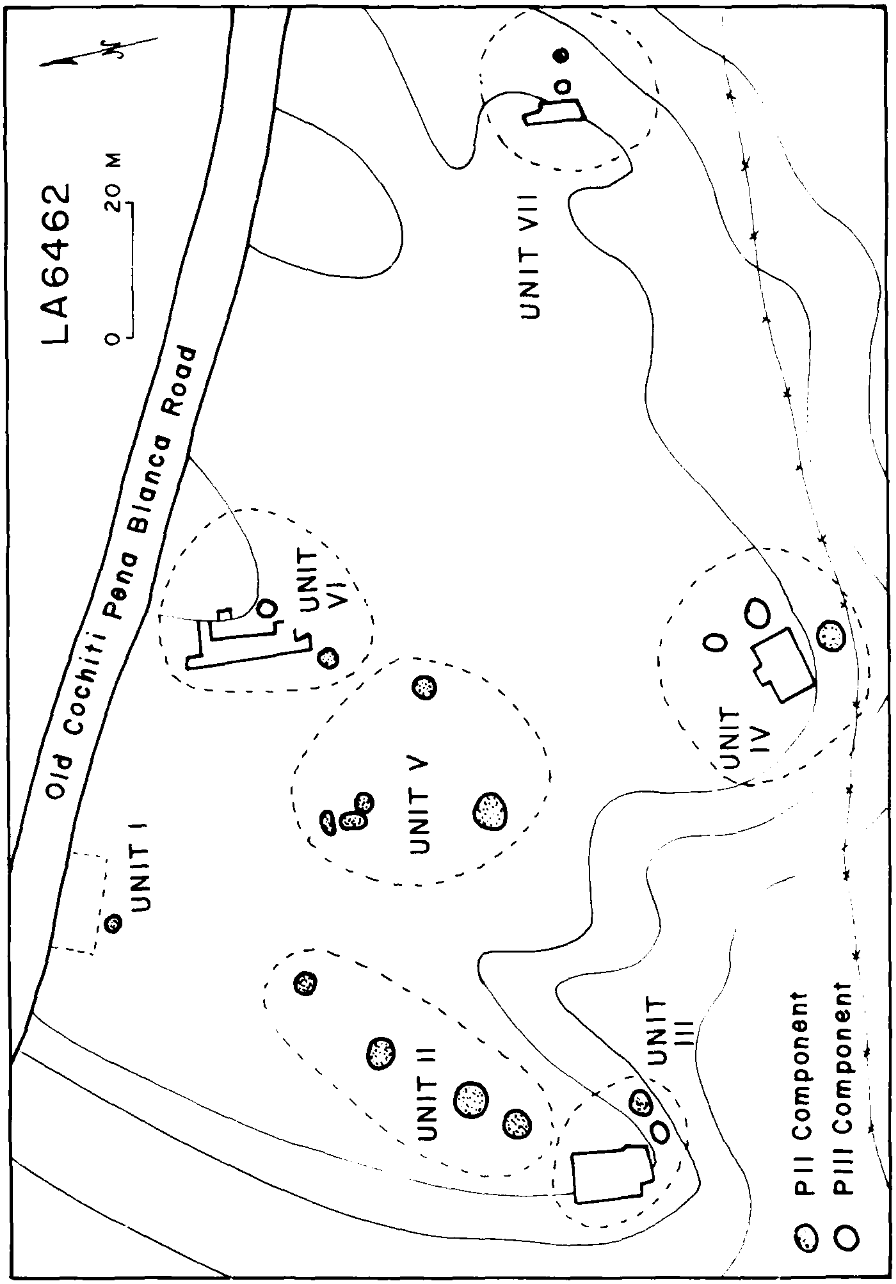


Fig. 6.2 Site plan and location of excavation units at LA 6462 (after Bussey 1968b:12)

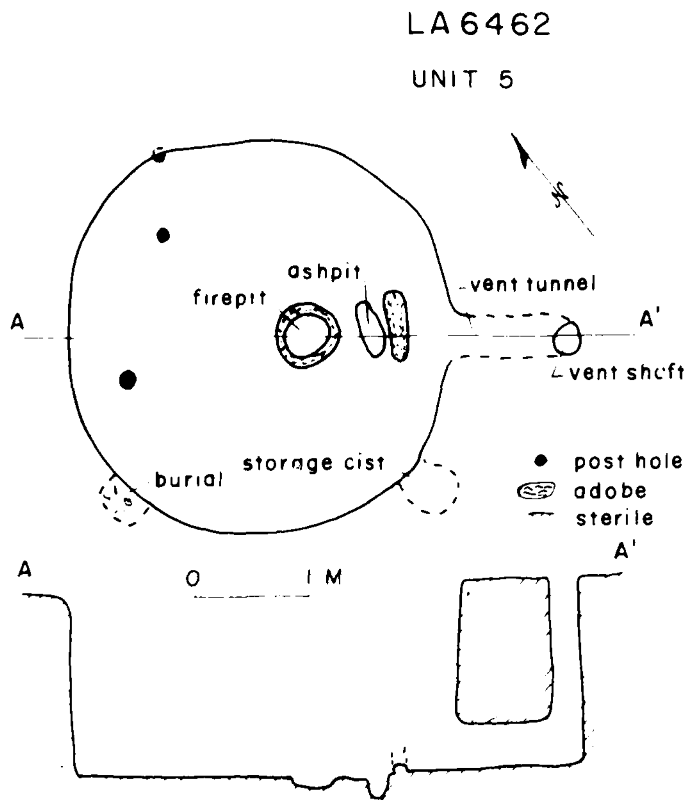


Fig. 6.3 Typical Kwahe'e phase (late Pueblo II) pithouse from LA 6462 (after Bussey 1968b:46)

Table 6.2
Architectural Data for Pueblo II Sites *

Site/Provenience	Feature	Area	Depth	Interior Cist/Bin	Area Adjacent Storage Pit	Comments
LA 6461	pithouse 1	9.35	2.4	none	none	trash filled
	pithouse 2	14.52	2.4	none	none	
LA 6462 unit II	pithouse 1	7.55	1.4	none	none	wall unfinished
	pithouse 2	—	—	—	—	unfinished structure
	pithouse 3	14.32	1.6	bin	1.82	
	pithouse 4	—	—	—	—	unfinished structure
LA 6462 unit III	pithouse	10.18	1.7	cist?	4.8	remodeled firepit
LA 6462 unit IV	pithouse	15.90	2.3	bin	none	
LA 6462 unit V	pithouse 1	9.08	1.7	cists	none	
	pithouse 2	13.85	2.0	cists	none	trash filled
	storage pit	6.35	1.31	—	—	
	storage pit	6.37	1.31	—	—	all connected by walk through tunnel
	storage pit	6.09	1.31	—	—	
LA 6462 unit VI	pithouse	12.57	0.50	cist	none	
	subsurface pit	0.79	unknown	—	—	burned interior; used as cooking oven? and storage?
	undescribed	—	—	—	—	mention of other storage pits and cooking pits

* all areas in m^2

Table 6.3
Basic Floral and Faunal Data for Pueblo II Sites

	LA 6461		LA 6462 unit II				III	IV	V					VI	
	ph1	ph2	ph1	ph2	ph3	ph4	ph	ph	ph1	ph2	p1	p2	p3	ph1	p
Flora:															
Zea mays	+*	+*	—	—	—	2	1	6	—	98	6	—	—	—	6
Croton (doveweed)	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—
juniper berries	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Artemesia	—	—	—	—	—	—	—	—	—	—	8	—	—	—	—
Physalis sp.	—	—	—	—	—	—	—	—	—	—	—	171	—	—	—
Grindella (gumweed)	—	—	—	—	—	—	—	—	—	—	—	—	300	—	—
unidentified grass	—	—	—	—	—	—	—	12gms	—	—	—	—	—	—	—
Fauna:															
FISH (undiff.)	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
BIRDS:															
turkey	2	1	—	2	3	—	1	2	—	5	—	—	—	—	1
waterfowl	1	—	—	—	—	—	—	—	—	1	—	—	—	—	2
other	—	—	—	1	—	—	—	—	—	1	—	—	—	—	2
REPTILES:															
turtle	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
other															
MAMMALS:															
lagomorphs	3	3	—	3	5	—	1	2	1	7	—	1	1	1	5
rodents—															
squirrels	—	—	—	—	1	—	—	—	—	1	—	1	1	—	—
beavers	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—
other	3	—	—	1	—	—	—	—	—	2	—	—	—	—	3
carnivores—															
badger	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
canis	—	—	1	—	1	—	—	—	—	1	—	1	2	1	—
bears	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
lynx	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
fox	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
artiodactyla—															
deer	1	1	1	1	2	1	1	2	1	1	—	—	—	—	—
pronghorn	—	1	—	—	1	—	—	—	—	2	—	—	—	1	—
bighorn	1	1	1	—	—	—	—	—	—	1	—	—	—	—	—
bison	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL MNI's	12	8	3	10	15	1	3	6	3	22	1	4	5	3	14

*at least 35 cobs from site as whole

Key: ph = pithouse
p = storage pit

Summary

In summary, information gained through excavation tends to substantiate survey evidence that early Developmental or Pueblo I occupations were characterized by more than one commensal group.

Later Developmental (Pueblo II) occupations seem clearly to reflect isolated, single-household residential patterns. From floral, faunal, artifactual, and architectural evidence, these occupations seem to have been year-round rather than seasonal. Considerable mobility over the long term is indicated by the degree of abandonment and reoccupation of particular site locales such as LA 6462, however. Excavated data thus suggest that interpretations of survey information concerning population sizes might be carefully considered.

COALITION (PUEBLO III) OCCUPATION

Introduction

In contrast to the relatively ephemeral occupation during the 400 year Developmental phase, an extensive occupation of the Cochiti study area during the 125 year Pueblo III (P-III) phase has been documented. Ceramic types associated with P-III settlement and dates proposed for those types are summarized as follows:

early P-III	Santa Fe B/W	A.D. 1175-1275 or 1175-1300	(Peckham and Wells 1967) (Warren 1977c)
late P-III	Wiyo B/W	1275-1325 or 1300-1400*	(Peckham and Wells 1967) (Warren 1977c)

*Note that the dates for Wiyo B/W extend well into the P-IV period.

Based upon a literature survey, 363 P-III sites have been located (Biella 1977:117). This represents an 800% increase in frequency of sites over the preceding phases. P-III architectural sites exhibit considerable variability and range from isolated one room structures to pueblos of more than 200 rooms.

P-III sites are relatively ubiquitous in distribution from the Santa Fe River northward to Los Alamos Canyon. The sole exception is the lack of P-III sites on the Caja del Rio Plateau where they are virtually absent. While the P-III settlement system overall would be characterized as dispersed, limited evidence exists of aggregated P-III villages on the northern Pajarito Plateau.

Residential Patterns

In the vicinity of Cochiti Reservoir, three basic kinds of residential sites characterize the P-III occupation: isolated surface or subsurface rooms; small roomblocks of up to eight rooms, generally in association with a kiva; and larger roomblock complexes of 15 to 20 rooms with one or more kivas. Chronological data recovered from excavated site locations are presented in Table 6.4.

The smallest site type consists of well-constructed structures with plastered floors and mortared walls (see Fig. 6.4). Both semisubterranean and surface rooms have been documented with hearth facilities occurring in all but one structure. Small bins and cists were found in roughly half of these structures. Eight small sites have been excavated:

LA 6462, unit IV	pitroom (1.4 m deep), subrectangular shape, 6.82 m^2 floor space, central adobe-rimmed hearth, corner wall cist, subfloor cist (Bussey 1968b).
LA 6462, unit VI	pitroom (2.0 m deep), rectangular shape, 6.96 m^2 floor space, central adobe-rimmed hearth, side wall adobe bin (Bussey 1968b).
LA 9138, room 6	generally surficial (20 cm deep), oval shape, 3.1 m^2 floor space, adobe-rimmed hearth along one wall (Chapman et al. 1977).
LA 12123, room 1	semisubterranean (50-80 cm deep), rectangular shape, 3.4 m^2 floor space, corner adobe-rimmed hearth (Traylor et al. 1977).
LA 12126, room 1	semisubterranean (1.0 m deep), oval shape, 2.01 m^2 floor space, two slab-lined bins along side walls (Traylor et al. 1977).
LA 12582, room 1	surficial (although partially excavated into slope), rectangular shape, 6.72 m^2 floor space, plaster-lined hearth along one wall (Traylor et al. 1977).
LA 13086, room 5	surficial, rectangular shape, 7.7 m^2 floor space, four interior features: central adobe-rimmed hearth, two slab bins (one subfloor), and an ash lens below the hearth (Hunter-Anderson et al. 1979).
LA 12511, feature 1	surficial, three-sided structure, 4.34 m^2, adobe and slab hearth displaced from eastern wall.
feature 2	surficial, living surface or open-ended structure immediately to east of feature 1, 2.91 m^2, two slab-lined bins (?), one along common wall and other displaced 50 cm from first bin (Laumbach et al. 1977).

The second type of site configuration, that characterized by a small roomblock and generally a kiva, may reflect the most basic residential unit which was operative during the P-III times. A kiva is distinguished from a pithouse or pitroom by the presence of a firepit/ash pit/deflector facility. Although some site-specific variation has been documented, this configuration consists of 7 or 8 surface rooms, generally arranged in two rows of rooms with the kiva situated either directly in front of the roomblock or displaced to one side. Three or four of the rooms contain hearths. These rooms are almost exclusively situated in the row closest to the kiva (see Fig. 6.5). With one or two exceptions, the roomblocks were constructed as single building episodes. Some remodeling of floors and changes in room function have been documented but these are unusual. Building materials and construction varies from locality to locality although the walls and floors are usually (but not exclusively) plastered. Interior features include hearths (usually centrally placed) and slab-lined bins. Six sites characteristic of this site configuration have been excavated:

LA 6462, unit I	pithouse and surface roomblock; roomblock had been destroyed but was of comparable size to

Table 6.4

Chronology for Excavated P-III Sites

Component	Archeo.	Dendro.	Ceramics	References
One Room Sites				
LA 6462 unit IV pitroom	–	–	early Santa Fe pre-1280	Bussey 1968b:42
LA 6462 unit VI pitroom	–	–	early Santa Fe	Bussey 1968b:50
LA 9138 room 6	–	–	1275-1325	Chapman et al. 1977: 123
LA 12123 room 1	–	–	1275-1350	Traylor et al. 1977
LA 12126 room 1	–	–	1275-1350	Traylor et al. 1977
LA 12582 room 1	–	–	1275-1350	Traylor et al. 1977
LA 13086 room 5	1175 ± 20	–	1175-1300	Hunter-Anderson et al. 1979:160
4-8 Room Sites				
LA 6462 unit I	–	–	late Santa Fe	Bussey 1968b:17
LA 6462 unit III	–	–	early Santa Fe	Bussey 1968b:36
LA 6462 unit IV	–	–	late Santa Fe	Bussey 1968b:42
LA 6462 unit VII	–	–	late Santa Fe	Bussey 1968b:62
LA 12121	1180 ± 13 (2 samples)	1149vv (3 samples) 1150v (1 sample) 1154vv (1 sample) 1162R (1 sample) 1177v,R (5 samples)	1175-1275	Traylor et al. 1977
LA 12522 lst occupation	1195 ± 10*		1200s	Laumbach et al. 1977:74
Large Sites				
LA 5014 eastern and western roomblocks	–	–	1250-1270	Laumbach et al. 1977:48
LA 6462 unit VI	–	1280R, RB (14 samples)	late Santa Fe	Honea 1968:127; Bussey 1968b:59
LA 12119 lst occupation	pre-1180 ± 40	1191vv, 1203vv, 1278vv (1 sample each)	late 1100s to 1400s	Traylor et al. 1977
2nd occupation	1180 ± 40 1190 ± 40 1200 ± 40 1230 ± 26 1250 ± 45 (1 sample each)			Traylor et al. 1977

* archeomagnetic date was analyzed after the 1977 publication, courtesy of the Chaco Research Center, National Park Service, Albuquerque.

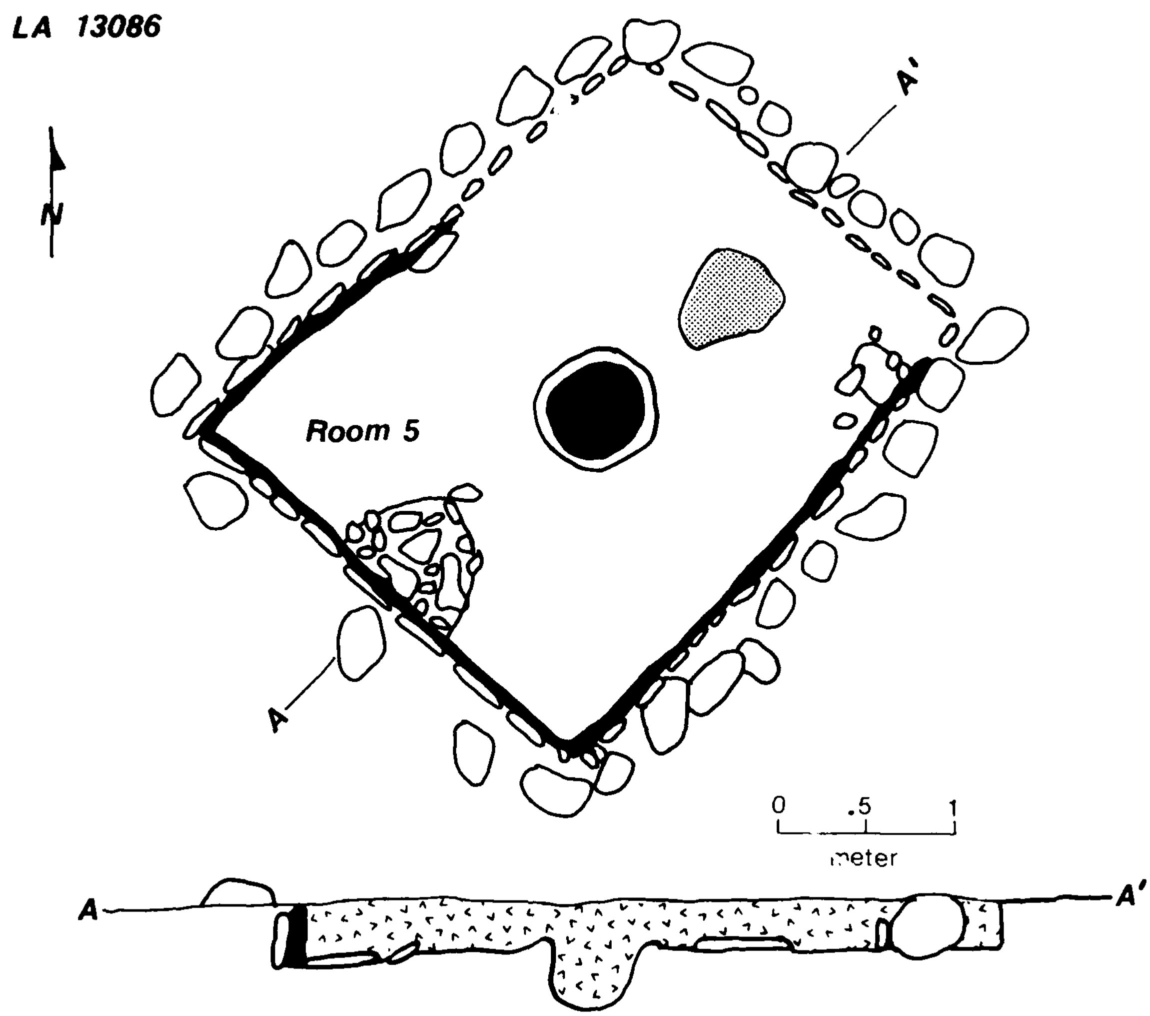


Fig. 6.4 Typical one room P-III site in White Rock Canyon, LA 13086 (after Hunter-Anderson et al. 1979:157)

	roomblocks in units III, IV and VI at LA 6462 (Bussey 1968b).
LA 6462, unit III	kiva and surface roomblock; 8 rooms arranged in two rows; single building episode; no remodeling; 4 rooms with hearths, 4 without; no exterior features (Bussey 1968b).
LA 6462, unit IV	kiva and surface roomblock; 7+ rooms arranged in two rows; one major buildling episode but 1 or 2 rooms may have been later (badly eroded); one room remodeled but no change in function; 4 rooms with hearths, 3 without; ramp entrance from one surface room to kiva; 2 exterior features: slab-lined bin and hearth (Bussey 1968b).
LA 6462, unit VII 1st occupation	kiva and surface roomblock; 8 rooms arranged in two rows; one major building episode; 3 rooms with hearths and 5 without; no exterior features.
2nd occupation	kiva and surface roomblock; 8 rooms; three rooms remodeled; one room changed function; 4 rooms with hearths and 4 without; no exterior features (Bussey 1968b).
LA 12121 1st occupation	surface roomblock only, no subsurface kiva; 8 rooms in two rows; one major building episode (small semicircular room maybe added later); 4 rooms with hearths, 4 without; 5 bins located in one room containing hearth; 1 ext. hearth.

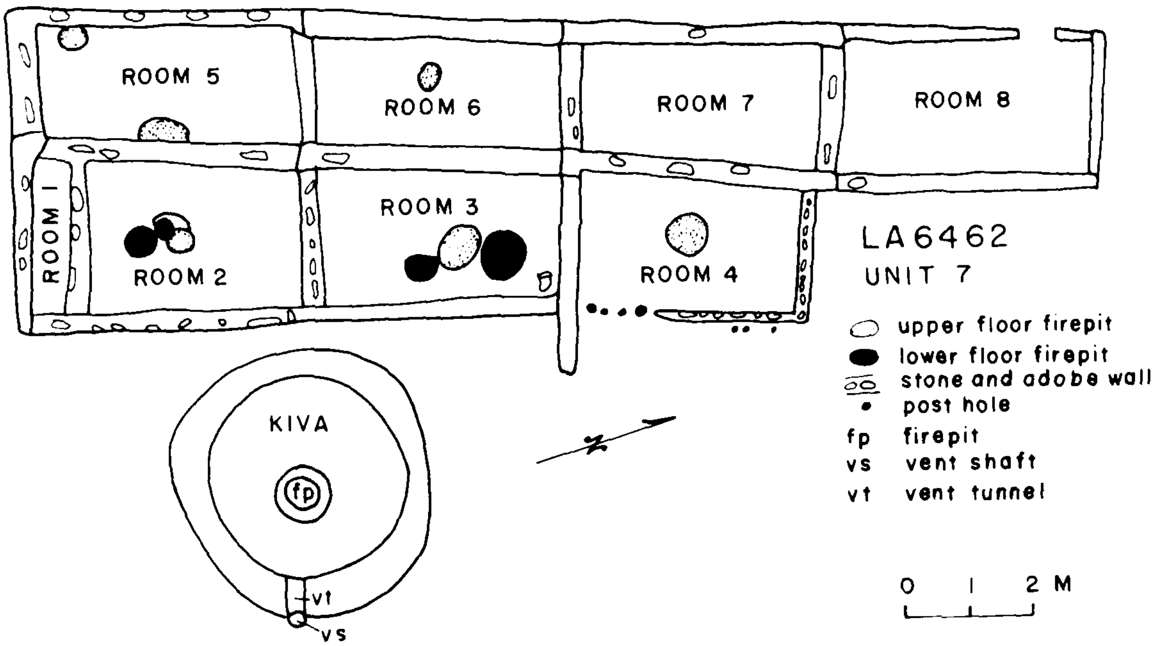


Fig. 6.5 Example of the basic P-III residential complex, LA 6462 (after Bussey 1968b:63)

2nd occupation	surface roomblock; 8 rooms in two rows; one room remodeled from habitation to storage function; 4 rooms with hearths and 4 without; one exterior hearth (Traylor et al. 1977).
LA 12522, feat. 1-5	pithouse and surface roomblock; 4 rooms in one row; badly eroded and 2 rooms postulated on basis of hearths; 2 rooms with hearths and 2 without; no exterior features (Laumbach et al. 1977).

The third type of site configuration is characterized by roomblock(s) totaling 15 to 20 rooms with one or more associated kivas. These sites appear to reflect the same basic residential structure identified for the smaller single roomblock P-III sites but are made up of two or more of these units. Specific site plan varies for each site represented in this site group and seems largely dictated by the amount of land available for construction. Building materials vary. Three of these sites have been excavated.

LA 5014	two noncontinuous roomblocks containing a minimum of 16 rooms (including one pitroom); 2 kivas; site badly eroded with few floors present—building episodes could not be identified; roomblocks probably inhabited contermporaneously.
western roomblock:	one kiva, 1 pithouse/pitroom (contiguous to roomblock) and linear roomblock of 12 rooms; westernmost 6 rooms arranged in two rows, others in single row; 8 of the surface rooms were excavated; 3 surface rooms with hearths (although 2 others contained molded adobe basins of unknown function (perhaps bottoms of hearths?); at least two of rooms were open-sided and both contained ash stains rather than formally constructed hearths; one exterior hearth.
eastern roomblock:	kiva and linear roomblock; 3 rooms; 2 with hearths and 1 without; one room with hearth contained an adobe basin and another feature of unknown function; roomblock had same orientation as western roomblock and may have been constructed simultaneously (Laumbach et al. 1977).

LA 6462, unit VI	kiva and surface roomblock; minimum of 19 rooms arranged in a linear to U-shaped fashion; two rows of 7-8 rooms; badly eroded; from width of walls may have been constructed as single unit but no wall abutment information preserved; 6 rooms with hearths, 5 in rooms in row closest to kiva; only one slab-lined storage bin; no exterior features (Bussey 1968b).
LA 12119	three kivas and surface roomblock of 20 rooms; one kiva incorporated into roomblock; multiple remodeling of floors and several building sequences with at least 3 occupations; one kiva fell into disuse by end of first occupation. Two rooms changed function; ca. 200 years of continuous occupation.
1st occupation	kiva and roomblock of at least 3 surface rooms; none exhibited hearths and exact extent of occupation is in question.
2nd occupation	two kivas and surface roomblock of 13 rooms; no regular arrangement to rooms; 4 rooms with hearths and 9 without.
3rd occupation	two kivas and irregularly shaped roomblock of 20 rooms; 7 rooms with hearths, 13 without; interior floor features included hearths, slab bins, cists and puddling basins; exterior features included 3 hearths (deposition of these with this or earlier occupation uncertain)(Traylor et al. 1977).

From the excavated P-III sites we may propose that there exists a basic residential unit which is characterized by an architectural complex including a kiva and a small roomblock of 4-8 rooms, several of which were excavated. The larger architectural sites appear to be made up of two, or perhaps, more of these residential complexes. Whether these latter reflect the growth of the population inhabiting these particular sites through time, or a larger initial occupying unit, is unclear. The occupation of LA 12119 was certainly complex and may have represented growth by accretion, although the maximum number of rooms at the site appears to have been reached fairly early on in the occupation. The last major building episode was clearly the addition of 7 rooms at one time.

The only other type of residential pattern which emerges from the P-III excavated sample is a small residence characterized by a single room. Clearly these latter served as residences since, they contained hearths, but whether they served as autonomous habitations or adjuncts of the larger sites is unclear and will be addressed in the next section of this chapter.

Architectural Evidence for Seasonality of Residence

In this section architectural data from excavated P-III site locations will be reviewed to assess whether rooms were constructed in a fashion which would make them suitable for cold weather residential occupation, warm weather occupation, or for prolonged bulk storage. Data for each occupational component used in this assessment will include amount of space enclosed, presence or absence of wall mortar, presence or absence of floor plaster, entrances, and any indications of routine activity performance outside rooms.

Inferences concerning seasonality of occupation based on these architectural details are based on a set of assumptions concerning the relationship between room construction and suitability for residence or storage. It is presumed, for example, that rooms suitable for cold weather residential use (rather than storage) should be fully enclosed by walls, contain an interior heat source, and exhibit walls which are constructed with adobe mortar or otherwise are sealed against drafts. Similarly, it is presumed that rooms which do not exhibit these features would not be suitable for cold weather occupation.

Long-term storage suitability is assessed using similar arguments of construction which would permit the enclosed space to be sealed or protected against moisture, insects, rodents, or other potential pests. Constructional details which are presumed to be minimally necessary for storage facilities include full enclosure by walls which are constructed from adobe or adobe mortar, and plastered or adobe sealed floors.

Positive evidence of warm weather occupation is presumed to be reflected by exterior facilities such as hearths or bins indicating routine performance of outdoor activities, evidence of ramada structures, open-sided rooms, or rooms containing hearths but constructed with dry-laid masonry walls.

Evidence of roof construction is rarely preserved among small one and two room sites and could not be routinely used as an attribute. For purposes of the analysis, it was assumed that all rooms once had roofs, unless positive indications to the contrary were described.

It should be noted that considerable variation in documentation was present among different room descriptions found in the various reports. All attributes desired were not routinely documented in terms of presence or absence. In some cases careful reading or illustrations permitted making reasonable guesses as to presence or absence of some particular constructional detail, and those have been included as data in this analysis. In cases where no reasonable determination could be made, "*n.d.*" (no data) was entered.

Measurements of interior room space were derived from dimensions given in the text if present and from maps where no room by room dimensions were presented.

All rooms containing hearth facilities or ash stains indicative of fire usage were defined as residential in function; whereas rooms which did not contain evidence of hearth usage were defined as storage facilities if they exhibited appropriate attributes, and as residential in function if they lacked attributes making them suitable for long-term storage.

Three categories of possible seasonal occupation were ultimately defined for each occupational component: cold weather only, cold and warm weather, and warm weather only. It should be noted that the seasonal residence assignments were made for *components*, based upon variation in constructional details exhibited by rooms comprising the components.

Cold weather only occupation was assigned if a component exhibited at least one habitation room suitable for cold weather occupation and no evidence of warm weather habitation such as rooms with hearths which were open-sided or built from dry laid masonry. Cold and warm weather occupation was assigned if positive evidence of warm weather habitation rooms, or exterior facilities were present in addition to a room suitable for cold weather residential use.

Warm weather only occupation was assigned to components which exhibited no rooms suitable for cold weather habitation.

Tables displaying basic architectural data used in the analysis have been organized by suggested seasonal terms of occupation for convenience in discussion.

As a final note, it is recognized that architectural construction details are not, in and of themselves, conclusive indicators of seasonality of residence. It is felt, however, that some kinds of obvious architectural attributes such as those dealt with in this analysis offer some clues about cold weather versus warm residence and are all too often ignored for their potential in this regard. It is hoped that the rudimentary attempt to use architectural variation as a monitor of seasonality developed here will stimulate others to refine such analysis.

One Room Sites: Seven occupational components characterized by single rooms and one component characterized possibly by two rooms dating to the P-III period have been *excavated within the study area.* Basic architectural data relevant for assessing whether these structures might have been adequate for cold weather residential use are presented in Table 6.5. One room components include both surface (3) and subsurface (4) structures, six of which contain hearth facilities. Floor space among those containing hearths ranges from 3.1 m^2 to 7.7 m^2, averaging 5.8 m^2. All but one exhibit wall mortar and plastered floors, and all are fully enclosed by walls, making them suitable for cold weather occupation.

One single room component consisted of a small (2.0 m^2) semisubterranean room which did not have a hearth feature, and the sole two-room component consisted of one open-sided room containing a hearth with an adjacent hardpacked surface which may or may not have once been a partially enclosed structure.

With two exceptions, then, small P-III sites characterized by single structures seem to have been constructed in a fashion making them suitable for cold weather residential occupation.

One of the rooms without hearths was semisubterranean in structure, exhibited use of mortar in its wall construction, and enclosed at least 2.01 m^3 of interior space. This feature could have served as a bulk storage facility although it exhibited two interior bins which indicate some compartmentalization of contents.

Table 6.5
Architectural Data for One and Two Room P-III Sites

Season	Site/feature	hearth type*	wall mortar	floor plaster	subsurf.	floor space (m^2)	Comments and/or exterior features
COLD	LA 6462 unit IV	H	+	+	+	6.82	
	LA 6462 unit VI	H	+	+	+	6.96	storage pit or oven
	LA 9138 room 6	H	n.d.	+	-	3.10	
	LA 12123 room I	H	+	+	+	3.40	
	LA 12582 room 1	H	+	+	--	6.72	
	LA 13086 room 5	H	+	+	—	7.70	
WARM	LA 12126 room 1	--	+	+	+	2.01	
	LA 12511 feature 2	H	+	+	-	4.34	open-sided
	feature 3	—	+	-	—	2.91	open-sided

*H = formally shaped hearth
-- = no evidence of hearth

4–8 Room Sites: Five site locations characterized by four to eight surface rooms and (with one exception) associated subsurface kivas have been excavated within the southern Pajarito Plateau area. For two of these sites at least one room exhibited remodeling which changed its function, thus resulting in definition of seven occupational components. Table 6.6 summarizes data concerning number of rooms, room function, room size, and presence of exterior features for these seven occupational components.

It must be emphasized that the state of preservation of P-III architectural remains is generally poor. Details of surface room construction at LA 12522, for example, are so ephemeral that evidence for the existence of two rooms was based solely upon spatial patterning in locations of two hearth facilities relative to other rooms for which walls could be defined.

Given this consideration, the following observations can be made concerning architectural evidence of warm weather versus cold weather habitation for those sites where structures are preserved. It will be assumed that those sites are representative of other 4-8 room P-III site locations in this respect.

Surface room structures are fully enclosed by walls, and substantial evidence exists indicating that upper walls were constructed entirely from adobe in some cases, or from masonry bonded with adobe in other cases. Floors were generally constructed from adobe or plaster. Kiva structures were characterized by similar substantial construction as well.

From a strictly architectural perspective, then, surface and subsurface rooms comprising 4-8 room P-III sites were all constructed in a manner suitable for cold weather habitation, given presence of interior heat sources.

Hearth facilities were documented in 24 of 51 surface rooms comprising all seven occupations. These rooms ranged from 4.24 m^2 to 15.63 m^2 in floor space, averaging 8.52 m^2. Rooms without hearth facilities ranged from 1.56 m^2 to 8.15 m^2 in floor space, averaging 5.34 m^2. It can be seen that rooms with hearths average 60 percent larger in floor space than rooms without hearths, although nearly equal numbers of both kinds were constructed at medium sized sites. Despite the relatively great variation in sizes characterizing the entire population of rooms, reference to Table 6.6 indicates that average room sizes for each occupational component are relatively similar to population totals.

It is interesting to note that floor space among rooms with hearths at 4-8 room sites averages 2.7 m^2 larger than floor space among one-room P-III sites.

Evidence of exterior hearth or bin facilities was found at LA 12121 (one hearth), and LA 6462, Unit IV (one bin, one hearth); but it can be suggested that the medium-sized site locations typical of much of the P-III settlement in the study area represent dominantly cold weather occupations, given characteristics of room construction. No open-ended rooms were identified through excavation, and the number of exterior features discovered during the course of excavation was rather minimal.

The quality of reporting is not adequate to evaluate how much site surface was in fact excavated outside rooms, however, and it must be offered that observations of exterior activity performance are not necessarily reliable because of this.

Most rooms without evidence of hearth usage found at these sites exhibit constructional details such as plastered floors and adobe or adobe mortared masonry walls (sometimes exhibiting plaster as well) which would make them suitable for long-term bulk storage. Construction techniques frequently involved setting wall foundations in trenches below the level of floors in surface roomblocks, such that rooms were tightly sealed whether or not they exhibited plastered floors.

From these observations, it can be offered that 4-8 room P-III components may well have served as locations for long-term bulk storage of food resources. Constructional details are admittedly sketchy in some cases due to poor preservation but all evidence as it exists indicates the suitability of some room facilities at these sites for cold weather habitation in conjunction with other rooms suitable for long-term storage.

Large Sites: Three site locations characterized by 15 or more surface rooms dating to the P-III phase were excavated within the study area. One of these, LA 12119, exhibited rooms which had been remodeled in addition to new room construction sequences. Together these permitted definition of at least two occupational episodes. Table 6.7 summarizes data concerning the number of rooms, room function, room size, and presence of exterior features for those occupations.

As with 4-8 room P-III sites, many details of construction at larger components are not well preserved. Data concerning wall abutments and sequences of room construction are scarce at LA 5014 and LA 6462 (unit VI), and the possibility exists that more surface rooms than documented once existed at both those components.

Despite this, several commonalities of architectural construction are apparent among the four occupations. In general, constructional details of surface rooms are quite similar to 4-8 room P-III components. Rooms were fully enclosed by walls constructed either from adobe, or adobe bonded masonry elements. Floors were plastered, and hearth facilities were constructed either in centers of rooms, or adjacent to walls or corners. Kivas at all three site locations and the pitroom at LA 5014 all were characterized by plastered floors and walls. The vast majority of structures containing hearths built at larger P-III sites were thus suitable for winter habitation.

Exceptions to this are found at LA 5014, where two rooms contained only burned areas on their floors rather than constructed hearth facilities. Both of these rooms were open-sided, as was another room containing no hearths at the same site. LA 5014 seems to be the only larger P-III component which exhibits architectural evidence of both cold weather and warm weather habitation in this respect.

Table 6.6
Architectural Data for 4-8 Room P-III Sites†

LA 6462 Unit III	Rooms with hearths	4
	x̄ floor space	7.37
	s.d.	1.71
	sum floor space	29.49
	Rooms without hearths	4
	x̄ floor space	7.17
	s.d.	0.85
	sum floor space	28.66
	Kiva	9.08
	Total surface space	58.15
	Total enclosed space	67.23
	Exterior features	none
LA 6462 Unit IV	Rooms with hearths	4
	x̄ floor space	7.89
	s.d.	2.65
	sum	31.57
	Rooms without hearths	3
	x̄ floor space	4.80
	s.d.	2.82
	sum	14.41
	Kiva	11.07
	Total surface space	45.98
	Total enclosed space	57.05
	Exterior features	hearth, bin
LA 6462 Unit VII (occupation 1)	Rooms with hearths	3
	x̄ floor space	9.03
	s.d.	1.40
	sum	27.08
	Rooms without hearths	5
	x̄ floor space	6.28
	s.d.	2.72
	sum	31.42
	Kiva	8.04
	Total surface space	58.50
	Total enclosed space	66.54
	Exterior features	none
LA 6462 Unit VII (occupation 2)	Rooms with hearths	4
	x̄ floor space	8.77
	s.d.	1.25
	sum	35.06
	Rooms without hearths	4
	x̄ floor space	5.86
	s.d.	2.94
	sum	23.44
	Kiva	8.04
	Total surface space	58.50
	Total enclosed space	66.54
	Exterior features	none
LA 12121 (occupation 1)	Room with hearths	4
	x̄ floor space	9.75
	s.d.	3.96
	sum	38.99
	Rooms without hearths	4
	x̄ floor space	5.26
	s.d.	2.24
	sum	21.02
	Kiva	none
	Total surface space	60.01
	Total enclosed space	60.01
	Exterior feature	hearth
LA 12121 (occupation 2)	Rooms with hearths	3
	x̄ floor space	10.29
	s.d.	4.67
	sum	30.86
	Rooms without hearths	5
	x̄ floor space	5.83
	s.d.	2.32
	sum	29.15
	Kiva	none
	Total surface space	60.01
	Total enclosed space	60.01
	Exterior features	hearth
LA 12522	Rooms with hearths	2
	x̄ floor space	5.70*
	s.d.	0.00*
	sum	11.40*
	Rooms without hearths	2
	x̄ floor space	6.08
	s.d.	0.49
	sum	12.16
	Kiva	11.64
	Total surface space	23.56
	Total enclosed space	35.20
	Exterior features	none

† all spatial measures refer to m^2
* room dimensions estimated

Twenty three rooms at larger P-III components contained evidence of hearth usage. These ranged in size from 3.25 m^2 to 7.95 m^2 and averaged 5.52 m^2. Forty-one rooms without evidence of hearth area were excavated ranging in size from 2.56 to 11.29 m^2 and averaging 4.94 m^2 in floor space. *Rooms containing hearths are thus, on the average, only 12 percent larger in floor space than rooms not containing hearths.* When compared to similar rooms excavated at 4-8 room P-III sites, rooms containing hearths averaged 3 m^2 smaller in floor space while rooms with no hearths averaged only 0.4 m^2 smaller in size. Sizes for presumed habitation rooms at larger P-III sites are more similar to one-room P-III sites than to the mid-sized sites.

In summary, larger P-III components at LA 6462 and two occupations at LA 12119 can be suggested to reflect predominantly cold weather occupation based upon architectural criteria. The component at LA 5014, while representing construction for winter habitation for many rooms, also exhibited some architectural characteristics such as open-sided rooms, hearth usage in rooms containing no constructed hearth facilities, an exterior hearth, and an exterior wing wall which seem to reflect warm weather occupation as well.

From presently available information, large P-III occupational components include rooms constructed in a fashion suitable for long-term protection or storage of bulk resources. The majority of rooms were constructed from adobe walls based upon masonry footings set in trenches below ground level or from adobe bonded masonry walls (LA 12119). Where data are available, floors were commonly constructed from adobe, or were plastered, as were wall interiors. With the exception of one room at LA 5014, nonhearth facilities were fully enclosed.

It is clear, then, that large P-III sites included rooms suitable for long-term protection of bulk goods as a substantial part of their architectural inventory. Since these same sites included rooms containing hearths which were constructed in fashions suitable for winter residence, it can be suggested that the larger P-III occupations, like the mid-sized sites, served as locations for winter residence by their occupants.

The extent to which these same sites served as warm weather residences is more difficult to ascertain, given the relative paucity of exterior archeological work conducted at these sites. LA 5014 seems, based upon some architectural features, to exhibit evidence of warm weather occupation in addition to winter habitation.

Table 6.7
Architectural Data for Large P-III Sites†

LA 5014	Rooms with hearths	6*
	$\bar{x}$ floor space	6.63
	s.d.	0.53
	sum	39.80
	Rooms without hearths	6
	$\bar{x}$ floor space	6.34
	s.d.	2.54
	sum	38.06
	Kivas	2**
	$\bar{x}$ floor space	10.68
	s.d.	1.65
	sum	21.36
	Unexcavated surf. rooms	4
	Total surface space	77.86*
	Total enclosed space	99.22
	Exterior features	1 hearth
LA 6462 Unit VI	Rooms with hearths	6
	$\bar{x}$ floor space	4.82
	s.d.	1.31
	sum	28.92
	Rooms without hearths	13
	$\bar{x}$ floor space	3.65
	s.d.	0.72
	sum	47.39
	Kivas	1
	$\bar{x}$ floor space	13.85
	s.d.	n/a
	sum	13.85
	Total surface space	76.31
	Total enclosed space	90.16
	Exterior features	none
LA 12119 (occupation 1)	Rooms with hearths	4
	$\bar{x}$ floor space	4.65
	s.d.	1.18
	sum	18.59
	Rooms without hearths	9
	$\bar{x}$ floor space	5.36
	s.d.	1.47
	sum	48.20
	Kivas	2
	$\bar{x}$ floor space	17.43
	s.d.	2.87
	sum	34.86
	Total surface space	66.79
	Total enclosed space	101.65
	Exterior features	3 ext. hearths
LA 12119 (occupation 2)	Rooms with hearths	7
	$\bar{x}$ floor space	5.65
	s.d.	1.79
	sum	39.56
	Rooms without hearths	13
	$\bar{x}$ floor space	5.31
	s.d.	1.93
	sum	69.03
	Kivas	2
	$\bar{x}$ floor space	17.43
	s.d.	2.87
	sum	34.86
	Total surface space	108.59
	Total enclosed space	143.45
	Exterior features	3 ext. hearths

† all spatial measures refer to m^2
* includes one pitroom and two rooms which are open-sided
** includes estimated floor space for one kiva which was not fully excavated.

Floral and Faunal Evidence for Seasonality of Residence

Direct evidence of floral and faunal species possibly used as food by P-III inhabitants of the region, while offering some potential for identifying seasonal patterns of residence, are not routinely preserved in quantities sufficient for comparative analysis. Table 6.8 presents data concerning floral remains recovered from excavated P-III sites, and Table 6.9 presents information for faunal remains.

Inspection of the first table indicates clearly that the majority of P-III sites exhibited no evidence of floral species. Only seven of 16 excavated sites contained any floral remains, although excavation techniques and variation in preservation are different from site to site.

Maize constituted the only evidence of plant resources at three sites including one single pitroom component and two 4-8 room components, while pinyon nuts constituted the only kind of plant foodstuff recovered from a third 4-8 room component. Maize and pinyon nuts are both kinds of resources that can be easily stored for relatively long time periods and, as such, do not provide much evidence concerning seasonality of residential occupation for those four components.

All three large P-III sites exhibited floral remains, but only in scarce quantities at LA 5014 and LA 6462, Unit VI. Aside from *Croton texensis* or doveweed which was not felt to be found in contexts indicating deliberate procurement (Ford 1968:250-251), the only other identifiable seeds recovered from LA 6462 were maize. LA 5014 yielded no maize, but one Cheno/Am indicating fall procurement and one Astragalus seed indicating spring procurement were identified. Another 22 seeds were noted as present but were not identified. Under the assumption that the two identified seeds represent the population of unidentified seeds from the site, floral procurement activities from mid-May through as late as October might be indicated (Tierney, this volume).

This implied warm weather occupation of the site is not inconsistent with architectural evidence pointing to warm weather residential use of at least three rooms, in addition to other rooms which were suitable for cold weather occupation.

The remaining large site (LA 12119) exhibited seeds or other parts of eight species in addition to maize, pinyon, Cheno/Ams and Astragalus. Three of these represent food items that can be stored for long periods of time (acorns, beans and juniper berries) and another (*Eleangus* or Russian

Table 6.8

Floral Remains Recovered from P-III Sites*

Species	One Room Sites 6462 IV	4-8 Room Sites 6462 IV	4-8 Room Sites 6462 VII	4-8 Room Sites 12121	Large Sites 5014	Large Sites 6462 VI	Large Sites 12119
Zea mays	6	5	5	—	—	1	5
Phaesolus sp.	—	—	—	—	—	—	1
Pinus edulis (nuts)	—	—	—	6	—	—	6
Quercus sp. (nuts)	—	—	—	—	—		3
Juniperus sp. (berry/seed)	—	—	—	—	—	—	10
Celtis sp.	—	—	—	—	—	—	5
Opuntia sp.	—	—	—	—	—	—	17
Cheno/Ams	—	—	—	—	1	—	3+
Portulaca	—	—	—	—	—	—	2
Astragalus sp.	—	—	—	—	1	—	5
Eleagnus sp.†	—	—	—	—	—	—	1
Prunus sp.	—	—	—	—	—		1
Croton sp.	—	—	—	—	—	78	—
unidentified seeds	—	—	—	—	22**	—	

* only sites with evidence of flora
** at least five different species
† introduced

Table 6.9

Faunal Remains Recovered from P-III Sites*

	One and Two Room Sites								4-8 Room Sites						Large Sites		
	LA 6462 (pr) IV	LA 6462 (pr) VI	LA 9138 R6	LA 12123 R1	LA 12126 R1	LA 12582 R1	LA 13086 R5	LA 12511 F2-3	LA 6462 units: I	III	IV	VII	LA 12121 1-8	LA 12522 F1-5	LA 5014	LA 6462 VI	LA 12119**
Fauna:																	
FISH (undiff.)	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
SNAIL	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
AMPHIBIAN	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BIRDS																	
turkey	1	—	—	—	—	—	—	—	1	2	4	1	3	1	—	4	25
waterfowl	2	2	—	—	—	—	—	—	—	—	6	—	—	—	—	6	8
other	—	3	—	—	—	—	—	—	—	—	—	—	1	—	1	1	23
REPTILES																	
turtle	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
other	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9
MAMMALS																	
lagomorphs	8	9	1	—	—	—	—	—	3	3	12	2	5	1	2	9	48
rodents:																	
squirrels	2	1	—	—	—	—	—	—	1	1	2	—	6	—	1	—	60
beavers	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
others	3	1	—	—	—	—	—	—	2	—	4	1	5	1	1	2	157
carnivores:																	
canis	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	6
badger	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	2	—
porcupine	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
ringtail	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
skunk	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
fox	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
lynx	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
artiodactyla:																	
deer	—	1	—	—	—	—	—	—	—	—	1	—	2	1	1	1	16
pronghorn	1	—	—	—	—	—	—	—	1	—	3	—	—	—	—	—	—
bighorn	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
bison	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
undiff. mammal	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—
TOTAL MNI's	17	23	2	0	0	0	2	0	9	7	34	4	22	4	8	25	364

pr = pitrooms

* all entries are calculated as minimum numbers of individuals

** MNI's calculated from totaling largest MNI figure for room fill, largest MNI figure for subfloor and test trenches, and kiva fill.

olive) is an introduced species. Remaining species providing possible clues as to season of acquisition include hackberry, Opuntia (probably prickly pear), and Portulaca, all of which are available from late August through September (Tierney, this volume). Coupled with other species at the site, both late spring and fall procurement is suggested.

The floral species recovered from P-III sites thus do not contradict interpretations of seasonal residence developed from architectural details, although both cold weather and warm weather occupation has been suggested for many sites. The absence of any floral remains from nine P-III sites may reflect differential preservation rather than procurement behavior, however.

Faunal remains are much better represented among the P-III site locations such that at least some evidence of faunal procurement is evident at all but four of the excavated sites. In general, it can be seen that substantially greater numbers of individuals are represented at sites which have subsurface features which again indicates that differences in preservation may account for much variation in faunal assemblages. This is especially true of the small P-III sites, where only pitrooms exhibit substantial frequencies of faunal remains.

When comparing the one room sites with 4-8 room sites, it can be seen that with two differences, about the same range of fauna are represented. The 4-8 room sites reflect substantially more procurement of turkeys and reflect, as well, a greater investment into procuring large mammals. In nearly all cases, however, rabbits (both cottontail and jack) constitute the single most numerous medium sized species.

Large P-III components reflect a pattern of faunal procurement basically similar to the 4-8 room structures. LA 12119 exhibits by far the greatest diversity of species, including several which are not usually procured as food resources such as ringtail, skunk and fox. These may reflect investment into procuring hides rather than food.

With the exception of migratory waterfowl and bison, fauna recovered from P-III sites are potentially available within the vicinity of Cochiti Reservoir on a year-round basis or would at least be logistically accessible by short duration hunts (Marchiando 1977). Various waterfowl use the Rio Grande as a flyway during both spring and fall migrations, and it is interesting to note that waterfowl are most prevalent archeologically in components at LA 6462, situated near the mouth of White Rock Canyon. No modern-day data exist concerning whether certain waterfowl routinely land in the vicinity of White Rock Canyon during their migrations. It can be suggested that the stiller waters and broader floodplain below the mouth of the canyon would have been more appropriate for resting and foraging by these species in the past, especially when compared to the turbulent and narrow channel characterizing the canyon itself.

Summary

In the previous discussion three basic residential patterns have been identified which typify P-III settlement of the Cochiti Reservoir study area from the vicinity of Alamo Canyon southward to the mouth of White Rock Canyon. These residential patterns include one room sites; small roomblock complexes of 4-8 rooms generally associated with a subterranean kiva; and large sites which are characterized by 15 or more rooms, in association with either one or two kivas.

A primary goal of the analysis was to ascertain whether these residential patterns might be accounted for simply as *seasonal variations* in numbers of individuals or commensal groups comprising the P-III social system, or whether these residential patterns might be accounted for as reflecting fundamentally different *social entities* comprising parts of that system of social behavior.

The combined results of analysis directed toward evaluating floral, faunal and architectural data potentially informing upon seasonal occupation of these site classes point toward the following conclusions in this regard.

First, all three residential patterns may represent different structural poses of social behavior, each of which comprised contemporarily interactive social segments of the P-III social system. No good evidence exists to indicate that one site configuration simply represents a seasonal variation of another social unit reflected at another larger site configuration.

Second, there exists an apparent pattern in association of those structural entities. Single room sites representing single commensal groups seem to reflect the smallest social unit which can maintain a viable residence on a year-round basis. Four to eight room sites, most of which consist of 3-5 commensal groups, constitute the next largest residential and social configuration. From several lines of evidence, this cooperative group seems to comprise the most common P-III social unit and is routinely evident as a roomblock of surface rooms constructed both for habitation and bulk storage in association with a kiva.

Larger P-III sites seem to be made up of two such household groups operating contemporaneously. No good evidence in the southern Pajarito Plateau exists at present to indicate that residential groups larger than two household units in fact existed during the P-III phase. Implications of this residential patterning will be discussed in the concluding section of the chapter.

CLASSIC (PUEBLO IV) OCCUPATION)

Introduction

The Pueblo IV (P-IV) occupation of the Cochiti study area is defined by a change in dominant ceramic manufacturing technology in the southern portion of the study area (glazewares) and by less dramatic changes in ceramic types for the northern part of the study area (biscuitwares). The P-IV period thus spans a time period of 275 years from ca. A.D. 1325 to the beginnings of historic Spanish settlement in New Mexico. Ceramic types associated with P-IV settlement and dates proposed for those types are summarized as follows:

early P-IV	Rio Grande glazes A, B; Biscuit A	A.D.1325-1425 or ?1325-1450	(Peckham and Wells 1967) (Warren1977c)
mid P-IV	Rio Grande glazes C, D, early E; Biscuit B	A.D.1450-1600	(Warren1977c)
late P-IV	Rio Grande late E	A.D.1600-1650	(Warren1977c)

Based upon a literature survey, some 322 P-IV sites have been documented for the Cochiti study area representing a slight decrease from the P-III period (Biella 1977: 117). Architectural sites range in size from single rooms to pueblos of up to 800 rooms. The population of sites represents a distinctly bimodal distribution of small (1-3 rooms) and large (greater than 50 rooms) sites. The latter are frequently reported to exceed 150 ground floor rooms in size. It has generally been assumed that the small sites represent seasonally inhabited procurement or production locales (often termed field houses) used by inhabitants of the large sites which have been interpreted as village centers.

Artifact scatters, trails, and agricultural terrace systems are also characteristic of the P-IV period. Although similar kinds of features have been occasionally documented for the P-III period, they are extremely rare in occurrence prior to the P-IV period. Chronological data derived through excavation of a range of P-IV sites within the study area are presented in Table 6.10.

Slight differences in the distribution of P-IV sites may be noted when compared to P-III settlement. P-IV sites occur in much lower frequencies on the Pajarito Plateau, decreasing in numbers over 65 percent from the previous period. Since many of the sites are significantly larger in size than those comprising the P-III period, the marked decline in numbers of sites during the P-IV period may not reflect a significant decrease in population. The P-IV occupation extends onto the Caja del Rio Plateau and into White Rock Canyon. A majority of P-IV sites date between A.D. 1325-1450 although the occupation continued into the 16th century. Nevertheless, a marked decrease in the number of sites is apparent toward the end of the 15th century. Principal exceptions include a few large villages located in the southern part of the Cochiti study area, both on the Pajarito Plateau and in the upper Middle Rio Grande Valley.

Residential Patterns

Three types of residential sites have been documented for the P-IV period: open camp sites, small 1-3 room architectural sites, and villages. Each will be discussed in turn below.

Nonstructural Sites: The nonstructural Anasazi sites are generally small in areal extent and exhibit high artifact densities when compared to open Archaic sites in the same localities. All of the hearth features are characterized by some amount of firecracked rock; only two hearth features were recovered, more or less, intact. Absolute frequencies of sherds varied (33 to 124 sherds), but each of the sites

Table 6.10
Chronology for Excavated P-IV Sites

Component		Archeo.	Dendro.	Ceramics	References
Open Campsties					
LA 12444	prov. 3-7	—	—	1400-1450	Chapman et al. 1977:218
LA 12483		—	·	1350-1450	Chapman et al. 1977:288-289
LA 12486		—	—	1350-1450	Chapman et al. 1977:297-301
One Room Sites					
LA 12120	room 1	—	—	1325-1400	Traylor et al. 1977
LA 12124	room 1	—	—	1325-1400	Traylor et al. 1977
LA 12443	room 1	—	—	1325-1425	Chapman et al. 1977:208
LA 12517	room 1	—	—	1400-1450	Chapman et al. 1977:339
LA 12522	feat. 6	—	—	1350-1450	Laumbach et al. 1977:74
LA 12567	room 1	—	—	1385-1400	Traylor et al. 1977
LA 12568	room 1	—	—	1390-1450	Traylor et al. 1977
LA 12584	room 1	—	—	?1350?	Traylor et al. 1977
LA 13049	room 1	—	—	1325-1425	Hunter-Anderson 1979:78
LA 13076	room 2	—	—	1350-1400	O'Leary 1979:122
	room 3	—	—	1350-1400	O'Leary 1979:122
LA 13084	room 1	—	—	1350-1450	Hunter-Anderson and Schutt 1979:134
	room 3	—	—	?1350-1450?	Hunter-Anderson and Schutt 1979:141

Table 6.10 (Continued)

Component		Archeo.	Dendro.	Ceramics	References
LA 13084 (continued)					
	room 4	—	—	?1350-1450?	Hunter-Anderson and Schutt 1979
	room 5	—	—	1350-1450?	Hunter-Anderson and Schutt 1979:145
Two and Three Room Sites					
LA 10119	rooms 1, 2	—	—	1450-1550	Traylor et al. 1977
LA 12124	rooms 2, 3	—	—	1325-1400	Traylor et al. 1977
LA 12125	rooms 1, 2	—	—	1325-1400	Traylor et al. 1977
LA 12127	rooms 1, 2	—	—	1325-1400	Traylor et al. 1977
LA 12144	rooms 1, 2	—	—	1325-1400	Traylor et al. 1977
LA 12454	rooms 1, 2	—	—	1350-1450	Chapman et al. 1977:248
LA 12512	feat. 1, 2	—	—	1350-1400?	Laumbach et al. 1977:64
LA 12518	rooms 1, 2	—	—	1325-1500?	Chapman et al. 1977:343
LA 12519	rooms 1, 2	—	-	1350-1400	Chapman et al. 1977:351
LA 12577	rooms 1, 2	—	—	1325-1400	Traylor et al. 1977
LA 12581	rooms 1, 2	—	—	1350-1450	Traylor et al. 1977
LA 13050	rooms 1, 2	—	—	1350-1400; 1490-1515	Schutt 1979a:91
LA 13054	rooms 1, 2	—	—	1350-1400	Schutt 1979b:107
LA 13084	room 2, wing walls	—	—	1350-1400	Hunter-Anderson and Schutt 1979:141
LA 13086	rooms 2-4	—	—	1325-1500	Hunter-Anderson,etal.1979:160
Large Sites					
LA 6455	eastern sector	—	—	1350-1400	Honea 1968:153
	western sector, 1st occ.	—	clustered dates (27 samples): 1358vv-1409vv	1450-1490s	Honea 1968:169
	western sector, 2nd occ.	—	1432vv-1469R, RB	1500-1525	Honea 1968:169
LA 12119**		1375 ± 19	1396vv; 1419vv	early 1400s	Traylor et al. 1977
LA 9154	lower floors western roomblock, Kiva 1, pitrooms	—	—	1350-1400	Snow 1971
	lower floors northern roomblock	—	—	1375-1400	Snow 1971
	upper floors both roomblocks	—	—	1400-1450	Snow 1971
LA 70	1st occupation	—	+*	?1300-1450	Snow 1976
	2nd occupation	—	+*	1450-1490	Snow 1976
	3rd occupation	--	+*	1490-1515	Snow 1976
	4th occupation	—	+*	1515-1539	Snow 1976

** exact extent of P-IV occupation is unclear; few P-IV sherds recovered
+* numerous dendrochronological samples from LA 70 have been analyzed. The reader is referred to Snow (1976) and Robinson et al. (1972) for these extensive data.

exhibited between 13 and 16 different vessels. The presence of firecracked rock on sites with ceramic vessels remains somewhat incongruous in that a cooking procedure which involves heat-retaining cobbles is generally interpreted as being a nonceramic (or preceramic) technology. Three non-structural sites have been excavated.

LA 12444, prov. 3-7	three hearths and a dispersed lithic and ceramic scatter; hearths defined by presence of firecracked rock (none were intact); density of 3.03 artifacts per m^2 scattered over 496 m^2 area (Chapman et al. 1977).
LA 12483, prov. 1-3	one hearth and a lithic and ceramic scatter; no intact hearths, all defined by firecracked rock; small areally (58 m^2) with a density of 4.38 artifacts per m^2 (Chapman et al. 1977).
LA 12486, prov. 1-5	four hearths with a lithic and ceramic scatter; two hearths partially intact and two defined by scatters of firecracked rock; small areally (192 m^2) with a density of 4.53 artifacts per m^2 (Chapman et al. 1977).

One Room Sites: Fifteen one room P-IV sites have been excavated within the study area. Although these single room structures exhibit considerable variation in size and shape, there are some similarities in construction worth noting. Most are masonry surface rooms which are made from unshaped dry-laid elements often incorporating large boulders as building elements. A few pitrooms are present as well. With the exception of the pitrooms, none of the one room sites had plastered floors. Roughly half of the structures exhibited hearth features. Often these hearths were not formally constructed adobe or slab-lined features (which characterized P-III one room sites) but consisted instead of circular or oval burned areas on room floors. Figure 6.6 illustrates a typical masonry surface room. The following one room P-IV sites have been excavated:

LA 12120, room 1	rectangular surface structure; 1.92 m^2 floor space; corner burned area with a slab bin (Traylor et al. 1977).
LA 12124, room 1	rectangular surface structure; 4.25 m^2 floor space; no interior features; possible entryway (Traylor et al. 1977).
LA 12443, room 1	rectangular surface structure; 3.70 m^2 floor space; slab-lined hearth along one wall (Chapman et al. 1977).
LA 12517, room 1	oval surface structure; 0.88 m^2 floor space; no formally defined features although fill contains firecracked rock and ash (Chapman et al. 1977).
LA 12522, feat. 6	subrectangular pitroom (1.61 m deep); 2.85 m^2 floor space; corner hearth; plastered floors (Chapman et al. 1977).
LA 12567, room 1	subrectangular, semisubterranean room (ca. 50 cm deep); 3.78 m^2 floor space; central burned area and slab bin displaced from wall; room built between boulders (Traylor et al. 1977).
LA 12568, room 1	circular pit excavated into natural slope (1.7 m deep); 6.16 m^2 enclosed space; no interior features; plastered floor; roof of vigas and latillas; doorway (Traylor et al. 1977).
LA 12575	incorporates natural shelter with ca. 8.58 m^2 available floor space (Traylor et al. 1977).
LA 12584, room 1	rectangular surface structure; 3.04 m^2 floor space; no interior features (only 1 glazeware sherd) (Traylor et al. 1977).
LA 13049, room 1	oval surface structure; 5.40 m^2 floor space; central burned area; possible doorway (Hunter-Anderson 1979d).
LA 13076, room 2	subrectangular surface structure; 2.20 m^2 floor space; no interior features; doorway (O'Leary 1979).
LA 13076, room 3	triangular surface structure built against boulder; 1.80 m^2 floor space; 2 burned areas against wall (O'Leary 1979).
LA 13084, room 1	oval surface structure; 4.75 m^2 floor space; hearth against wall; entrance; petroglyphs around interior and exterior of room; built in basalt talus (Hunter-Anderson and Schutt 1979).
LA 13084, room 3*	L-shaped surface structure; 4.70 m^2 floor space defined between walls; no interior features (Hunter-Anderson and Schutt 1979).
LA 13084, room 4	circular surface structure; 1.80 m^2 floor space; burned area in center of room (Hunter-Anderson and Schutt 1979).
LA 13084, room 5	U-shaped surface structure; 4.20 m^2 floor space defined within walls; no interior features (Hunter-Anderson and Schutt 1979).

* P-IV ceramics found in close proximity to room but not in room itself.

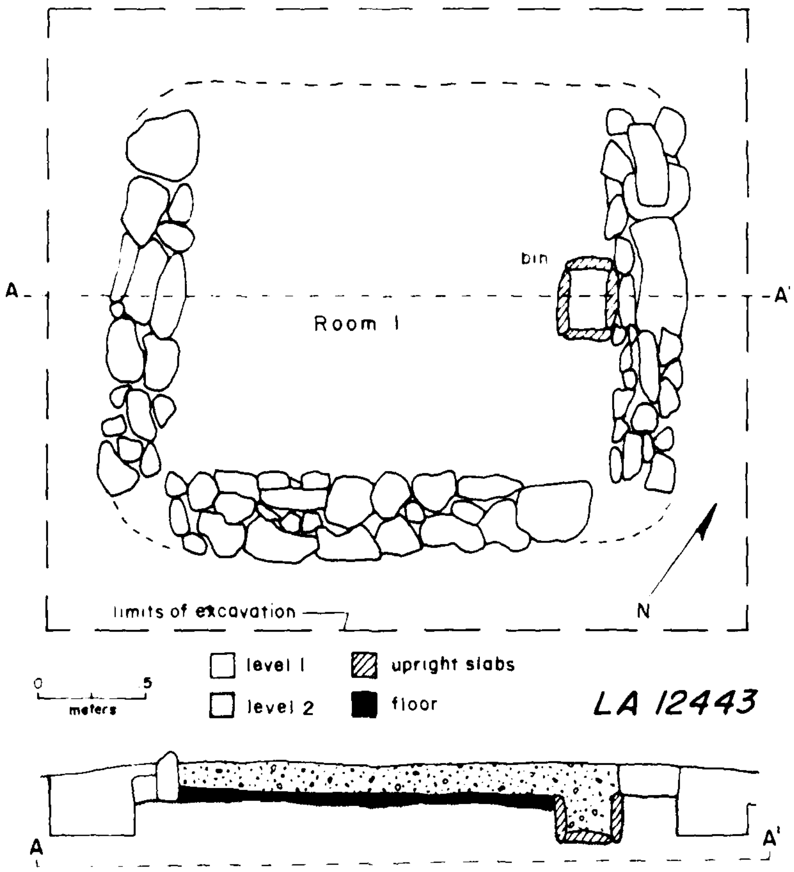


Fig. 6.6 Typical one room P-IV site in White Rock Canyon, LA 12443 (after Chapman et al. 1977:203)

Two and Three Room Sites: The two and three room sites share many constructional features with the one room sites in that they often incorporate existing boulders as a wall or portion of a wall, and many of the masonry elements are unshaped. There is a tendency, however, for at least one of the rooms to be characterized by slightly greater labor investment into construction in the form or coursing, mortared or plastered walls and prepared or plastered floors. The rooms in these sites also tend to be larger as a class of sites although, like the one room sites, they exhibit considerable variability. Exterior features, either bins or hearths, occur occasionally at these sites. Examples of two room sites are illustrated in Figs. 6.7 and 6.8.

Sixteen two and three room sites dating to the P-IV period have been excavated, and are described below:

LA 10119, rooms 1, 2 — two masonry rooms built under an overhang somewhat irregular shape; room 1 (6.84 m^2) 2 side bins with plastered floor; room 2 (7.05 m^2) central ash area and not fully enclosed (Traylor et al. 1977).

LA 12122, rooms 1-3 (2 occupations) — three contiguous masonry rooms arranged in single linear row; all rooms subrectangular; room 1 (3.96 m^2) with 2 wall hearths; room 2 (3.12 m^2), no interior features; room 3 (4.32 m^2) with corner hearth; at least 2 occupations represented by replastered floors in rooms 1 & 2; floor in room 3 at same level as upper floor in room 2. Hearths in room 1 associated with lst occupation only; exterior hearth adjacent to room 2 (Traylor et al. 1977).

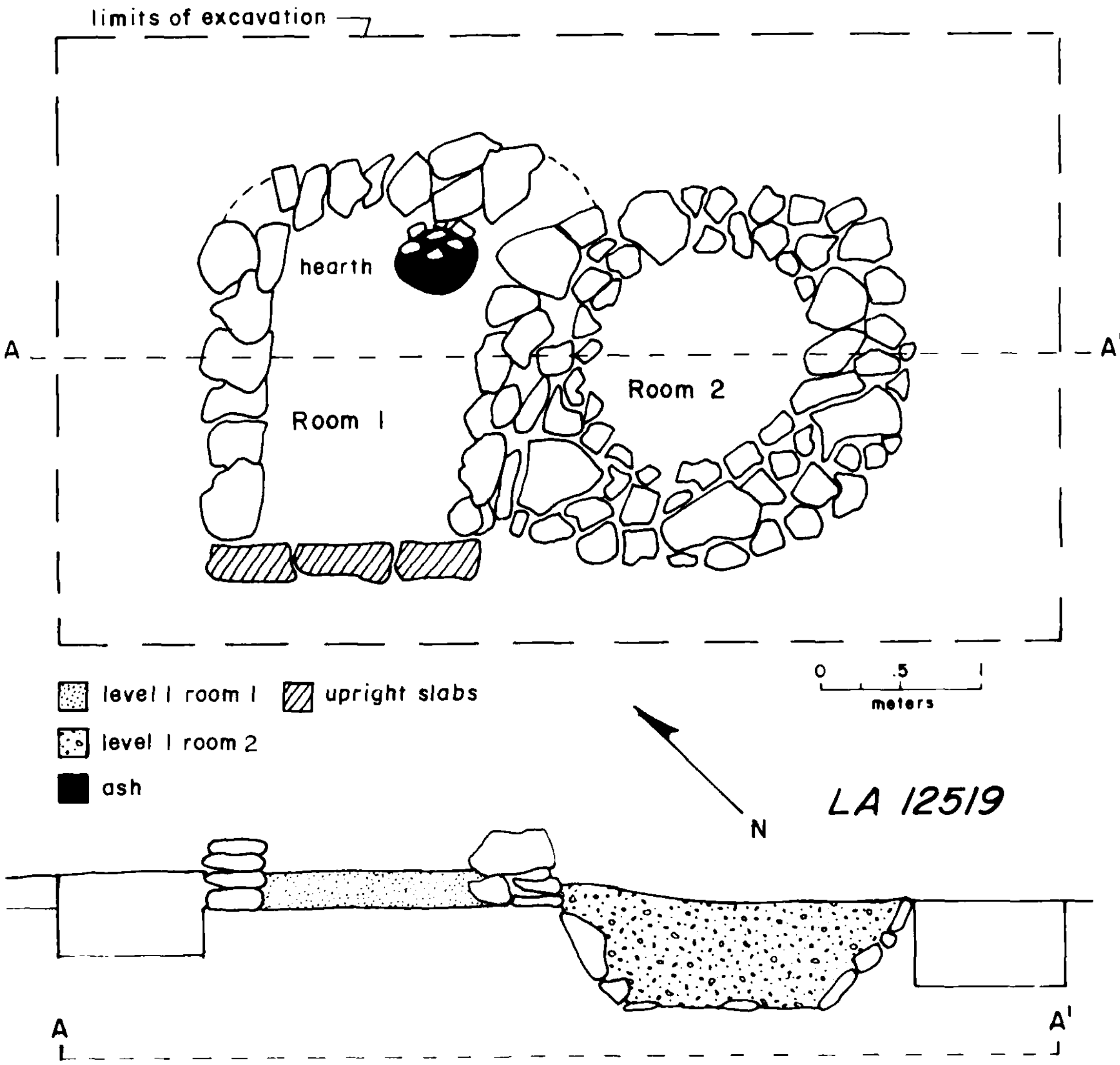


Fig. 6.7 One example of a two room P-IV site, LA 12519. Note construction detail. (after Chapman et al. 1977:347)

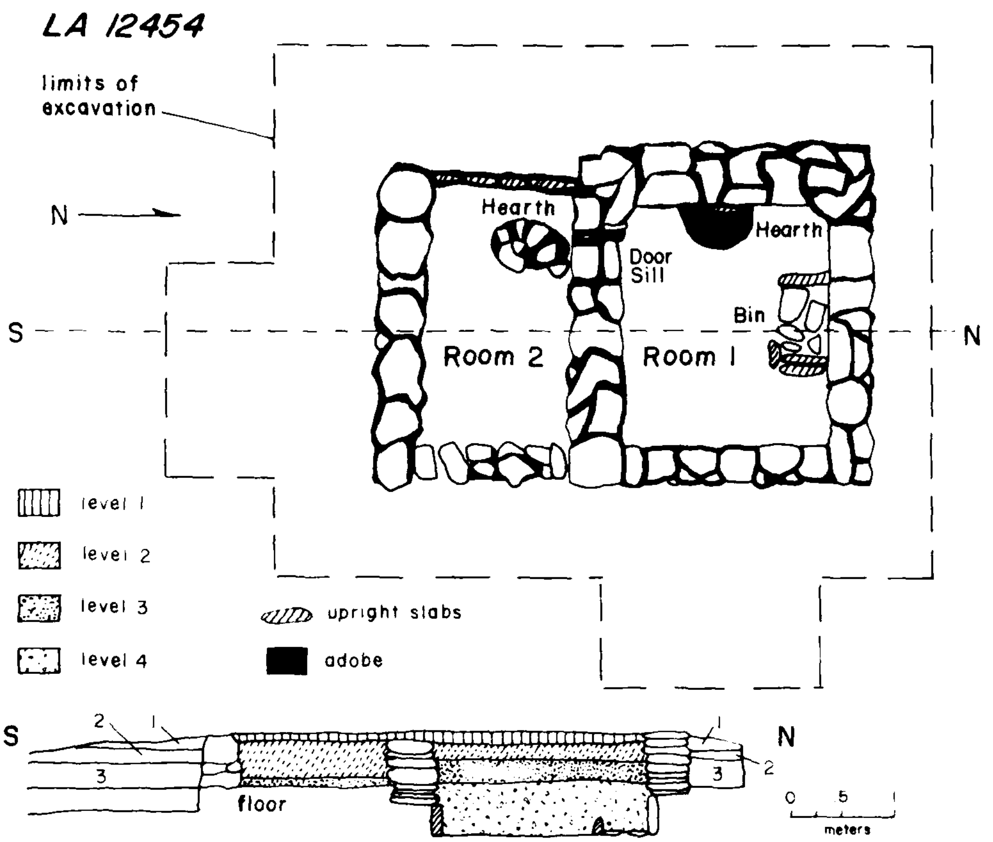


Fig. 6.8 A second example of a two room P-IV site, LA 12454. Note construction detail. (after Chapman et al. 1977:244).

LA 12124, rooms 2, 3 (1st occupation) two contiguous masonry rooms; rectangular shape; room 1 (4.73 m^2) with hearth along end wall; room 2 (4.68 m^2) with 2 central ash pits; exterior feature wing wall with hearth.

(2nd occupation) construction same; room 2, two hearths against wall; room 3, no interior features, exterior hearth may be associated with this occupation. (Traylor et al. 1977).

LA 12125, rooms 1, 2 two contiguous masonry structures; both rectangular; room 1 (3.15 m^2) with subfloor bin; room 2 (3.60 m^2) ash pit against wall and a plaster-lined bin; latter room slightly subterranean; noncontiguous slab-lined bin (Traylor et al. 1977).

LA 12127, rooms 1, 2 two contiguous masonry rooms; both rectangular; room 1 (2.10 m^2) with hearth along wall; room 2 (2.73 m^2), no interior features; doorway in second room at ground level (Traylor et al. 1977).

LA 12144, rooms 1, 2 two contiguous masonry rooms; both rectangular; room 1 (6.30 m^2) with side bin; room 2 (2.66 m^2), no interior features (Traylor et al. 1977).

LA 12454, rooms 1, 2	two contiguous masonry rooms; both rectangular; room 1 (4.20 m^2) surficial with hearth against wall and slab-lined bin; room 2 (3.30 m^2) semisubterranean (47 cm deep) with hearth against wall; doorway between rooms (Chapman et al. 1977).
LA 12512, feat. 1, 2	two contiguous masonry rooms; both rectangular; room 1 (2.83 m^2) semisubterranean (1.13 m deep), no interior features; room 2, partially destroyed surface structure, dimensions indeterminant, slab bin; doorway between rooms (Laumbach et al. 1977).
LA 12518, rooms 1, 2	two contiguous masonry rooms; both rectangular; room 1 (0.94 m^2), no interior features; room 2 (0.96 m^2), no interior features (Chapman et al. 1977).
LA 12519, rooms 1, 2	two contiguous masonry rooms; room 1 (2.50 m^2), surficial rectangular structure, burned cobbles area in corner; room 2 (3.10 m^2) semisubterranean (65 cm deep) circular structure, no interior features (Chapman et al. 1977).
LA 12577, rooms 1, 2	two contiguous masonry rooms; both rectangular; room 1 (2.52 m^2), with corner hearth; room 2 (3.06 m^2), no interior features (Traylor et al. 1977).
LA 12581, rooms 1, 2	two contiguous masonry rooms; both subrectangular; room 1 (6.20 m^2), no interior features but doorway to outside; room 2 (2.85 m^2), no interior features; exterior bin (Traylor et al. 1977).
LA 13050, rooms 1, 2 (2 occupations in room 2)	two contiguous masonry rooms; both circular; room 1 (3.10 m^2), no interior features; room 2 (3.40 m^2), no interior features 1st occupation, hearth against wall for 2nd occupation; exterior door; doorway between rooms (Schutt 1979a).
LA 13054, rooms 1, 2	two masonry rooms, 1.15 m apart; room 1 (1.76 m^2), semisubterranean (1.14 m deep) rectangular structure with corner hearth; room 2 (3.76 m^2), surficial rectangular structure, 2 hearths against walls (one burned cobbles); 2 burned areas outside rooms (Schutt 1979b).
LA 13084, room 2 and walls	two contiguous masonry rooms; room 2 (2.3 m^2) subrectangular, hearth against wall; second feature is U-shaped (3.4 m^2), no interior features; doorway between structures (Hunter-Anderson and Schutt 1979).
LA 13086, rooms 2-3 (1st occupation) rooms 2-4 (2nd occupation)	three contiguous rooms; roomblock forms L-shape; all rooms rectangular; room 2 (4.0 m^2), no interior features; room 3 (2.5 m^2 no interior features; room 4 (4.0 m^2) with 4 hearths (3 along walls, one in center), central hearth was ash only; rooms 2 and 3 built first, room 4 added later (Hunter-Anderson et al. 1979).

Large Sites: The third basic P-IV site configuration is represented by large sites comprised of 50 or more rooms and one or more kivas. Considerable variation in overall numbers of rooms, arrangements of roomblocks and numbers of kivas is evident among these large P-IV sites. Smaller sites consist of single roomblocks and only one or two kivas, whereas larger sites may consist of several plazas fully enclosed by roomblocks and containing several kivas. Three of these large P-IV sites in the Cochiti study area have been excavated (see Figs. 6.9–6.10).

LA 6455 eastern sector	one kiva enclosed by an L-shaped roomblock consisting of 6 pitrooms, 2 surface rooms with hearths and 5 surface rooms without hearths. One arm of the roomblock consists entirely of pitrooms, and the other consists of a row of pitrooms facing the kiva with a roomblock of surface rooms behind it. Only one occupation is evident. At least three unfinished pitrooms occur and other pitrooms may be present. Surface rooms are badly eroded. No clear evidence of exterior features were encountered. Two additional pitrooms and an associated surface room were found east of the roomblock, but represent a different occupation (Lange 1968).
LA 6455 western sector	two kivas and a single roomblock of 37 surface rooms, 12 of which contain hearths and 15 of which do not. The roomblock was constructed as a single unit, although several rooms and one kiva exhibit substantial remodeling. Rooms are arranged in a block 3-4 rooms wide, with the 2 rows nearest the kivas containing hearths. Some evidence of exterior features exists

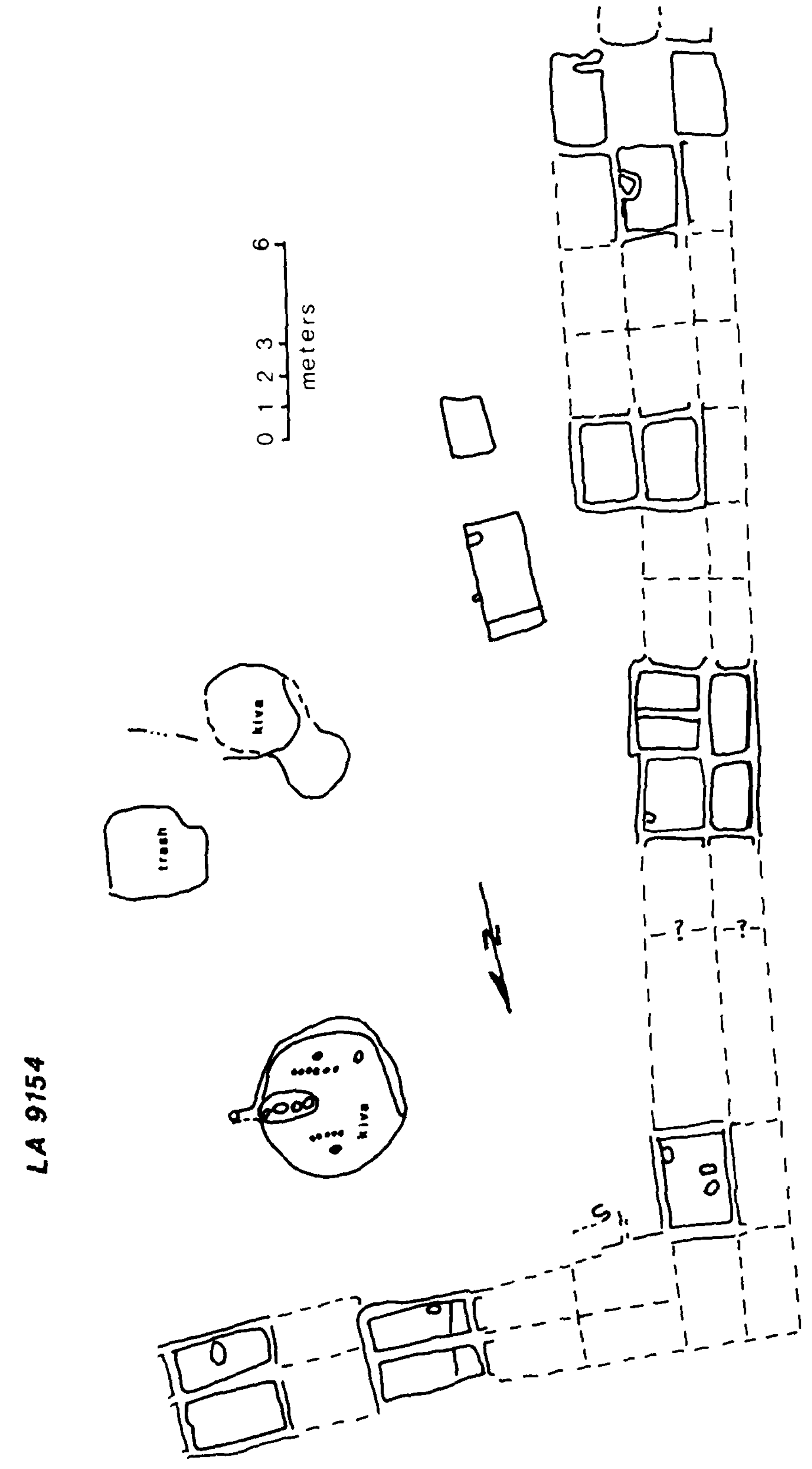


Fig. 6.9 An example of a large P-IV site, LA 9154 (modified from Snow 1971)

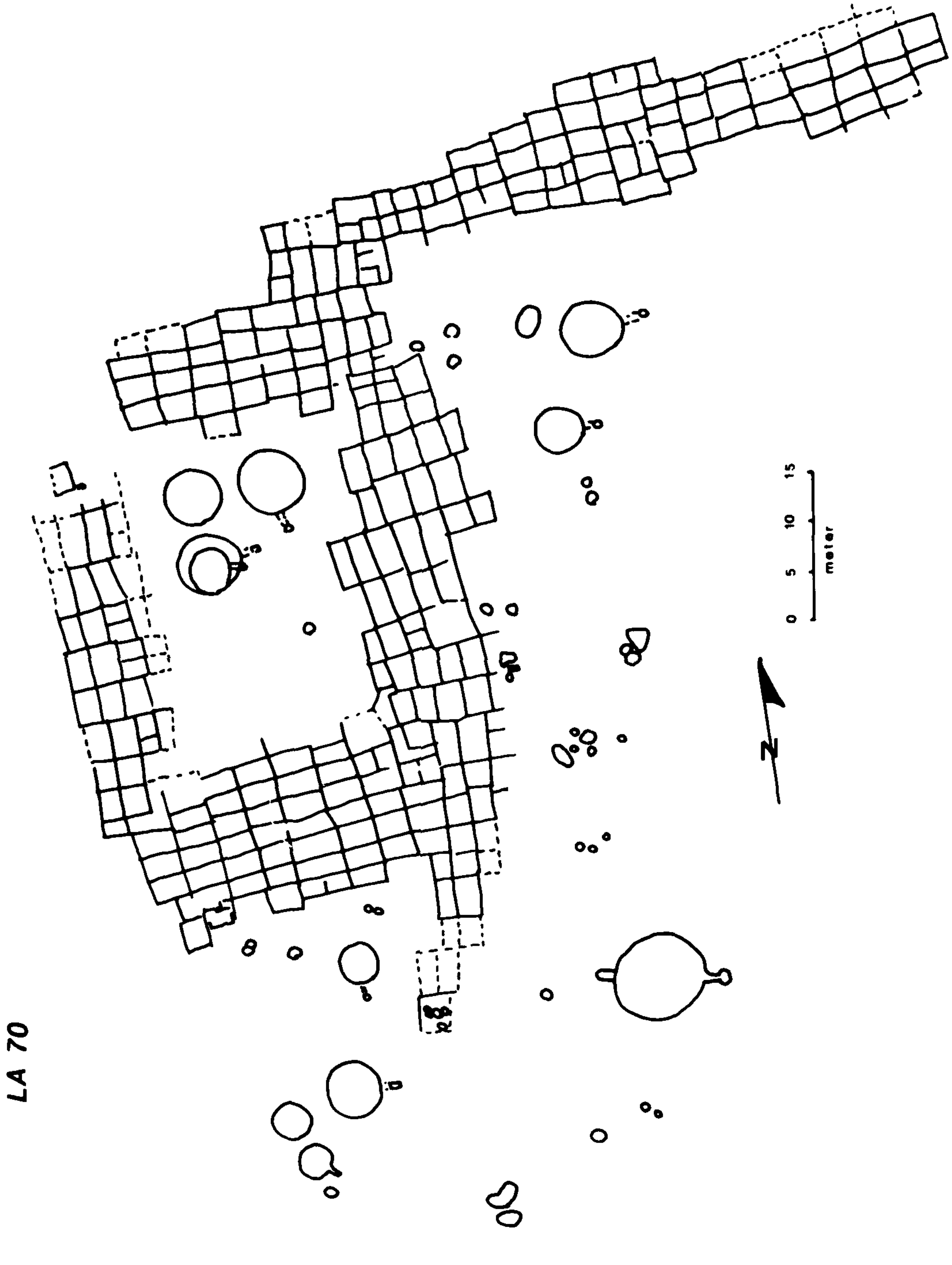


Fig. 6.10 A second example of a large P-IV site, LA 70 (modified from Snow 1976)

as an open sided room and wing walls. Two occupations represented by ceramics, but data insufficient to determine which surface rooms were occupied during each component. One pitroom of earlier occupation not associated with the roomblock was located north of the roomblock and the kivas (Lange 1968).

LA 9154 — two kivas enclosed by an L-shaped roomblock of 43 surface rooms (estimated), with an earlier component of at least 3 pitrooms. Surface rooms arranged in rows 2-3 rooms wide for both arms of the roomblock, with rooms containing hearths located toward the inside of the L. Data exist for 18 excavated surface rooms (of ca. 23 known to be excavated), 11 containing hearths, 7 with no hearths.

Two major components of occupation suggested, but data are insufficient to identify number of rooms associated with each. Only one kiva associated with each occupation. Many rooms characterized by remodeling and rebuilding episodes. No clear evidence of exterior features, but excavation outside rooms was not extensive (Snow 1971).

LA 70 — nine kivas, 195+ surface rooms, 7 known pitrooms, 10 or more ramada structures and a variety of exterior features such as wing walls, hearths, adobe mixing basins and unknown structures represented by posthole patterns.

At least four occupations represented, the earliest including one square kiva and 7 pitrooms. Subsequent occupations involved construction and use of the surface rooms, arranged in roomblocks forming a hollow square with one attached wing. Of the 195 rooms excavated, 134 contained hearth facilities, and 61 did not. Many rooms exhibited remodeling episodes, and considerable complexity of construction, use and abandonment of rooms is evident over occupation of the site. Three plaza areas containing kivas represented. Roomblocks vary from 2-7 rooms wide, generally with rooms containing hearths in rows closest to plaza areas (Snow 1976).

Perhaps one of the more important observations to be made concerning large P-IV sites is the fact that the occupational history of each site appears to be quite complex. Accretional sequences of construction are evident at some site locations such as LA 70, whereas other site locations such as LA 6455 are characterized by construction and use of different facilities at different locations within the site through time. All the excavated sites have rooms which have undergone extensive remodeling, again indicating complex sequences of occupation, abandonment and reoccupation of many facilities.

There are three implications of this occupational complexity in terms of understanding variation in residential groups comprising P-IV society. First, the sequential nature of occupation on a site by site basis may reflect considerable mobility on the part of residential groups throughout the P-IV period rather than relatively stable village based residential patterns. Second, the degree of occupational complexity has resulted in an archeological record which is very difficult to dissect into discrete occupational episodes which might provide clues as to the structure of residential groups inhabiting larger sites. Third, the actual size of population for residence groups inhabiting a site for any given occupational episode may well be considerably smaller than is implied by the immense numbers of rooms, roomblocks, and plazas found at some sites. In this sense, if LA 70 is taken as an example of a *typical* P-IV site of ca. 200 rooms, the actual size of the site seems to represent the end product of a long history of sequential construction, habitation and abandonment events. Actual sizes of residential groups inhabiting the site during any single occupational event may not be significantly larger than those represented by smaller sites such as the western sector of LA 6455 or LA 9154.

In order to evaluate the residential structure at these sites, a rudimentary attempt has been made to use available data concerning numbers of rooms and amount of floor space to arrive at a per occupation average residential group size. These figures are given in Table 6.14. It can be seen that the smallest residential component is the eastern sector of LA 6455, with only 13 rooms (8 with hearths), one kiva and a total enclosed habitation storage space of ca. 124 m^2 exclusive of kivas.

The western sector of the same site was larger, consisting of 27 rooms (12 with hearths) and 2 kivas and a total enclosed habitation storage space of 189 m^2 exclusive of kivas. Two occupational components may be reflected at this sector, however.

Figures for LA 9154 are more speculative because the site was only partially excavated. Two distinct occupational episodes were present and the per-occupation average residential group is reflected as 22 rooms, one kiva and total enclosed habitation/storage space of 164 m^2 exclusive of kivas.

Averages for LA 70, in contrast to these smaller components, reflect 50 rooms, two kivas and 351 m^2 of enclosed habitation/storage space per occupation exclusive of kivas.

Although these comparative measures are based upon very gross estimates and averages per number of occupational events, it is quite interesting to note that the mean residential group size at LA 70 is just about twice as large as the residential group sizes indicated at the other large sites. It might be suggested, then, that a basic residential unit characterizing occupation of large P-IV sites consists of households or related households who share a common kiva and who use a combined floor space totaling from ca. 125 m^2 to 175 m^2 for both habitation and storage. Actual numbers of commensal groups involved in these residential units is more subject to question, although a range from as few as 8 to as many as 33 can be posited from average numbers of rooms containing hearths.

This range seems much more variable than estimates of enclosed room space and serves to illustrate how tenuous these speculations are. It remains apparent, however, that LA 70 decidedly reflects an average residential occupation roughly twice the size of individual residential components characterizing the two other *large* P-IV sites, given ratios of total numbers of rooms, to kivas to enclosed room space characterizing occupations.

Taking the average P-III household size of ca. 4 commensal groups inhabiting up to 60 m^2 of room space per kiva, P-IV sites might be seen as reflecting a distinct increase in residential unit size but which, at the same time, reflects a similar household size as the fundamental social group comprising residential units. Thus the eastern sector of LA 6455 represents roughly two such household groups sharing a single kiva; the western sector of the same site reflects three such groups using a total of three kivas counting the remodeling of one kiva as two occupations; LA 9154 represents two occupations each consisting of two to three such groups sharing a kiva; and LA 70 represents on the average four occupations of six such groups sharing two kivas.

Of interest in this review is identifying whether a similar fundamental residential unit might be defined as the basis of site-specific occupation such that variation in particular histories of site occupations might be ultimately understood as a kind of shifting residential relocation on the part of such household entities. Two things are clear from the preceding review in this regard: (1) that an argument can be made that some striking similarities in possible measures of household residence can be identified for P-III and P-IV sites which may point to a fundamentally similar kind of social organization underlying residential strategies at different sites; (2) that a basic property of residential behavior through time seems to be one of mobility insofar as no given household unit seems to occupy the same site or roomblock for any great period of time; (3) that the small number of larger P-IV sites which have been excavated to date are insufficient in and of themselves to provide data necessary for exploring the full range of residential strategies necessary for resolving this problem; and (4) that the degree of occupational complexity characterizing all the large sites excavated so far may dictate that future programs addressing similar concerns of residence and social articulation of commensal groups may well have to focus upon complete excavation of roomblocks or sites rather than sample excavation strategies to gather useful information.

Architectural Evidence for Seasonality of Residence

Rooms and other facilities dating in construction and usage to the P-IV period were analyzed for evidence of residential versus storage function and for evidence of cold weather versus warm weather habitation suitability. The assumptions underlying this analysis, and particular architectural details employed have been discussed previously with respect to P-III period sites.

Architectural details for P-IV site locations are documented in Tables 6.11 through 6.14.

One Room Sites: Fifteen P-IV components characterized by single isolated rooms have been excavated within the area of study. Architectural data relevant for assessing whether or not these structures may have been built for warm weather or cold weather residential occupation are presented in Table 6.11. Nine of these structures are fully enclosed by walls and contain evidence of interior hearth usage. In only three cases, however, were hearth facilities actually constructed witnin the rooms. The remainder exhibit evidence of interior fires as burned areas, ash pits or ash lenses.

The relative paucity of constructed hearth facilities is paralleled by a lack of investment into floor and wall construction. Only one room containing a hearth was constructed using adobe mortar in wall and floor construction. The remaining rooms were constructed of dry laid masonry walls, and exhibited unprepared floors.

Rooms containing evidence of hearth usage ranged in floor space from 0.88 m^2 to 5.40 m^2 and averaged 2.99 m^2 (s.d. = 1.52). No evidence of exterior facilities such as bins or hearths was associated with any of the rooms.

Another six single room components dating to the P-IV phase exhibited no evidence of interior hearth usage (Table 6.11). With the exception of one subsurface room exhibiting floor plaster, all were constructed with unprepared floors and dry laid masonry walls. Two of the structures were open sided. Rooms without hearths ranged in floor space from 2.2 m^2 to 6.2 m^2 and averaged 4.1 m^2 in area with a standard deviation of 1.4.

In summary, it can be suggested that of the 15 excavated single room P-IV components, only one exhibits architectural characteristics which would make it suitable for cold weather residential occupation. The remaining structures are characterized by dry laid masonry walls, generally unprepared floors, and often exhibit only burned areas or ash lenses as indication of hearth usage. These rooms stand in clear contrast to the single room P-III components, nearly all of which would have been suitable for cold weather habitation.

Only one room (LA 12568) exhibited constructional features suitable for use in bulk storage. This room was semisubterranean, exhibited a well plastered floor, no hearth, and a lateral above-floor entrance. The room had burned and roof fall indicated it had been built with an adobe plastered viga latilla roof. The room enclosed 6.16 m^2

Table 6.11
Architectural Data for One Room P-IV Sites

Season	Site/feature	hearth type*	wall mortar	floor plaster	subsurf.	floor space (m^2)	Comments and/or exterior features
COLD	LA 12522 feat. 6	H	+	+	+	2.85	
WARM	LA 12120 room 1	A	–	–	–	1.92	
	LA 12124 room 1	–	n.d.	–	–	4.25	entrance?
	LA 12443 room 1	H	–	–	–	3.70	
	LA 12517 room 1	–	–	–	–	0.88	ash in floor fill, no defined hearth area
	LA 12567 room 1	A	–	–	+	3.78	
	LA 12568 room 1	–	–	+	+	6.16	doorway
	LA 12584 room 1	–	–	–	–	3.04	
	LA 13049 room 1	A	–	–	–	5.40	possible doorway
	LA 13076 room 2	–	–	–	–	2.20	doorway
	LA 13076 room 3	A	–	–	–	1.80	
	LA 13084 room 1	H	–	–	–	4.75	entrance
	LA 13084 room 3	–	–	–	–	4.70	open-sided
	LA 13084 room 4	A	–	–	–	1.80	
	LA 13084 room 5	–	–	–	–	4.20	open-sided

*H = formal hearth
A = ash lens or pit
— = no evidence of hearth

of floor space, or at least 10.5 m^3 of interior space given wall height estimates.

Two and Three Room Sites

Fourteen two-room sites and two three-room sites dating to the P-IV phase have been excavated in the southern Pajarito Plateau. Two-room sites are most common by far as evidenced from survey data. All are characterized by rooms which are contiguous in construction, or which are separated by only a few centimeters. Both subsurface and surface rooms occur, and room outline shapes vary from square or rectangular to nearly circular. Four sites exhibited evidence of two distinct occupations, while the remainder were characterized by single occupational episodes. Architectural data relevant for assessing whether these structures might have been constructed for predominantly cold weather or warm weather residential use is presented for each room in Table 6.12. The table illustrates the fact that considerable variation in room construction exists among all 20 occupational components. Using information presented in Table 6.12, the following rationale was employed to suggest a *cold weather, warm weather*, or *cold and warm weather* occupation for each component.

Cold weather occupation is suggested in cases where both rooms were constructed with mortared walls, at least one room contained a hearth facility, and no evidence of exterior features such as hearths or bins were observed.

Cold and warm weather occupation is suggested in cases where at least one room containing a hearth facility was constructed with mortared walls, other exterior features indicating outside activity performance occurred, or another room constructed without use of mortar in the walls was present.

Warm weather occupation alone is suggested in cases where no rooms exhibiting hearths were enclosed by mortared walls.

When these criteria were applied to the 20 occupational components, only three were identified as solely cold weather occupations. Four components were identified as exhibiting properties of both cold and warm weather occupation, and 13 exhibited architectural variation suggesting they would be suitable for residential occupation only during warm weather. Summary data concerning room sizes for these proposed seasonal occupations are presented in Table 6.13.

It is interesting to note that average room sizes for rooms containing hearths and rooms not containing hearths are substantially smaller for suggested cold weather occupations. Room sizes for cold and warm weather occupations are only slightly larger than those for components suggested

Table 6.11
Architectural Data for One Room P-IV Sites

Season	Site/feature	hearth type*	wall mortar	floor plaster	subsurf.	floor space (m^2)	Comments and/or exterior features
COLD	LA 12522 feat. 6	H	+	+	+	2.85	
WARM	LA 12120 room 1	A	–	–	–	1.92	
	LA 12124 room 1	–	n.d.	–	–	4.25	entrance?
	LA 12443 room 1	H	–	–	–	3.70	
	LA 12517 room 1	–	–	–	–	0.88	ash in floor fill, no defined hearth area
	LA 12567 room 1	A	–	–	+	3.78	
	LA 12568 room 1	–	–	+	+	6.16	doorway
	LA 12584 room 1	–	–	–	–	3.04	
	LA 13049 room 1	A	–	–	–	5.40	possible doorway
	LA 13076 room 2	–	–	–	–	2.20	doorway
	LA 13076 room 3	A	–	–	–	1.80	
	LA 13084 room 1	H	–	–	–	4.75	entrance
	LA 13084 room 3	–	–	–	–	4.70	open-sided
	LA 13084 room 4	A	–	–	–	1.80	
	LA 13084 room 5	–	–	–	–	4.20	open-sided

*H = formal hearth
A = ash lens or pit
— = no evidence of hearth

of floor space, or at least 10.5 m^3 of interior space given wall height estimates.

Two and Three Room Sites

Fourteen two-room sites and two three-room sites dating to the P-IV phase have been excavated in the southern Pajarito Plateau. Two-room sites are most common by far as evidenced from survey data. All are characterized by rooms which are contiguous in construction, or which are separated by only a few centimeters. Both subsurface and surface rooms occur, and room outline shapes vary from square or rectangular to nearly circular. Four sites exhibited evidence of two distinct occupations, while the remainder were characterized by single occupational episodes. Architectural data relevant for assessing whether these structures might have been constructed for predominantly cold weather or warm weather residential use is presented for each room in Table 6.12. The table illustrates the fact that considerable variation in room construction exists among all 20 occupational components. Using information presented in Table 6.12, the following rationale was employed to suggest a *cold weather*, *warm weather*, or *cold and warm weather* occupation for each component.

Cold weather occupation is suggested in cases where both rooms were constructed with mortared walls, at least one room contained a hearth facility, and no evidence of exterior features such as hearths or bins were observed.

Cold and warm weather occupation is suggested in cases where at least one room containing a hearth facility was constructed with mortared walls, other exterior features indicating outside activity performance occurred, or another room constructed without use of mortar in the walls was present.

Warm weather occupation alone is suggested in cases where no rooms exhibiting hearths were enclosed by mortared walls.

When these criteria were applied to the 20 occupational components, only three were identified as solely cold weather occupations. Four components were identified as exhibiting properties of both cold and warm weather occupation, and 13 exhibited architectural variation suggesting they would be suitable for residential occupation only during warm weather. Summary data concerning room sizes for these proposed seasonal occupations are presented in Table 6.13.

It is interesting to note that average room sizes for rooms containing hearths and rooms not containing hearths are substantially smaller for suggested cold weather occupations. Room sizes for cold and warm weather occupations are only slightly larger than those for components suggested

Table 6.12
Architectural Data for Two and Three Room P-IV Sites

Season	Site/feature	hearth type*	wall mortar	floor plaster	subsurf.	floor space (m^2)	Comments and/or exterior features
COLD ONLY	LA 12127 room 1	H	n.d.	—	—	2.10	walls probably mortared
	room 2	—	n.d.	—	—	2.73	entrance, walls probably mortared
	LA 12454 room 1	H	+	—	+	4.20	door between rooms
	room 2	H	+	—	—	3.30	
	LA 12577 room 1	H	n.d.	+	—	2.52	walls probably mortared
	room 2	—	n.d.	+	—	3.06	walls probably mortared
COLD & WARM	LA 12124 room 2	H	+	+	—	4.73	exterior wing wall and hearth?
	1st occup. room 3	A	+	+	—	4.68	
	2nd occup. room 2	H	+	+	—	4.73	exterior wing wall and hearth?
	room 3	—	+	+	—	4.68	
	LA 12125 room 1	—	n.d.	+	—	3.15	exterior bin; wall probably mortared
	room 2	A	n.d.	+	—	3.60	both rooms
	LA 13084 room 2	H	+	—	—	2.30	doorway between rooms open-sided
	feature	—	—	—	—	3.40	
WARM ONLY	LA 10119 room 1	—	+	+	—	6.84	
	room 2	A	—	—	—	7.05	not fully enclosed
	LA 12122 room 1	H	—	+	—	3.96	
	1st occup. room 2	—	—	+	—	3.12	exterior hearth
	room 3	H	—	—	—	4.32	open-sided?
	2nd occup. room 1	—	—	+	—	3.96	
	room 2	—	—	+	—	3.12	exterior hearth
	room 3	H	—	—	—	4.32	open-sided?
	LA 12144 room 1	—	n.d.	+	—	6.30	
	room 2	—	+	—	—	2.66	
	LA 12512 feat. 1	—	+	—	+	2.83	doorway between rooms
	feat. 2	—	+	—	—	n.d.	partially destroyed
	LA 12518 room 1	—	+	+	—	0.94	
	room 2	—	+	+	—	0.96	
	LA 12519 room 1	H	—	—	—	2.50	
	room 2	—	—	—	+	3.10	
	LA 12581 room 1	—	—	—	—	6.20	exterior bin; entrance
	room 2	H	—	—	—	2.85	exterior bin; entrance
	LA 13050 room 1	—	—	—	—	3.10	door between rooms
	1st occup. room 2	—	—	—	—	3.40	exterior entrance
	2nd occup. room 1	—	—	—	—	3.10	door between rooms
	room 2	H	—	—	—	3.40	exterior entrance
	LA 13054 room 1	H	—	—	+	1.76	two exterior burned areas
	room 2	H	—	—	—	3.76	two exterior burned areas
	LA 13086 room 2	—	+	—	—	4.00	
	1st occup. room 3	—	+	+	—	2.50	
	2nd occup. room 2	—	+	—	—	4.00	
	room 3	—	+	+	—	2.50	
	room 4	H,A	—	+	—	4.00	

*H = formal hearth
A = ash lens or pit
— = no evidence of hearth

to reflect occupations solely during warm weather. It is also of interest to note that the relative proportion of total enclosed floor space associated with hearths versus enclosed nonhearth floor space exhibits a directional trend from 64 percent (cold weather habitation) to 58 percent (cold plus warm weather) to 38 percent (warm weather only). Although this latter trend is in part an artifact of analysis in that some components having no hearths have been classified as warm weather occupations, the fact that variation in other constructional attributes and associated exterior features were used to assign seasonality of occupation must be considered. It can be suggested that the directional decrease in enclosed, potentially heatable floor space reflects differences in seasonal usage of the components.

In summary, two and three room P-IV occupational components tend to reflect predominantly warm weather occupations, but are characterized in general by more investment into construction of walls, floors, and interior hearth facilities than are the single room components.

When the same data (Table 6.12) are examined for evidence indicating possible use of facilities for bulk storage, nine fully enclosed rooms are characterized by mortared walls, plastered floors, and no evidence of hearth usage. Another four rooms do not have plastered floors, but otherwise are similar in construction. It is suggested that these thirteen rooms might have been suitable for use either as short-term or long-term bulk storage facilities.

Three of the facilities occur as second rooms at components which also contained a habitation room suitable for cold weather occupation, a situation which might be expected if such sites were indeed occupied during winter months.

The remaining possible bulk storage rooms are not associated with rooms suitable for cold weather habitation however, and eight of the remaining ten in fact constitute the *only* room facilities at given components. This is an especially intriguing situation, because it would be expected that bulk storage facilities used for long term, winter storage, would be situated nearby site locations where winter residences were maintained. The existence of several sites characterized *solely* by bulk storage facilities (assuming the validity of analysis) might be taken as evidence pointing to a short-term storage use of the facilities perhaps more consistent with warehousing harvested or collected foodstuffs prior to transportation to a more permanent storage location.

Large Sites: Details of architectural construction characterizing large P-IV sites are very similar to those characterizing large P-III sites. Room walls were constructed from adobe, based upon mortar and cobble foundations set in shallow trenches. Room floors were generally plastered, as were wall interiors in many cases. Rooms fully enclosed by walls were thus constructed in fashions making them suitable for winter habitation (when containing hearths) or for long-term bulk storage (when not containing hearths). Evidence of warm weather occupation was most apparent at LA 70, where a great variety of facilities such as ramada structures, open-sided rooms, cists, hearths, wing walls, and posthole alignments indicating various other structures were encountered in plaza areas outside roomblocks.

Only limited positive evidence of warm weather occupation was recovered at other large P-IV sites. It should be emphasized that excavation at these sites focused primarily upon rooms, trenching plaza areas to discover kivas or pitrooms, and excavation of such subsurface features as were defined through trenching. The absence of evidence of exterior ramada features or other facilities indicating possible warm weather occupation must not be considered decisive.

Table 6.13

Comparison of Two Room P-IV Sites by Seasonal Occupation

Season	Rooms with Hearths				Rooms without Hearths			
	N	$\bar{x}$	s.d.	Σ	N	$\bar{x}$	s.d.	Σ
COLD ONLY	4	2.61	0.50	10.42	2	2.90	0.23	5.79
COLD & WARM	4	3.84	1.16	15.36	3	3.74	0.82	11.23
WARM ONLY	10	3.79	1.42	37.92	19*	3.48	1.61	62.63

*** includes one room with no floor space data**

Table 6.14

Architectural Data for Large P-IV Sites

LA 6455 Eastern Sector	Rooms with hearths	8*
	$\bar{x}$ floor space	8.58
	s.d.	2.88
	sum	68.66
	Rooms without hearths	5
	$\bar{x}$ floor space	11.06
	s.d.	4.08
	sum	55.31
	Kiva	1
	floor space	47.90
	Total surface space	79.91
	Total pitroom space	44.06
	Total enclosed space exclusive of kiva	123.97
	Total enclosed space	171.87
	Exterior features	none
LA 6455 Western Sector	Rooms with hearths	12
	$\bar{x}$ floor space	6.90
	s.d.	2.70
	sum	82.81
	Rooms without hearths	15**
	$\bar{x}$ floor space	7.07
	s.d.	3.59
	sum	106.06
	Kivas	2***
	$\bar{x}$ floor space	17.43
	s.d.	4.68
	sum	34.13
	Total surface space	188.87
	Total enclosed space	223.00
	Exterior features	wing walls
LA 9154 (Two occupations, undifferentiated)	Rooms with hearths	11
	$\bar{x}$ floor space	7.72
	s.d.	1.37
	sum	84.97
	Rooms without hearths	7
	$\bar{x}$ floor space	7.51
	s.d.	1.67
	sum	52.54
	Kivas	2
	floor space	no data
	Unexcavated surface rooms	25
	Pitrooms	3
	floor space	no data
	Total surface space (excavated rooms)	137.51
	Est. surface space (unexcavated rooms)	190.38
	Total est. surface space	327.89+
	Average rooms for occup.	22
	Average surface space per occupation (est)	163.95+
	No. kivas per occup. (actual)	1
LA 70 † (four occupations)	Rooms with hearths	134
	$\bar{x}$ floor space	6.95
	sum	931.30
	Rooms without hearths	61
	$\bar{x}$ floor space	7.75
	sum	472.70
	Pitrooms	7
	$\bar{x}$ floor space	6.13
	s.d.	1.56
	sum	42.94
	Pitroom/kiva (#229)	1
	floor space	9.42
	Large kiva (#231)	1
	floor space	63.58
	Other kivas	7
	$\bar{x}$ floor space	24.49
	s.d.	7.11
	sum	171.42
	Total surface space	1,404.00
	Total enclosed habitation space	1,446.94
	Total enclosed space	1,691.36
	Average number rooms per occupation	50
	Average number kivas per occupation	2
	Average enclosed habitation space per occupation	361.74
	Average total enclosed space per occupation	422.84

* includes 6 pitrooms

** includes one open-sided room

*** includes one kiva which had been remodeled. Statistics reflect remodeling episodes, but sum floor space is based on average size of structure throughout its life history.

† data for this table were derived from the following sources:
Snow (1976:Tables A28, A29, A33)
Hunter-Anderson (this volume)

All spatial measures refer to m^2

Recognizing these considerations, it can be suggested that the character of architectural construction of room facilities found at the larger P-IV sites clearly demonstrates them as winter residences. The degree to which these sites served as primary loci of summer habitation by members of households is not as clear. A great number of one and two room sites dating to the P-IV period have been excavated, and they generally seem to have been constructed as if they were intended primarily for warm weather usage.

It is of interest in this regard that average room sizes for potentially habitable rooms among these small one and two room sites do not exceed much over 4 m^2 (Tables 6.11 and 6.12), whereas rooms containing hearths found at large sites average near 7 m^2 in floor space (Table 6.14). This difference in floor space in habitation rooms might be expected if the small sites were in fact inhabited predominantly during warmer weather when a substantially greater number of activities would be performed outside rather than inside, and when the needs for interior sleeping space would be lessened.

In summary, it can be suggested that anlaysis of constructional details among different classes of P-IV site locations has resulted in some indications to support the contention that small single room or two room sites may have served as seasonally occupied residences during warmer seasons of the year. Evidence clearly exists at large sites to indicate both cold weather and warm weather habitation, with an emphasis upon cold weather habitation and long-term bulk storage.

Given this preliminary evidence pointing toward a seasonally based residential strategy involving perhaps winter residence at large site locations coupled with warm weather residence at small one or two room locations, the question still remains as to what the fundmental social unit of residence then was within the framework of P-IV society. In this sense, evidence exists which points toward a continuation of the ca. 4 commensal group household definable during the P-III period, as being the fundamental base unit of P-IV residence at large sites. Despite this, numerous small sites apparently inhabited on a seasonal basis seem to have been a function of single, or at most two commensal groups.

Given a truly *seasonal* strategy of habitation by basic units of society from winter village residence to summer dispersed residence, one might have expected that the seasonally occupied P-IV sites may have consisted of more than one or two commensal group habitations. The fact that these seasonal residential occupations reflect only one or two commensal groups implies a kind of fundamental social segmentation which is not in any way consistent with that reflected at larger sites, and must stand as a subject for future investigation.

Floral and Faunal Evidence for Seasonality of Residence

Direct evidence of floral species possibly used as food resources at small P-IV sites is presented in Table 6.15.

Floral remains were recovered from only 9 of 33 components, with the vast majority of specimens occurring at LA 12581. This tends to indicate that such remains are not generally well preserved among small sites.

Among components which have been suggested to reflect cold weather residence based on architectural details, only two exhibited floral remains. Maize was the only plant food recovered from LA 12522, and both Cheno-am and Portulaca seeds were found at LA 12454. Although maize does not necessarily indicate season of residence, Cheno-ams and Portulaca were presumably procured in the months of September or October (Tierney, this volume). Neither case necessarily contradicts a postulated cold weather residence indicated by architecture.

No floral remains were recovered from any of the three components exhibiting positive evidence of both cold and warm weather residential use, and only 4 of the 16 components suggested to represent warm weather residential use contained floral remains. Pinyon nuts found at LA 12483, an open campsite, may be intrusive from a relatively modern occupation. Physalis (ground cherry) found at LA 13049 indicate a possible June occupation, whereas hackberry and Sporobolus seeds found at LA 13054 indicate a fall occupation (Tierney, this volume). The unidentified grass seeds recovered from LA 13050 may indicate a fall occupation as well.

Three of the ten sites which exhibited no evidence of residential occupation as rooms with hearths exhibited floral remains. One of these (LA 12581) contained over 80 specimens, representing both spring and fall procurement. The other two components of this kind contained evidence of fall procurement only, although both included juniper seeds which might indicate storage.

The overall low frequencies of floral remains encountered at small P-IV sites probably reflect poor preservation rather than subsistence behavior. When seasonal availability of those remains which were found is compared against architectural data indicating possible seasonality of residence, no overtly contradictory occurrences were noted. It is interesting, however, to note that only one case of the 33 components exhibited cultigens, and that this was a room suggested as suitable for winter habitation.

Large P-IV sites stand in distinct contrast to this, in that the predominant floral species recovered from them is maize. Data from the three excavated sites in this category have not been summarized here and the reader is referred to Snow (1976) for information from LA 70, Snow (1971) for information from LA 9154, and Ford (1968) for information from LA 6455. Extensive flotation samples were not collected from these sites, but most yielded considerable volumes of maize in a wide variety of contexts. These clearly indicated that maize was stored in bulk and consumed at the sites, and thus tends to substantiate inference concerning cold weather habitation of the large sites derived from architectural details.

Faunal remains are much better represented among the small sites, and occur at 18 of the 33 components (Table 6.16). In general, sites with hearths, characterized by at least one room suitable for cold weather residential use, or sites with no facilities having hearths exhibit the fewest numbers of fauna. Sites exhibiting the greatest numbers of

Table 6.15

Floral Remains Recovered from Small P-IV Sites

Species	HEARTHS PRESENT																							NO HEARTHS									
	Cold Weather				Cold & Warm Weather			Warm Weather Only																Warm Weather Only									
	12522, F6	12127, R1-2	12454, R1-2	12577, R1-2	12124, R2-3	12125, R1-2	13084, R2+F	12444, P3-7	12483, P1-3	12486, P1-5	12120, R1	12443, R1	12567, R1	13049, R1	13076, R3	13084, R1	13084, R3	10119, R1-2	12122, R1-3	12519, R1-2	13050, R1-2	13054, R1-2	13086, R2-4	12124, R1	12517, R1	12568, R1	12584, R1	13076, R2	13084, R3	13084, R5	12512, F1-2	12518, R1-2	12581, R1-2
Zea mays	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pinus edulis (nuts)	—	—	—	—	—	—	—	—	12*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Juniperus sp. seeds or berries	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	2	—	—	5
Celtis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	60+
Opuntia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
Cheno/Ams	—	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	6
Portulaca	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Physalis	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Astragalus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Eleagnus sp.†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Sporobolus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
unid. grass seeds	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
unid. seeds	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	—	—	—

* possibly intrusive
† introduced

Table 6.16

Faunal Remains Recovered from Small P-IV Sites

	HEARTHS PRESENT																							NO HEARTHS									
	Cold Weather				Cold & Warm Weather			Warm Weather Only																Warm Weather Only									
Species	12522, F6	12127, R1-2	12454, R1-2	12577, R1-2	12124, R2-3	12125, R1-2	13084, R2+F	12444, P3-7	12483, P1-3	12486, P1-5	12120, R1	12443, R1	12567, R1	13049, R1	13076, R3	13084, R1	13084, R4	10119, R1-2	12122, R1-3	12519, R1-2	13050, R1-2	13054, R1-2	13086, R2-4	12124, R1	12517, R1	12568, R1	12584, R1	13076, R2	13084, R3	13084, R5	12512, R1-2	12518, R1-2	12581, R1-2
FISH	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1?	—	—	—	1	—	—	—	—	—	—	—
LANDSNAIL	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—
BIRDS:																																	
turkey	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	1	1	1?	—	—	—	—	—	—	—	—	—	—
waterfowl	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
other	—	—	—	—	—	—	—	—	—	1*	—	—	—	—	—	—	—	2	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
REPTILES:																																	
turtle	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
other	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—
MAMMALS:																																	
lagomorphs	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	1	—	—	2	—	—	3	—	—	—	—	1	1	—
rodents:																																	
squirrels	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	5	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—
other	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	1	—	8	—	1	3	1	2	—	—	4	—	—	—	—	—	—	—
carnivores:																																	
canis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
skunk	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
artiodactyla:																																	
deer	1	—	—	1	—	—	—	—	—	1	—	—	1	—	—	—	—	2	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
undiff.	—	—	1	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
small undiff.	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
medium undiff.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—
large undiff.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—
undifferentiated	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL MNI's	1	0	1	1	0	0	1	0	2	4	0	0	5	2	0	1	0	30	0	2	7	8	10	0	0	9	1	0	0	0	1	2	0

* eggshell

Table 6.17

Faunal Remains Recovered from Large P-IV Sites*

	LA 70	LA 6455	LA 9154
FISH (undiff.)	23	9	1
SNAIL	--	—	—
AMPHIBIAN	—	9	1
BIRDS:			
turkey	191	90	56
waterfowl	40	38	8
raptors	23	3	18
other	51	13	7
REPTILES:			
turtle	2	—	-
other	—	—	—
MAMMALS:			
lagomorphs	272	86	65
rodents:			
squirrels	?	10	28
beavers	?	1	1
muskrat	?	1	—
other	3	26	25
carnivores:			
canis	20	1	1
badger	—	—	2
fox	3	—	—
lynx	1	3	1
bear	1	1	—
artiodactyla:			
deer	26	10	1
pronghorn	3	2	—
bighorn	7	9	—
elk	2	—	-
bison	2	—	—

* all figures refer to MNI's

fauna are two room structures, at least one room of which would be suitable for warm weather residential use.

Unlike P-III sites where turkey and rabbits were represented in relatively greater frequencies than other kinds of species, the small P-IV sites seem to represent a diversity of fauna procured. The fact that considerably more components characterized bv surface rooms exhibit faunal remains than is the case with P-III sites perhaps indicates that inhabitants of the small P-IV sites emphasized broad-spectrum faunal procurement to a much greater degree as part of their subsistence than did inhabitants of the P-III sites. Given the generally very poor representation at P-III sites, however, differential preservation might account for some of this variation.

Fauna from the large P-IV sites represent a broader range of species than found at the small P-IV sites (Table 6.17). Waterfowl, turkey and rabbits are clearly subsistence emphases at these sites. Variation in procurement of large mammals such as deer, antelope, bighorn sheep, elk and bison is evident from site to site. Thus all of these larger species are represented at LA 70, three were found at LA 6544, and only a single deer was recovered from LA 9154. Some of this variation is undoubtedly due to differences in recovery procedure or sampling strategies. The general representation of other kinds of fauna at all three sites, however, must be taken as an indication that some behavioral differences in large mammal procurement may have existed among the large sites.

The relatively high incidence of migratory waterfowl among the large P-IV sites indicates procurement during both spring and fall. As discussed in conjunction with occurrences of such species at P-III sites, the location of excavated large sites in the vicinity of the mouth of White Rock Canyon may account for relatively large numbers of migratory waterfowl in the faunal assemblages.

Other species of fauna, with the possible exception of bison, are potentially accessible within the general vicinity of the three sites during all seasons of the year. Those not accessible within a day's walk of the site location itself could have been acquired through brief hunting forays.

Given this situation, it is clear that any attempt to use the presence of fauna at sites within the Cochiti study area to identify patterns of seasonal residence would have to be done from the standpoint of modeling seasonal distributional behavior for each species relative to *each* site location in turn. Controlled sampling procedures could then be employed on a site by site basis for recovering faunal remains, and a comparative analysis of relative variation in species representation could be assessed much more rigorously than is possible at present. At the present time, fauna from P-IV sites basically imply a very broad spectrum and generalized procurement strategy operative at the large residential sites. Indications are that similarly generalized faunal procurement was undertaken from small P-IV site locations, especially those which architecturally seem suitable only for warm weather residence. The data are in general so scanty that little more than general speculative statements can be made at this time.

Summary

Basic residential configurations characterizing P-IV settlement in the study area include open campsites, small structural sites made up of no more than two residences, and large sites. These latter reflect complex and differing histories of occupation, accretional growth, abandonment and reoccupation. Residential group sizes inhabiting large sites during given terms of occupation vary from as few as eight commensal groups to as many as 35 or more. Habitations at large sites are nearly all suitable for cold weather residence, and are constructed in conjunction with rooms suitable for bulk storage. Kivas are routinely associated with large site habitation episodes.

In contrast to these large residential groups, smaller P-IV residential units are represented by several site types including single hearth open campsites, multiple hearth campsites, single room habitations, two room habitations, and three room habitations. With the exception of one campsite (LA 12486), these small residential groups consist of only one or two commensal groups. Several small structures are also present which exhibit no evidence of residential habitation. Many of these may have served as either short-term or long-term bulk storage facilities.

Social implications of these various site types have been explored through analysis of data which might inform upon the seasonal contemporaneity of occupation characterizing each. Tentative results of this combined architectural, floral and faunal analysis can be summarized briefly as follows.

Unlike the P-III settlement system, evidence indicates that small P-IV sites may well represent simply seasonal habitations by commensal groups who maintained primary residences at larger contemporary sites. Only seven of the 33 excavated small P-IV components contained structures suitable for cold weather residence, and another ten were characterized by rooms containing no evidence of internal heat sources whatsoever.

A considerable diversity in faunal remains was recovered from these sites, whereas hardly any evidence of cultigens was found. In contrast, the larger sites were characterized by large amounts of maize, in addition to a considerable volume of faunal remains.

It can be offered, then, that with few exceptions small P-IV sites serve as warm weather seasonally inhabited residences by one or two commensal groups whose primary winter residences are at large sites within the region. At the same time, the extreme variation in architectural detail, artifact assemblages and kinds of floral and faunal remains recovered from these sites points very clearly to the fact that contexts of occupation and subsistence behavior are quite different from site to site. Small P-IV sites can be argued to vary in function from short-term open camps to relatively long duration habitations; and from ephemerally used open-sided structures to fully enclosed storage facilities.

The larger sites thus offer the best potential for identifying structural and organizational features of the social makeup of populations during the P-IV phase. It can be suggested in a preliminary sense that the basic residential group during the P-IV is commonly larger in numbers of individuals or commensal groups, than is evident during the P-III. It can also be suggested that a basic feature of P-IV residential behavior may well involve considerable relocation between large sites during the lifetime of a single individual.

The social implications of residence during this phase will be discussed in more detail in the following section.

IMPLICATIONS OF THE ANALYSIS

As was suggested at the beginning of this chapter, the Anasazi occupation of the Cochiti Reservoir locality exhibits considerable variability in residential pattern both with respect to the overall distribution of sites from one time period to another and with respect to the actual size and structure of the residences themselves. One may, in fact, view the residential occupation of the Cochiti area as one characterized by marked contrasts in continuity and discontinuity through time. Since residence is but a single variable which may be scaled, an attempt will be made here to evaluate some of the behavioral implications of the residential patterns which have been identified in this chapter.

BM-III and P-I

Any discussion of residential patterns and overall adaptive strategies engaged in by the earliest Anasazi inhabitants of the area must remain quite speculative. Few sites have been documented and correspondingly few have been excavated. Occupational dates are inferred from the presence of different ceramic wares without independent means of assessing these dates from the sites in the Cochiti area. Despite the limitations of the sample, several provocative inferences might be made concerning the early Developmental (BM-III/P-I) occupation of the Cochiti locale.

First, there exists no clear evidence of a transitional stage from the broad spectrum foraging Archaic adaptive strategy to a predominantly horticultural strategy which may be traced from the archeological evidence in Cochiti Reservoir. Second, the earliest Anasazi occupation of the area (beginning in ca. A.D. 750 or later) is somewhat later than nearby regions. The early Developmental occupation is ephemeral and reflects, at best, extremely low population densities and, perhaps, an intermittent occupation of the upper Middle Rio Grande Valley.

On the basis of a single excavated site, it is impossible to generalize about the range in settlement behavior which characterizes this period beyond a recognition that one type of residential pattern consisted of a cooperative unit of at least three separate households and up to six commensal or food sharing groups. This particular residential strategy was operative minimally during the winter into early spring months and probably represented year-round residence.

Perhaps, one of the more important observations to make about the early Developmental occupation is the fact that there exists absolutely no evidence for a continuous occupation of the Cochiti area by an indigenous, resident population. Rather, use of the locality is one which was intermittent and short-lived at any particular point in time. Thus, one might characterize the early Developmental use of the Cochiti area as one of occasional forays into an apparently marginal region. Although there is a growing body of literature on early Anasazi settlements farther south into the Middle Rio Grande Valley proper (Cordell 1979), whether the occupants of Cochiti area were articulated with these populations or were incorporated into an adaptive system farther east remains a question for future investigations.

P-II

The late Developmental is similar to the early Developmental occupation in reflecting an extremely ephemeral and intermittent use of the Cochiti area. One contrast is that more late Developmental sites have been recorded on survey and, while the upper Middle Rio Grande Valley remains a favored locality, sites are also documented in the southern Pajarito Plateau. From the excavated sample in Cochiti Reservoir, one may suggest that the overall intensity of occupation remains quite limited. Few other similarities in residence, however, may be identified. In fact, the P-II occupation is in complete contrast to the earlier residential strategy.

Although any summary statements presented here are based upon only two excavated sites situated virtually in the same geographic locality (below the mouth of White Rock Canyon), an interesting residential pattern emerges. This pattern consists of an autonomous single household group which occupied a pithouse structure. This residential unit is much smaller than that noted in either the preceding or subsequent phases. The P-II residences were apparently occupied year-round with maize serving as one aspect of the subsistence base.

While storage facilities occur in association with several of the pithouses and direct evidence of maize is found as well, it is interesting to note the comparatively small amount of storage space available at these sites. The smaller size of storage units may be a function of a smaller resident population dependent upon stored goods or may represent a slight shift in economy. Certainly the faunal remains recovered from LA 6461 and LA 6462 suggest an extremely diversified subsistence base. It is also possible that maintenance of a focal horticultural or agricultural subsistence may have been too labor intensive for such a small family unit and that a foraging economy was a more reasonable subsistence alternative.

In addition to the overall contrast in residential structure and size documented for the P-II sites, another point should be emphasized. The occupation of the Cochiti area does not reflect a temporal continuity with the preceding BM-III/P-I phases. Instead, the P-II occupation may be comparatively late. From the few dendrochronological samples recovered from LA 6462, the late Kwahe'e occupation dates to ca. A.D. 1100-1150. It is possible that these dates are not representative of the P-II occupation of the Cochiti study area as a whole, but it should be noted that, with few exceptions, the P-II sites in the study area exhibit Kwahe'e B/W ceramics (late P-II) and not Red Mesa B/W ceramics (early P-II).

P-III

In contrast to the earlier occupations, there is evidence of a substantial, intensive use of the Cochiti study area during the P-III period which began toward the end of the 12th century A.D. The systematic character of this occupation in terms of a redundant residential pattern, the areal expansion virtually throughout the Cochiti area over a short period of time, and the sheer magnitude of the occupation as measured by frequency of sites have clear implications of a substantial and rapid *colonization* of a region which had previously been occupied only intermittently.

Characteristics of this colonization include the operalization of three different residential patterns including one room residences, a residential complex of 7 or 8 surface rooms, and slightly larger residential groups. There is no evidence to suggest that the one room sites served as seasonal adjuncts of the larger sites nor is there evidence of a temporal progression of smaller residential occupations being replaced by larger aggregates at later times. Rather, all three residential options appear to be roughly contemporaneous. This interpretation is based upon the fact that for each of the P-III sites for which archeomagnetic or dendrochronological data were available, all reflected initial construction during the last quarter of the 12th century (see Table 6.4).

If one considers the problem of a colonization of a new territory, this type of multiple residential settlement is not unexpected. Clearly, it might be advantageous to adopt several different strategies until it is evident that the new area could support an expanded resident population.

It is also interesting to note that the initial colonization only post-dates the Kwahe'e occupation by a short period of time, perhaps 25 or 50 years and, in terms of ceramic tradition, there is a strong similarity between the Kwahe'e and Santa Fe wares. In fact, Santa Fe B/W is often considered a carbon-painted outgrowth of Kwahe'e B/W. An examination of the residential structure for the P-II and P-III occupation of the area, however, does not reflect a similar continuity. The two residential patterns are completely different.

In evaluating the implications of the ceramic and residential data, two diametrically opposed conclusions might be drawn: (1) based upon the similarities in ceramic tradition, the P-III residential strategy might be seen as reorganization of a local population, perhaps due to social and/or economic stresses; or (2) based upon the presence of completely different residential strategy over a very short period of time coupled with the magnitude of the occupation throughout the region, the P-III settlement could be interpreted as representing a colonization of the area by a nonindigenous population. In my opinion, the weight of evidence at this time points to the latter alternative, but certainly this should be a topic of future research.

If the second alternative proves to hold, variation in residence might be used in comparative fashion to gain further insight into the process of migration and colonization. It may also help in an understanding of some basic properties of Anasazi social organization. In this sense, one might suggest that if the process of colonization was carried out by small populations, perhaps population segments who once inhabited larger village aggregates, then an examination of residential groups in the colonized area might provide insight into the social structure of the donor population.

P-IV

At the end of the P-III phase, there is evidence of a shift in settlement strategy from the autonomous small residential complexes which characterize the P-III, to a bimodal residential pattern of small 1-3 room sites and larger (greater than 50 rooms) villages. Often in the literature, the P-IV phase in the northern Rio Grande is assumed to represent a developmental process which results in the reorganization of an existing population from dispersed settlements to a few large aggregated village centers. Such a scenario was in fact offered for the Cochiti area during initial stages of this project (Biella and Chapman 1977a).

One might ask the question, however, "*to what extent does the residential analysis conducted in this chapter provide positive evidence for such an interpretation?*"

There are several lines of analysis which can be followed to examine the degree to which the P-IV residential settlement strategy may represent a developmental outgrowth of the P-III. One technique is to examine the character of sites which may have been occupied during the transition from a dispersed to an aggregated strategy. Based upon a literature search for the general Cochiti study area, approximately 20% of all P-III and P-IV sites may reflect multiple occupations (Biella 1977). That is, both classic ceramic wares diagnostic of the P-III (Santa Fe B/W, Wiyo B/W) and the P-IV (glazewares, biscuitwares) would have been documented for these site locations. It is possible, however, that this percentage is inflated in that the presence of a single sherd might result in the assignment of a site to a multiphase or transitional occupation. It should be noted that frequencies of ceramic types are often not included in previous survey documentations.

During the surveys of Cochiti Reservoir, sites were recorded by separate spatial provenience in an attempt to reduce such a blurring or inflated figure, and only 14% of the P-III and P-IV sites reflected multiple occupations (Biella and Chapman 1977c). Using the excavated sample presented in Lange (1968), Chapman and Biella (1977a), Traylor et al. (1977), and Biella (1979), this multicomponent figure is reduced even further to 8%. A brief examination of these multicomponent sites may be instructive.

A multicomponent site may be defined as one in which a discrete P-III occupation could not be discerned from a P-IV occupation. Many site locations which exhibited both P-III and P-IV occupations were not of this type; rather they were made up of two completely separate occupations. One excellent example of this type of site is LA 12522. The P-III occupation consisted of a pithouse and small roomblock and the P-IV occupation consisted of a single room excavated into the P-III roomblock. Thus, two occupations are present but these occupations do not represent a continuity of occupation. Instead they represent a reuse of a site locality, but not a reuse of facilities at that locality.

True multicomponent sites are few in number and only four sites of this type have been excavated: LA 9138, room 7 (Chapman et al. 1977); LA 1067 (Traylor et al. 1977); LA 5011 (Biella et al. 1979); and LA 13086, room 1 (Hunter-Anderson et al. 1979). Three of these sites consist of a single masonry structure. In constructional detail they represent a similar range noted for one room P-IV sites. Two were of dry laid construction and the other contained a mortared wall. The remaining multicomponent site (LA 1067) consisted of two rooms and an open-ended contiguous feature.

Only one other site, LA 12119, may reflect a transitional occupation although there exist some problems in assigning it to a multicomponent status. With the exception of eight glazeware sherds (of over 30,000 sherds recovered from the site as a whole), any P-IV occupation stems from dendrochronological and archeomagnetic dates recovered from several rooms. These samples extend the occupation of the site into the late 14th and early 15th centuries. With the lack of ceramics generally expected to occur on 14th-15th century sites, it is probable that the late dates pertain to the Santa Fe occupation and not a glaze occupation. Similar late dates have been recovered for a Santa Fe occupation at Arroyo Hondo Pueblo near Santa Fe, New Mexico (Lange, personal communication). Thus, while LA 12119 was occupied during a period of time usually assigned to the P-IV phase, it probably represents a P-III occupation based upon the overwhelming number of Santa Fe B/W sherds with a late occupation date rather than a transitional P-III/P-IV occupation.

Overall, then, there is no evidence of a transitional P-III/P-IV village aggregate in the area. The only transitional sites are represented by a few small structural sites. This is not to say that a transition and reorganization of residential structure would necessarily be expected to take the form of using an existing location, but it is interesting to note that in the upper Middle Rio Grande and southern

Pajarito Plateau areas, all aggregated site locations for which we have data represent the selection of new localities.

Another means of evaluating whether the P-IV residential pattern is an outgrowth of the P-III strategy is through examining the pattern of residential structure between the two periods. While the P-IV sites are consistently larger than their P-III counterparts, they do appear to share the basic residential unit (7-8 surface rooms, frequently with a kiva) identified during the P-III phase. The principal difference is that the P-III occupation is characterized by between one and three of these units and the P-IV consists of between four and eight units. Consistent with this is an observation made by Snow (1976:1) concerning building sequences at LA 70, the largest P-IV village which has been excavated in the Cochiti area:

> *Contiguous rooms were apparently built in units of up to 7 or 8, with an effort being made to continue the linearity and alignment of walls already in place in adjacent room clusters.*

Such an independent observation certainly is an interesting parallel to the basic P-III residential unit discussed in this chapter and provides support for the proposition that there exists a continuity in residential pattern as inferred from architectural constructional detail.

One final observation concerning the concept of aggregation during the P-IV period should be addressed. This concerns the actual magnitude or lack of magnitude of the aggregate. As suggested above, the three excavated large *P-IV sites reflect multiples of the basic residential unit* identified during the analysis of the P-III residential patterns. LA 9154 and LA 6455 are both roughly twice as large as the largest excavated P-III residence. These two sites may thus represent an aggregate of four basic residences, but they may not represent a large population.

LA 70 is much larger, but even with population estimates that Snow (1976) provides a maximum population estimate, based upon the assumption that all habitation rooms were occupied contemporaneously, would range from 83 individuals using one population technique up to 367 using another (Snow 1976:Table 38). Since four major building episodes are represented at LA 70, this population estimate must also be considered high. Thus, the number of people who lived in the aggregated P-IV villages in the upper Middle Rio Grande Valley and southern Pajarito Plateau areas may not be large. As a result, complex social integrative mechanisms need not have been necessitated to maintain a large corporate entity. The aggregated village may not have been a highly cohesive society given this line of speculation.

Overall, then, it may be suggested that the P-IV large sites may have represented an aggregation of several residential complexes similar to those documented for the P-III phase. The lack of direct evidence of a transitional occupation for these large sites between P-III and P-IV leaves open an interpretation that the occupational sequence between the two reflects a short-lived hiatus for given localities, with populations returning to the general area but not to specific site locations. Further, despite the specific dates for the transition (cf. LA 12119 discussion above), the aggregated residential strategy clearly is associated with populations who used glazeware ceramics.

Conclusions

Aside from the variation in residential group size and structure which may be documented for the Anasazi sites in Cochiti Reservoir, two common residential factors emerge. One concerns an observation that several residential strategies (in terms of the actual size of particular sites) may be operative contemporaneously. When attempting to provide overviews of settlement systems, there is often a tendency by archeologists to overlook these differences, or to suggest that they represent a progressive sequence from smaller to larger through time. For the sites examined in this chapter, this kind of intraphase progressive sequence is without support. A second commonality in residence between the various phases documented in the reservoir may be termed a *mobility* option. When scaling the various sites with respect to annual versus seasonal occupations, evidence seemed to indicate that at least one residential pattern was of an annual or permanent nature for the duration of occupation for a particular site. The length of occupations appeared fairly short with multiple revisitation of particular site locations which may also be interpreted as *frequent occupational hiatuses*. One may propose that a fundmental aspect of the Anasazi adaptive strategy may have been the ability of the structure to cope with frequent moves between regions or within a region. If the basic P-III residential group proposed here ultimately has any analytical utility, it is apparent that as many as eight of these residential units could be successfully articulated into a *village* settlement but that they were capable of being relatively self-sufficient or autonomous economically as well.

In conclusion, what I have attempted to do in this chapter is to explore the concept of residence as a property of human social and adaptive behavior. In particular, several avenues for identifying whether some forms of residential behavior may be defined analytically as seasonal variants of a basically similar social configuration or whether those forms of residential behavior reflect different structural parts of prehistoric social systems have been examined. It is clear that attempting to use archeological data as independent information bearing upon significant properties of past social behavior is a task fraught with difficulty. The general problem is not without solution, however, and it is hoped that analyses and approaches discussed in this chapter will serve to illustrate that fact.

Chapter 7
GEOLOGIC CONTROLS OF ANASAZI SETTLEMENT PATTERN

Stephen Fosberg

INTRODUCTION

This chapter is concerned with settlement changes that occurred among certain Anasazi groups between ca. A.D. 1175 and 1500 in north-central New Mexico. Although a number of factors have been linked causally with settlement shifts, climatic change is one of the most frequently cited *prime movers*. Climatic fluctuations like population pressure undoubtedly strongly influenced the course of Anasazi cultural evolution; however, it is felt by the writer that climatic factors are being carelessly cited as the principal stimulus behind shifts in settlement patterns in many areas of the American Southwest that have not been clearly documented as having experienced such climatic modulations in the past. For those archeologists who consider their science to be a deterministic one, such a heavy reliance upon climatic causes for cultural evolution is paradigmatically awkward because such explanations rest upon extrasystemic determinants of cultural change that are as yet only partially understood. Therefore, such accounts offer no immediate hope for the formulation of predictive statements concerning the archeological record.

While the writer is not prepared to reject all arguments for climatic change out of hand, it is argued here that a more productive approach toward the explanation of Anasazi settlement patterns should focus instead on those factors operative between the Anasazi cultural system and its physical environment. It is the central assumption of the writer that for the Anasazi agricultural economy, the critical factors determining shifts in settlement were geologic, pedologic, hydrogeologic, and geomorphic. By studying the properties of these environmental variables, one will be able to make predictive statements concerning Anasazi settlement pattern shifts in the past. One need no longer escape the explanation of settlement pattern changes with the illusion that "*. . . the history of Anasazi culture change represents a sequence of changes in emphasis, controlled in large part by the* historical accidents of environmental fluctuation *acting upon established culturally defined imperatives*" (Schoenwetter and Dittert 1968:60) (writer's emphasis).

THE PROBLEM

To understand better the degree to which geologic factors condition Anasazi settlement shifts, five initial hypotheses were framed. The first two are static; they pertain only to the distribution of Anasazi sites over a landscape for a given time period. The last three, however, seek to explain the evolution of Anasazi settlement patterns over time. These hypotheses can be summarized as follows:

Hypothesis 1

If the distribution of field houses and habitation sites were determined by the geologic structure in the area, then we can expect sites to be located on the down dip side of landforms where springs might be expected to exit. It is anticipated that hydrogeologic conditions might favor the distribution of seeps or springs on certain aspects (exposure) of landforms and that the Anasazi might have been selecting for these locations where water would have been available for small garden plots or drinking purposes.

Hypothesis 2

If habitation sites were concerned with a much wider variety of economic pursuits than the small agricultural field house sites, then we would expect the former to be located on lands considered to be more marginal for agriculture than the latter. Marginality here is measured by slope, aspect, type of soil, porosity, permeability, and susceptibility of a soil to suffer from damaging salt build-up.

Hypothesis 3

If settlement pattern shifts over time were due to problems of salinity in the soil, then we would anticipate that the areas to be abandoned would be those with high clay contents and poor permeabilities. Favorable areas would be those localities where drainage conditions were superior and where slope or pedological conditions lessened the dangerous possibility of salt accumulation in the soil horizons.

Hypothesis 4

If the change in field house site locations over time was the result of the mineralogical and/or nutritional exhaustion of the soils in the immediate vicinity of the structure, then we might expect the percentages of particular soils being exploited to remain the same through time while the aspect of sites on the same soil types might shift. A strong body of geomorphic and pedologic literature has documented the fact that different aspects of the same soil will have significant differences in such properties as texture, pH, base saturation, exchangeable bases, free iron content, organic matter content, carbon to nitrogen ratios, etc. If Anasazi fields were moved through time to a particular aspect regardless of the soil type on which it was situated, then statements can be made that predict the particular soil property that determined where agricultural sites would succeed or fail.

Hypothesis 5

If the dramatic shifts in Anasazi settlement patterns over time were due to the inherent geologic limitations of the environment, regardless of climatic shifts, then the archeological record should show a progression through time in the location of Anasazi field houses toward increasingly marginal areas for agriculture. Systemic crashes (with

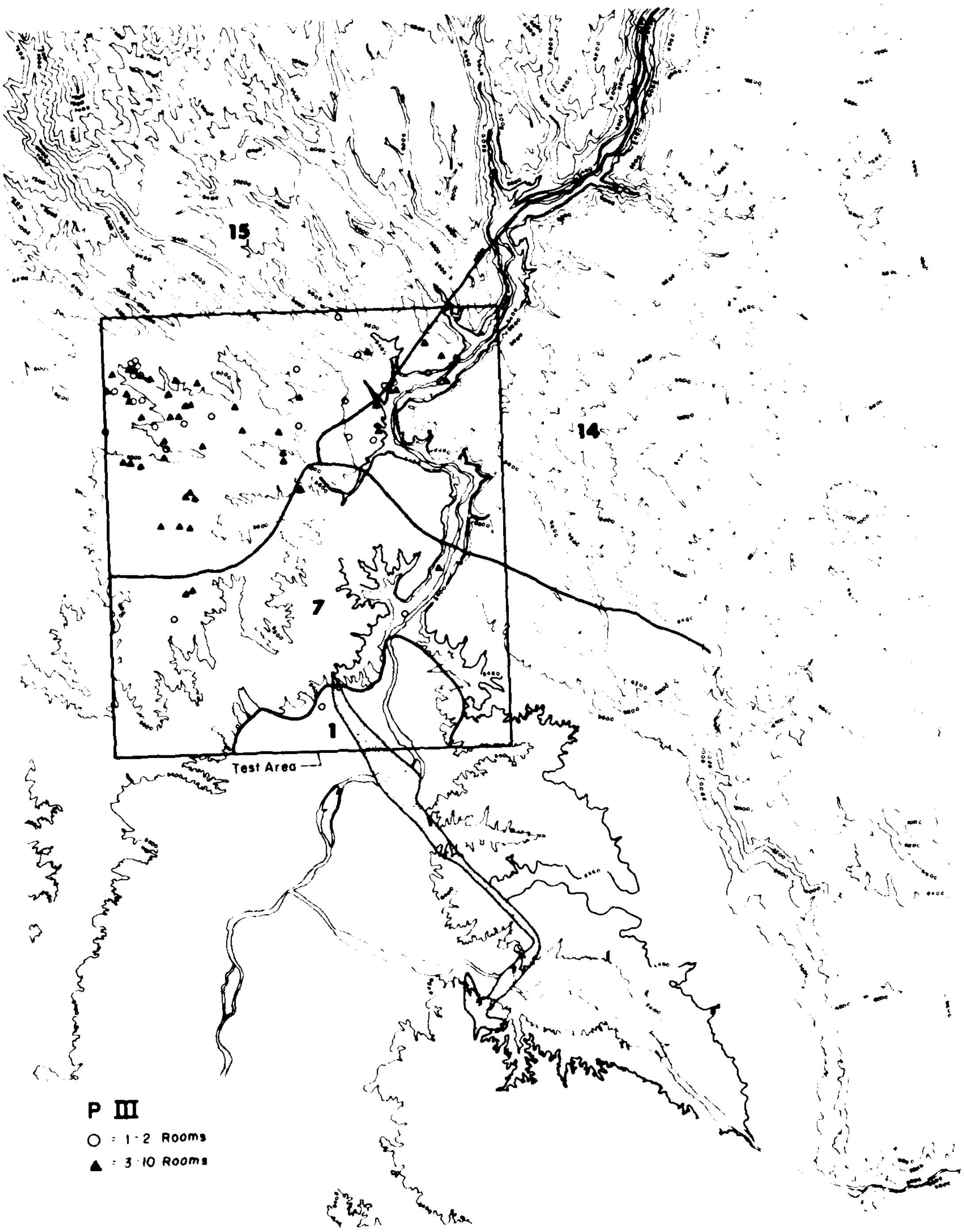


Fig. 7.1 Distribution of Pueblo III sites within sample quadrat (Test Area); note location of soil associations 1, 7, 14 and 15 (in bold type).

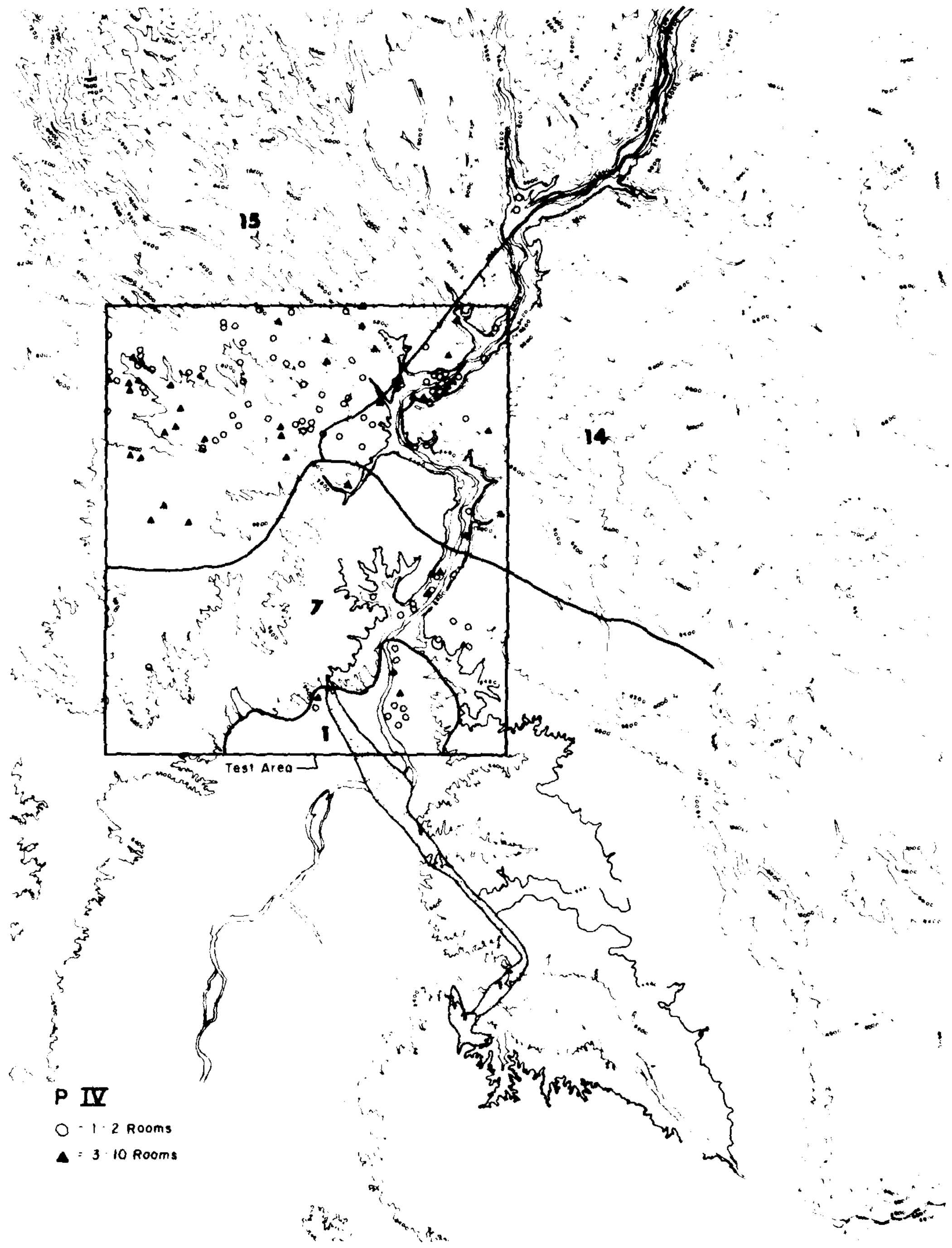


Fig. 7.2 Distribution of Pueblo IV sites within sample quadrat (Test Area); note location of soil associations 1, 7, 14 and 15 (in bold type).

the attendant shifts in population) should occur soon after the least desirable areas for agriculture were being exploited.

THE COCHITI REGION AND DATA UTILIZED AS A TEST CASE

In order to test the hypotheses presented above, certain archeological and geological data requirements must be met. Archeologically, we must be able to demonstrate and monitor shifts in Anasazi settlement pattern(s). Geologically, the area to be investigated must exhibit a variety of geomorphic landforms and lithologies to evaluate the predictions cited above. The Cochiti study area defined by Chapman and Biella (1977a:12) meets both requirements.

Prehistoric Anasazi utilization of the Cochiti region was apparently not significant until the beginnings of the Pueblo III period in the late 12th century A.D. From that point onward, the region became increasingly exploited until, by Pueblo III–Pueblo IV transition times (ca. A.D. 1325-1350), the population in the area reached its maximum density. However, a sharp decline in the population occurred by mid-Pueblo IV times (by the late 15th century) and, by the late Pueblo IV, large portions of the Cochiti region had been abandoned by the Anasazi (Biella 1977: 117). Concomitant with these shifts in population densities were changes in the distribution and size of sites in the Cochiti region.

Within the general Cochiti region, a smaller 165 km^2 quadrat, extending roughly from the mouth of White Rock Canyon 8 km north to the lower reaches of Sanchez and Medio Canyons in the southern Pajarito Plateau, was selected as a test area. This area was selected under the assumption that it encompassed one of the most intensively surveyed portions of the Cochiti study area and should most closely approximate an accurate representation of the numbers and distributions of Anasazi remains for the entire Cochiti region.

Combining information derived from the two Cochiti Reservoir surveys (Biella and Chapman 1977c:224-238) with earlier studies (summarized by Biella 1977:122-137) yields some 92 Pueblo III (P-III) and 139 Pueblo IV (P-IV) structural sites. For purposes of the present study two classes of structural sites were differentiated: small habitation sites, which were defined as those exhibiting an estimated 3-10 rooms; and field houses or 1-2 room sites. This classification resulted in the documentation of 59 P-III habitation sites, 33 P-III field houses, 48 P-IV habitation sites, and 91 P-IV field houses (see Figs. 7.1, 7.2).

As will be discussed in greater detail below, the Cochiti test area is also acceptable geologically for an evaluation of the hypotheses. The area contains a fair amount of geologic variability, both structural and lithological. The most common rock types include Pleistocene rhyolitic tuff and basalt, and Tertiary sediments, all of which differ radically in their permeability, mineralogy, and susceptibility to salt build-up.

Thus, the test area within the Cochiti region appears well suited for testing the five hypotheses presented above. The large number of Anasazi field houses and small habitation sites coupled with the variability of the geologic setting should facilitate the evaluation of predictions of Anasazi settlement evolution based upon the articulation of their economy with the geologic factors determining its success.

ETHNOGRAPHIC EVIDENCE

As an educational strategy, the writer examined accounts in the ethnographic literature that pertained to agriculture to determine if the hypotheses appeared reasonable in light of the extant practices among the native farmers in the Southwest today. Such a literature review provides additional insight into causative factors not originally considered important in determining agricultural strategies. The accounts in no way, however, are considered as valid tests or confirmations of the initial predictions. Testing of the hypotheses can best be performed employing archeological data, since this will permit a comparison of the propositions with independent sets of data. A mere reliance upon ethnographic analogy does not permit this (see Binford 1972:56).

With reference to the first hypothesis, concerning the geologic, structural control of the distribution of sites, it is important to note that the Hopi area represents a series of layered Mesozoic sedimentary rocks. Widely exposed at the surface is the Toreva Formation (the local representative of the Mesa Verde Sandstone Formation). This is underlain by the Mancos Shale and Dakota Sandstone in turn. The washes in the Hopi area are formed on the Mancos Shale while the cliffs are upheld by the Toreva Formation (Bradfield 1971:7). Hack (1942:11) points out that these formations give rise to four principal types of springs: first, a mesa seep where the Mesa Verde Sandstone overlies an impervious shale layer; second, a contact spring where the colluvium on a convex slope thins upward at the toe of the slope where bedrock protrudes; third, a landslide spring where groundwater seepage through colluvium on slopes is checked by beds of impermeable landslide debris; and fourth, seeps in dune depressions. Hopis utilize these springs to irrigate their gardens of melons, squashes, onions, chiles, sunflowers, and tomatoes (Clark 1928:234). Thus, the distribution of irrigated fields is strongly controlled by the lithologic and structural make-up of the land. Regional dips of the sandstone are to the northwest and it is along the northwest mesa sides that the principal springs issue forth and the most successful irrigated plots can be found (Hack 1942:13).

There is little ethnographic literature that relates to the second hypothesis that habitation sites should be located on more marginal agricultural land than field houses. Thus, the evaluation of this prediction will depend entirely upon archeological data. In contrast, much attention has been paid to hypothesis 3, the problem of salt build-up in an arid regime. Mention is made that both the Navajo (Hill 1938:140) and the Yuma (Castetter and Bell 1951:140) tasted their soils for salt content before selecting an area for planting. The preferred texture seems to have been sandly loam. Although the Hopi prefer deep soils with clay substratum some four to five feet below the surface that can be farmed by flood water techniques (Clark 1928:252), these areas often suffer from alkaline conditions. Flood waters pond up on clayey soils, evaporate, and deposit salts. Hack (1942:25) notes that at least certain minimum drainage conditions must be met for valley alluvium areas to be farmed since *"There are areas in the Hopi country, otherwise ideally situated for farming, where there are no* *fields because of a clayey soil and poor drainage*". Where flood water farming is not possible, the Hopi prefer sandy soils because of their natural drainage and ability to retard evaporation (Clark 1928:252; Hack 1942:25; Bradfield 1971:5).

Bradfield (1971) represents the only ethnologist to date who not only described Hopi agricultural practices but also collected and analyzed soil samples for moisture content and salinity. Interestingly enough, Bradfield (1971:58-59) discovered that the clayey valley bottom soils for the Oraibi and Chaco Canyon were slightly to strongly saline (0.15 to 0.75 percent). The sandy loam soils from agricultural plots on the sloping flanks of Bakabi valley which drains into Oraibi Wash were salt-free with values of salinity ranging from 0.008 to 0.02 percent. The sandy slope samples were also free of salinity with lower values of 0.005 percent. These figures reflect the fact that in arid regions, saline conditions rarely occur on well-drained slopes (Bradfield 1969-136).

The fourth hypothesis that mineralogical and/or nutritional exhaustion of the soils led to major movements does not find support in the ethnographic literature. Castetter and Bell (1951:12) feel that the annual flooding of the Colorado River deposited fresh silts which restored the fertility of the land on a regular basis. Forde (1934: 230) states that the accumulation of valley alluvium in addition to eolian deposits sufficed to maintain the fertility of Hopi fields. And finally, Hill (1938:37) discloses that "*The Navajo never knew of a piece of land that became exhausted*".

The last prediction of movements to increasingly marginal agricultural lands over time is also suggested by Phillips (1972:208) who describes the variations in settlement types for Black Mesa through time, from lowland sites practicing floodwater farming along riverbanks to later upland areas where dry farming was employed. Such an evolution involved moving towards areas of increased slope, less dependable water supply, and increased susceptibility to erosion. Relying on archeological evidence, Rohn (1963:454) posits that the use of water and soil control devices on less desirable agricultural lands by the Pueblo III inhabitants of Mesa Verde came about after the productivity of the optimum farmland was diminished due to the erosion of cleared fields and the declining fertility of the soil. The use of higher sloped lands is especially significant since "*There is as yet no positive climatic evidence to indicate a change toward dryness during the construction and use of these farming terraces*" (Rohn 1963:446).

To summarize the compatibility between the ethnographic literature and the five hypotheses, it would appear that the second cannot be evaluated. The fourth appears to be contradicted, since the specific reason for abandoning fields is never described as due solely to the exhaustion of the fertility of the soil. The first, third, and fifth hypotheses, however, are supported to various degrees by the ethnographic accounts. It does appear that the geologic structure of the Hopi area controls the location of springs, which in turn determines where irrigated gardens will be successful. The correlation between geologic structure and habitations or irrigated garden plots of the Anasazi then is expected to be strong. Field house operations, however, do not depend on springs or seeps for their success since they rely upon rainfall and runoff as sources of moisture. We would expect, therefore, for there to be a less direct relationship between these types of sites and the local geologic structure. Salinity build-up which could have forced farmers to move their plots also appears highly likely from the ethnographies. All agree that clayey soils are most vulnerable to rapid salt accumulation. It would not be surprising to find that these areas were among the first to be abandoned. Finally, a shift to more marginal farmland over time appears reasonable since both ethnographic and archeologic reports document trends toward the use of land classes with less reliable water and steeper slopes.

GEOLOGY OF THE REGION

As mentioned previously the examination of ethnographic data in light of the hypotheses is not considered to represent a valid test of the ideas. Rather, the predictions will be tested by comparing the archeological patterning and salt testing within the Cochiti Dam area to the geologic and pedologic conditions in the region, in light of what is known about hydrogeology, salinity conditions, and pedological variability on a general theoretical level.

Bedrock Lithology

In the absence of extensive fieldwork the determination of lithologies present in the study area on the basis of a literature search proves difficult. Surprisingly little work has been performed in the region and publications are replete with contradictory terms and reclassifications. Although various reports will be detailed below, the most recent work has been performed by Anderson (1960); Ross, Smith and Bailey (1961); Hoge (1970); and Galusha and Blick (1971).

Early workers in the Cochiti Dam area tended to classify all deposits along the Rio Grande flood plain as belonging to the Santa Fe Formation (Denny 1940; Kelley 1948). Emmanuel (1950), in an unpublished Master's Thesis at the University of New Mexico, mapped the White Rock Canyon area to determine the geomorphic history of the region (Emmanuel's map depicting the distribution of the formations is included as Fig. 7.3). He described the Tertiary Santa Fe Formation as a basin deposit whose beds are slightly cemented by $CaCO_3$ and whose strata within any given basin may range from fanglomerates to clay. The formation can be divided into two units: alluvial fan deposits and flood plain materials. The first consists of silts, sands, and gravels that are cross-bedded, irregularly stratified, and variable in thickness. Interbedded within this are layers of clay, tuff, and intraformational breccia slightly cemented with $CaCO_3$. The second includes chiefly subangular to rounded pebbles within a matrix of poorly sorted sand (Emmanuel 1950:6-7).

Above the Santa Fe lies the Puye Gravel. This occurs along the top of mesa cliffs facing the Rio Grande on the west side of the river. These deposits are very coarse and are composed of subangular to rounded cobbles and boulders of andesite, rhyolite and latite that are poorly consolidated with little cement (Emmanuel 1950:10).

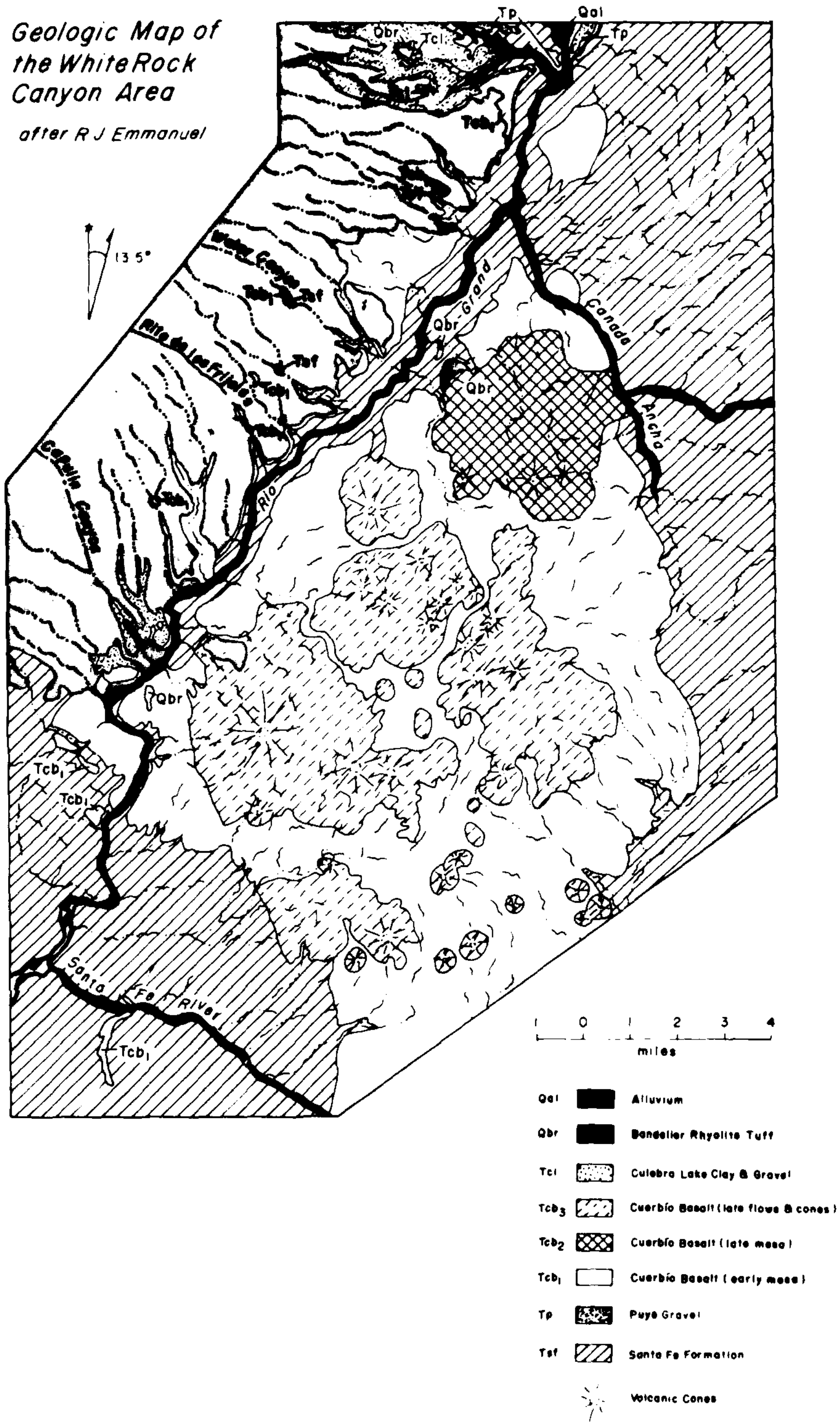


Fig. 7.3 Geologic Formations (after Emmanuel 1950)

To the east of the river, Cuerbio Basalts can be found at the surface. These flows are separated by thin beds of sand, gravel and silt. While the basalts form the east and west rims of White Rock Canyon, they are capped to the west of the canyon by tuff (Emmanuel 1950:13-16).

The Quaternary rocks are represented by the Bandelier Tuff and recent alluvial deposits. The former contains a variety of pumice and tuff-breccia layers that are exposed extensively in the west and northwest section of the Cochiti Dam area. The latter is a heterogeneous mixture of clays to boulders that can be found on the valley bottoms and along the stream beds of most major tributaries (Emmanuel 1950:18-21).

Anderson (1960) completed a Master's Thesis on the geology of the Santa Domingo basin just south of the Cochiti Dam area. He resubdivided the Santa Fe Formation into the Tano Member, the Domingo Member, and the Cochiti Member. Only the Cochiti Member extends into south-central portions of the study area. It contains many fine-grained materials including clays, siltstones, sandstones, and channel sands. Interbedded within these layers are basalt flows, gravels, and lake clays (Anderson 1960:28). Like Emmanuel (1950), he places the Cuerbio vesicular pahoehoe basalts just on the west edge of the Rio Grande extending eastward while the Bandelier Rhyolite Tuff overlies the Santa Fe Formation to the northwest of the river (Anderson 1960:31-49).

More recent workers have upgraded the Santa Fe into a group designation. Griggs (1964) was one of the first workers to do so. Three units were proposed for inclusion into the group: 1) an undifferentiated unit (Emmanuel's alluvial and flood plain deposits); 2) Puye Conglomerate (the former Puye Gravels); and 3) a basaltic Chino Mesa (the old Cuerbio Basalts) (Griggs 1964:19).

Only a few years after Griggs' (1964) report was published, Hoge (1970), in a doctoral dissertation, again redefined the stratigraphy for this area of Sandoval County. The Santa Fe group now was to include a Zia-Sand Formation and a Tesuque Formation [equal to Anderson's (1950) Tano, Domingo, and Cochiti Members]; however, according to Hoge (1971:49), no Tesuque Formation extends into the Cochiti Dam area.

Hoge feels the basalts present in the study area are Quaternary and thus post-Santa Fe in age. Older Piedmont Gravels, Young Terrace Alluvium, and Flood Plain Alluviums are all mapped as Quaternary. What Anderson (1960) noted as the Cochiti Formation, Hoge retitles as the Tonque and Edith Formations, both of which are no longer included in the Santa Fe group (Hoge 1970:49-103).

Finally, Galusha and Blick (1971) agree with Hoge (1970) and separate out as distinct formation units that formerly were included in the Santa Fe. The many formations that they describe include the Puye Conglomerate, the Ancha Formation, the Zia Marl, the Servilleta Formation, the Otowi Lava Flow, the Bandelier Tuff, and the Corros del Rio Lava Flows (Galusha and Blick 1971:76-86).

Regardless of the confusion over terminology, the basic pattern of rock types remains. Rhyolitic tuff occurs to the west and north in the study area while basalts outcrop to the east and south. At the extreme southern portion of the Cochiti Dam area, sediments derived from igneous and sedimentary rocks occur. These distinct rock types are most important since, upon weathering, they produce soils with widely divergent characteristics.

Structure

The structural setting of the central Rio Grande rift, across which the Cochiti Dam area is located, is complex. The area is severely dissected by numerous normal and reverse faults. Both Hoge (1970) and Anderson (1960), working in the Santa Domingo basin report strikes generally northwest-southeast with dips less than 10^0 to the northeast. Emmanuel (1950:23) states that nearly all the beds in White Rock Canyon are horizontal. Cuerbio basalts dip very slightly to the west, while the Bandelier tuff is inclined a mere 3^0 east.

Geohydrology

Also of importance for assessing the first hypothesis about the effects of structure on archeological site placement is the fact that, because the Cochiti Dam area straddles the Rio Grande trough, dips to the west of the river are generally to the east or northeast while those on the east bank area dip to the west. The mesas west of the Rio Grande are covered with fairly permeable strata (Spiegel and Baldwin 1963:200). Where tuff overlies basalt flows, one may anticipate springs outcropping along northeast exposures where the land surface intersects the tuff-basalt contact. Basalt is impermeable to ground water flow. However, ground water can move through zones of gravel or sands deposited between different flows, as Griggs (1964:93) discovered in White Rock Canyon. Therefore, in those areas to the east of the river underlain by basalts, springs may be expected to exit where the land surface meets gravel layers underlain by westwardly dipping basalt beds. Such seeps might appear on west exposures.

Pedology

Naturally, the various rock types have weathered into distinct soils within the Cochiti Dam area. Maker et al. (1971) mapped and described the general soil associations of Los Alamos and Sandoval counties. It is important to remember that the types of soils subsumed under a single soil association may not necessarily share the same properties since associations represent *landscapes, or geographical areas, that have a distinctive proportional pattern of soils* (Maker et al. 1971:4).

The Cochiti Dam Quad contains four major soil associations. The distribution of these groups within the study area is portrayed on Figs. 7.1 and 7.2.

Mountain soils forming in materials of igneous origin (No. 15) are developing on gentle to moderately steep mesas and ridges or steep mountain slopes. They are evolving from volcanic materials such as andesite, pumice, rhyolite, or tuff. Significantly, the authors stress that "*The major soils of this unit are relatively productive and support good stands of native vegetation*" (Maker et al. 1971:19).

Two subdivisions are described within this poorly known association. Unnamed A soils are moderately deep with surfaces of noncalcareous sandy loam overlying a slightly acid sandy clay loam subsoil. Tuff can be found underneath the soil at a depth of 30 inches (Maker et al. 1971:20). The unnamed B soil is shallow to moderately deep and has coarser subsurface levels than A. Its surface is made up of slightly acid sandy loam over subsurfaces of similar texture. The soils are underlain by rhyolitic rocks at a depth of 10 to 20 inches (Maker et al. 1971:20).

While No. 15 is found in the northwest, the Apache-Silver-Rockland association (No. 14) occurs over the east and central sections of Cochiti Dam Quad. These soils are forming from old basaltic lava flows. They may by stony and while their depths vary they are generally quite shallow. Surfaces are gentle to highly sloped, although generally not as steep as No. 15 (Maker et al. 1971:19).

Apache soils are calcareous and have a loam to sandy clay loam texture. Pieces of basalt increase with depth in these soils and unweathered basalt can be encountered a mere 8-20 inches below the surface (Maker et al. 1971:19).

The Silver soils are generally deep since they form over depressions on mesa tops or between outcrops of basalt. They feature surface layers of noncalcareous loam over a thick clay subsoil. A gravelly loam makes up the substratum (Maker et al. 1971:19).

Rockland soils are developing over a group of basalt outcrops. They are extremely rocky and shallow (Maker et al. 1971:19).

The Rough Broken Land-Embudo association (No. 7) can be found across the southern sections of the study area. It extends over rolling upland hills that have been cut by numerous intermittent drainages. Slopes are generally steep. The soils are developing from old unconsolidated alluvium which is coarse to medium textured and gravelly. The authors characterize the association as a poor one for agriculture because of its unfavorable soil characteristics and broken, steep, rough landscapes (Maker et al. 1971:13).

Embudo soils vary in depth. They reveal calcareous sandy loam to gravelly fine sandy loam surfaces over subsoils of gravelly fine sandy loam. The subsoil layers are gravelly loamy sand, to gravel. This soil type has developed from, and is therefore underlain by, siltstones, lime layers, poorly cemented sandstones, and pumice beds (Maker et al. 1971:13).

Cascejo soils expose a thin surficial layer of calcareous gravelly sandy loam. A well developed lime layer exists at a depth of 10-24 inches, which is in turn underlain by gravelly sands to sandy loams (Maker et al. 1971:13).

Finally, a minor extension of the Gila-Vinton-Glendale association (No. 1) can be located in the extreme south-central area. These rich soils have formed from alluvium of mixed origin on the gently sloping flood plain of the Rio Grande. They are therefore deep and highly stratified. They are moderately well-drained for having medium to fine textures (Maker et al. 1971:8-9).

Gila soils contain surficial layers of calcareous loam. They are underlain by stratified loams and sands at a depth of five feet (Maker et al. 1971:9).

Vinton soils' surfaces are made up of loamy fine sand above stratified loamy sands. The substrata are similar to those of the Gila soils, but are slightly coarser with fine to medium sands being dominant (Maker et al. 1971:9).

Glendale soils are finer with surfaces of clay loam over silty clay loam. Thin layers of silt or clay occur throughout the subsurface, decreasing the permeability. The subsurface is generally of a moderately-fine textured nature (Maker et al. 1971:9).

SALINITY

Much literature exists to support the hypothesis number three that soils with high clay content may have been abandoned due to salt accumulation in the soil. Soil permeability (capacity to transmit a fluid) and porosity (ratio of total volume of interstices to the total volume) are a direct reflection of the texture of the parent materials. Clayey beds contain fairly high porosities, but extremely low permeabilities. These layers tend to impede the movement of ground water. Sands and gravels transmit water faster than do clayey shales because of fewer but larger pores. Hence, while shales might yield on an average of five gallons per minute of ground water, a comparable layer of sandstone could produce from five to two hundred gallons per minute (Davis and DeWiest 1966:355).

When ponded waters or groundwater evaporates, calcium (Ca), potassium (K), magnesium (Mg), and sodium (Na) ions precipitate out of solution. Soluble cations may also be introduced to a soil through eolian deposition of fine salt-laden sediments or through the weathering of rocks whose chemical makeup includes abundant salts. Regardless of the mode of introduction, if these salts are not flushed through the soil layers by a fairly constant flow of water, colloidal particles of clay will absorb them. The clay will become deflocculated, leaving the resulting structureless soil nearly impermeable to ground water movement. Further ponding or runoff by check dams or terraces could then raise the ground water table above this impenetrable layer to the point where dissolved salts and harmful exchangeable ions are brought into contact with the root zone of crops (Jacobsen and Adams 1958:125).

Soils with poor drainage characteristics, such as those derived from basalts or shales, tend to build up salt deposits as floodwaters or ponded runoff stand on agricultural fields and evaporate. Removal of accumulated salts by leaching is difficult because of low soil permeability. In addition, basalts themselves may be regarded as prolific sources of soluble salts because their mineralogy is composed chiefly of calcic plagioclase (Socholoff and Lorenzo 1953:51; Travis 1955:12). Such conditions exist on the Apache-Silver-Rockland association (No. 14).

Salinity is detrimental to plants for a variety of reasons. Black (1968:372-378) has summarized the principal hypotheses that account for the damaging effects of soil salinity. The first (water availability theory) holds that saline solutions lead to increased osmotic pressure that prevents effective moisture uptake by the plant which then suffers from water deficiency. The second (osmotic-inhibition theory) states that growth is stunted by an excess of solutes taken up from the saline media. The third (specific-toxicity theory) reveals that solutions are harmful because of the toxic presence to one or more specific ions. These ions generally include the cations Na, Ca, and Mg and the anions sulfur (S), chloride (Cl), and carbonate (CO_3).

Beans and corn are among the least tolerant crops for germinating under saline conditions (Haywood 1954:50). While salt tolerance during germination may be poorly correlated with a plant's salt tolerance during later stages of development, it is generally acknowledged that corn is more liable to salt damage than other cereals and that beans are among the most sensitive crops to salinity concentrations (Haywood and Bernstein 1958:596). Interestingly enough, Gauch and Wadleigh (1943:384) demonstrated that the salts Ca and Mg (which would be high in soils derived from basalts) decreased the succulence in bean roots much more severely than Na ions.

THE EFFECT OF GEOMORPHOLOGY ON SOILS

A convincing body of literature from the fields of geomorphology and pedology can be drawn upon to evaluate hypothesis four. It will be recalled that this prediction sought to explain the shift in locations of Anasazi fieldhouses through time due to the mineralogical and/or nutritional exhaustion of the soils. If discernible trends could be found in the orientation and placement of field houses on the landscape, it was hoped that the specific soil properties controlling successful fieldhouse locations could be isolated.

A soil's physical properties will vary for a given parent material depending on the degree of slope at the location, the position of that soil relative to the slope profile, and the aspect (or exposure) of the landform. Concerning soils in relation to the severity of the slope, summits of hills are less prone to erosion and are therefore more clayey since rainfall has an opportunity to infiltrate rather than run off (Walker, Hall, and Protz 1968:100). Similarly, the lack of water percolation and increased erosion maintain thin soils on slopes. Zing (1940) conducted an interesting experiment on loam soil where he simulated the effects of twenty years of rainfall on varying slopes. He found that doubling the degree of slope increased the total soil loss in runoff by a factor of 2.61 and that the moisture content of a soil displayed an inverse relationship with the amount of runoff flowing down its slope (Zing 1940:64). When considering soil properties in relation to the degree of slope of that station regardless of its position within the hillslope profile, the following trends have been obtained. With an increase in slope gradient, the depth to the lowest subhorizon of >1% organic carbon (C), the weighted percent of clay of the solum (A and B horizons), the weighted percent of organic C in the solum layer >1%, the depth to a subhorizon of base saturation of 80% or more, and the depth to a subhorizon of pH of 6.0 or more all decrease exponentially (Ruhe and Walker 1968:554). Beckett (1968:14) found that with an increase in slope, the depth of the A soil horizon, the organic C content, the pH, and the total carbonate diminished while the exchangeable phosphorus (P_2O_5) increased. Similarly, Furley (1968:38) found negative linear correlations between pH and gradient on acidic soils, between carbon (C)% and nitrogen (N)% and gradient on all soils, and between the percent silt and clay and gradient on calcareous soils. He discovered a positive linear correlation between pH and gradient on calcareous soils.

Regular relationships also hold between slope properties as one moves down a hill from the summit to the toeslope. Following Kleiss (1970:289) and Walker and Ruhe (1968:563), Table 7.1 summarizes these trends for a given hillslope.

Table 7.1

Properties Down a Hill from Summit to Toeslope

Property	Summit	Shoulder	Backslope	Footslope	Toeslope
mean particle size	minimum	maximum	min.-max.	decrease	minimum
F/C ratio cation exchange	minimum	minimum	increase	increase	maximum
organic C	maximum	minimum	increase	increase	maximum
base saturation	maximum	decrease	decrease	decrease	minimum
depth to carbonate	maximum	minimum	maximum	decrease	zero
bulk density	maximum	decrease	decrease	decrease	minimum

Superimposed upon slope variations are differences in soil properties that result from a hillslope's particular aspect. Finney, Holowaychuk, and Heddleson (1962) performed a series of transect studies across the soils of four northwest-southeast oriented valleys in southeastern Ohio. They found that the soils on the southwest (SW) facing slopes contained significantly thinner A_1 and much more strongly developed A_2 and B horizons than the profiles on the northeast (NE) facing slopes. The acidity for the upper layers of soil for the NE samples was much less than for the SW ones. The two exposures also contributed to differences in base saturation of the soils. For the NE soils, base saturation reached a maximum value in A_1 layers and then decreased down to the C horizon while for the SW slopes, these trends were reversed. The total quantity of organic matter was much greater for the NE exposed soils although if expressed as a percentage, it did not vary greatly between the two groups. Finally, a wider range in values with higher means for C/N ratios were measured on SW slopes. The authors posit that the differences in the soil samples can largely be attributed to microclimatic and vegetational differences, although the particular configuration of the slopes, soil moisture conditions, and higher incidences of forest fires on the south and west slopes may also have played a role (Finney, Holowaychuk and Heddleson 1962:287-292).

Franzmeier et al. (1969) examined soils derived from Pennsylvanian shales, siltstones, and sandstones in the Cumberland Plateau of Kentucky and Tennessee. Not surprisingly, they concluded that the southern (S) slopes were consistently drier than the northern (N) ones. More organic matter could be found throughout the profiles of the N slopes because warmer temperatures on the S slopes led to a faster oxidation rate of the material. Another consistent trend was the presence of more strongly developed B horizons on SW soil samples than those from NE slopes regardless of parent material type (Franzmeir et al. 1969:759-761).

In a similar study designed to evaluate the influence of soil temperatures, parent material, and climate on soil-forming processes, Losche, McCraken and Davey (1970) measured soil characteristics in Virginia and North Carolina. Interestingly enough, they found little difference in the soil properties from the Virginia samples that were based on sandstones and shales. The authors speculate that this may be due to a lack of enough variety among the precursor minerals in the highly siliceous parent material. The North Carolina soils developed from a granitic biotite gneiss and did produce significant differences. Southern slopes consistently contained a higher free iron content, a higher soil temperature, a thicker solum, and more clay in the B horizon than N slopes. Thus, S slopes appeared to be weathering more thoroughly because of higher soil temperatures; they yielded thicker soil profiles with a greater differentiation between the horizons as a result. The investigators assert that the great range in precursor minerals, the high annual precipitation, and the aspect-induced soil temperature differences in the soils from North Carolina were responsible for the soil variations (Losche, McCraken, and Davey 1970:473-477). Just why aspect-related soil characteristics should be dependent upon the absolute amount of rainfall and the range of mineral types within the parent material is not made clear and this flaw seriously undermines the value of the study.

Cooper (1960) focused his interests on the subject of different microclimatic environments produced by slope aspects and how these affect soil properties. He based his report on the examination of a series of grey-brown podzolic soils on several N and S slopes in southeastern Michigan. Like other soil scientists, he found that the S exposures had greater light intensities, air temperatures, water losses, and soil temperatures than their N counterparts. Cooper (1960:114) observed that winter snow cover on the N slopes tended to cover the ground continuously while snows on S aspects melted off rapidly. The more frequent freeze-thaw cycles on S soils contribute to conditions of greater physical and chemical weathering. Therefore, it is not surprising that greater quantities of silt and clay were located on S slopes in this study. The total depth of the solum and the depth at which soil horizons were located, however, were less on S than on N samples. This led Cooper (1960:118) to conclude that:

> *These data emphasize the differences in the B horizons of the slopes and suggest that soil-forming processes are more intensive under the conditions of environment found on south slopes . . . Thus, the micro-climatic conditions of south slopes favor shallow, intense profile development, whereas those of north slopes produce a deeper, less intensely weathered profile.*

This stems from the fact that while N slopes enjoyed greater overall moisture, the alternate wetting and drying on S exposures increased the hydration and dehydration of the material which contributes to a faster particle disintegration and mineral transformation rate.

Soil temperatures were also monitored by Aikman (1940) at four soil stations for N, S, E and W exposures in southern Iowa. Aikman discerned a greater difference in climatic factors between E and W slopes than for any others. Differences between soil temperatures at a two inch level were greater than between the air temperatures. Western slopes had the longest frost-free season, the highest average soil and air temperatures, the fastest wind velocities, and except for the N soils, the smallest number of alternate freeze-thaw cycles. He rated the slopes for heat danger and cold danger to crops from most to least as W, S, E and N and E, S, N and W, respectively (Aikman 1940:161-167).

Volobuev (1964) explains why these relationships hold. He points out that a soil's temperature is influenced not just by the intensity of the solar radiation striking it, but also by the condition of the soil itself, especially in regard to humidity. The first light of day hits a fairly moist soil laden with dew. Much of the solar energy striking it is expended upon evaporation and soil desiccation. Later in the day, the rays can more efficiently heat up SW slopes which are already dry since the absorbed energy can increase the soil's temperature almost exclusively. For these reasons, then, maximum soil temperatures, rather than occurring on S slopes, are shifted somewhat to the SW (Volobuev 1964:81).

Chang (1968:87) emphasized that soil temperature is actually of greater ecological significance to plant growth than is air temperature. The former affects seed germination, the speed and length of plant growth, the functional ability of roots, as well as the occurrence and severity of plant infections. Although air temperatures are important during the reproduction stages of a corn crop, soil temperatures are critical during the early stages of growth. Willis, Larson, and Kirkham (1959:327) determined that between 60^{o}F and 80^{o}F, corn growth increased by a factor of 2.0 to 2.8 for each 10^{o} increase in temperature. Adams (1962: 257) showed further that a higher soil temperature can also improve a plant's ability to absorb nutrients and water and translocate carbonhydrates.

In assessing the significance of soil temperature for hypothesis four (settlement pattern shifts due to nutritional/mineralogical depletion of soils), it must be emphasized that the soil temperature will vary according to soil depth and color, the availability of soil moisture, the percent and distribution of soil porosity, the amount of insulation of the landform, and the angle of surface exposure to that insulation (Willis, Larson, and Kirkham 1959:323). For these reasons, it is not surprising that sandy soils warm up more quickly than do clayey soils in the spring.

THE PATTERNING

The research strategy for this investigation has involved five key steps. First, the hypotheses were framed. Second, ethnographic literature was reviewed to determine the extent to which the predictions appeared reasonable in light of what is known about the farming strategies of contemporary native groups near the region today. This stage was viewed primarily as an educational process that could neither confirm nor reject the hypotheses. Third, we have seen how literature from the physical sciences can help to anticipate where conditions postulated in the hypotheses could be met within the Cochiti test area. The present section, the fourth stage of research, will summarize the patterning of archeological sites within the study area vis-a-vis the physical conditions at the sites so that the final step may be presented – the evaluation of the hypotheses (see Table 7.1, Figs. 7.4-7.13).

Hypothesis 1 (structural control of the distribution of sites). The patterning of both field and habitation sites for the west and east sides of the Rio Grande was determined by examining each site, which was on the *Cochiti* Dam, New Mexico, United States Geologic Survey (USGS) 7.5 minute series map, and ascertaining for each site its orientation within a 0.5 kilometer radius with respect to the landforms on which it was located. One of eight possible orientations was recorded for each site (N, NE, E, SE, S, SW, W and NW). On the west bank, 100 one or two room structures were measured and 93 sites with three to ten rooms. Of the smaller ruins, 55% were oriented to either the NE, E or SE while 54% of the larger sites were similarly situated.

For the east bank, 23 small and 15 larger sites were investigated. Some 74% of the smaller and 74% of the larger sites enjoyed SW, W or NW aspects. A summation of the orientations of the sites is presented graphically in Figs. 7.4 and 7.5.

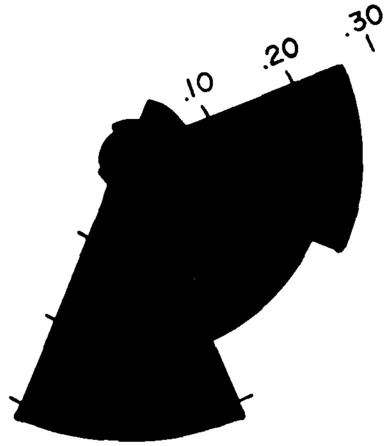
Table 7.2

Changing Utilization of Soil over Time

	Soil 15	Soil 14	Soil 7	Soil 1	Totals all Soils
P-III					
1-2 Rooms:					
No. of Sites	25	4	2	2	33
% of all P-III Sites on this soil	(36)	(44)	(33)	(50)	(36)
3-10 Rooms:					
No. of Sites	44	9	4	2	59
% of all P-III Sites on this soil	(64)	(56)	(67)	(50)	(64)
Total No. of P-III Sites	69	13	6	4	92
% of P-III Sites on Cochiti Dam Quad on this soil	(75)	(14)	(7)	(4)	(100)
P-IV					
1-2 Rooms:					
No. of Sites	48	23	12	8	91
% of all P-IV Sites on this soil	(64)	(61)	(80)	(73)	(65)
3-10 Rooms:					
No. of Sites	27	15	3	3	48
% of all P-IV Sites on this soil	(36)	(39)	(20)	(27)	(35)
Total No. of P-IV Sites	75	38	15	11	139
% of P-IV Sites on Cochiti Dam Quad on this soil	(54)	(27)	(11)	(8)	(100)

(a) 1-2 Room Sites:

	No. of Sites
N	4
NE	7
E	26
SE	22
S	32
SW	4
W	2
NW	3
	100 Sites



(b) 3-10 Room Sites:

N	1
NE	20
E	17
SE	13
S	36
SW	2
W	2
NW	2
	93 Sites

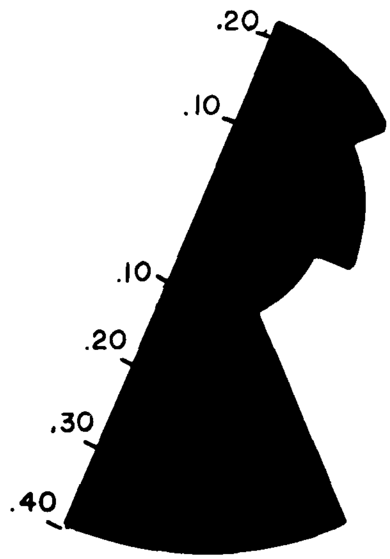
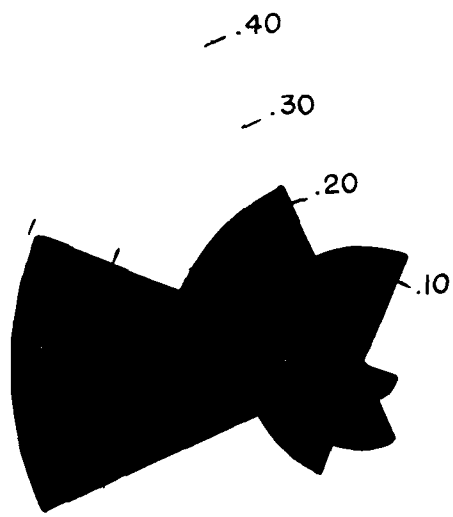


Fig. 7.4 Orientations of sites west of the Rio Grande



(a) 1-2 Room Sites:

	No. of Sites
N	3
NE	0
E	0
SE	1
S	2
SW	3
W	9
NW	5
	23 Sites

(b) 3-10 Room Sites:

N	4
NE	0
E	0
SE	0
SW	0
W	6
NW	5
	15 Sites

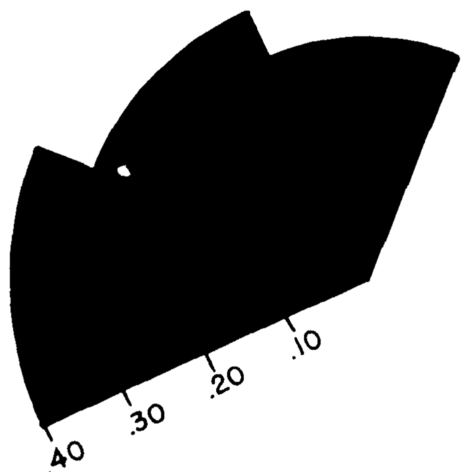
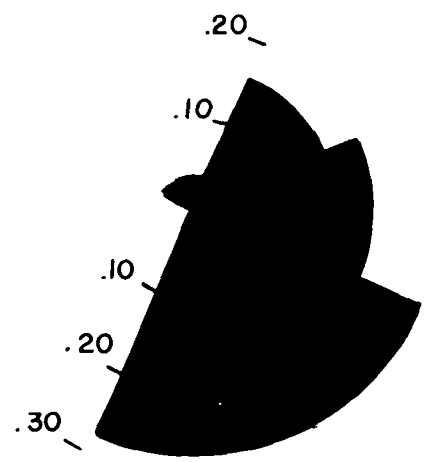


Fig. 7.5 Orientations of sites east of the Rio Grande

(a) 1-2 Room Sites:

	No. of Sites
N	1
NE	4
E	5
SE	7
S	7
SW	0
W	0
NW	1
	25 Sites



(b) 3-10 Room Sites:

N	1
NE	7
E	6
SE	8
S	17
SW	4
W	0
NW	1
	44 Sites

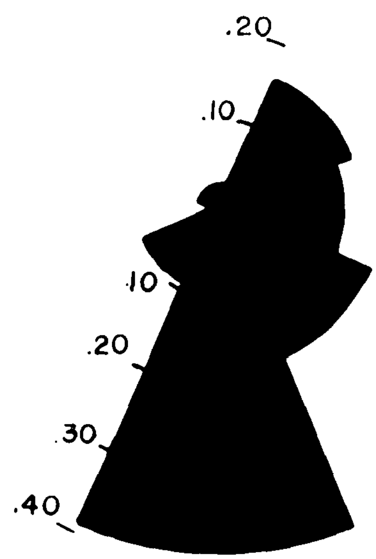


Fig. 7.6 Orientations of sites on Soil 15 during P-III times

(a) 1-2 Room Sites:

	No. of Sites
N	1
NE	6
E	11
SE	12
S	10
SW	5
W	0
NW	3
	48 Sites

(b) 3-10 Room Sites:

N	0
NE	8
E	2
SE	3
S	12
SW	1
W	0
NW	1
	27 Sites

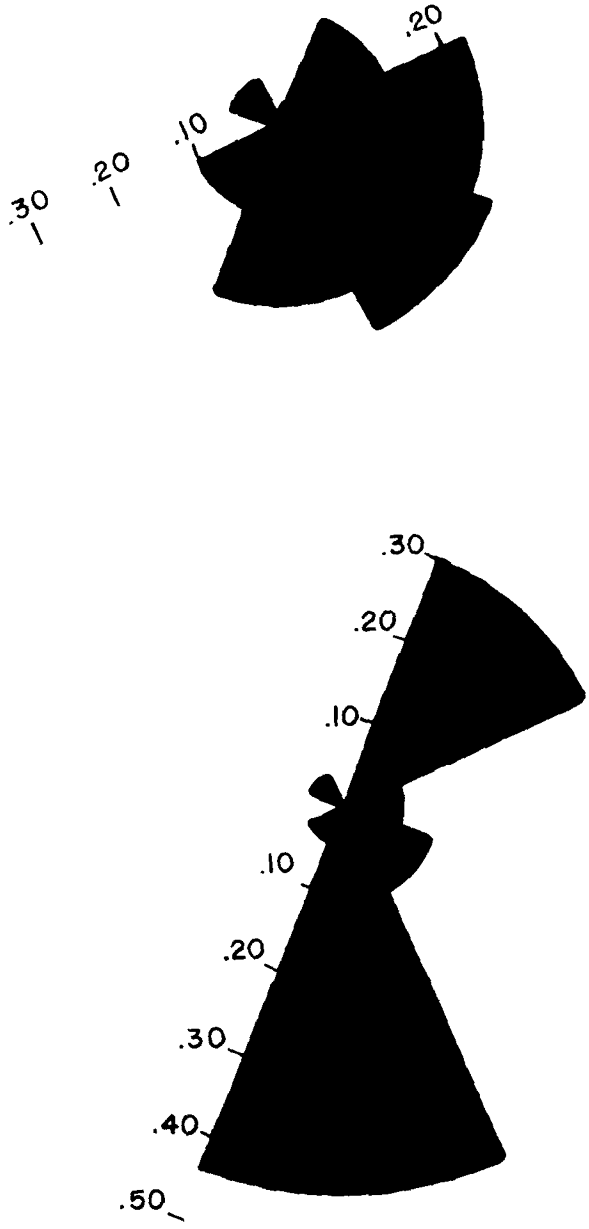
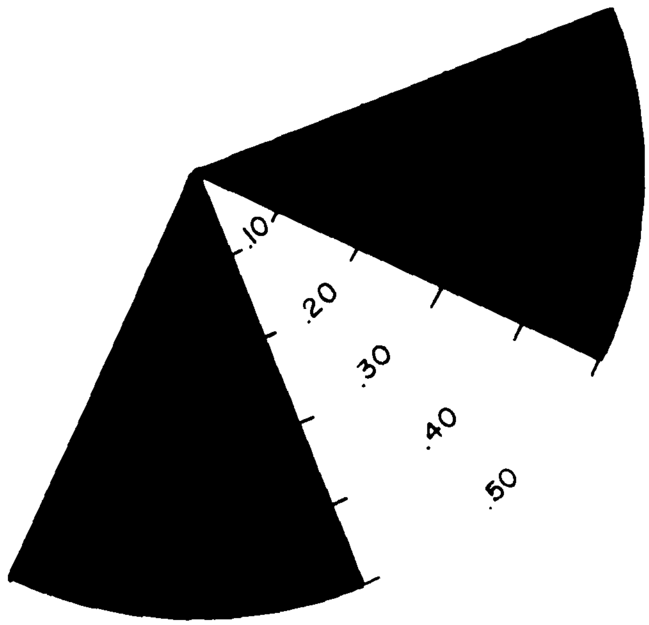


Fig. 7.7 Orientations of sites on Soil 15 during P-IV times

(a) 1-2 Room Sites:

	No. of Sites
N	0
NE	0
E	2
SE	0
S	2
SW	0
W	0
NW	0
	4 Sites



(b) 3-10 Room Sites:

N	1
NE	1
E	4
SE	0
S	2
SW	0
W	0
NW	1
	9 Sites

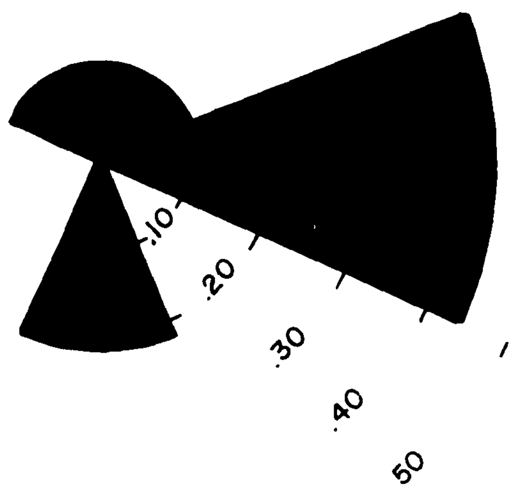
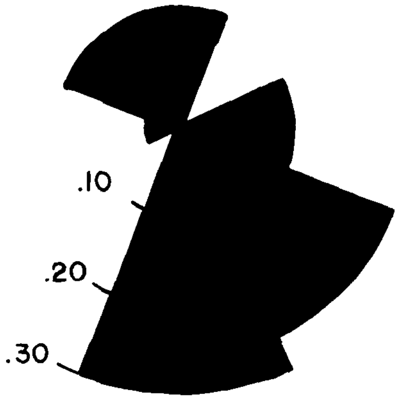


Fig. 7.8 Orientations of sites on Soil 14 during P-III times

(a) 1-2 Room Sites:

	No. of Sites
N	3
NE	0
E	3
SE	6
S	7
SW	0
W	1
NW	3
	23 Sites



(b) 3-10 Room Sites:

N	4
NE	2
S	1
SE	1
SW	0
W	3
NW	4
	15 Sites

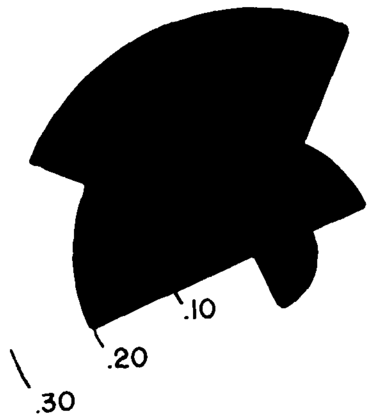
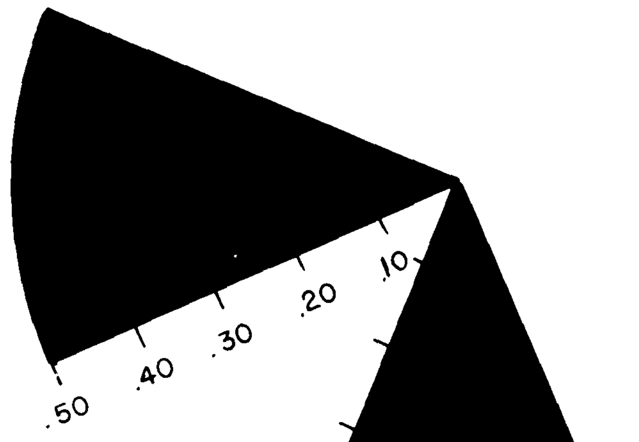


Fig. 7.9 Orientations of sites on Soil 14 during P-IV times

(a) 1-2 Room Sites:

	No. of Sites
N	0
NE	0
E	0
SE	0
S	1
SW	0
W	1
NW	0
	2 Sites



(b) 3-10 Room Sites:

N	0
NE	0
E	0
SE	1
S	1
SW	0
W	2
NW	0
	4 Sites

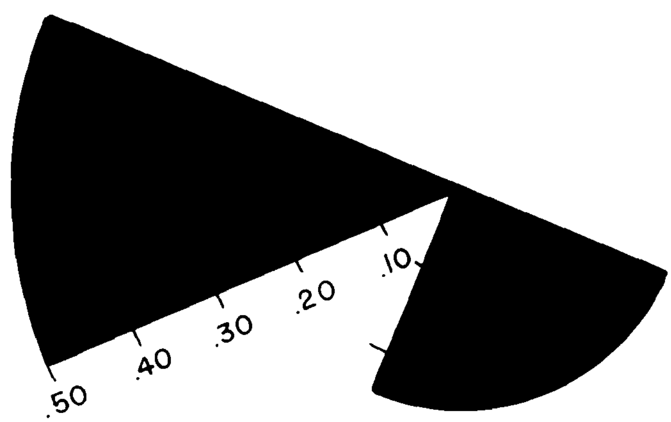
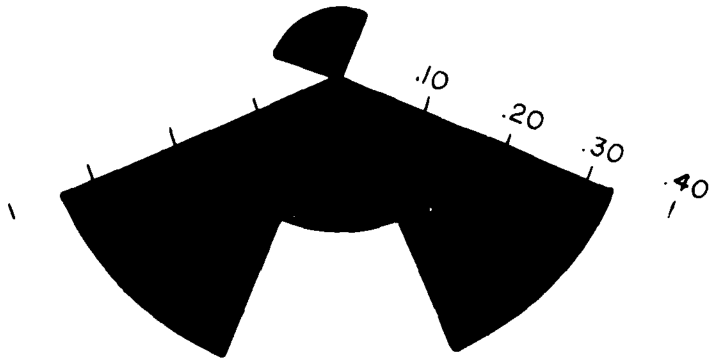


Fig. 7.10 Orientations of sites on Soil 7 during P-III times



(a) 1-2 Room Sites:

	No. of Sites
N	1
NE	0
E	0
SE	4
S	2
SW	4
W	0
NW	1
	12 Sites

(b) 3-10 Room Sites:

N	0
NE	0
E	0
SE	3
S	0
SW	0
W	0
NW	0
	3 Sites

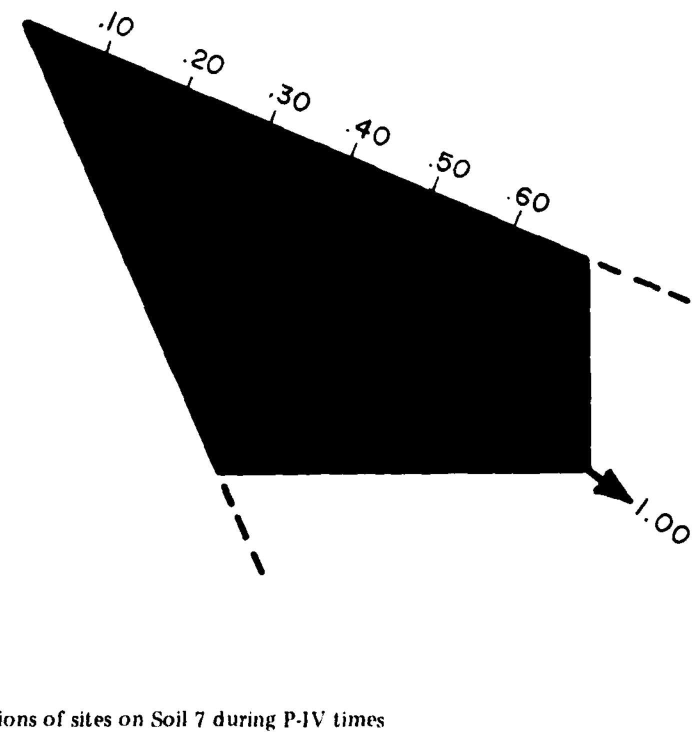
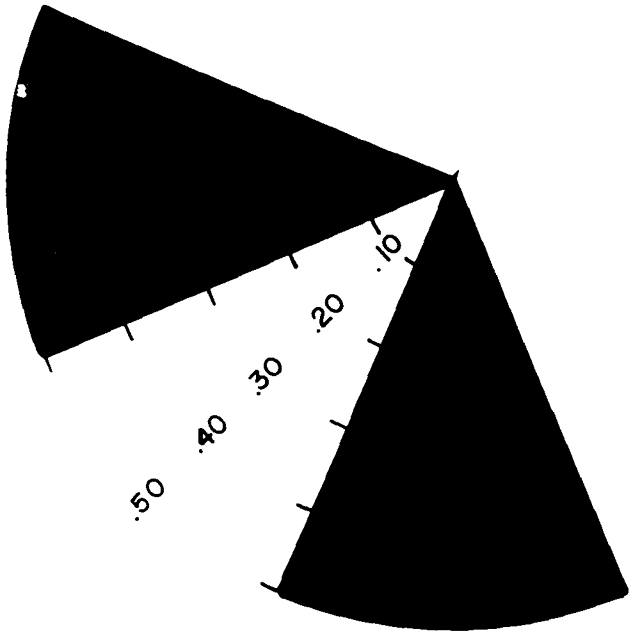


Fig. 7.11 Orientations of sites on Soil 7 during P-IV times

(a) 1-2 Room Sites:

	No. of Sites
N	0
NE	0
E	0
SE	0
S	1
SW	0
W	1
NW	0
	2 Sites



(b) 3-10 Room Sites:

N	0
NE	0
E	1
SE	0
S	1
SW	0
W	0
NW	0
	2 Sites

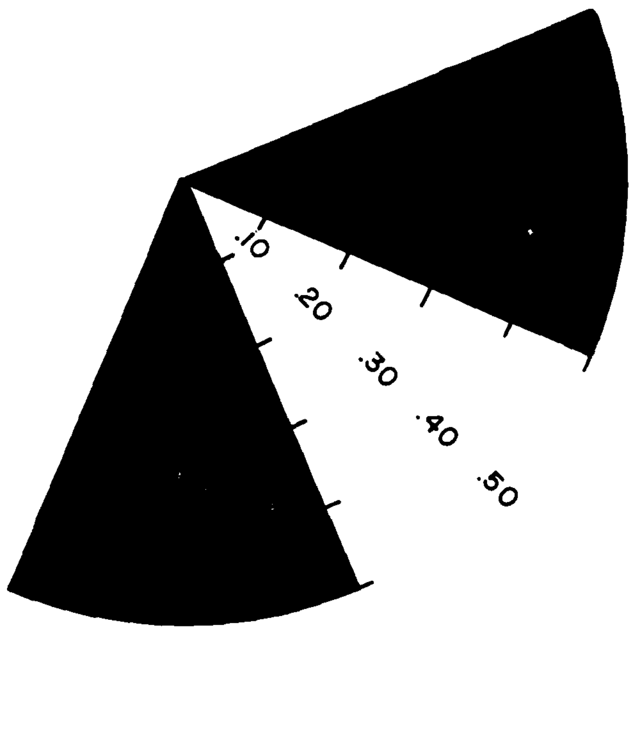
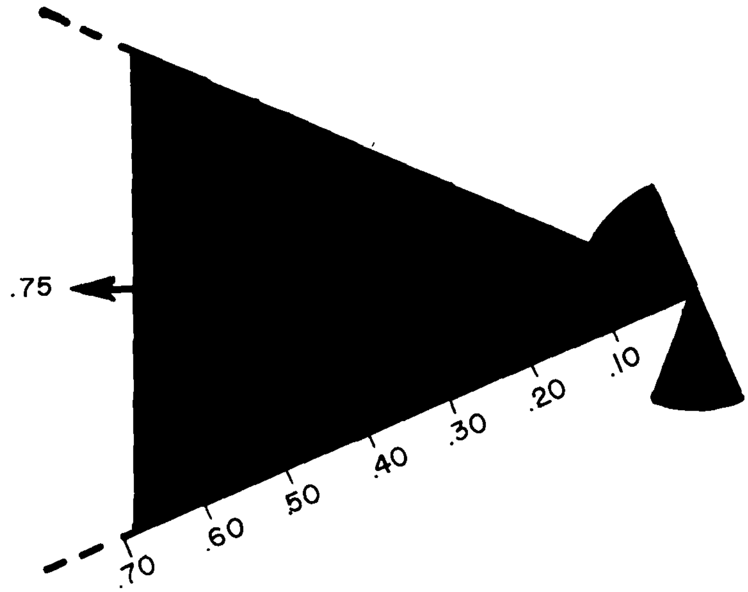


Fig. 7.12 Orientations of sites on Soil 1 during P-III times

(a) 1-2 Room Sites:

	No. of Sites
N	0
NE	0
E	0
SE	0
S	1
SW	0
W	6
NW	1
	8 Sites



(b) 3-10 Room Sites:

N	0
NE	0
E	0
SE	0
S	1
SW	1
W	1
NW	0
	3 Sites

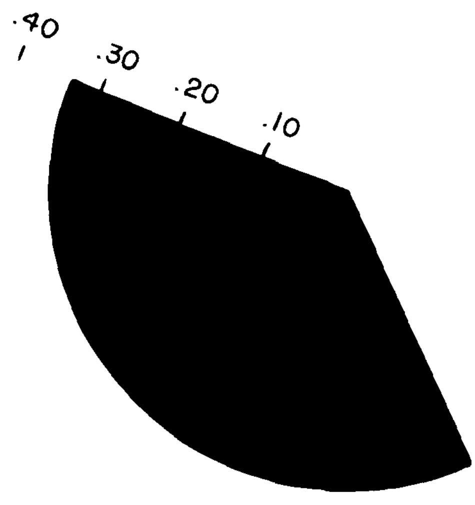


Fig. 7.13 Orientations of sites on Soil 1 during P-IV times

Hypothesis 2 (habitation sites on marginal agricultural land). When investigating the aspect of land 0.5 km around both small (one or two rooms) and large (three rooms or greater) sites for both sides of the river combined, the following patterns were obtained. Approximately 18% (22 of 123) of the small sites were surrounded (up to 0.5 km) by NW, N, or NE facing slopes. In contrast, 30% (32 of 108) of the larger sites were located within land so oriented.

Since it can be argued that Anasazi agriculturalists probably were not locating their houses directly on valuable cropland, the slopes of sites as reported by survey and excavation data were of little use. Instead, following Ramage (1977:82) the percentages of land in various slope classes within the 500 x 500 meter quadrat in which the site was located were calculated. Considering the small sites, the following breakdown results: Class 1 (<4%) 10.3%; Class 2 (4-6%) 16.8%; Class 3 (6-15%) 27.3%; Class 4 (>15%) 43.0%; and land adjacent to the river 3.1%. The breakdown for 3-10 room sites was Class 1, 16.7%; Class 2, 19.5%; Class 3, 29.6%; Class 4, 32.7%; and river frontage, 1.4%.

From the breakdown of P-III versus P-IV one or two room structures and 3 to 10 room sites, it becomes apparent that a shift in settlement strategy is occurring by P-IV times. P-III consistently maintained approximately twice as many larger sites as small field houses. By P-IV times, this trend is reversed. As Table 7.2 reveals, the exploitation of soils 15 and 14 also changed from P-III to P-IV times. In the P-III period, the superior soil 15 was used by 69 P-III sites. Some 64% of them were habitation sites. P-IV use of these soils shifted to the point where 64% of these sites were field houses and only 36% larger habitation sites. The utilization of the inferior soil 14 experienced similar trends. However, it is important to note that by P-IV times, 39% of the sites were larger ones, the highest proportion of P-IV habitation sites for any soil group.

Hypothesis 4 (mineral/nutritional exhaustion of soils). In Table 7.2, it can be seen that the percentages of particular soils being exploited by P-III and P-IV groups certainly does not remain constant through time. Figs. 7.6-7.9 demonstrate also that the basic orientation of fieldhouses between P-III and P-IV does not change significantly for soil groups 15 and 14. The aspects of habitation sites, in contrast, do shift over time to a decidely more northern exposure. Of the larger P-III habitations on soil 15, 20% are located on land having NE, N, or NW exposures; by P-IV the percentage climbs to 34%. Similarly, the figures for soil 14 from P-III to P-IV are 22% versus 67%.

Hypothesis 5 (shift to more marginal soils) **and 3** (shift caused by salinity build-up). Trends over time of soil utilization (Table 7.2) are toward increased reliance upon the inferior soil units 14, 7 and 1. Soil unit 15 continued to be important though the percentage of sites on it decreased from 75% to 54% from P-III to P-IV times.

The land which experienced the greatest increase on exploitation over time is association 14. Sites on this unit increase from 14 to 27% from P-III to P-IV times. It will be recalled that these soils lie above a substratum of stony loam and clay on top of basalt or loamy sediments. Their permeability is moderate to slow, while their principal limiting factors are shallow soil depth and soil characteristics.

DISCUSSION AND EVALUATION OF HYPOTHESES

Hypothesis 1

This hypothesis appears to have been confirmed. The west bank sites were generally oriented from the NE to SE, while east bank sites overwhelmingly possessed SW to NW aspects. Additionally, only 9% of the small and 6% of the large west bank sites faced SW to NW, while a mere 4% of the small and none of the large east bank ruins enjoyed NE to SE orientations.

Thus, it appears that sites may indeed have been located in areas most likely to have enjoyed seepage from spring flow. Apparently, both small field houses as well as 3-10 room habitation sites took advantage of those locations that enjoyed slightly more moist conditions in an arid environment. That sites were situated in down-dip directions does not imply that springs were present at many of these sites. Rather, the most likely affect on lands down dip would have been a slightly more moist subsoil enabling the location to yield a more successful crop or support a slightly more luxuriant stand of edible flora.

Hypothesis 2

Overall, habitation sites do appear to have been situated in areas considered to be more marginal for agriculture than fieldhouse locations. Larger sites more often were located within northerly oriented landforms where with the exceptions of increased organic matter and moisture, all other pedologic conditions would have been inferior to the more southern exposures.

The hypothesis also gains support from the fact that there are a higher percentage of habitation sites in P-IV times on soil 14. The many drawbacks to this thin soil have already been pointed out. Presumably, the Anasazi were building a higher proportion of habitation sites on this soil since they were less concerned about using up valuable cropland for the sites of larger structures.

Somewhat puzzling is the fact that a larger percentage of land around habitation sites is flatter than land surrounding field houses. This pattern may have resulted from the fact that field houses were located near very small fields surrounded by much steeper land. In many of the fields visited by the author, this is certainly the case. Just why flatter land should surround larger sites is more difficult to explain.

Hypothesis 4

This prediction is rejected. The proportion of sites on soils of differing qualities varies significantly from P-III to P-IV times. Moreover, the fact that the aspects between P-III and P-IV field houses on soils 15 and 14 did not vary greatly suggests that the Anasazi farmers were not shifting their locations primarily to obtain nutrients or minerals that were limited at the original field locations. From P-III to P-IV, soil 15 continued to be exploited as the primary soil type, and most field houses continued to possess easterly aspects. The difference between the two time periods is an increasing reliance upon soil types 1, 7, and 14, which will be discussed below.

Hypotheses 5 and 3

These hypotheses are accepted. During P-III times, soil types 1, 7 and 14 supported a mere 25% of Anasazi sites of two rooms or less. By P-IV, the proportion climbed to 46%, with most of the increase occurring within soil 14.

Soil 15 was exploited less intensively over time as measured by percentage of P-III to P-IV sites. The absolute number of sites actually increases from 69 to 75 from P-III to P-IV. This is a surprisingly productive soil for the Southwest. It is deep and its sandy loam subsoil provides excellent drainage (Maker et al. 1971:26-27).

Soil association 14 comes under much greater use during P-IV. As mentioned, its clayey subsoil provides poor permeability for the thin soil.

Soil associations 7 and 1 also are exploited more heavily over time, though they never supported major segments of the population. The first association (7) is very stony and gravelly; although providing good permeability, these soils lack a sufficient amount of fine materials to offer an adequate available water holding capacity (Maker et al. 1971:31). Maker et al. (1971:9) describe association 1 as very well suited for cropland use under modern irrigation systems. For the Anasazi, however, these lands would not have been nearly as desirable. Farming along the Rio Grande in White Rock Canyon would have proved a risky venture because of the danger of severe flooding. In addition, the ancient means of floodwater farming may not have been able to thoroughly leach all the salts from this loamy, clayey soil. Salinity and wetness would have limited its utility.

Support for hypothesis 3 is derived from two sources: one, the general patterning of sites over time in the Cochiti test area; and two, detailed chemical analyses of the soils of P-III/P-IV multicomponent site (LA 13086) on soil association 14. As has been mentioned, the settlement pattern shift in P-IV times is one of continued exploitation of soil 15 with increased reliance upon formerly minor soil associations. Soils 14 and 1, which are clayey, have poor permeability. It is soon after they came to be heavily relied upon (35% of P-IV sites) that the system collapsed and the area was abandoned.

Intense investigations of the soils at LA 13086 on soil 14 (see Fosberg and Husler, this volume) revealed two paleosol horizons. In the B soil horizon that the occupants during P-IV times would have tilled, the salt content (primarily Ca, Mg and K) increases dramatically. Salt concentrations of this strength could well have damaged agricultural crops and led to the abandonment of the field.

An overview of the patterning in Table 7.2 allows the following summary of Anasazi farming within the Cochiti test area from A.D. 1175 to 1500. As the Anasazi began moving into the region during P-III times in massive numbers, they initially utilized the superior agricultural soils (15) almost exclusively. In fact, during P-III times, soils from unit 15 underlay 76% of all field houses. As agricultural land was relatively plentiful, even habitation sites could be located on good farmland. By P-IV times, the population had grown considerably. It is interesting to note that this period represents the time of maximum experimentation. Every inferior soil unit within the Cochiti test area was utilized to a greater extent as an attempt to handle the strain on the system. Habitation locations now began to compete for scarce farmland and their positions shifted to less desirable soil areas. The percentage of habitation sites (3-10 rooms) located on soil 15 decreased from 75% to 56% from P-III to P-IV times. Finally, after A.D. 1500, the system collapsed. Marginal lands either suffered from salinity problems (soils 14 and 1) or failed to yield good crops from thin, rocky soils (7). The one adequate soil unit (15) could no longer support the remaining population and the area was abandoned.

CONCLUSIONS

This essay has attempted to explain how the archeological patterning among the Anasazi sites within the Cochiti test area in north-central New Mexico directly relates to the influences of the geologic and pedologic conditions present. It is suggested that the patterns of field house locations and habitation sites as revealed by survey information and data retrieved by excavation support the following hypothesis. First, the success of both field houses (1-2 rooms) and small habitation sites (3-10 rooms) was partially controlled by the regional geologic structure. By placing sites on down-dip sides of tilted strata, the Anasazi were able to benefit from slightly higher ground moisture conditions. This fact suggests that future archeological surveys might profit from conducting preliminary research into the geologic structure of an unknown region. Higher concentrations of sites could be expected in specific locations where the conditions for springs or ground flow seepage would be favored.

Second, it appears that habitation sites tended to be located within agriculturally more marginal land than were field houses. A higher proportion of habitation sites began to shift to inferior lands, over time because their presence could no longer be afforded on scarce cultivatable soils. Again, knowledge of this trend may permit future surveyors, following preliminary geologic and pedologic investigations of a region, to predict where the highest concentrations of field versus larger habitation sites might be located over the landscape.

Third, the shift of field houses to different soil types over time was toward inferior soils with either thin, rocky layers or poor permeability. These marginal soils were increasingly utilized until the system collapsed.

Fourth, the patterning of field houses and habitation sites plus soil data collected at a field house (LA 13086) suggests that salinity problems may have been responsible for the collapse of marginal soils which led to the abandonment of the region. It was shortly after these clayey soils became utilized to a major extent that the area was deserted by the Anasazi. Heavy salt concentrations within the B soil horizons of one field house confirm the probability that trapped salts could easily have built up over the substratum of soil 14.

While shifts in rainfall patterning or lengthening of periods of drought may have been responsible for the locational shifts of Anasazi settlement systems in other areas of the Southwest, the writer would maintain that problems stemming from the increased reliance upon inferior lands or salinity are a more plausible explanation in the Cochiti test area. This study has attempted to demonstrate that explanations for Anasazi settlement shifts may well be found in the articulation between the cultural system's economy and the geologic base determining its success. Hopefully, this essay has contributed toward a clearer understanding of those environmental factors which conditioned the evolution of Anasazi settlement systems in the Southwest.

Chapter 8

EXPLAINING RESIDENTIAL AGGREGATION IN THE NORTHERN RIO GRANDE: A COMPETITION REDUCTION MODEL

Rosalind Hunter-Anderson

INTRODUCTION

This paper will be concerned with northern Rio Grande Anasazi settlement changes which seem to be indicated from a study of site placement through time on the Pajarito Plateau and along the northern middle Rio Grande, from roughly Guaje Canyon in the north to the Santa Fe River in the south (see Fig. 8.1). The settlement changes were (1) a shift from extensive occupation of upland zones of higher rainfall from the Pueblo II (or Developmental) through the mid-Pueblo III (or mid-Coalition) periods (ca. A.D. 600 through A.D. 1300), to more concentrated occupation of upland and lowland zones of lower rainfall beginning in the late Pueblo III (P-III) period (post A.D. 1300) and continuing through the Pueblo IV (P-IV) or Classic period; and (2) the rise of extremely large residential sites post A.D. 1300, a trend which may have begun in the northern Pajarito Plateau and culminated in the Historic pueblos such as Cochiti, and was the predominant form of settlement in many areas of the Southwest at the time of initial Spanish contact.

The trend toward aggregated settlement will be viewed here as a manifestation of a general adaptive process common to many parts of the world. In the terminology of Chapter 1 (this volume) we are proposing an adaptive shift in land use on the part of local groups. Some indication that we are dealing with a general process is that residential movement out of higher rainfall zones into those with lower rainfall has been observed to correlate with large residential aggregations in the semiarid Near East (Adams 1962; Hole, Flannery and Neely 1969; also see Dickson 1975). Another indication that a general process is involved is that limited use of productive environmental zones for residential purposes has been observed in many places, for example, in North America (Hickerson 1962; Hudson 1976), in South America (Harner 1972; Kelekna, personal communication) and in Melanesia (Heider 1970; Meggitt 1977).

We have been fortunate in having access to settlement data from several sources in addition to the Office of Contract Archeology's Cochiti Reservoir permanent and flood control pool surveys. These reports summarize survey and excavation projects in the vicinity of the mouth of White Rock Canyon or the Cochiti Dam site area (Lange 1968; Snow 1976), in the southern portion of Bandelier National Monument at the mouths of Lummis and Alamo Canyons (Traylor et al. 1977), and in portions of the Pajarito Plateau on Los Alamos Scientific Laboratory lands (Worman 1967; Steen 1977). The most comprehensive documentation exists for the southern Pajarito Plateau-Cochiti Pueblo areas. Because of the regional perspective taken here, we have included a discussion of the northern Pajarito Plateau, although comprehensive coverage of this area is lacking and generalizations about settlement pattern are tentative.

ENVIRONMENTAL ASPECTS OF THE NORTHERN RIO GRANDE

Mean Annual Precipitation and Variable Productivity

An important aspect of the climate of the northern Rio Grande is the amount of moisture which falls as precipitation and is available for plant growth. In arid environments where temperature is not severely limiting and water is the *master limiting factor*, mean annual precipitation is a fair measure of net primary production biomass (Pianka 1974: 14-15). Keeping in mind the relationship between water and plant growth in dry climates, we can characterize the northern Rio Grande with respect to mean annual precipitation as having three basic forms: (1) areas which enjoy relatively great mean annual precipitation; (2) areas which do not enjoy great mean annual precipitation but which contain perennial streams that drain relatively large areas or which derive from high elevations where snow melt and or large amounts of summer rain account for dependable stream flow; and (3) areas which have neither perennial streams nor great mean annual precipitation. The significance of these differences is that, in the first kind of area, species useful to man as hunter-gatherers are relatively abundant, and the moisture conditions are sufficient for growing crops without elaborate technology for water control as well. In the second kind of area, naturally occurring species are not abundant, but with energy investment into agricultural technology, such as canals, terraces, and check dams, crops can be raised. In the third kind of area, neither crops nor wild species can be obtained in abundance nor with any certainty.

Zones of High and Low Rainfall in the Northern Rio Grande

The upland zones referred to in the Introduction are areas of the first kind, in which the mean annual precipitation is relatively great. For our purposes we have bounded this zone at approximately 16 inches of annual precipitation, of which some 10-11 inches fall as rain in summer (U.S. Department of Commerce 1967). This boundary has been drawn on Fig. 1. The lowlands referred to above are areas of the second kind, in which water is available for farming mainly through the use of water control devices that divert and spread water to fields from a concentrated source. These areas lie below the 10 inch mean annual precipitation isohyet and include the Rio Grande Valley below White Rock Canyon and major southern tributaries such as the Santa Fe River. The third kind of area produces wild species useful to man and is capable of being farmed only

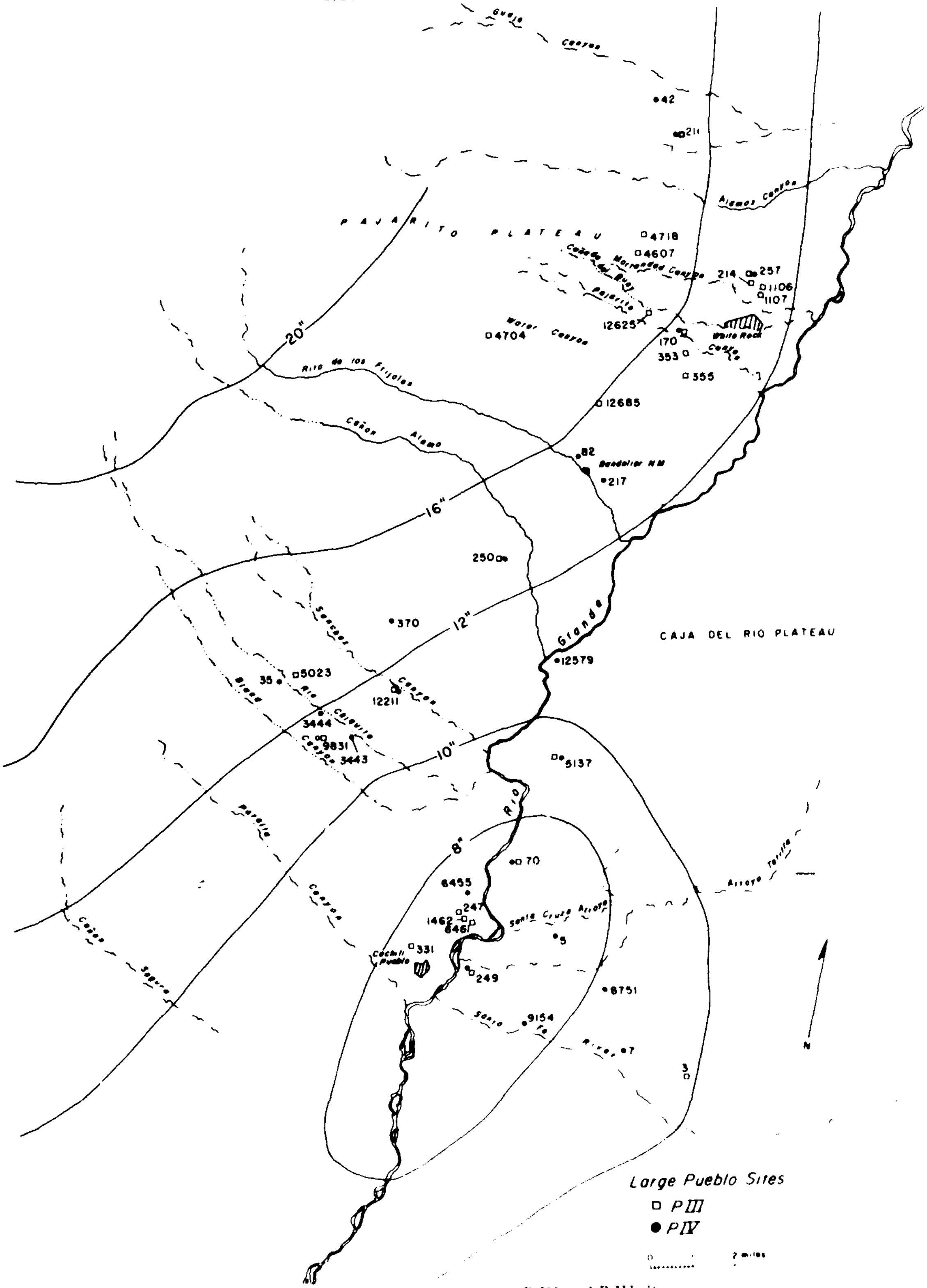


Fig. 8.1 Locations of P-III and P-IV sites

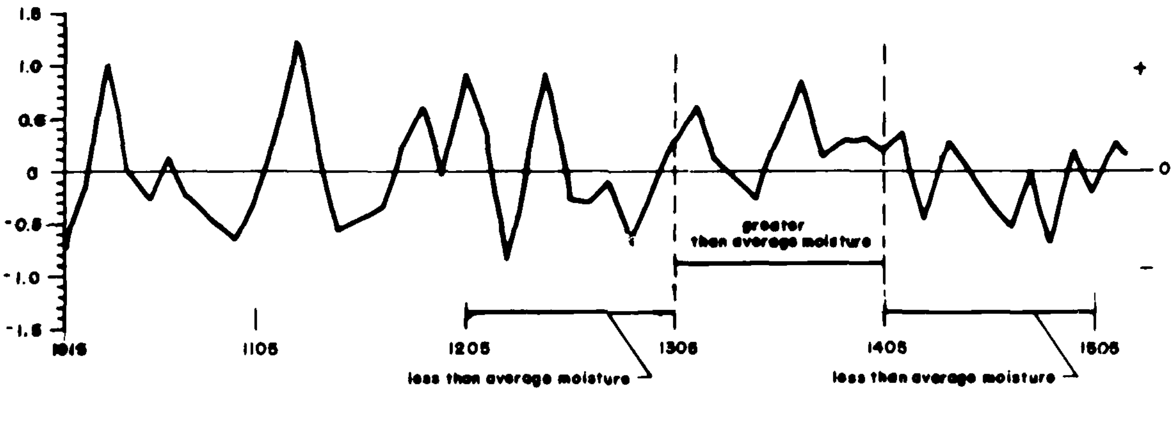


Fig. 8.2 Northern Rio Grande tree-ring Station No. 7 (Ten year means of growth indices converted to relative departure from the mean of the period of record) (after Fritts 1965)

under unusually moist conditions which have no predictable long-term cyclicity. These areas are found on either side of the Rio Grande in White Rock Canyon and away from the Rio Grande floodplain below White Rock Canyon but at low elevations, such as the land southwest of White Rock Canyon below the 5300 ft contour.

Of course the edges of these zones are arbitrarily defined, and transitional areas exist, specifically the band of land between the 16 inch and the 10 inch isohyets. This transitional zone is an ecotone of sorts, as it separates heavily forested land from grass/scrubland. In addition, in the northern portion of the area depicted in Fig. 8.1, there is no zone comparable to the dry sections south of the Plateau; the lowland/upland distinction becomes a matter of degree.

THE SHIFT TOWARD LOWLAND SETTLEMENT

On the basis of available literature for the northern Rio Grande, Dickson (1975) recently investigated the settlement pattern change from earlier (pre P-III) occupation of sites in the piedmont, away from the semiarid Rio Grande floodplain, to general abandonment of the piedmont for the Rio Grande floodplain and its major tributaries after P-III. His survey sample was taken from a 108 mi^2 transect across the middle northern Rio Grande, roughly from Cochiti Pueblo to the Arroyo Hondo Pueblo, in a band 4 mi wide and 27 mi long (see Dickson 1975: Fig. 1). Along with known sites from the Laboratory of Anthropology files, his one-man survey documented a total of 164 sites. Dickson found no clear pattern of downward movement through time in his sample. However, he did find that the two geographic districts which contained perennial streams (the Rio Grande floodplain and terraces, and the Santa Fe River) also contained the highest occupational densities of all areas studied (Dickson 1975: 164).

Dickson offered an explanation for the settlement data he collected which falls within the *population pressure labor intensification school* (*cf.* Boserup 1965). This is not the place for a detailed review of Dickson's methods, data and explanatory arguments; suffice it to say that he found the general pattern of late, aggregated settlement in the Rio Grande floodplain and one of its major tributaries, the Santa Fe River.

A New Mode of Settlement

While population seems to have increased during the P-III period in the Rio Grande (Wendorf 1954; Biella and Chapman 1977b), during the P-IV period this growth may not have continued. However, during P-IV, a new settlement configuration, the large, multistoried pueblo village, became characteristic in a century that enjoyed highly favorable moisture conditions compared to the centuries prior to and after the A.D. 1300s (see Fig. 8.2). From ca. A.D. 1305 to A.D. 1405, in only one decade (from A.D. 1345 to A.D. 1355) did the moisture fall below average for the period of record, and during most of the century it was well above average (Fritts 1965).

One of the implications of the tree-ring record is that higher than normal moisture conditions during the 14th century would have rendered the northern Rio Grande, and particularly the better-watered parts of it, an attractive region for settlement and subsistence from the point of view of indigenous and adjacent populations. A recent review of Puebloan prehistory, with special reference to the Rio Grande region (Ford, Schroeder and Peckham 1972), indicates that there was an apparent influx of Keres deriving from the Rio Salado Valley below Jemez and from the San Juan region into the Rio Grande north to Frijoles Canyon and east to San Marcos in the Galisteo (following Ford, Schroeder and Peckham 1972) during the early A.D. 1300s, displacing some in situ groups of Tewa and Towa presumably in the Pajarito Plateau. Reed

(1949:170) and Dittert (1959:558) assert that an influx into the Rio Grande of peoples traceable to the Acoma district is evident during the early A.D. 1300s as well. These interpretations are based largely on pottery variations.

While the correspondence between linguistic/ethnic groups and distinctive pottery styles can be questioned, the fact remains that local regional differentiation of pottery styles which have continuity with the Historic pueblos in the northern Rio Grande began to be pronounced at this time (see Maps 4-6 in Ford, Schroeder and Peckham 1972). It is probably accurate to infer that a considerable amount of social readjustment was taking place during this century, from the evidence of new architectural and ceramic configurations (*cf.* McGregor 1974:414).

HOME RANGE USE AND PAN-SOUTHWESTERN RESIDENTIAL AGGREGATION

The puzzle contained in the above observations is why, under climatic conditions of greater-than-normal moisture for about a century, should the Anasazi populations in the northern Rio Grande tend to concentrate their settlements in lower settings when, presumably, farming of uplands was again feasible after the drought of the late A.D. 1200s? We suggest that the large aggregations in the northern Rio Grande, those located south of White Rock Canyon and those below the 16 inch isohyet on the Pajarito Plateau, are manifestations of a general adaptive process which occurs under conditions of competition for home range.

As generally used, the term home range includes all the area that an organism (or population) covers in the course of gaining a living (Burt 1943:346). It implies nothing about the evenness with which that area is utilized (*cf.* Shalk 1978). What we are proposing here is that the relative evenness with which Rio Grande populations used their home range changed from more even to less even exploitation, manifested in a shift toward large aggregations for residential purposes and a radial pattern of small farming locations closely associated with the large villages. The village-satellite pattern contrasts with the previous land use strategy of locating residential sites, along with small farming locales, more evenly across space within the home range.

The process of residential aggregation has been recorded elsewhere at about the same time in the Southwest; Martin has stated

> *By A.D. 1400 all the towns in northern Arizona, in the Mesa Verde area, and in the Chaco Canyon were abandoned. Many of the great towns farther south (Kinishba, Grasshopper, and others) began to grow with the arrival of displaced persons.*
> [Martin and Plog 1973:209]

Population decline in the northern and central Anasazi area seems to have been accompanied by a rise in populations occupying major river valleys such as the Little Colorado and the Rio Grande, the well-watered Mogollon Rim country and the lower Gila-Salt drainage during the A.D. 1300s and on, until roughly A.D. 1450 (McGregor 1974: 417).

The salient context for Southwestern residential aggregation into *great towns* seems to be large-scale demographic shifts, correlated with specific climatic events in the source area but not necessarily in the receiving area. In other words, drought may stimulate a migration out of an area but the rainfall conditions in the receiving area may or may not be favorable for runoff farming. For instance, the move to the major river valleys in Arizona was a move toward higher rainfall regimes, while movement to the lower Little Colorado was toward a low rainfall regime. The fact that the post A.D. 1300 settlement mode was one of large villages rather than a dispersion of smaller settlements may indicate that competition for home range was a general problem and was responded to in similar manner across the Southwest at this time.

A MODEL FOR THE RISE OF LARGE AGGREGATED SETTLEMENTS IN THE NORTHERN RIO GRANDE

We propose that it was the demographic context of population influx and resulting competition for home range which accounts for increasing residential aggregation and more labor-intensive farming, with limited use of better-watered uplands for other purposes, such as hunting, gathering and some farming, during the P-III period and on.

Ethnographic Documentation at Unoccupied Zones: The Chippewa Case

A number of ethnographic examples of unoccupied zones between competitive units have been documented (Hickerson 1962; Heider 1970; Harner 1972; Hudson 1976; Meggitt 1977). A graphic case of an unoccupied but desirable zone in North America was the rich hunting grounds of the deciduous forest and park region in western Wisconsin (Hickerson 1962). In the middle of the 18th century, this region was subject to heavy competition between the Southwestern Chippewa and the Dakota for whom it had become an effective *war zone*, uninhabitable except by hunting parties who entered at great risk. Chippewa residential sites were located at lakesides within the bordering coniferous forest, an environmental zone of relatively low utility for man and further depleted through intensive trapping for furs. According to Hickerson,

> *All information indicates that these Chippewa, from Leech Lake to Lac du Flambeau, carried their hunts south and southeast from their lakeside villages into the transition forest belt, and the edge of the prairies beyond, of Wisconsin and Minnesota where game was usually plentiful.*
> [Hickerson 1962:17]

As Schoolcraft noted in 1831,

> . . . *the* [Chippewa] *hunting camps, and other signs of* temporary occupation, *(found within the deciduous forest belt) . . . may be attributed*

> *to the abundance of the Virginia deer in that vicinity, many of which we saw, and of elk and moose, whose tracks were fresh and numerous . . . Game, of every species common to the latitude, is plentiful . . . A country more valuable to a population having the habits of our North-Western Indians, could hardly be conceived of; and it is therefore cause of less surprise that its possession should have been so long an object of contention between the Chippewa and Sioux.*
>
> [Schoolcraft 1834:168 169]
> (brackets and emphasis author's)

The rich deciduous forest zone was needed as well by the Dakota, who increasingly needed to rely on hunting there; their bison prey were rapidly disappearing and they needed furs for trade.

> *These pursuits made them* [the Dakotas] *more reliant than ever on occupying territory to their north and northeast*, lying on the periphery of Chippewa hunting grounds. *The transition forest zone in which deciduous trees predominated and the adjacent prairie, then, was the seat of competition and the theater of war between contiguous Chippewa and Dakota.*
>
> [Hickerson 1962:17]
> (brackets and emphasis author's)

Examples of contested areas, essentially devoid of residents, have been described in South America (Harner 1972; Kelekna, personal communication), the Southeastern United States (Hudson 1976); and Melanesia (Heider 1970; Meggitt 1977), in regions with relatively high population densities. The common link among these cases is the competitive strategy of withdrawal from contested zones for residential purposes and exploitation of the uninhabited space by small logistical forays. A similar strategy may have been taken by Rio Grande Anasazi during the 14th century A.D.

Residential Withdrawal to Reduce Costs of Competition

The process of withdrawal would first be manifested in residential aggregations within desirable zones, as opposed to a more dispersed form of settlement; where possible, the next step would be movement away from such zones into adjacent ones with lower productivity but which were capable of supporting large numbers of persons if the labor devoted to food producing were increased. The strategy of withdrawal from an area in order to reduce the costs of competition is taken when the costs of defense are great relative to the payoff for staying. In such an energy budget for northern Rio Grande farming peoples, the cost of defense would be saved by withdrawal from desirable areas but the price of security--moving to less contested areas--would be paid in higher labor costs to support more intensive agricultural systems and in the risk of crop and even village decimation from flooding (*cf.* Ford 1972:3-6). Since a lowland alternative existed, the loss in natural productivity could be made up through increased labor investment in food production.

The reader may have noted the apparent similarity of this model to a notion found in the early Southwestern literature on residential aggregation, *the need for defense* (e.g. Mera 1940:39). Perhaps the reason this interpretation of large villages has not found much support is that the term defense implied active hostilities (*warfare*) and the need for fortification against armed attack, and there is little consistent archeological evidence for either in the Southwest. In contrast, we are suggesting that fortification and active hostilities were too *expensive*, relative to the payoff for staying in an area whose chief virtue was that one did not have to work as hard to gain a living. The Southwest is relatively unproductive on a world-wide scale; so we cannot expect heavy energy investment into protection and armed defense of any location. In the face of competition, withdrawal by all parties is a more economical response in such settings. Further, considering that even in a highly productive region such as the transition forest belt in dispute between Chippewa and Dakota, residential withdrawal was taken as a response to competition, we have little reason to expect that it was not taken also in the less productive Southwest.

THE SEQUENCE OF AGGREGATION IN THE NORTHERN RIO GRANDE

The Cochiti Project Settlement Data

The general settlement configurations inferrable from observations made during survey and an assessment of the literature on prehistoric settlement in the 1325 km² Cochiti Study Area which pertain to the competition reduction model have been summarized by Biella (1977:117) as follows:

> *By A.D. 1200-1325 (Coalition or P-III), the number of Anasazi sites increases dramatically. Three hundred sixty-three P-III sites have been documented for the study area. P-III sites occur in all districts. Their density is greatest in the Pajarito Plateau District but it is high throughout the study area. The range of size for P-III sites range from 6-10 rooms in extent, 11-30 room sites (or 'medium-sized' sites) constitute a class of sites which occur in P-III times but are rare in any other Anasazi phase....In the northern portion of the study area, large P-III sites have been recorded, documenting the first tendency toward aggregation*
>
> *By A.D. 1325 (beginning of Classic or P-IV), the tendency for aggregation becomes the dominant settlement strategy. A number of large P-IV sites have been documented throughout the study area. most major drainage systems have one or two large P-IV sites. These appear to be surrounded by several small, one to three room sites (field houses?) with terraces and/or isolated lithic and ceramic scatters...These smaller sites may indicate an intensification in land use by the aggregated population centers*
>
> *The majority of P-IV sites in the study area are early Glaze A or B sites (A.D. 1325-1450). The later sites are fewer in number and there is some*

indication that the populations may have been moving out of the study area by the time of the arrival of the Spanish in A.D. 1540.

We interpret the P-IV residential aggregations in the Cochiti Study Area as manifestations of the competition reduction strategy whereby extensive occupation of higher rainfall zones was precluded by the high cost-to-benefit ratio of defending these locations.

Fig. 8.1 depicts the locations of all known large P-III and P-IV residential sites documented by Biella and Chapman (1977b). As can be seen by inspection, P-III sites are located both in areas above and below the 16 inch isohyet while P-IV sites are located below it. The configuration of a large aggregated settlement *surrounded by several small, one to three room sites . . . with terraces and/or isolated lithic and ceramic scatters* is the spatial expression of this strategy, particularly in the southern portion of the Cochiti Study Area. It provides a marked contrast to the previous configuration typical of P-III, in which many more *medium-sized* sites were occupied and the distribution of sites of all sizes is more even throughout the Plateau (see Biella and Chapman 1977b:Figs. III.5.5 and III.5.6).

The Northern Pajarito Plateau Site Data

Although comprehensive settlement pattern data are lacking for the northern Pajarito Plateau, site size information (by room count) is available for 32 excavated sites. Table 8.1 lists these sites and their respective room counts and room sizes, by period. Although this group is not an accurate reflection of actual size frequencies by size in the area, it may not be a sampling accident that the northern Pajarito Plateau contains several representative (the Bandelier-Frijoles area and the Los Alamos sites) of the medium size category, 11-50 rooms, three in the 20-30 room range (LA 12119, LA 4632, LA 8681). By way of comparison, in the southern Pajarito, within the Cochiti Reservoir floodpool, there is one site in this size range, the rest containing less than 20 rooms. The northern Plateau 20 room sites all date to the P-III period. Although they were not amenable to systematic treatment, since room frequency and size were not available, several very large sites are known from the northern Pajarito Plateau, dating to P-III (Biella and Chapman 1977b:116-117).

As suggested above, the process of aggregation may have begun with a contraction of residence within high rainfall zones prior to abandonment of these areas. This would have the effect of reducing the cost of competition within these optimal zones by decreasing the amount of contested residential area while still allowing the total area to be utilized in some way. The large P-III villages in the northern Pajarito, where precipitation goes no lower than 12 inches even near the Rio Grande (see Fig. 8.1), lend some credence to this observation (Gauthier, personal communication) of large several hundred room P-III sites in the extreme northern portion of the Plateau boundary of the Cochiti Study Area. Unfortunately our settlement pattern information for the northern Pajarito is not sufficient to make any firm generalizations, a shortcoming it is hoped will be obviated by the current field work of James Hill and his colleagues at U.C.L.A.

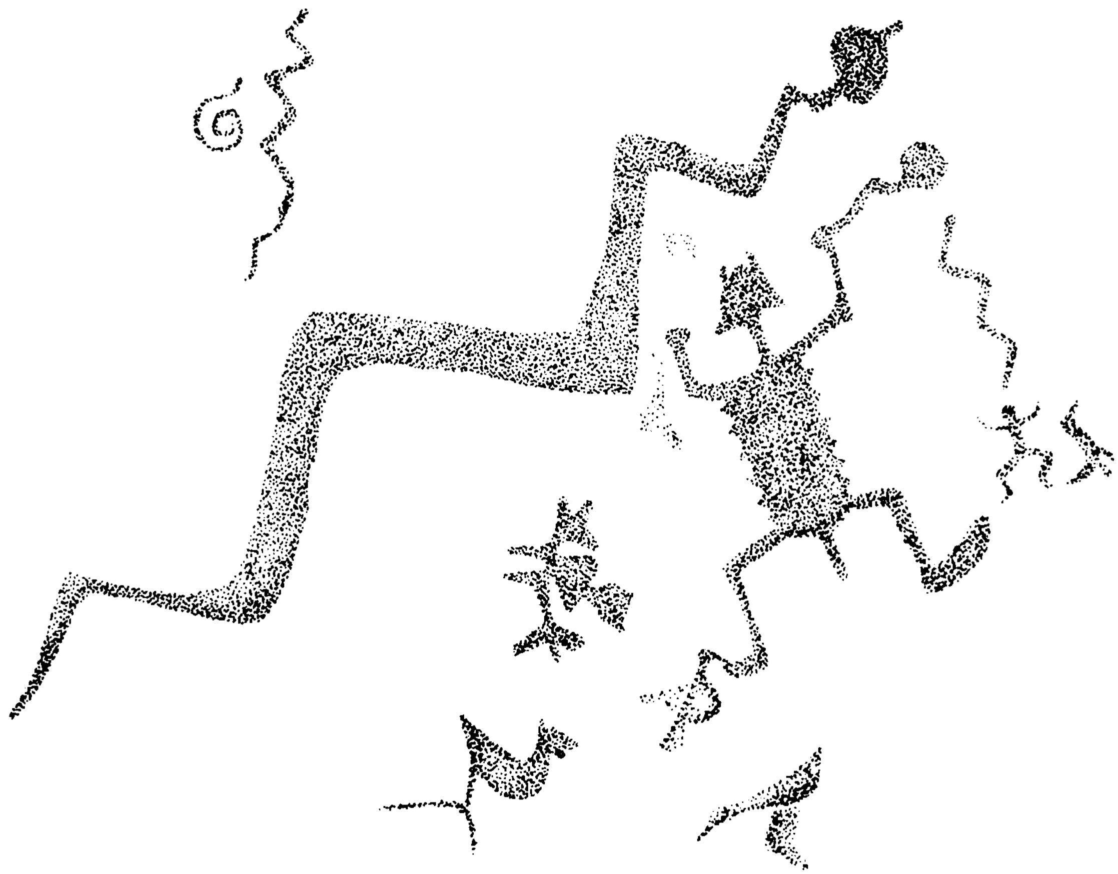
Table 8.1

Number of Excavated Sites and Number of Rooms per Site, Cochiti Study Area, by Subarea

	P-III		P-IV	
	No. Sites	No. Rms/Site	No. Sites	No. Rms/Site
Bandelier National Monument—Frijoles Area	4	1	3	1
	1	8	7	2
	1	12	3	3
	1	23	1	12
	-	—	1	56
Los Alamos—Northern Pajarito Plateau Area	1	3	1	3
	2	2	1	9
	2	7	—	—
	1	8	—	—
	2	20	—	—
Cochiti Reservoir and Dam Area	1	1	5	1
	1	2	7	2
	1	3	1	4
	1	4	1	6
	1	13	1	47
	1	17	1	200-400
	1	27	-	-

CONCLUSIONS

This paper has focused on settlement pattern differences between P-III and P-IV in the northern Rio Grande, with particular attention to observations made in the 1325 km^2 Cochiti Study Area. We offered a tentative explanation for the apparent shift toward large aggregated settlement primarily in zones of lower precipitation near the Rio Grande and its major tributaries. This explanation included a competition reduction model and incorporated what is known of the climatic record for the P-III and P-IV periods in the northern Rio Grande. In another paper (this volume) we attempt to explain differences in the use of space at small structural sites in the northern Rio Grande with reference to the northern Rio Grande settlement strategy changes. It is hoped that the interpretations offered in both papers will provide a stimulus for further model-building in the important areas of settlement pattern and the use of space on archeological sites. Particularly for the northern Rio Grande, it is hoped that they have indicated specific directions for further research into the links between extant Pueblos and their not so remote past.



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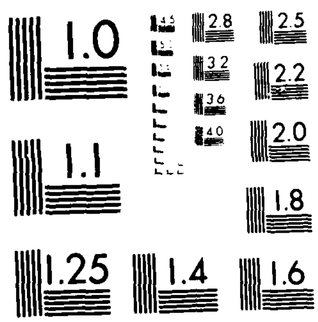

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Chapter 9

OBSERVATIONS ON THE CHANGING ROLE OF SMALL STRUCTURAL ANASAZI SITES IN THE NORTHERN RIO GRANDE

Rosalind Hunter-Anderson

INTRODUCTION

The initial archeological assessment and subsequent survey and excavations in the Cochiti Study Area (Biella and Chapman 1977a; Chapman and Biella 1977b; Biella 1979) provide information which pertains to an understanding of a regional shift in settlement from P-III to P-IV, toward lowland settings near the Rio Grande and its tributaries, and to the rise of large aggregated villages in the 14th century A.D. (P-IV) (see also Dickson 1975). In another paper (this volume), we proposed a competition reduction model to account for this regional shift. This paper will be concerned with the apparent functional differences in small structural sites which occurred in the context of the P-III to P-IV settlement changes.

OBSERVATIONS ON THE ROLE OF SMALL SITES

The Cochiti Reservoir excavations were confined to locales close to the Rio Grande in White Rock Canyon, at generally low elevations where the valley is steep and narrow, precluding large settlements and extensive floodplain farming near its banks. Thus our investigations were restricted to smaller sites, most with fewer than ten rooms. It was decided to investigate the role of these small sites in the changing settlement system and pattern of land use occurring in the northern Rio Grande during the period ca. A.D. 1175 to A.D. 1450 (P-III through mid P-IV) and the extent to which changes in the use of these sites might be a function of larger regional processes of adaptation, such as the contraction of settlement into lowland areas.

Since we were interested in the role(s) that small structural sites played in the P-III and P-IV settlement systems, we wished to extend our observations beyond the confines of Cochiti Reservoir. We began by reviewing small site frequencies in a 165 km^2 quadrat situated in the southern Pajarito Plateau. It extended roughly from the mouth of White Rock Canyon in the south, to the lower reaches of Sanchez Canyon in the north. This area was outstanding in having the most reliable and thorough coverage of any in the Cochiti study area (Biella 1977:113) and corresponds to the test area defined by Fosberg (this volume). Within this area, 92 small (1-10 rooms) structural P-III and 139 P-IV sites were documented. During this review we noted that the ratio of 1-2 room sites to 3-10 room sites changed through time. During the P-III period, the ratio of 1-2 room sites to 3-10 room sites was .559, while in P-IV it was reversed, 1.896.

Next we reviewed the literature on sites which had been excavated in the general Cochiti study area. Although only limited excavation data were available, we were fortunate in having access to Lange (1968) and Snow (1976) for additional information on the Cochiti Dam area (at the mouth of White Rock Canyon); to Traylor et al. (1977) on the southern Bandelier National Monument area (in the vicinity of Alamo and Lummis Canyons); to Steen (1977) and Worman (1967) on portions of the northern Pajarito Plateau (located on Los Alamos Scientific Laboratory lands); and to the Laboratory of Anthropology, Museum of New Mexico, files on both the Pajarito Plateau and Cochiti areas.

Data from three different areas were thus defined; the Cochiti Reservoir/Dam area (White Rock Canyon and environs); the Bandelier National Monument area (from Alamos to Frijoles Canyon); and the northern Pajarito Plateau area (including Los Alamos Scientific Laboratory lands). Tables 9.1 to 9.5 summarize mean room size variability per site and mean percentage of enclosed storage space per site for P-III and P-IV sites in each area.

COCHITI RESERVOIR EXCAVATED DATA

Room Size

For all of the small P-III and P-IV structural sites excavated during the 1975 and 1976 field seasons (Chapman and Biella 1977; Biella 1979), it was found that mean room size markedly decreased from P-III to P-IV (see Table 9.5). For example, among 1-2 room sites in P-III, mean room size was 5.64 m^2; while among 1-2 room sites in P-IV, mean room size dropped to 2.61 m^2. For all P-III small sites (1-2 and 3-10 rooms) the mean room size was 8.57 m^2 compared with 2.69 m^2 during P-IV. These differences are striking and may indicate a change in the function of small structural sites through time coincident with the trend toward large aggregated ssettlements.

Storage Space

A further indication of a change in function of small sites in the Cochiti Reservoir excavations is the proportion of enclosed space which cannot be attributed primarily to residence (domestic activities which fulfill daily living requirements) and has therefore been interpreted as primarily storage space. The proportion of storage space was determined by measuring the floor space of each structure on a site and then calculating the percentage of floor space of those structures without definite hearths, per site. We reasoned that if a hearth were present in a structure, then the function of that room was not exclusively for storage; whereas if a hearth feature were not present, the quantity of domestic activity, such as food preparation and eating, was probably minimal, and a primary function of storage could be inferred for that structure. Although our cases are few for the P-III period, provocative differences can be seen when the distribution of storage space percentages by site size and period are compared (see Tables 9.3 and 9.4).

Table 9.1

Mean Room Size and Standard Deviation – P-III

	1-2 Rooms				3-10 Rooms				11-50 Rooms				>50 Rooms				1-10 Rooms		>11 Rooms	
	LA#	N	$\bar{x}$	s.d.	LA#	N	$\bar{x}$	s.d.	LA#	N	$\bar{x}$	s.d.	LA#	N	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.
Bandelier-Frijoles	12568	1	5.80	—	12121	8	7.51	3.81	12119	23	6.90	4.36	—	—	—	—	—	—	—	—
	12582	1	6.88	—	—	—	—	—	4997	12	4.07	3.24	—	—	—	—	—	—	—	—
	16109	1	3.84	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12123	1	3.40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	# Sites	4	4.98	1.64	# Sites	1	7.51	—	# Sites	2	5.49	2.00	—	—	—	—	5.49	1.82	5.49	2.00
Los Alamos		—	—	—	—	—	—	—	4632	20	6.61	2.71	—	—	—	—	—	—	—	—
		—	—	—	4633	3	3.90	0	8681	20	5.50	1.81	—	—	—	—	—	—	—	—
		—	—	—	4631	8	6.72	1.83	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	4628	7	6.58	1.82	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	4630	2/4	11.48	3.42	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	4722	7	7.37	1.23	—	—	—	—	—	—	—	—	—	—	—	—
					# Sites	5	7.21	2.73	# Sites	2	6.06	.78	—	—	—	—	7.21	2.73	6.06	.78
Cochiti Reservoir	12511	2	3.28	1.55	12522	3	11.07	4.07	5014	13	7.11	1.47	—	—	—	—	—	—		—
	13086	1	8.0	—	6461	2/4	11.94	3.66	6462				—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	Units 3 + 4 (early S.F.)	17	7.09	2.08	—	—	—		—	—	—	—
	—	—	—	—	—	—	—	—	Units 6 + 7 (late S.F.)	27	6.29	1.94	—	—	—	—	—	—	—	—
	# Sites	2	5.64	3.34	# Sites	2	11.51	.62	# Sites	3	6.83	.47	—	—	—	—	8.57	3.91	6.83	.47

Table 9.2

Mean Room Size and Standard Deviation -- P-IV

	1-2 Rooms				3-10 Rooms				11-50 Rooms				>50 Rooms				1-10 Rooms		>11 Rooms	
	LA#	N	x̄	s.d.	LA#	N	x̄	s.d.	LA#	N	x̄	s.d.	LA#	N	x̄	s.d.	x̄	s.d.	x̄	s.d.
Bandelier-Frijoles	12584	1	2.63	—	12122	3	3.80	.62	47	12	4.27	1.62	217	56	5.41	3.82	—	—	—	—
	16097	2	4.52	.29	12124	3	4.49	.24	—	—	—	—	—	—	—	—	—	—	—	—
	16114	2	4.38	.62	12125	3	2.22	1.76	—	—	—	—	—	—	—	—	—	—	—	—
	12120	1	2.88	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12567	1	3.78	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12583	2	4.75	.35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12144	2	4.17	2.13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12577	2	2.81	.27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12581	2	4.53	2.37	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12127	2	2.71	.87	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	# Sites	10	3.72	.87	# Sites	3	3.50	1.16	# Sites	1	4.27	—	# Sites	1	5.41	—	3.67	.89	4.84	.81
Los Alamos	—	—	—	—	170	9	5.47	1.59	—	—	—	—	—	—	—	—	—	—	—	—
					12588	3	4.07	.81	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	# Sites	2	4.77	.99	—	—	—	—	—	—	—	—	4.77	.99	—	—
Cochiti Reservoir	5011	1	2.68	—	13086	4	2.75	.85	6455	47	7.97	4.55	70	157	8.82	9.95	—	—	—	—
	12512	2	1.58	1.44	13084	6	2.77	.79	w/o Great Kivas	46	7.46	2.91	w/o Great Kivas	151	7.20	2.50	—	—	—	—
	12518	2	1.26	.14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12522	1	2.85	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12517	1	1.13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12519	2	1.85	.89	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12454	2	3.38	.80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12443	1	3.74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	13076	2	2.35	.92	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	13050	2	3.30	.23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	13049	1	4.38	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	13054	2	2.78	1.16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	# Sites	12	2.61	1.01	# Sites	2	2.76	.01	# Sites	1	7.97	—	# Sites	1	8.79	—	2.69	.89	7.79	1.10

Table 9.3
Mean Percentage of Enclosed Storage Space per Site P-III

	1-2 Rooms			3-10 Rooms			11-50 Rooms			> 50 Rooms	
	LA#	%	N	LA#	%	N	LA#	%	N	LA#	%
Bandelier-Frijoles	12568	100	1	12121	35	8	12119	43.5	23	-	
	16109	100	1	—	—	—	4997	38.2	12	—	
	12582	0	1	—	—	—	—	—	--	—	
	12123	0	1	—	—	—	—	—	—	—	
			4			8			35	—	
	# Sites = 4; $\bar{x}$ = 50%			# Sites = 1; $\bar{x}$ = 35%			#Sites = 2; $\bar{x}$ = 40.85%			—	
Los Alamos	—	—	—	6461	0	2/4	4632	72.8	20	—	
	—	—	—	4633	100	3	8681	69.5	20	—	
	—	—	—	4631	91.8	8	—	—	..	—	
	—	—	—	4628	55.0	7	—	—	—	—	
	—	—	—	4630	100	2/4	—	—	—	-	
	—	—	—	4722	69.4	7	—	—	—	—	
						29			40		
				# Sites = 6; $\bar{x}$ = 69.4%			#Sites = 2; $\bar{x}$ = 71.2%			-	
Cochiti Reservoir	12511	0.0	2	12522	65.0	3	5014	56.6	13	—	
	13086	0.0	1	—	—	--	—	—	—	—	
	5011	0.0	1	—	—	—	—	—	—	—	
	9138	0.0	2	—	—	—	—	—	—	..	
			6			3			—	--	
	# Sites = 2; $\bar{x}$ = 0%			# Sites = 1; $\bar{x}$ = 65.0%			#Sites = 1; $\bar{x}$ = 56.6%			—	

Table 9.4
Mean Percentage of Enclosed Storage Space per Site — P-IV

	1-2 Rooms			3-10 Rooms			11-50 Rooms			>50 Rooms		
	LA#	%	N	LA#	%	N	LA#	%	N	LA#	%	N
Bandelier-Frijoles	12584	100.0	1	12122	65.3	3	47	49.2	12	217	76.3	56
	16097	52.2	2	12124	64.7	3	—	—	—	—	—	—
	16114	55.0	2	12125	100.0	3	—	—	—	—	—	—
	12120	100.0	1	—	—	—	—	—	—	—	—	—
	12567	100.0	1	—	—	—	—	—	—	—	—	—
	12583	100.0	2	—	—	—	—	—	—	—	—	—
	12144	100.0	2	—	—	—	—	—	—	—	—	—
	12577	53.3	2	—	—	—	—	—	—	—	—	—
	12581	68.5	2	—	—	—	—	—	—	—	—	..
	12127	61.3	2	—	—	—	—	—	—	—	—	—
			17			9			12			56
	# Sites = 10; $\bar{x}$ = 79.0%			# Sites = 3; $\bar{x}$ = 76.7%			# Sites = 1; $\bar{x}$ = 49.2%			# Sites = 1; $\bar{x}$ = 76.3%		
Los Alamos	—	—	—	170	n.d.	9	—	—	—	—	—	—
	—	—	—	12588	n.d.	3	—	—	—	—	—	—
Cochiti Reservoir	12512	n.d.	2	13086	74.0	4	6455	44.3	46	70	32.5	157
	12518	100.0	2	13084	82.0	6	6462	51.5	45	—	—	—
	12522	0.0	1	—	—	—	—	—	—	—	—	-
	12517	100.0	1	—	—	—	—	—	--	—	--	—
	12519	49.0	2	—	—	—	—	—	—	—	—	—
	12454	0.0	2	—	—	—	—	—	—	—	—	—
	12443	100.0	1	—	—	--	—	—	—	—	—	--
	13076	71.0	2	—	—	—	—	—	..	—	—	—
	13050	48.0	2	—	—	—	—	—	—	—	—	—
	13049	100.0	1	—	—	—	—	—	—	—	—	—
	13054	0.0	2	—	--	—	—	—	—	—	—	—
	5011	0.0	1	--	—	—	—	—	—	—	—	—
	# Sites = 11; $\bar{x}$ = 51.6%			# Sites = 2; $\bar{x}$ = 78.0%			# Sites = 2; $\bar{x}$ = 47.9%			# Sites = 1; $\bar{x}$ = 32.5%		

Table 9.5

Variability in Mean Room Size from P-III to P-IV

		m^2			Δm^2	% Δ
1-2 Room Sites:						
Bandelier-Frijoles	decrease from	4.98	→	3.72	1.26	25.3
Los Alamos	none					
Cochiti Reservoir	decrease from	5.64	→	2.61	3.03	53.7
3-10 Room Sites:						
Bandelier-Frijoles	decrease from	7.51	→	3.50	4.01	53.4
Los Alamos	decrease from	8.00	→	4.77	3.23	40.4
Cochiti Reservoir	decrease from	11.07	→	2.76	8.31	75.1
1-2 and 3-10 Room Sites Combined:						
Bandelier-Frijoles	decrease from	6.25	→	3.61	2.64	42.2
Los Alamos	decrease from	8.00	→	4.77	3.23	40.4
					(no 1-2 Room Sites)	
Cochiti Reservoir	decrease from	8.36	→	2.69	5.67	67.8
11-50 Room Sites:						
Bandelier-Frijoles	decrease from	5.49	→	4.27	1.22	22.2
Los Alamos		6.06	→	n.d.	—	—
Cochiti Reservoir	slight increase	7.11	→	7.29	–.18	–2.5
>50 Room Sites:						
Bandelier-Frijoles		n.d.	→	5.41	—	—
Los Alamos		n.d.	→	n.d.	—	—
Cochiti Reservoir		n.d.	→	8.79	—	—
11-50 and >50 Room Sites Combined:						
Bandelier-Frijoles	decrease from	5.49	→	4.94	.65	11.8
					(no P-III >50 Room Sites)	
Los Alamos		6.06	→	n.d.	—	—
Cochiti Reservoir	increase from	7.11	→	8.04	–.93	–13.1
					(no P-III >50 Room Sites)	

Table 9.6

Room Shape Variability in Small Sites – P-III and P-IV

Shape	Rectangular	Round	Oval	D-shape	Triangular	Irregular
P-III	15	4*	–	–	–	–
P-IV	18	3	4	2	1	1

* Two kivas, one pithouse, one above ground structure

In the P-III 1-2 room site category, the average percentage of storage space on a site is 0; all structures contained hearths. In contrast, on P-IV 1-2 room sites, the average percentage of storage space per site is 51.6%. Among 3-10 room sites for both periods the percentages of storage space are more similar. However, from P-III to P-IV there is a trend toward more storage space per site; for P-III (one case) it is 65.0%, and for P-IV the mean is 78.0%.

CHANGING SMALL SITE FUNCTIONS FROM P-III to P-IV IN THE COCHITI STUDY AREA

The documented decrease in the number of rooms on small sites, the decline in average room size on them and the increase in the percentage of storage space enclosed within structures (see Tables 9.1 to 9.5) all may relate to the shift in land use under competitive conditions in the Classic period (P-IV). In our analysis of small site variability, we reasoned that the function served by above ground structures occurring in configurations of 3-10 rooms is likely to have been a combination of residence and storage. Similarly, the function of structures occurring in configurations of 1-2 rooms is likely to have been storage alone. If these interpretations are substantially correct, the decrease in frequency of dual function (residence and storage) structural configurations from P-III to P-IV, and the concomitant increase in the frequency of single function (storage) structural configurations indicate a decrease in the energy invested in housing residential activities at farming locations, but not necessarily an absence of such activities.

While it seems reasonable to expect that some residential activities were carried out at small site locations, not providing structures specifically for them and differentiated from storage structures indicates a decrease in the frequency, volume, and/or duration of residential activities on these sites (see Hunter-Anderson 1977).

HYPOTHESES TO ACCOUNT FOR SMALL SITE FUNCTIONAL DIFFERENCES

Three hypotheses to account for changing small site functions are presented below. Unfortunately, their testing is beyond the scope of this paper. The hypotheses and limited discussions of their implications are offered to show some possible research directions that could be pursued in the future.

Hypothesis 1

The decrease in the residential activities at small sites could be due to a decline in the average number of participants during a given field season per farming locale. The implications of fewer personnel per farming site per season are that (1) less gear, (2) less food, and (3) less site use time devoted to maintenance activities for the group were necessary per site. If the hypothesis of smaller farming groups is true, there may have been a concomitant increase in resident personnel at large residential sites and therefore a corresponding increase in (1), (2) and (3) at the large sites. This should have resulted in increased spatial differentiation due to different functions of rooms within large sites, other things equal.

Elsewhere we (Hunter-Anderson 1977:304-305) have argued that high volumes of materials processed or stored at a given location or high frequencies of prolonged activities involving the processing and storage of materials will result in the spatial separation by housing or walling off of these locations from others, due to the need to protect the contents of these areas from mutual interference. Archeologically this may be seen in architectural variations.

Room Size Differentiation

Although our sample is small for the very large sites, we have the dimensions of many rooms. Tables 9.1 and 9.2 present the mean and standard deviation of room areas at small sites and large sites by period. As can be seen, on small sites (1-10 rooms) dating to the P-IV period, there is considerable variance in room size, and the rooms tend to be small. We have suggested that this decline in room size variance and in mean room size is a function of fewer personnel being accomodated at the farming locales. We then suggested that an increase in architectural specialization (room size differentiation due to differences in the function of rooms) should be apparent at the large residential sites from P-III to P-IV. From the limited data we have available, this appears to be the case. These data include one P-III site of 13 rooms (LA 5014); two P-III components at LA 6462 (an early component of 17 rooms and a late component of 27 rooms); one P-IV site of 47 rooms (LA 6455); and one P-IV site of over 200 rooms of which 157 were available for measurement (LA 70).

The three P-III sites have a range in standard deviation in room size of from 1.47 m^2 to 2.08 m^2 while the standard deviations at the two large P-IV sites range from 4.55 m^2 to 9.95 m^2. There is also an apparent trend toward more variance in room size the larger the site, which here is a temporal trend as well. On two of the P-IV sites (LA 6455 and LA 70), Great Kivas (very large kivas which measured over 20 m^2 in area) contributed to the high room size variance and high mean room size per site. To eliminate the effect of these large structures which might be argued not to have fulfilled a residential function in spite of containing hearths (as opposed to smaller kivas which more confidently can be assumed to have fulfilled a residential as well as a ritual function), mean room size and variance were recalculated without them. In both cases, mean room size decreased only slightly, and variance in room size was brought more closely in line with the P-III sites (the two component LA 6462) which had no very large kivas. However, from P-III to P-IV there is the expected trend toward room size differentiation on large sites, as evidenced in higher standard deviations in room size on these large P-IV sites.

Hypothesis 2

An alternative hypothesis to account for the apparent decrease in residential activities on small sites during the P-IV period is that less time was spent at these locations during the growing season than previously, while the number of persons on a given farming location did not decrease from P-III to P-IV. Whether it was a decrease in time spent at farming locations per season or a decrease in the number of persons with no decrease in time spent

(Hypothesis 1), the architectural expectations of room size differentiation on large sites and a lack of such differentiation on small sites are the same. Less site use hours per season would be necessary if small sites were located near the large residential sites so that only stored materials (food and farming equipment) would require housing. Under this hypothesis, farming locales during P-IV served as food-generating and holding stations which were ancillary to and dependent upon nearby large residential sites; whereas, in P-III, farming locales may have been more self-sufficient and independent, housing residential activities as well as serving as storage stations. A spatial implication of this hypothesis is that, in P-IV, the distance between a large residential structure and its nearest small site neighbors should be less than the distance between a large residential site and its nearest large site neighbors. Conversely, during the P-III period, the distance between the large and small sites should be similar to that between large sites, other things equal.

Hypothesis 3

Another hypothesis to account for the small site differences is that less certainty about the reuse of farming locales existed in P-IV, while more certainly about reuse of farming locales existed in P-III. With less certainty about reuse, less investment in residential structures can be expected (Hunter-Anderson 1977:111-12). The distribution of farming locales (see Fosberg, this volume) during the P-III period on the southern Pajarito Plateau indicates that they are concentrated along the lower Rio Chiquito, the only perennially flowing tributary to the Rio Grande. During the early to mid P-IV period, this area along with Rio Chiquito continued to be preferred for small sites, but they expand onto the terraces overlooking the Rio Grande as well. The terrace locations would receive the maximum amount of runoff from the adjacent, very gently sloping land but would be unsuitable for residential purposes in the long run. Thus, a move from a certain runoff source provided by the Rio Chiquito to an area of less certain runoff provided by the drainage of land of only minimal slope is a trend from P-III to P-IV.

The expansion of small sites exhibiting a low proportion of enclosed residential-to-total enclosed space into less certain runoff areas such as Rio Grande terraces south of the Rio Chiquito, may reflect an opportunistic response to the unusually favorable moisture conditions prevailing at this time (see Hunter-Anderson this volume, Fig. 8.2) and thus lend support to the hypothesis relating low predictability of reuse with the lack of residential structures at farming sites.

The distribution of small sites in question is illustrated in Fosberg (this volume). As can be seen, the expansion of P-IV sites into other than optimal soil association 15 is limited to places where runoff would be maximal, along the narrow terraces of the Rio Grande which runs through the less optimal soil associations 1, 7 and 14. Availability of runoff during the P-III through mid P-IV periods could account for the use of the higher runoff-receiving areas within all soils in the Cochiti Quad, and the converse, a decline in available runoff after that period, could account for its disuse after A.D. 1450.

As Fosberg has pointed out, Southwestern farming peoples such as the Navajo and Yuma are well aware of the salt content characteristics of soils, and they even test soils before selecting an area for planting. We can assume a similar familiarity with soil properties on the part of prehistoric Anasazi and therefore suggest that in spite of salt build-up tendencies, the decision to use less optimal soils was taken when necessary, that is, when other factors outweighed this disadvantage. An alternative explanation for the disuse of the Cochiti Quad area for farming, then, is that sufficient runoff was not available after A.D. 1450.

The above hypotheses and discussions relating to small site differences in farming strategies in the context of a shift toward aggregated settlement require extensive testing. Some appropriate data bases for such testing might be intersite and intrasite artifact variability between and within assemblages, variability in vessel form and mode of decoration through time in large and small sites, and possibly other architectural attributes which would indicate the degree of effort invested in building and maintaining structures and other features. An initial attempt to pursue some of the implications of the three hypotheses follow.

LABOR INVESTMENT AND SHAPE VARIABILITY IN SMALL SITE STRUCTURES

An Indirect Measure of Labor Investment in Structures

A preliminary analysis of data relating to the degree of effort invested in building and maintaining structures was made using excavated sites within the Cochiti Reservoir area. A series of eleven factors (see Table 9.7) which were thought to be indirect measures of labor investment were tabulated for each structure, and their combined scores were used as an index of labor investment (ILI). For each structure information was not always available for each factor, so a correction had to be made allowing for different numbers of factors monitored per structure. This was done by dividing the cumulative score for a structure by the number of factors monitored:

ILI = cumulative score per # factors

A minimum ILI of 1, meaning little investment, and a maximum ILI of 4, meaning heavy investment, were possible. The results of this analysis are presented in Fig. 9.1. It can be seen that there is a decrease in labor investment from P-III to P-IV among the sites analyzed. While this is admittedly a crude estimate of labor investment, the clear separation of the two curves may indicate a real difference in the use of small sites from P-III to P-IV.

Shape Variability

A check on the plausibility of Hypotheses 1 and 2 was made by monitoring the shape variability in Cochiti Reservoir P-III and P-IV small site structures. It was reasoned that more expedient building standards would result in a tendency for the shape of structures to be round or irregular, reflecting less internal differentiation of activities within structures (see Hunter-Anderson 1977) in P-IV.

Table 9.7

Eleven Factors Used to Calculate Index of Labor Investment (ILI)

1. Range of size of elements, not including boulders (length x width, largest element — length x width, smallest element
   - 1 = 3000 cm^2
   - 2 = 2000 cm^2 3000 cm^2
   - 3 = 1000 cm^2 2000 cm^2
   - 4 = 1 cm^2 1000 cm^2
2. Proportion of in situ boulders used
   - 1 = two or more walls consist of boulders
   - 2 = one wall consists of boulders
   - 3 = one element in wall is a boulder
   - 4 = no boulders present
3. Shaping of elements
   - 1 = no shaping
   - 4 = shaping present
4. Regularity in placement of elements; coursing or footing
   - 1 = no regularity
   - 4 = regularity
5. Wall facing with stone
   - 1 = no facing
   - 4 = facing present
6. Chinking
   - 1 = no chinking
   - 4 = chinking present
7. Plaster
   - 1 = no plaster
   - 4 = plaster present
8. Prepared floor
   - 1 = none
   - 4 = prepared floor present
9. Roofing materials
   - 1 = none
   - 4 = roofing materials present
10. Built-in features, such as prepared hearths, bins
    - 1 = none
    - 4 = one or more present
11. Use of mortar
    - 1 = none
    - 4 = mortar present

Highest score possible: $\frac{44}{11} = 4$ Lowest score possible: $\frac{11}{11} = 1$

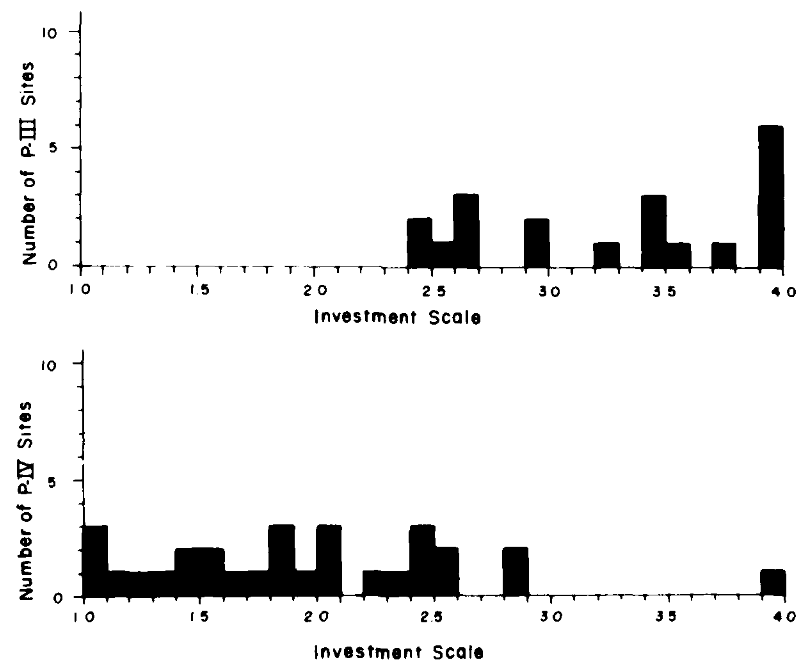

Fig. 9.1 Index of labor investment for P-III and P-IV sites

As argued above, less internal differentiation of activities within a structure is expected when the volume of materials processed or stored at a location is low. The tendency would be to *bin* (cf. Hunter-Anderson 1977) these materials and for activities taking place within structures not to be spatially separated from one another since the interference factor would be relatively low.

The results of the shape analysis are presented in Table 9.6. As can be seen, shape variability increased considerably from P-III to P-IV, although the rectangular form continued to be preferred. Rectangularity is often associated with contiguous rooms, both in P-III and in P-IV; however, the interesting phenomenon of contiguous rooms which are not both rectangular only occurs in P-IV, if we do not include kivas, whose shape seems to be independently determined regardless of the nearby *room environment.*

In P-IV the combination of a rectangular room and a round one in one structural configuration may indicate less certainty about continued use of the structure (see above). Because curvilinear walls do not allow the simple addition of rectangular shaped rooms, there would seem to have been no anticipation of such remodeling needs. Neither of these preliminary analyses can be considered verification of our interpretations, but they are offered as examples of ways excavation data can be used to perform initial evaluations of hypotheses.

SPACE USE COMPARISONS BETWEEN THE PAJARITO PLATEAU AND THE COCHITI RESERVOIR AREA

As indicated in Tables 9.1 to 9.5, site size, room size, and room function data have been compiled for portions of the Pajarito Plateau as well as the Cochiti Reservoir area itself. It was thought that somewhat different settlement strategies may have been taken in the northern Plateau where the productivity of the environment as measured in gross biomass is higher, due to higher mean annual precipitation. Another factor contributing to a difference between the northern Plateau and the Cochiti Reservoir is the length of the growing season, which is shorter in the north (Tuan et al. 1974:Fig. 38). In comparison, the Cochiti Reservoir area receives much less precipitation and enjoys a longer growing season. To some extent the expectation of settlement differences in the two areas was confirmed.

Table 9.5 summarizes the room size changes evident in all areas studied. In contrast to Cochiti Reservoir sites, northern Plateau sites follow the same general trend toward a decrease in room size from P-III to P-IV among sites in the 1-10 room size category. Within the northern Plateau, the percentage of room size decrease is about 40% in the Bandelier-Frijoles and Los Alamos subareas; in the Cochiti Reservoir it is more dramatic, nearly 67%. Particularly interesting is the observation that among 1-2 room sites in Bandelier-Frijoles there is little change in room size (a decrease of ca. 25%) from P-III to P-IV, while the percentage of storage space on these sites is relatively high in both periods. In comparison with 1-2 room sites from Cochiti, where room size drops by ca. 54% from P-III to P-IV, the Bandelier-Frijoles sites may have been serving a different function in the settlement system than did the Cochiti ones during the P-III period. That is, on Cochiti 1-2 room sites dating to P-III, none has a separate storage room, indicating that a very small proportion of enclosed space was exclusively devoted to storage. On the other hand, in Bandelier-Frijoles, an exclusive storage function for two out of the four P-III structures (one per site) excavated can be inferred, due to the absence of hearths within them (see Table 9.5).

Although our data are only suggestive, it may be possible that the high percentage of storage and the lack of dramatic change in room size in all Bandelier-Frijoles 1-2 room sites are indicative of an earlier aggregative residential strategy than in the Cochiti area, where high storage percentages do not occur on 1-2 room sites until P-IV. This possibility was raised elsewhere (Hunter-Anderson, this volume) when it was noted that the majority of documented *medium-sized* sites (of at least 20 rooms) occurred in the northern Plateau area in P-III, and that some very large single component P-III sites have recently been observed in the northern Plateau (Gauthier, personal communication). On the other hand, another possibility is that more storage on all sites can be expected in the northern Plateau as a function of the shorter growing season and the need to live from stores for a longer period than further south and at lower elevations.

Another interesting difference between the northern Pajarito sites and those in the Cochiti Reservoir area is the reversal in site size mode (by room count), within the size category 11-50 rooms, from P-III to P-IV. In P-III Cochiti area sites in this size category (three sites), the range is from 13-27 rooms with no clear mode, while in Bandelier and Los Alamos (four sites) the range is from 12-23 with a mode of ca. 20 rooms. By P-IV, the single Cochiti site contains 47 rooms while in Bandelier the sole representative in this size class has only 12. This latter site (LA 47 or Puyé) is actually a section of the cavate series lining the cliff face below the main site of Puyé and perhaps may be best regarded as a summer component of the Puyé site.

What may be reflected here, assuming these observations are not simple sampling error, is (1) a lag in the Cochiti Reservoir area in the process of aggregation and (2) a land use difference between the northern Pajarito Plateau and the Cochiti Reservoir areas during P-IV.

The Aggregation Lag in the Cochiti Area

By P-IV times in the northern Pajarito Plateau, mid-size (ca. 20 room) sites such as those observed in P-III may no longer have been a viable mode of settlement, and the shift to extremely large aggregations had taken place as exemplified in the P-IV site LA 217 and other large sites not available for room count and size measurement (cf. Hewett 1906). On the other hand, in the Cochiti Reservoir area the move toward very large sites does not take place until P-IV and then the shift is more accelerated but parallels the northern Plateau in P-III. By P-IV the Cochiti area site size mode in the category 11-50 rooms is 47 rooms in our sample, and LA 70 is a case of a P-IV very large village with over 200 rooms.

Land Use Differences in P-IV Between the Northern Pajarito and Cochiti Areas

A considerable difference is apparent between the northern Plateau and the Cochiti Reservoir areas in the percentage of site space devoted to storage rooms in very large sites (Tables 9.3 and 9.4), such as LA 70 (in Cochiti) and LA 217 (in Bandelier). At LA 217 the percentage of storage is over 75% while at LA 70 it is only 3%. A major land use strategy difference in P-IV may be indicated by these figures. According to Biella (1977:117), an apparent P-IV settlement pattern in the southern Cochiti part of the study area was one of a large settlement with associated small satellite sites. We have suggested that these smaller sites contained mainly storage structures. In the Bandelier area and possibly the entire northern Pajarito Plateau, the use of small satellite storage locales may have been supplemented by a within-site seasonal shift from winter mesa top rooms to summer cliff-face rooms, with little distance between the two seasonal components and relatively large proportions of storage space at each. Puyé (LA 47), Tsirege (LA 170) and Rainbow House (LA 217) may be examples of this pattern. As Chapman (personal communication) has characterized it, the difference in land use strategies may have been one of dispersed stores in the Cochiti area and *agglomerated* stores in the northern Plateau. Unfortunately data on storage are not available for the main pueblos of Puyé and Tsirege, so the expectation of a high proportion of storage space on these sites, relative to the large sites in the Cochiti area, cannot be evaluated.

SUMMARY

This paper has focused on the changing role of small sites in the settlement systems in the Cochiti Study Area which includes the Cochiti Reservoir floodpool north to approximately Guaje Canyon in the Pajarito Plateau.

We have placed particular emphasis on the relationship between architectural variations such as room size and the proportion of storage space and the trend toward residential aggregation which occurred from P-III to P-IV. Limited comparisons were made between the northern Pajarito Plateau excavated sites and those from the Cochiti Reservoir area in order to highlight differences and similarities which may be attributed to common adaptive problems and somewhat different environmental contexts for solving them.

Chapter 10

THE GLAZE PAINT WARES OF THE UPPER MIDDLE RIO GRANDE

A. H. Warren

INTRODUCTION

For nearly 400 years, the Pueblo Indians living on the mesas and in the canyons of the southern Pajarito Plateau, Mesa Negra, and the upper Santo Domingo Basin used Rio Grande glaze paint pottery for every day culinary wares. Intermittent mineralogical studies during the past ten years of glaze paint pottery from 47 archeological sites in the upper middle Rio Grande region are summarized and reviewed in this report. By observing the variables between two interrelated pottery and temper classifications systems, it has been possible to make observations about numerous aspects of the behavior of the populations who produced the pottery.

Highlights of the study include:

1. Delineation of trade networks as revealed by persistent patterns of pottery and temper type distributions through time.

2. Identification of manufacturing and trade centers: isolation of ceramic traits and refinement of local ceramic sequences. For instance, glaze paint vessels with red slips or surfaces are produced in different areas and with differing temper types from the white or yellow slipped pottery of the same periods, indicating distinct ceramic, and probably cultural, traits.

3. Establishment of chronological sequences within temper classes, which permits dating otherwise unidentifiable glaze paint sherds.

4. Development of guidelines for interpretation of data from temper or source area studies, including (a) differentiation between locally produced and trade wares; (b) recognition of methods of ceramic trait diffusion; (c) use of temper traditions in establishing local ceramic sequences.

5. Development of regional distribution patterns through time that present a picture of a highly mobile population; multiple occupation of villages; and frequent relocation of permanent residences. The presence of extensive trade systems in ceramics, numerous prehistoric trails within the study area, and an abundance of seasonal or special use sites all emphasize the concept of population mobility.

GLAZE PAINT WARE STUDIES

By the mid 1300s, Rio Grande glaze paint pottery was being made in the Pueblo villages of the Cochiti Reservoir area, from Frijoles Canyon south to the Santa Fe River. For the next 350 years or more, the glaze painted vessels were the principal decorated ware in the villages and small sites on the southern Pajarito Plateau, on Mesa Negra, in the Cochiti area, and within White Rock Canyon. The period of archeological history characterized by the Rio Grande glaze wares falls mainly within the time designations of Pueblo IV (Pecos Classification) or the Rio Grande Classic Period (Wendorf and Reed 1955).

The Rio Grande glaze paint wares were produced in Pueblo villages over a broad area from the vicinity of San Marcial in the central Rio Grande Valley, to Taos and Picuris pueblos in northern New Mexico, and eastward to Pecos Pueblo. The first classification and description of the glaze paint pottery was published in 1916, by N. C. Nelson. The classic design study of the pottery of Pecos was published by A. V. Kidder (1936) and included the first technological study of the Rio Grande glazes made by Anna O. Shepard. A sequence of pottery types and groups for all Rio Grande glazes was established in 1933, by H. P. Mera, followed by a study of the pottery of 170 glaze sites in the Rio Grande Valley in 1940. The sequence of glaze paint types in the Cochiti area was not well known at the time archeological excavations were first undertaken by the Museum of New Mexico in 1963, in connection with the proposed Cochiti Dam construction and under contract with the National Park Service. Ceramic studies relating to centers of manufacture, economic specialization and trade among villages, ceramic tradition and technology, and chronological refinement were initiated by the Museum in 1965 (Warren 1968, 1970, 1974a) and, more recently, have been continued during the Cochiti Reservoir Archeological Project, Office of Contract Archeology, University of New Mexico (Warren 1977a, 1977b).

The initial purpose of the ceramic studies of the Cochiti sites was to learn something of the methods of manufacture and the source materials used by local potters through time in order to refine ceramic sequences and classifications. By using mineral analysis techniques to identify temper materials in the pottery, techniques that had been developed by Anna O. Shepard (1936, 1942), it was hoped that the resultant data, combined with other lines of archeological investigation, could be used in the reconstruction of the prehistory of the study area. The study sought to identify the villages where pottery was produced and to establish the extent of trade relations among villages through recognition of intrusive wares.

This report summarizes the data obtained during the analytical studies relating to distribution patterns of pottery of local manufacture as well as trade ware through the 400 years of glaze paint ware production in the upper Middle Rio Grande region. The mobility of resident populations reflected in changing ceramic sequences and production centers is discussed and graphically illustrated in Figs. 10.1-10.16.

GENERAL PROCEDURES

The classification of Rio Grande glaze wares defined by Mera (1933) has been used with slight modification throughout the ceramic studies (Table 10.1) and has provided a framework for comparing glaze types among production centers and distribution networks. Mera's system for classifying all Rio Grande glaze wares, with the exception of those produced at Pecos Pueblo, was recommended by the 8th Ceramic Conference on Rio Grande Glazes (1967). One exception to Mera's classification has been the inclusion of Pecos Glaze Polychrome, or Glaze V, because that type appears in small amounts as a trade ware at some of the 17th century sites in the Cochiti area.

Data employed in the study were derived from sherd collections from 47 site locations (see Table 10.2). Sherd lots selected for study came mainly from surface collections, although material from excavated sites was included when available. Only rim sherds were examined, since rim form is the basis for chronological distinctions within the glaze wares. Several hundred sherds were analyzed from each site, if possible, but in some cases less than 100 sherds could be obtained. The sherds analyzed were from collections deposited at the Laboratory of Anthropology, Museum of New Mexico, Santa Fe; the Office of Contract Archeology, University of New Mexico; and private collections.

Each potsherd was classified by ceramic type and examined with a stereomicroscope in order to identify the temper material. Most of the temper classes had been established and defined during earlier studies, but some new varieties were added (Shepard 1942; Warren 1968). Both pottery and temper classifications were used to organize the data with the temper types varying within each pottery type. Percentages of the major temper types within the glaze group were calculated for each site (Tables 10.3–10.7) and plotted by site on maps of the upper Middle Rio Grande region (Figs. 10.2 to 10.16). Isopleths were drawn to show the highest spatial concentration of a temper type for each ceramic group. Decreasing percentages away from the cen- of high frequencies are also indicated by isopleths.

As the spatial patterns of pottery and temper class distributions emerged within a chronological framework spanning nearly 400 years, interpretive guidelines for examining the results were sought; some have been suggested; and numerous questions have been asked (Warren 1977b).

Local manufacture of pottery at a site or in the general area might be inferred if the rock used for temper could be found in geologic outcrops nearby, and when high frequencies of pottery with that temper type were present on that site or sites within the immediate area of the temper source. Exceptions to this guideline will occur and may require additional data for explanation.

Trade ware is suggested by lower frequencies of a particular ware and temper class, but exceptions to this guideline must be noted. If a village did not produce any of its own pottery, it might be obtaining nearly all its vessels from one production center. Or, a very small percentage of culinary needs may be met with local production while the rest of vessels used could come from one or numerous suppliers. Special problems can be best interpreted if areal patterns of manufacture and distribution are established through quantitative studies of ceramic and temper classes on a regional basis. Deviation from the patterns might be explained then in terms other than trade or normal distribution, such as procurement or seasonal sites, population mobility, or even time differential. An example of this situation was found in the Salinas area in the middle Rio Grande. Shepard (1942) had noted that glaze paint wares on the Jornada del Muerto were tempered mainly with *soda diorite* and concluded that it was a local material. Subsequent studies of pottery at Abo Pueblo revealed that soda diorite had been used by glaze paint potters there from around 1350 through 1670 while the Jornada sites were occupied only during the 1600s, indicating the source of the pottery was probably Abo Pueblo (Warren, in press).

Perhaps the most provocative of archeological problems that we might hope to consider with data obtained from various research methods, including the source area studies, is that of mobility among prehistoric populations (people moving for trade, hunting, special use sites as well as residence). Others include identification of multiple occupations at a site, or brief abandonment of a village. If problems of cultural evolution are to be considered, pottery must be explained in terms of producer and user before changes within a culture can be identified or traced. Inferences concerning these and other problems have been made; their validity may increase or decrease in time as more and diverse information is gathered.

ORIGINS OF THE RIO GRANDE GLAZES

In discussing the possible origins of the Rio Grande glaze paint traditions, several writers have suggested that the technique was derived from the western glaze decorated pottery of the Little Colorado and Zuni regions (Mera 1935; Shepard 1942; Wendorf and Reed 1955). The migration of people has been considered as the means of bringing the new traditions to the Rio Grande; on the other hand, transmittal of techniques by a small number of potters has also been visualized.

More recently, DiPeso et al. (1974) and Ellis (1975) have discussed the appearance of new cultural traditions in the American Southwest during early Pueblo IV times, although they do not deal directly with the origins of the Rio Grande glazes. The appearance of the *awanyu*, or the plumed serpent, on both Biscuit and glaze wares has been noted (Kidder 1936). Ellis (1975) traces the appearance of the two horned snake in northern New Mexico to the Huichol of Nayarit in western Mexico, during this time period. Paired birds and the human hand are other motifs that first appear in the early glaze period.

Rectangular kivas with ritual wall paintings are considered a new trait during Glaze A time (Lambert 1954). Vessel forms that are common for the first time include stirrup jars, rectangular bowls, and cylindrical vessels reminiscent of an inkwell. Pottery molds or *pukis* are technological innovations at Glaze A and biscuitware sites. Spiral grooved axes are also considered to be a new trait (Wendorf and Reed 1955).

Rock terracing of agricultural fields appears to have been introduced in the early glaze period on the Pajarito and Mesa Negra. One excavated site in White Rock Canyon, LA 13292, had a set of terraced alignments and was associated with Glaze A red sherds. The rock terracing may cross small arroyos, but at least one hill top on Mesa Negra was completely ringed by rock terraces in an effort to capture overland flowing during a rain.

Although a variety of new cultural traditions in an area may be interpreted as evidence of migration, the source of the glaze paint technique remains in question. Shepard (1954) argues that the technique of glaze paint is highly complex and is not likely to be accidently acquired or copied without instruction. Her conclusion is supported by ethnographic studies of ceramic technology and learning processes (Foster 1948; Stanislawski 1975). The western glaze decorated pottery first became common about A.D. 1290, while the Rio Grande glazes appeared shortly after A.D. 1300. Ceramic trait studies as well as chronological refinements may be needed before the origins of the glaze pottery or its makers can be guessed.

GLAZE PAINTS OF THE PREHISTORIC SOUTHWEST

The technological knowledge for production of glaze paints was present from the beginning of pottery making in the Southwest. During Basketmaker III times, ca. A.D. 450 to 750, lead glaze paints were used to decorate pottery in the Four Corners area (Shepard 1939). However, these were short-lived. Black glaze paints on whiteware pots appeared frequently throughout northwestern New Mexico and northeastern Arizona, until about A.D. 1300. These may be of similar composition as the iron-silica glaze paint described by Shepard (1954:187-188) in the La Plata District of the Four Corners region. Black glaze paints also appear on Basketmaker III vessels, including San Marcial Black-on-white, which dates between A.D. 500 to ca. A.D. 850 (Frisbie 1967; Warren 1976).

As noted above, glaze paints were used in the Little Colorado area beginning about A.D. 1290, appearing on Pinedale Glaze-on-red and on St. John's Polychrome vessels. These western glaze paints have a much higher copper content than the lead paints of the Rio Grande (Shepard 1942).

Glaze decorated wares also occur in northern and western Mexico and were contemporary with those produced in the American Southwest (Weigand 1975). Both iron and copper-lead glaze paints have been reported from the Casas Grandes area from the Medio Period, A.D. 1060 to 1340 (DiPeso, Rinaldo and Fenner 1974:93).

Numerous deposits of lead ore in the Middle Rio Grande undoubtedly played an essential part in the florescence of lead glaze-paint ceramics after A.D. 1300. At this time, it seems most likely that potters with the technological skills for making glaze paint, moved into the Rio Grande, from either the west or the south, and soon began using galena and associated lead minerals to produce their glazes. These minerals are found in several mining districts, including Cerrillos, Placitas, New Placers, Cochiti, Willow Creek north of Pecos Pueblo, and Magdalena in Socorro County. Extensive prehistoric lead mining has been reported in the Cerrillos district (Warren 1974a). Although no archeological evidence has been reported from other mines, lead ore was probably mined in numerous districts.

THE LOS PADILLAS PERIOD (A.D. 1300–1350)

By A.D. 1300, or shortly thereafter, villages within and peripheral to the Cochiti Study area were beginning to produce glaze paint decorated redware vessels, forerunners of the Rio Grande glaze paint wares. Mera (1935) recognized a glaze paint ware transitional between the western glazes of the Little Colorado and Zuni areas and the Rio Grande glaze wares and named the varieties collectively, *Los Padillas Glaze-Polychrome*, a time designation, rather than descriptive term.

Locally made copies of western glaze types were recognized at two pre-Group A sites in the upper Middle Rio Grande, Pueblo Camada (LA 8943), a village west of Cochiti Pueblo on the Pajarito Plateau, and a Galisteo Phase site at Chackam (LA 375) in the Jemez River Valley (Warren 1977c). Galisteo Black-on-white is predominant at both of these sites, while Santa Fe Black-on-white is accessory. Intrusive redwares from Zuni and the Little Colorado are present at both sites.

No Los Padillas ceramics were recovered within the Cochiti Reservoir Project area, but a variety of early pre-Glaze A pottery has been reported from Cochiti Dam sites, including the Alfred Herrera Site (LA 6455) and Pueblo del Encierro (LA 70). Sherds from these early Los Padillas G-P vessels which have been examined were found to contain the same types of crushed rock as the later Group A redware pottery (Warren 1974a). The Los Padillas ware is not well dated, but is found with Galisteo B/W, Santa Fe B/W, St. John's Polychrome and Heshotauthla Polychrome, placing it within the early decades of the 14th century. Los Padillas Polychrome vessels were probably produced well into the early Group A period as there is a continuity in temper preferences from the earlier to the later period.

THE GLAZE-ON-RED PERIOD (A.D. 1315–1425, Group A)

The pottery types included in the Glaze A red period are Agua Fria Glaze-on-red, San Clemente Glaze-polychrome, and Arenal Glaze-polychrome. These types are, for the most part, contemporary with Cieneguilla Glaze-on-yellow and Cieneguilla Glaze-polychrome, two other Group A types. However, the patterns of temper usage suggest that the three red slipped types were made within a similar ceramic tradition, while the *yellow* wares evidence separate temper traditions, although exceptions do occur.

The 14th century was a period of population movement, settlement, and building in the Middle Rio Grande region. Numerous villages, whose potters made glaze-decorated redwares, were built within the Cochiti Study area, including Kuapa (LA 3444), Tuvuoni (LA 82), Pueblo del Encierro (LA 70), and Caja del Rio Pueblo (LA 5137). Potters may have found suitable clay deposits in the axial river gravel of the ancestral Rio Grande. Red clays were available in the Galisteo Formation near La Bajada. Lead ore to produce glaze paint was available close by in the Cochiti or the Cerrillos Mining Districts. Tempering materials were varied, but red basalt scoria (3431), fine-grained basalt (3405) and andesite (3821) from the Jemez and Cerros del Rio volcanic rocks were preferred. Centers of production for the scoria tempered glaze wares were probably at Caja del Rio and Tuyuoni Pueblos which are characterized by high percentages of sherds with scoria temper. These wares appear outside the Cochiti study area, but never in large quantity, indicating that some degree of vessel exchange existed.

Many of the small sites located within the Cochiti Reservoir study area date to the Glaze A red period. Vessel fragments found at the sites were tempered mainly with crushed scoria (3431) and may have been associated with the nearby Caja del Rio Pueblo (LA 5137) on Mesa Negra. The presence of sherds from later glaze groups indicates that continued or intermittent occupation of a small site is common. The glaze decorated types from these sites generally follow the production and distribution patterns for ceramics that were established during earlier temper studies.

THE GLAZE-ON-YELLOW PERIOD (A.D. 1325–1450, Group A and B)

Before the end of the 14th century, glaze painted vessels with white, cream, *yellow*, or pink slips were being made at sites within the Cochiti study area, including Cieneguilla Glaze-on-yellow, Cieneguilla Glaze-polychrome, Largo G/Y and Largo G-P. Tree-ring dates associated with these types at Pueblo del Encierro (LA 70) suggest that the yellow ware tradition may have appeared as late as the A.D. 1420s at that village (Robinson et al. 1972; Warren 1974a).

Glaze-on-yellow wares were first made in the Galisteo Basin during the early decades of the 14th century and were soon widely traded throughout the Rio Grande Valley and the eastern plains. Several villages in the Galisteo were probably producing pots at this time, but the main ceramic industry was at San Marcos Pueblo (LA 98), which was strategically located near extensive clay deposits and within two miles of the Cerrillos lead mines. The distinctive tempering material, augite latite (3260) from the Espinaso Volcanics, was quarried nearby. Distribution patterns of the San Marcos wares are indicated in Figs. 17.10–17.12. Although trade from the pueblo declined in the late 1400s, pottery was produced at the village almost continuously until the Pueblo Revolt of 1680. Augite latite temper in both the Cieneguilla and Largo vessels at Pueblo del Encierro, in the Cochiti area, indicates that these are intrusive from the Galisteo Basin. Possibly these vessels were brought by new arrivals or may be an indication of continuous trade through time. In any case, potters of the Cochiti study area were making white-slipped wares and were gathering local rocks for temper by A.D. 1380-1400. Some used crushed scoria (3431), similar to that found in the Glaze A red pottery, but others preferred the lighter colored welded tuffs of intermediate composition. Villages producing the yellow wares probably included Pueblo del Encierro (LA 70), the Caja del Rio Pueblo (LA 5137), Yaposhi (LA 250), and Cieneguilla (LA 16) on the Santa Fe River. Numerous trait differences were noted at Pueblo del Encierro (LA 70) between the Glaze A red and the Glaze A yellow wares. Small rectangular vessels were found only in the Glaze-on-yellow wares, usually associated with burials. Stirrup jar fragments had mainly red surfaces. Glaze-on-red ollas or jars were common while Glaze-on-yellow jars of the Galisteo Basin tradition were quite rare.

It seems possible, on the basis of ceramic evidence, that a new group of people had moved into the area, bringing material traits differing slightly from those of the indigenous *Glaze A red* inhabitants. Some of the redware sites may already have been abandoned, for by A.D. 1450, much of the southern part of the region was unoccupied. La Bajada (LA 7), Taskatze (LA 249), Ha'atse (LA 370), and the Ojito de Canoncito (LA 9455) villages were never lived in again during prehistoric time.

The production of Glaze-on-yellow pottery never reached the heights of the Glaze A red wares and by A.D. 1450, other glaze types began to appear to replace the Group A and B glazes. In the southern part of the area, the frequency of scoria tempered pottery dropped sharply, although no decline has been noted in the northern pueblos of Tuyuoni and Rainbow House in Frijoles Canyon.

THE INTERMEDIATE GLAZE PERIOD (A.D. 1450–1600; Groups C, D, and Early E)

During the late 1400s, as many of the southern villages were abandoned and trade from the Galisteo Basin declined, pottery from another ceramic center at Tonque Pueblo (LA 240) was taking over the trade industry. The potters at Tonque tempered their pots with the Espinaso Volcanics which crop out north of the pueblo (Warren 1970). The Tonque Pueblo wares were traded in large quantities to neighboring villages, while exports from other villages throughout the upper Middle Rio Grande virtually ceased. Many of the Rio Grande villages continued to produce glaze paint pottery for home consumption, including Zia villages, San Marcos, and Kuaua; while others, including La Vega Pueblo, Pueblo del Encierro, Gipuy, and Katishtya obtained most of their decorated wares from Tonque Pueblo.

Biscuit ware that was produced in the Tewa villages on the northern Pajarito appears as trade at Intermediate Glaze Period sites in the Cochiti study area. In turn, glaze paint wares of this period are found at Tewa sites. Mera (1934:19) noted that this trade exchange was confined to the Pajarito and did not occur at villages to the east.

Occupation at Pueblo del Encierro and its neighboring pueblo across the river, the Alfred Herrera site, did not last long. The kiva at Encierro burned, and both sites were probably abandoned around A.D. 1525. Only Kuapa (LA 3444), along the Rio Chiquito, was still occupied in the southern Pajarito Plateau, while in the north population concentrated at Tuyuoni. Kuapa had never been a ceramic center but had imported most of its pottery from known centers throughout its occupation. However, it seems probable that Tuyuoni continued to produce Glaze E pottery with rhyolite tuff temper and possibly Rainbow House (LA 217) did so as well, as no other sites with this particular ware are known on the Pajarito Plateau.

Toward the end of the 16th century, there was a movement of people to sites in the northern Pajarito Plateau. For the first time, glaze wares were made in villages in that area, also with rhyolite tuff temper but with distinctively different clays. Glaze wares were probably made at Puyé (LA 47) and at Yunque (LA 59) in the Espanola Valley. At the same time Tuyuoni, Rainbow House, and Intermediate Period sites in the Santo Domingo Valley north of the present day San Felipe Pueblo were left unoccupied. Pottery making at the ceramic center of Tonque ceased, but may have been transferred to the San Felipe area, for the manufacture of vessels with hornblende latite temper from the Tonque source continued through the following century.

The first contact with the Spanish explorers came toward the end of the Intermediate Period, as several expeditions arrived from Mexico between A.D. 1540 and 1598. Cochiti was one of the seven Keres towns listed by the Spanish during this period, which poses a problem concerning the location of Cochiti at that time. Early during the current study, several visits were made to the modern pueblo of Cochiti but no glaze paint sherds of the late 16th century could be found, although earlier and later glaze wares were present in fair quantity. Possibly the village visited by the Spanish was at another location during the late 16th century and has since been washed away by floods. Cochiti legend indicates that there was a village on the east side of the river prior to and immediately after the Pueblo Revolt (Benedict 1931). There is also a possibility that the Cochiti Pueblo was farther south along the Rio Grande, but there is no evidence of such a location.

About the time that Spanish colonists arrived in A.D. 1598, and settled in the Espanola Valley near the present San Juan Pueblo, then called Yunque, a similar contraction of biscuitware villages in the northern Rio Grande has occurred (Mera 1934:19). All sites in the Chama Valley and the upper Rio Grande were abandoned, and population apparently concentrated in the villages along the river in the Espanola, Nambe, and Tesuque valleys.

To the west of the Cochiti study area, new villages were built on the high mesas of the southern Jemez Mountains, presumably by the Pueblo Indians. Along the foothills of the Ortiz Mountains and the eastern slopes of the Sandias and Manzanos many villages were reoccupied at this time, including San Lazaro, Paako, San Antonio, and Quarai.

Various explanations for the unrest and mobility of the Pueblo people at this time have been offered. Ellis (1975:99) suggested that the Tewas moved into the Espanola Basin to take advantage of irrigation waters of the Rio Grande following a long dry spell in the 1580s. Mera (1934) listed continued harrassment by nomadic maurauders, epidemic disease, or serious drought as possible causes for population withdrawals in the Northern Rio Grande.

THE KOTYITI PERIOD (A.D. 1600 1750; late Group E; Group F)

The arrival of Spanish colonists in the Rio Grande Valley in A.D. 1598 had a profound effect upon the ceramic industries of the Puebloan Indians. Glaze paint ware continued to be made for another 125 or 150 years, but numerous changes occurred during that time in pottery form, decoration, and areas of production.

Flange bowls or *soup plates* appear in the glazes for the first time. Shouldered and hemispherical bowls were made at some villages. The glaze paints became increasingly runny, a characteristic of Group F vessels. Many undecorated vessels were produced, mainly for use by the Spanish colonists. These were named *Salinas Red* by Toulouse (1949). Production centers became dispersed and were often short lived. Pottery making decreased after the Pueblo Revolt of 1680, and was revived after the Reconquest in 1692-3. Galisteo Pueblo may have been the main producer in the early decades of the 18th century, but the use of glaze paint ceased completely, probably around A.D. 1750.

A major factor in the disappearance of the glaze paint tradition may have been the loss of lead mines as Spanish colonists increased their mining activities in the early 18th century. At first the Spanish sought gold and silver. A few of the more practical mined lead ore for bullets. Although evidence of pre-Revolt mining by the Spanish has been found both at Cerrillos and the New Placers Districts, official mining grants were not made until the early 18th century. The first registration of a mine was at Los Cerrillos, by General Juan de Uribarri, in 1709 (Twitchell n.d.).

By the time the Spanish began mining at Cerrillos, the Indian miners had opened veins to unknown depths seeking *potters ore* to make lead glaze paint. It has been my impression that most of the accessible ore had already been mined by ca. A.D. 1700. With increasing depths, lead content of the ore tends to increase which might account for the 17th century runny glazes caused by high lead content. In any case, the increased mining activities of the Spanish colonists undoubtedly made lead ore virtually inaccessible to the glaze paint potters.

The occurrence of a specimen of litharge and massicot (lead oxides), at the Las Majadas sites (LA 591) near Pueblo del Encierro might be an indication of Spanish Colonial metallurgical activities, according to Robert H. Weber, New Mexico State Bureau of Mines (letter, 1967). Litharge has not been reported as a naturally occurring mineral in New Mexico, but was a common product of early smelting of lead and lead-silver ores. The site dates to the middle decades of the 17th century. Two vessels of overall green glaze, in the tradition of the Mexican green glazes of northern Chihuahua, may have been produced at the site but petrographic analyses of the sherds were not made.

No Pueblo sites contemporary with the Las Majadas homestead are known in the Cochiti study area. During the early decades of the 1600s, the area was virtually without occupation, of even transitory nature. Late Puaray G-P, characteristic of this period, was probably being made somewhere in the vicinity of the modern Cochiti Pueblo but, if so, the site is not known.

Group F pottery has been found at the Pueblo, and also at *Old Kotyiti* (LA 295) on the Potrero Viejo. Since

Group F pottery was produced between A.D. 1650 and 1700, or later, Cochiti Pueblo (LA 126) might have been resettled by the middle of the century. After the Pueblo Revolt of 1680, the people of Cochiti moved up to the Potrero and built a large pueblo (LA 295) where they stayed until they were brought back down in 1694, after the Spanish Reconquest.

After 1680, production of Group F pottery virtually ceased in the Cochiti area although a few post 1700 glaze-paint vessels are tempered with crushed scoria, a temper material available locally. Intrusive pottery, probably from Galisteo, has been found in post 1700 sites in White Rock and Cochiti Canyons associated with early 18th century carbon polychrome vessels. During the decade or two following the Pueblo Revolt, there was a return to small, one or two room dwellings. These were often located at long abandoned prehistoric villages. None of these has been noted in White Rock Canyon, although several are located along the Rio Chiquito. The only reason these are assigned to the post Revolt period is that they are located on lands that were occupied by Spanish colonists prior to 1680. These appear to be special use sites, most likely field houses. They are found in areas where agricultural lands were plentiful but, more important, associated Group F pottery suggest that they are satellite sites of the large post Revolt pueblo of Old Kotyiti. Located high on a digitate mesa, the residents of Old Koytiti still had to return to the valley bottoms to plant crops each year, as the wooded and rocky mesas provided little land for growing crops for such a large population.

By the turn of the century, the Cochiti people were settled in their present pueblo and, shortly after A.D. 1700, Spanish colonists began to build their homes along the Rio Grande in White Rock Canyon and its western tributary, Rio Chiquito. Late glaze paint ware found on these early 18th century sites point to economic exchange between the Spanish colonists and the potters of the resettled Galisteo Pueblo. Similar late Glaze F sherds have been found at La Cieneguilla (LA 16), an historic site reported to have been settled by Tanos around A.D. 1700.

IN REVIEW

The glaze decorated wares from the Cochiti study area present a continuous record from Group A through Group F, although changing materials and ceramic traits and frequent site abandonments indicate many habitational and possibly cultural changes through time. The same patterns of expansion, unrest, and movements of people that Mera (1934) recognized in the Biscuit Ware area in northern New Mexico can be noted on the southern Pajarito Plateau, Mesa Negra, and the Cochiti areas.

The underlying causes for the movements of these early residents are yet to be defined. Many factors can be involved in the simple act of moving out of a one room house and, when entire pueblos are on the move, no simple answers can be expected. In the study area, ceramic analyses have provided information concerning the mobility of the area residents. Causes must be sought in other lines of investigation. Some of the factors that have been suggested in the past include hostilities and warfare, depletion of natural resources, severe droughts, epidemic disease, and *greener pastures* elsewhere. We may never know the extent of concentration of Pueblo Indians that was initiated in 1609 by the Viceroy of Spain in order to *facilitate their administration* and promote their welfare, or how many relocations during this period were effected by this order. Few controlled studies of factors of population mobility have been made although the need for such research has been recognized (Cordell 1975:190).

Mineralogical studies of the tempering materials of pottery from sites in the upper Middle Rio Grande Valley have resulted in the recognition of manufacturing centers for pottery production and have established patterns of pottery trade or distribution through time. The analytical system used throughout the ceramic studies in the Cochiti area includes (1) mineralogical studies of aplastic inclusions in potsherds in order to determine the nature of the temper material used; (2) determining how temper classes vary in space and time within one pottery type in order to establish centers of production and patterns of distribution; and (3) comparative studies of ceramic attributes within one production area to determine trait preferences and evolution through time, or from one production area to another.

The patterns obtained from statistical data can then be used as a constant for other comparative studies. For instance, if the patterns of local and trade ware distributions are similar at contemporary sites within an area, as in the Cochiti region, any unusual deviation from the general pattern alerts the archeologist to an anomaly that may need additional study and explanation. An example of this was found at the Torreon site (LA 6178). The Group F pottery contained rock temper characteristic of the Galisteo Basin; however, most Group F sherds were slipped red, a trait which is not common in the Galisteo. The few locally made Kotyiti sherds were tempered with red scoria, a temper type which did not show up in other locally made Glaze F pottery. None of local rhyolite tuff tempered Kotyiti G-P, so common at Old Kotyiti and other Glaze F sites of the late 17th century, were present. In 1967, I suggested the perhaps a group of refuges from the Galisteo Basin had occupied the site (LA 295). However, more recent studies along the Rio Chiquito, indicate that late Group F vessels were being made well into the 18th century, presumably at the reoccupied Galisteo Pueblo (LA 26). What was first thought to be a Revolt period occupation at the Torreon site, based upon the late glazes present, now appears to be part of the early 18th century Spanish garrison site.

Another unexpected, but welcome outcome of the mineralogical studies in the Cochiti area has been the apparent independent technique of identifying multiple occupation periods. Three distinct occurrences of tempering material could be correlated with three occupations at the Alfred Herrera site. The components were identified by both architectural features and tree-ring dates (Honea 1968). Subsequent analysis of pottery from Pueblo del Encierro (LA 70) showed an almost identical trichotomy of temper classes (Warren 1974a:Fig. 44). Tree-ring date clusters correlated with three temper groups, dated by pottery types, and with the dates obtained from the

Herrera site. In neither case did the ceramic types suggest multiple occupation at the site. At this time, the use of mineralogical studies to identify multiple components at unexcavated sites seems promising; it is essential that the mineralogical classes be well understood in regard to chronological sequence, source area, and related pottery types.

The completion of the present study of ceramics from the Cochiti study area leaves many important archeological questions unanswered. The origin of the Rio Grande glaze paint wares and its early development in the region will be topics for speculation many years to come. At least one source of lead ore for glaze paint has been found in the Cerrillos Mining District. We know now that the prehistoric Indian did extensive underground mining, contrary to previous beliefs, and we also know something of his mining tools and techniques (Warren 1974b).

When the Spanish explorers arrived in the Middle Rio Grande, they found that glaze potters spoke several different languages or dialects, but we still cannot be certain what kind of glaze paint ware each linguistic group made, nor do we know much about the associated material culture of each glaze type or variety. A. V. Kidder (1958) reminded us that, despite their common Towa language, Jemez and Pecos Pueblos were totally unlike in architecture, social and religious habits, pottery, and economics. The evolution and diffusion of ceramic traits alone present an extraordinary problem in prehistoric and historic reconstruction, but one that may help us solve some of the less tangible developments within prehistoric societies. The translation of the unwritten records of the past is a very slow process.

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Table 10.1

Classification of Rio Grande Glazes
(modified from Mera 1933)

Group	Type Name	Estimated Date of Manufacture (A.D.)
pre-A	Los Padillas G-P	?1300 to 1325?
A	Arenal G-P	?1315 to 1350?
	Agua Fria G/R	1315 to 1425
	San Clemente G-P	1325 to 1425
	Cieneguilla G/Y, G-P	1325 to 1425
B	Largo G/Y, G-P	1400 to 1450
C	Espinoso G-P	1425 to 1500
	Pottery Mound G-P	1400 to 1490
D	San Lazaro G-P	1490 to 1515
E	Puaray G-P (early)	1515 to 1600
E-F	Puaray G-P (late)	1600 to 1650
E and F	Pecos G-P	1600 to 1700
F	Kotyiti G/Y, G/R, G-P	1650 to 1700 (or 1750?)

Table 10.2

Rio Grande Glaze Paint Sites in the Upper Middle Rio Grande Valley with Glaze Groups and Major Temper Types Indicated

Site No.	Name of Site	Glaze Groups	Major Temper Types (codes)
LA 7	La Bajada	A-C, F	Sherd; San Marcos latite* (3260)
LA 16	Cieneguilla	A-C, F	Basalt, scoria, San Marcos latite (3260); sandy latite (Galisteo?) (3266)
LA 17	Nambe Pueblo	A, late E, F	Sherd; scoria, San Marcos (3260) latite, sandy hornblende (3266) latite (Galisteo?)
LA 25	Las Madres	A	Sherd, San Marcos latite (3260)
LA 26	Galisteo Pueblo	A-F	Sandy hornblende latite; (3260) San Marcos latite
LA 28	Zia Pueblo	A-F	Diabase basalt; Tonque latite (3270)
LA 34	Cochiti Spring	E-F	Rhyolite tuff (3811), Zia diabase (3421) sandstone
LA 35	Pueblo Canada	A-E	Basalt, scoria (3431) San Marcos latite (3260), Tonque latite (3270)
LA 47	Puye	late E, F	Rhyolite tuff (3811); vitric tuff (3860)
LA 70	Pueblo del Encierro	A-E	Scoria (3431), San Marcos latite (3260), Tonque latite (3270)
LA 80	San Cristobal Pueblo	A-F	San Marcos latite; hornblende (3266) latite (local), sandy latite (Galisteo?) (3266)
LA 82	Tuyuoni	A-F	Scoria (3421), rhyolite tuff
LA 91	San Lazaro Pueblo (historic)	A-F	San Marcos latite, Tonque latite, hornblende latite
LA 92	San Lazaro Pueblo	A-D	San Marcos latite, augite latite (local?) (3262)
LA 96	San Diego	late E, F	Zia diabase, sandy latite (3266)
LA 98	San Marcos Pueblo	A-F	San Marcos augite latite, basalt (3400)
LA 126	Cochiti Pueblo	A-D, F	Scoria, basalt (3400) rhyolite tuff (3811)
LA 169	Otowi	C-late E	Jemez andesite (3821) rhyolite tuff (3811)
LA 170	Tsirege	A-late E	Rhyolite (3811), Jemez andesite, Pecos sandstone
LA 182	Gipuy Pueblo	A-early E	Latite (local?) (3263) San Marcos latite, Tonque latite
LA 187	Kuaua	A-F	Andesite vitrophyre (local?) (3710) Tonque latite (3270)
LA 217	Rainbow House	A-E	Scoria, rhyolite tuff
LA 240	Tonque Pueblo	A-E	Tonque hornblende latite (3270)

Table 10.2 (Continued)

Site No.	Name of Site	Glaze Groups	Major Temper Types (codes)
LA 249	Tashatze	A-C	Scoria, basalt, San Marcos latite
LA 250	Yaposhi	A-D	Jemez andesite tuff (3821) San Marcos latite, Tonque latite
LA 278	Espinaso Ridge	A-D	Tonque latite, San Marcos latite
LA 295	Old Kotyiti	F	Rhyolite tuff (local) (3811)
LA 326	Puaray	A-F	Andesite vitrophyre (local?) (3710) Tonque latite, rhyolite tuff
LA 370	Ha'atse (San Miguel)	A-C	Scoria, Jemez andesite (3710) San Marcos latite, Tonque latite
LA 374	Chackam	A-E	Zia diabase (3421) Tonque latite
LA 412	La Vega Pueblo	A-E	Sherd, San Felipe basalt (3405), San Marcos and Tonque latites
LA 591	Las Majadas	late E, F	Rhyolite tuff (local) (3811)
LA 679	Jemez Mission	A-F	Zia diabase (3421), Tonque latite, rhyolite tuff (3811)
LA 922	Katishtya	A-E	San Felipe basalt (3405), San Marcos and Tonque latites, rhyolite tuff
LA 1825	Astialakna	late E, F	Zia diabase (3421), andesite vitrophyre (3710)
LA 2048	No Name	late E, F	Zia diabase, rhyolite tuff
LA 2047	"Old San Felipe"	F	Rhyolite tuff, hornblende latite
LA 2049	Canjilon Pueblo	F	Hornblende latite, rhyolite tuff
LA 3137	Tamita	A-F	San Felipe olivine basalt (3405), Tonque latite (3720)
LA 3444	Kuapa	A-E, F	Scoria (3431) rhyolite tuff, andesite tuffs (3821) Tonque latite
LA 4450	Palace of Governors	F	Pecos sandstone (2200), vitric tuff (3860), Galisteo sandy latite (3266)
LA 5137	Caja del Rio Pueblo	A-D	Scoria, San Marcos latite, Tonque latite
LA 6178	Torreon	A-E, F	As LA 70; Glaze F; Galisteo (3266) sandy latite, scoria (3431)
LA 6455	Alfred Herrera Site	A-E	Scoria, andesitic tuffs (3821) volcanic sandstone (local) (3470)
LA 6869	Waldo	A	Augite latite (local) (3262) sherd, San Marcos latite
LA 9154	Ojito de Canoncito	A-C	Scoria (3431) basalt (3400) latites (3025)
LA 12579	No Name	A	Basalt (local) (3400), scoria (3431) San Marcos and Tonque latites

* Proper nouns refer to pueblo where temper type is used, and not to a rock name.

Table 10.3

Percentage of Occurrence of Scoria Basalt Temper within Glaze Groups at each Site Listed

LA Site Number	Percentages: Glaze A Red	Glaze A Yellow	Glaze B	Glaze C	Glaze D	Glaze E	Glaze E-F	Glaze F	Total Sherds per Site
LA-7	23	10	7	5	—	—	—	—	508
-16	34	7	5	8	—	—	—	—	254
-17	19	*	—	—	—	—	—	—	148
-25	—	—	—	—	—	—	—	—	92
-26	—	2	—	—	—	—	—	—	565
-28	3	—	—	—	—	3	2	—	192
-34	—	—	—	—	—	—	—	—	255
-35	25	13	40	10	—	—	—	—	226
-47	—	—	—	—	—	—	—	—	143
-70	53	—	25	21	5	—	—	—	1,094
-80	6	1	—	—	—	—	—	—	899
-82	88	20	24	14	39	19	—	—	417
-91	—	—	—	—	—	—	—	—	261
-92	12	—	—	—	—	—	—	—	222
-96	—	—	—	—	—	—	—	—	26
-98	5	—	—	—	—	—	—	—	586
-126	45	40	—	—	—	—	—	—	362
-169	—	—	—	—	—	—	—	—	21
-170	—	—	—	—	—	—	—	—	24
-182	5	2	5	—	—	—	—	—	876
-187	5	1	3	—	—	—	—	—	888
-217	*	*	*	73	64	33	—	—	176
-240	10	—	—	—	—	—	—	—	429
-249	46	15	43	33	—	—	—	—	181
-250	22	11	12	12	—	—	—	—	342
-278	4	—	—	—	—	—	—	—	287
-295	*	—	—	—	—	—	—	—	411
-326	*	—	—	*	—	—	—	—	337
-370	42	4	20	7	—	—	—	—	242
-374	7	4	6	3	—	—	—	—	572
-412	3	—	—	2	2	—	—	—	285
-591	—	—	—	—	—	—	1	—	1,494
-679	—	—	—	—	—	—	—	—	93
-922	4	*	15	—	—	—	—	—	155
-1825	—	—	—	—	—	—	—	—	80
-2047	—	—	—	—	—	—	—	—	170
-2048	—	—	—	—	—	—	—	—	11
-2049	—	—	—	—	—	—	—	—	142
-3137	4	—	—	3	—	—	*	1	285
-3444	39	36	37	12	4	6	—	—	839
-4450	—	—	—	—	—	—	—	—	186
-5137	69	56	39	29	18	—	—	—	723
-6178	—	—	—	—	—	—	—	6	226
-6455	37	33	23	11	—	—	—	—	1,413
-6869	6	—	—	—	—	—	—	—	215
-9154	39	22	10	7	—	—	—	—	360
-12579	16	17	—	—	—	—	—	—	95

* present in traces

Table 10.4

Percentage of Occurrence of Crystalline Basalt Temper within Glaze Groups at each Site Listed

LA Site Number	Percentages: Glaze A Red	Glaze A Yellow	Glaze B	Glaze C	Glaze D	Glaze E	Glaze E-F	Glaze F	Total Sherds per Site
LA-7	14	3	5	—	—	—	—	—	508
-16	21	4	2	—	—	—	—	—	254
-17	5	—	—	—	—	—	—	—	148
-25	3	—	—	—	—	—	—	—	92
-26	—	—	2	—	—	—	—	—	565
-28	12	—	—	—	—	—	—	—	192
-34	—	—	—	—	—	—	—	—	255
-35	30	—	—	—	6	—	—	—	226
-47	—	—	—	—	—	—	—	—	143
-70	20	—	6	—	1	—	—	—	1,094
-80	4	—	—	—	—	—	—	—	899
-82	*	—	—	14	6	3	—	—	417
-91	—	—	—	—	5	—	—	—	260
-92	4	—	—	—	—	—	—	—	222
-96	—	—	—	—	—	—	—	—	26
-98	—		—	—	—	—	—	—	586
-126	35	—	—	—	—	—	—	—	362
-169	—	—	—	—	—	—	19	—	21
-170	—	—	—	—	—	—	—	—	24
-182	10	1	8	—	—	—	—	—	876
-187	14	7	4	1	—	—	—	—	888
-217	*	—	—	—	—	—	—	—	176
-240	35	—	16	—	—	—	—	—	429
-249	23	9	—	—	—	—	—	—	181
-250	11	6	6	3	—	—	—	—	342
-278	20	13	9	—	—	—	—	—	287
-295	—	—	—	—	—	—	—	—	411
-326	—	—	—	—	—	—	—	—	337
-370	42	24	—	32	—	—	—	—	242
-374	11	9	6	4	—	—	—	—	572
-412	34	21	—	—	—	—	—	—	285
-591	—	—	—	—	—	—	—	—	1,494
-679	—	—	—	—	—	—	—	—	93
-922	40	*	15	—	—	—	—	—	155
-1825	—	—	—	—	—	—	—	—	80
-2047	—	—	—	—	—	—	—	—	170
-2048	—	—	—	—	—	—	—	—	11
-2049	—	—	—	—	—	—	—	*	142
-3137	75	*	*	6	—	—	—	—	285
-3444	24	2	4	—	—	—	—	—	839
-4450	—	—	—	—	—	—	—	—	186
-5137	15	2	—	—	—	—	—	—	723
-6178	—	—	—	—	—	—	—	—	226
-6455	17	5	2	*	—	—	—	—	1,413
-6869	3	—	—	—	—	—	—	—	215
-9154	27	—	—	—	—	—	—	—	360
-12579	47	33	—	—	—	—	—	—	95

*** present in traces**

Table 10.5

Percentage of Occurrence of Augite Latite Temper (San Mareos Latite) within Glaze Groups at each Site Listed

	Percentages								
LA Site Number	Glaze A Red	Glaze A Yellow	Glaze B	Glaze C	Glaze D	Glaze E	Glaze E-F	Glaze F	Total Sherds per Site
LA-7	2	53	56	43	—	—	—	—	508
-16	13	63	69	38	—	—	—	—	254
-17	10	33	—	—	—	—	—	1	148
-25	26	33	—	—	—	—	—	—	92
-26	33	44	78	44	33	9	—	6	565
-28	—	20	—	—	4	—	—	—	192
-34	—	—	—	—	—	—	—	*	255
-35	—	40	20	16	—	—	—	—	226
-47	—	—	—	—	—	—	—	—	143
-70	1	44	60	26	5	—	—	—	1,094
-80	42	45	49	37	17	8	—	4	899
-82	10	31	—	—	38	38	38	—	417
-91	8	38	40	20	10	—	—	2	261
-92	28	59	60	33	16	—	—	—	222
-98	65	97	95	87	64	54	—	70	586
-126	—	20	—	—	10	—	—	—	362
-182	7	59	76	44	11	3	—	—	876
-187	*	31	17	8	1	—	—	—	888
-217	—	—	—	—	—	—	—	—	176
-240	—	8	5	—	—	—	—	—	429
-249	—	53	29	33	—	—	—	—	181
-250		17	30	27	—	—	—	—	342
-278	2	2	14	3	—	—	—	—	287
-295	—	—	—	—	—	—	—	*	411
-326	—	—	—	4	1	—	—	—	337
-370	—	31	40	11	—	—	—	—	242
-374	—	9	29	—	—	—	—	—	572
-412	—	38	73	4	—		—	—	285
-591	—	—	—	—	—	—	5	—	1,494
-922	—	60	23	12	—	—	—	—	155
-1825	—	—	—	—	—	—	—	1	80
-2047	—	—	—	—	—	—	—	*	170
-2048	—	—	—	—	—	—	—	—	11
-2049	—	—	—	—	—	—	—	—	142
-3137	—	20	40	6	—	—	—	*	285
-3444	1	17	22	12	—	—	—	—	839
-4450	—	—	—	—		—	—	10	186
-5137	1	31	55	22	*	—	—	—	723
-6178	—	—	—	—	—	—	—	*	226
-6455	1	29	34	21	—	—	—	—	1,413
-6869	11	—	—	—	—	—	—	—	215
-9154	1	42	58	48	—	—	—	—	360
-12579	—	4	17	—	—	—	—	—	95

* present in traces

Table 10.6

Percentage of Occurrence of Hornblende Latite Temper (Tonque Pueblo) within Glaze Groups at each Site Listed

LA Site Number	Percentages: Glaze A Red	Glaze A Yellow	Glaze B	Glaze C	Glaze D	Glaze E	Glaze E-F	Glaze F	Total Sherds per Site
LA-7	3	8	2	52	—	—	—	—	508
-16	2	3	—	—	—	—	—	—	254
-17	—	—	—	—	—	—	—	—	148
-25	1	—	—	—	—	—	—	—	92
-26	—	—	—	3	12	9	—	1	565
-28	—	40	—	43	12	—	—	20	192
-34	—	—	—	—	—	—	—	12	255
-35	7	7	—	49	77	77	—	—	226
-47	—	—	—	—	—	1	—	—	143
-70	1	6	4	63	91	94	—	—	1,094
-80	—	—	—	5	7	—	—	—	899
-82	10	14	—	14	*	3	*	—	417
-91	—	6	10	25	30	59	37	5	261
-92	—	4	—	17	37	—	—	—	222
-96	—	—	—	—	—	—	—	—	26
-98	3	—	—	3	26	11	—	2	586
-126	—	20	—	86	70		—	19	362
-169	—	—	—	—	—	*	14	—	21
-170	—	—	—	—	—	—	—		24
-182	—	9	2	50	79	93	—	—	876
-187	4	11	—	57	52	21	—	7	888
-217	—	—	—	18	9	—	—	—	176
-240	33	79	74	98	100	100	—	—	429
-249	1	8	—	17	—	—	—	—	181
-250	—	22	—	37	100	—	—	—	342
-278	50	48	56	93	95	—	—	—	287
-295	—	—	—	—	—	—	—	8	411
-326	—	—	—	37	55	23	18	—	337
-370	—	14	—	40	—	—	—	—	242
-374	1	13	—	29	32	31	—	—	572
-412	5	21	—	90	98	100	—	—	285
-591	—	—	—		—	—	15	—	1,494
-679	—	—	—	—	—	25	—	—	93
-922	4	—	31	88	88	58	—	—	155
-1825	—		—	—	—		11	1	80
-2047	—	—	—	—	—	—	—	36	170
-2048	—	—	—	—	—	—	—	—	11
-2049	—	—	—	—	—	—	—		142
-3137	15	20	—	73	82	81		70	285
-3444	1	4	4	47	61	26		40	339
-4450	—	—	—	—	—	—	—	2	186
-5137	1	—	—	41	65	—	—	—	723
-6178	—	—	—	—	—	—	—		226
-6455	1	4	7	52	97	100	—	—	1,413
-6869	2	—	—	—		—	—		215
-9154	—	2	4	37	—	—		—	360
-12579	9	8	—		—	—	—	—	95

* present in traces

Table 10.7

Percentage of Occurrence of Rhyolite Tuff (Bandelier) Temper within Glaze Groups at each Site Listed

LA Site Number	Percentages: Glaze A Red	Glaze A Yellow	Glaze B	Glaze C	Glaze D	Glaze E	Glaze E-F	Glaze F	Total Sherds per Site
LA-7	3	2	—	—	—	—	—	70	508
-16	4	—	—	—	—	—	—	—	254
-17	5	—	—	—	—	—	33	8	148
-26	—	—	—	—	—	8	—	1	565
-28	—	—	—	—	—	9	—	—	192
-34	—	—	—	—	—	—	—	50	255
-35	2	—	—	—	—	—	—	—	226
-47	—	—	—	—	—	—	63	—	143
-70	1	—	—	—	1	5	—	—	1,094
-80	—	—	—	—	—	1	1	—	899
-82	—	—	—	—	—	—	47	—	417
-91	—	—	—	—	—	—	—	—	261
-92	—	—	—	—	—	—	—	—	222
-96	—	—	—	—	—	—	8	—	26
-98	—	—	—	—	—	4	—	2	586
-126	—	—	—	—	10	—	—	57	362
-169	—	—	—	—	—	—	24	—	21
-170	—	—	—	—	—	—	56	—	24
-182	—	—	—	—	1	2	—	—	876
-187	2	—	1	2	8	30	—	36	888
-217	—	—	—	—	23	58	—	—	176
-240	—	—	—	—	—	—	—	—	429
-249	2	—	—	—	—	—	—	—	181
-250	—	—	—	3	—	—	—	—	342
-278	—	—	—	—	—	—	—	—	287
-295	—	—	—	—	—	—	—	65	411
-326	—	—	—	15	6	16	—	43	337
-370	—	—	—	2	—	—	—	—	242
-374	—	—	—	3	5	2	—	—	572
-412	—	—	10	—	—	—	—	—	285
-591	—	—	—	—	—	—	57	—	1,494
-679	—	—	—	—	—	15	2	—	93
-922	—	—	2	—	8	35	—	—	155
-1825	—	—	—	—	—	11	11	—	80
-2047	—	—	—	—	—	—	—	38	170
-2048	—	—	—	—	—	—	25	—	11
-2049	—	—	—	—	—	—	—	—	142
-3137	—	—	—	—	6	6	4	—	285
-3444	2	—	—	6	19	40	—	40	839
-4450	—	—	—	—	—	—	—	9	186
-5137	—	—	—	—	—	—	—	—	723
-6178	—	—	—	—	—	—	—	2	226
-6455	4	—	—	—	—	—	—	—	1,413
-9154	2	—	—	—	—	—	—	—	360
-12579	—	—	—	—	—	—	—	—	95

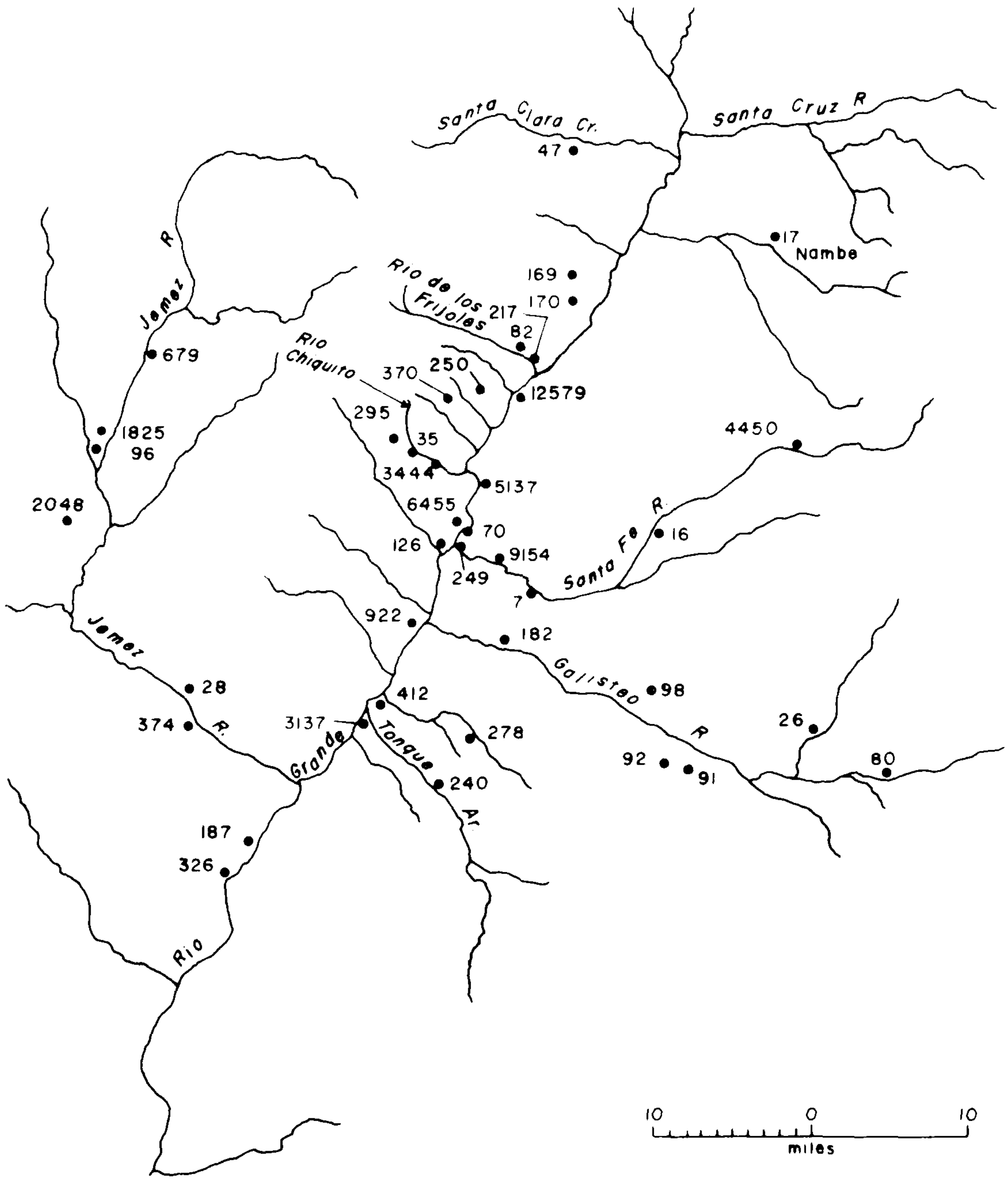

Fig. 10.1 Location of the 47 archeological sites used in the glaze ware study

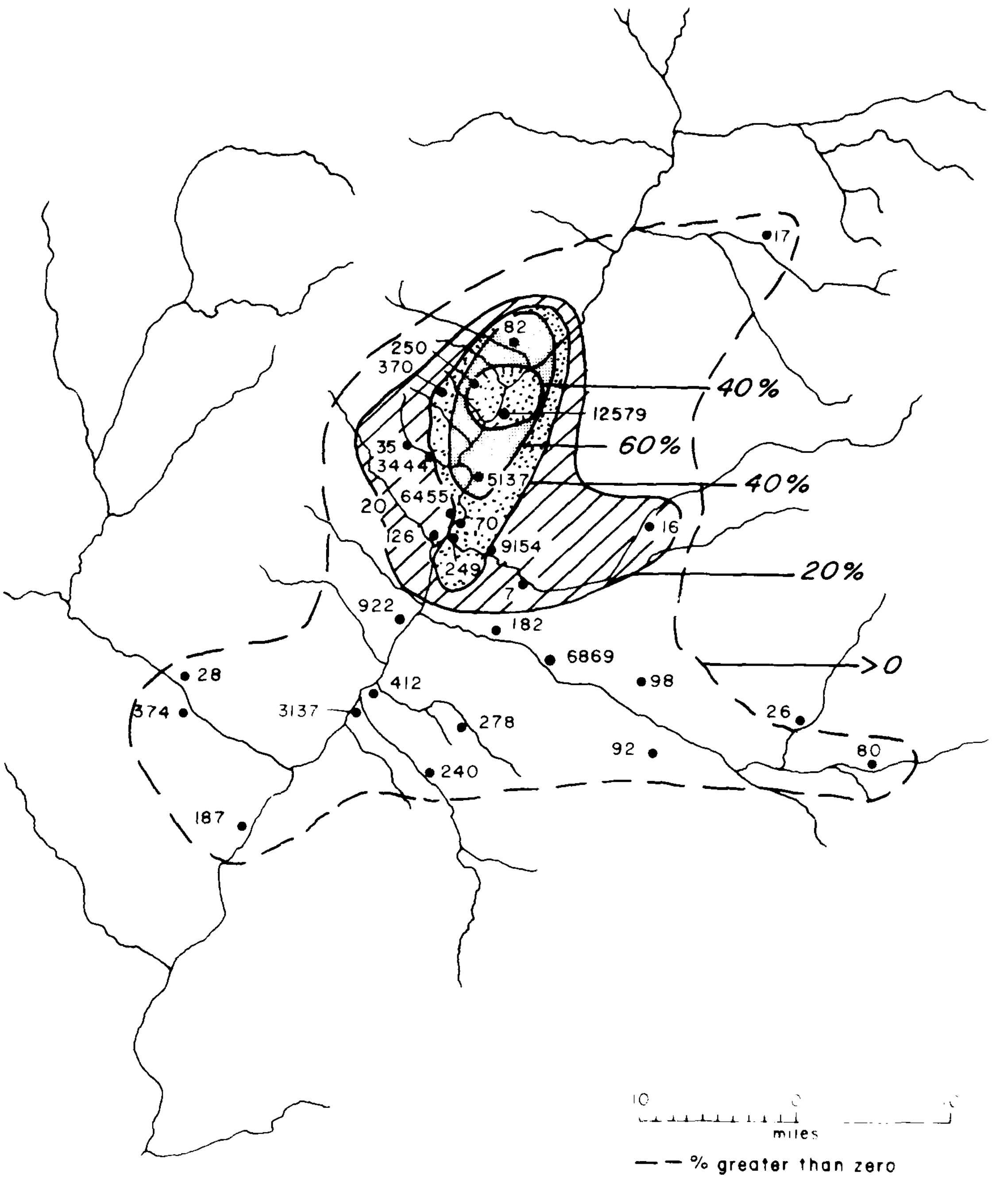

Fig. 10.2 Glaze A red sites (Isopleths denote percentages of scoria tempered sherds per site)

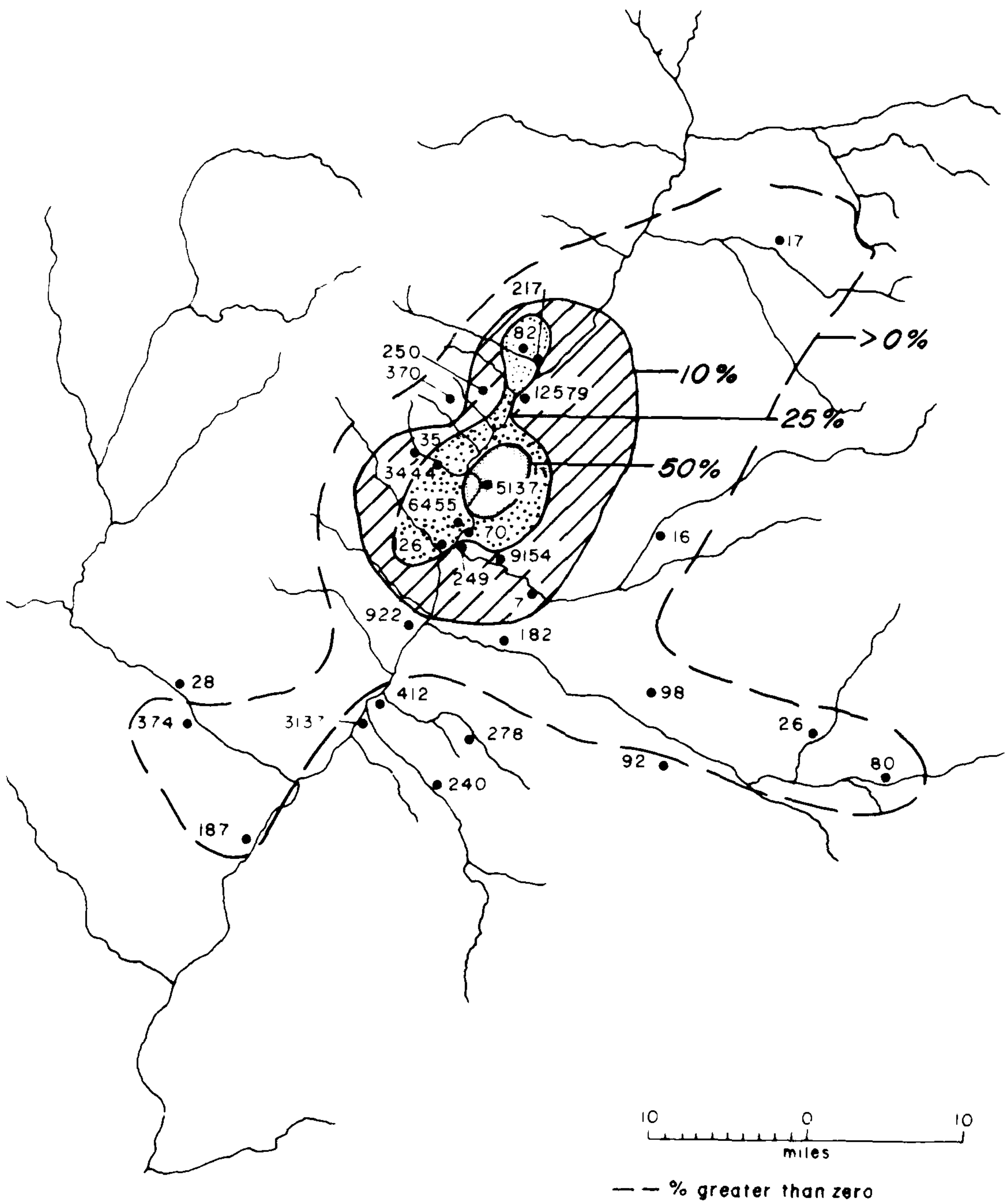

Fig. 10.3 Glaze A yellow sites (Isopleths denote percentages of scoria tempered sherds per site)

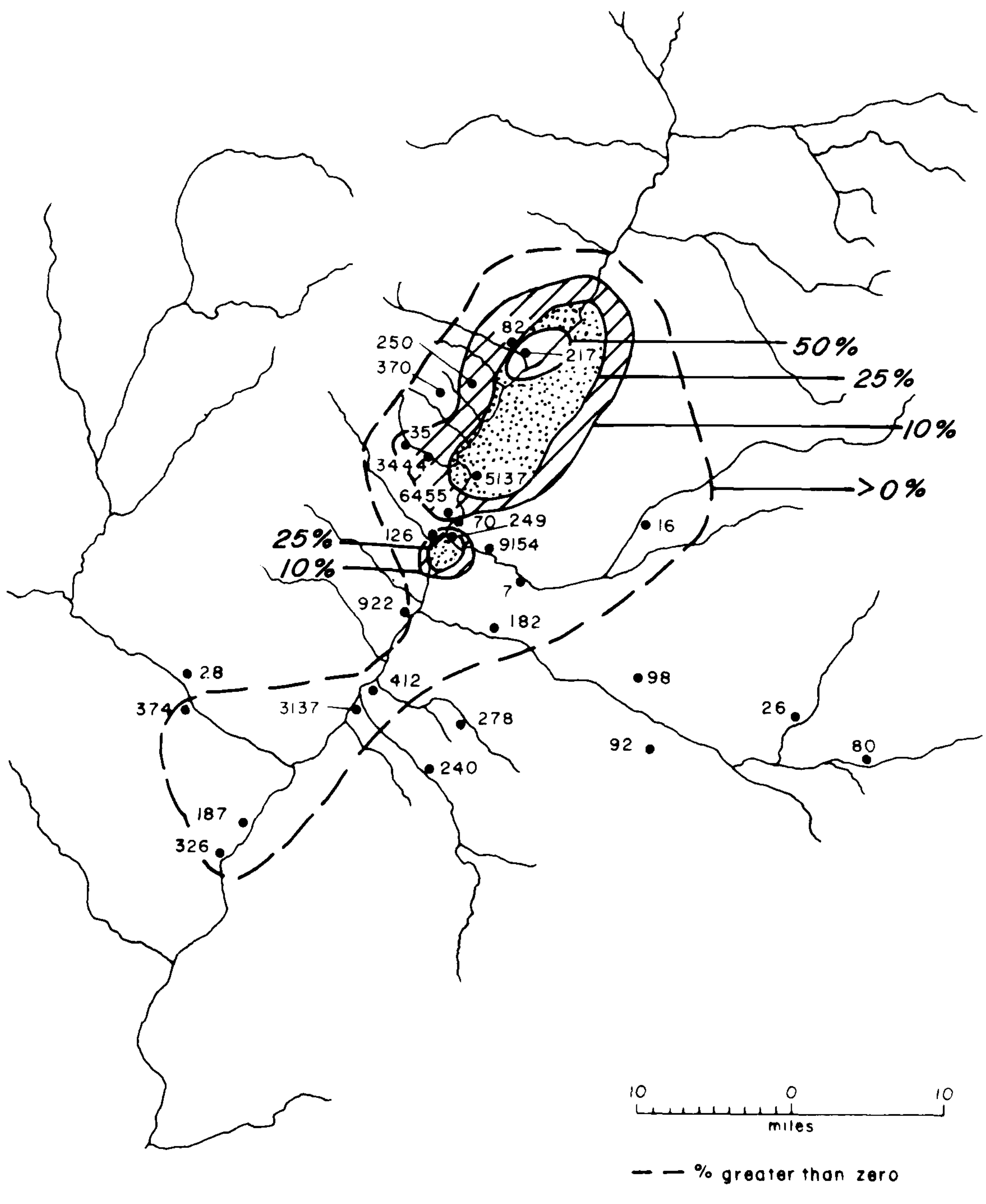

Fig. 10.4 Glaze C sites (Isopleths denote percentages of scoria tempered sherds per site)

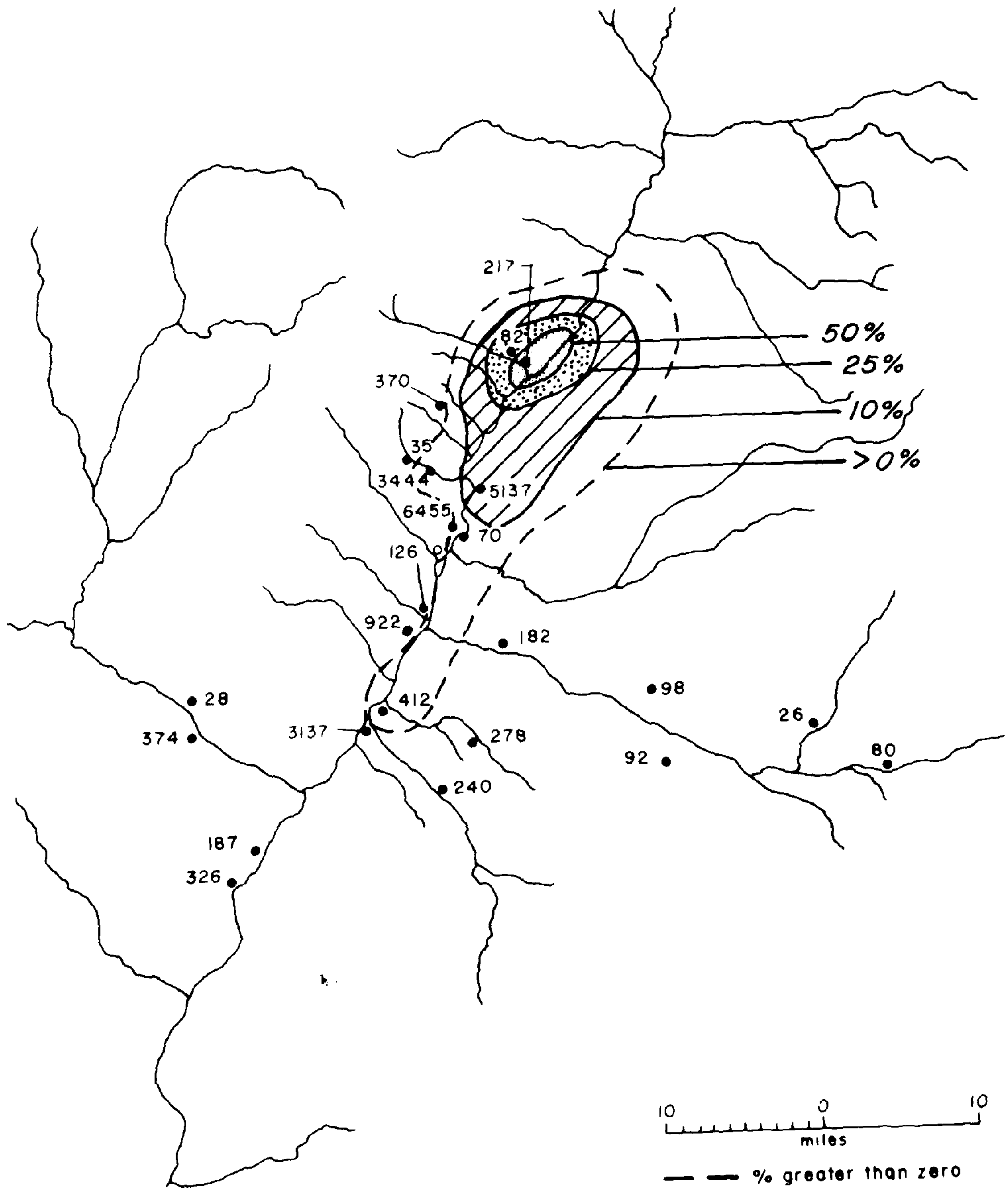

Fig. 10.5 Glaze D sites (Isopleths denote percentages of scoria tempered sherds per site)

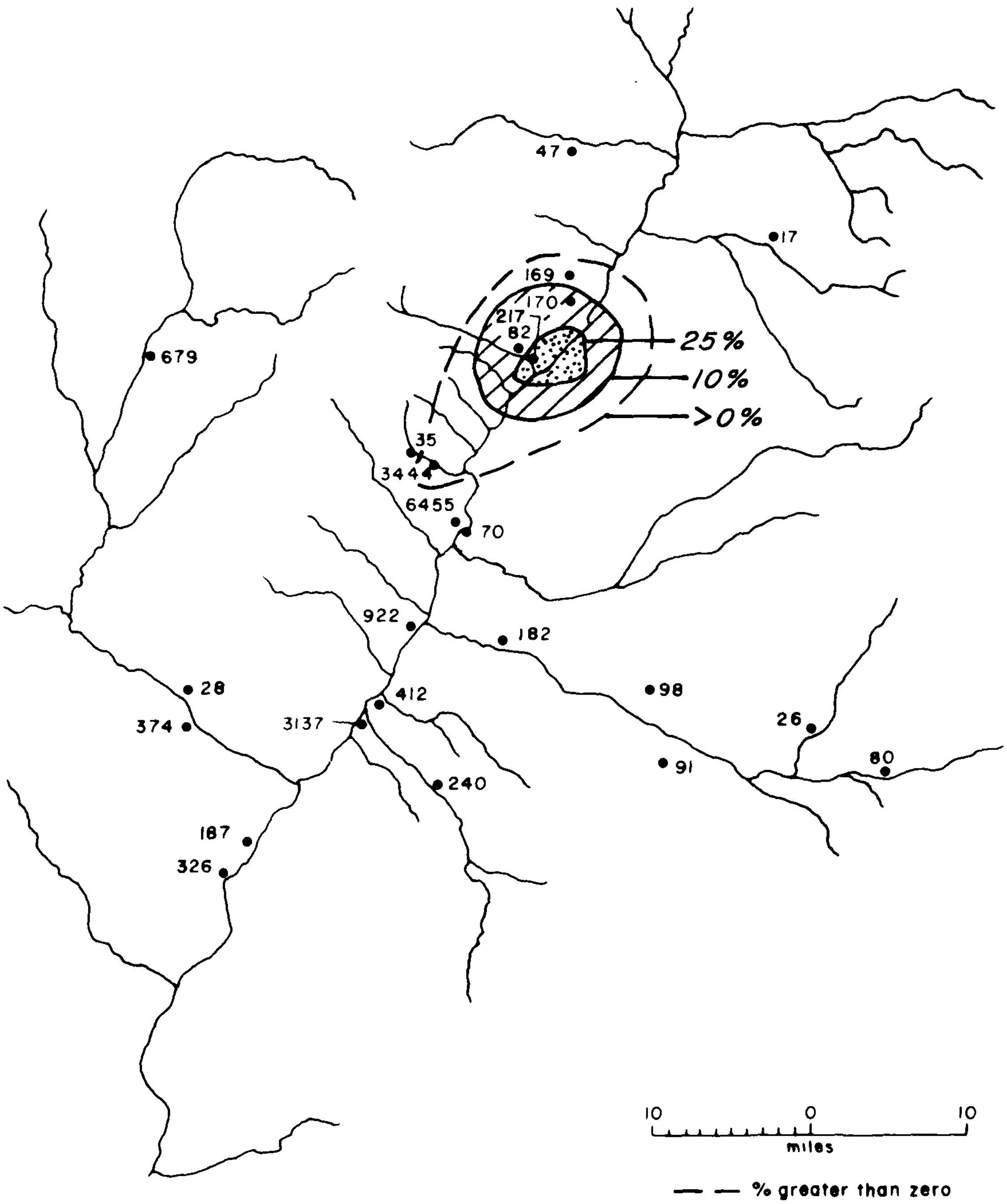

Fig. 10.6 Glaze E sites (Isopleths denote percentages of scoria tempered sherds per site)

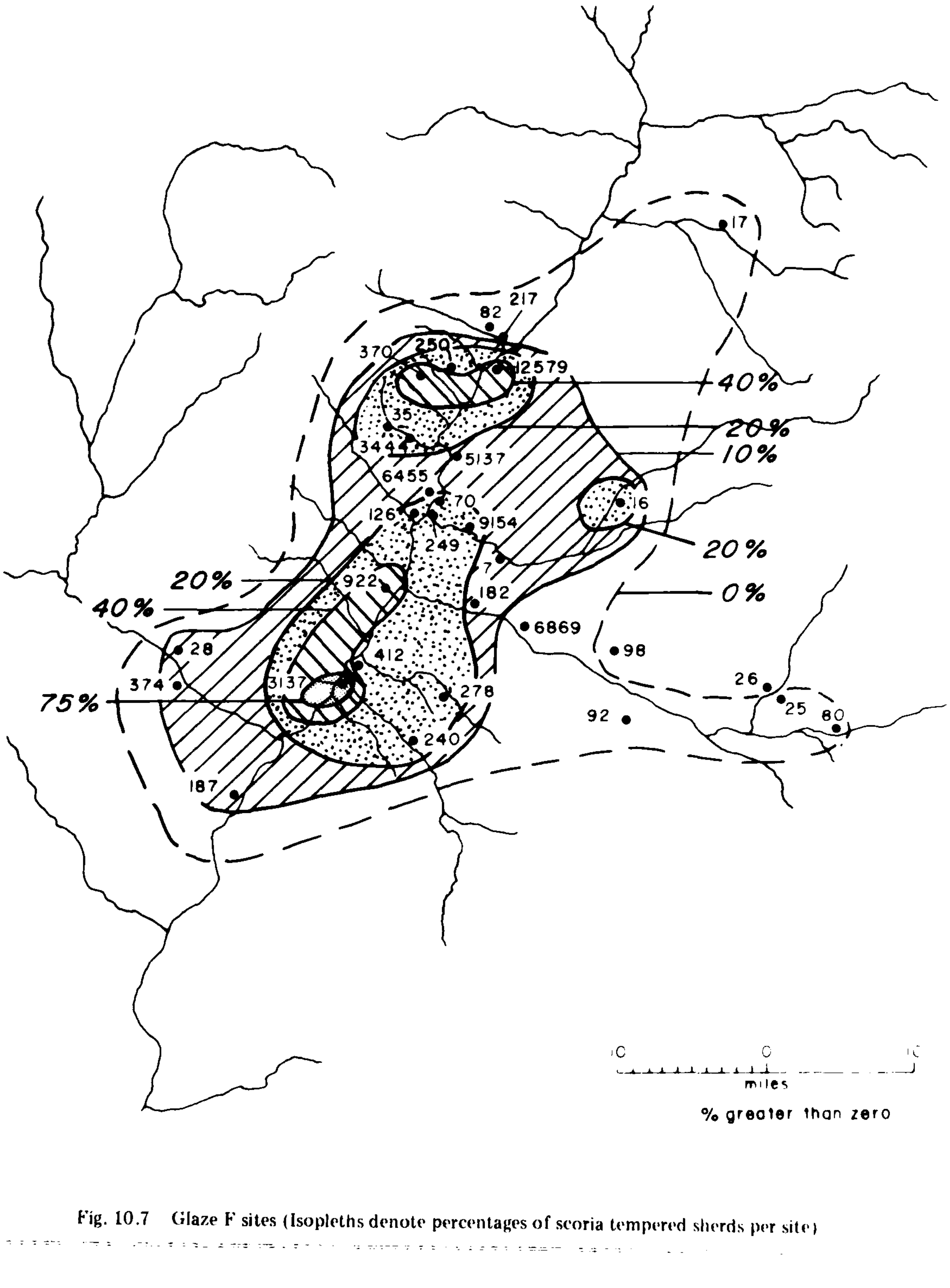

Fig. 10.7 Glaze F sites (Isopleths denote percentages of scoria tempered sherds per site)

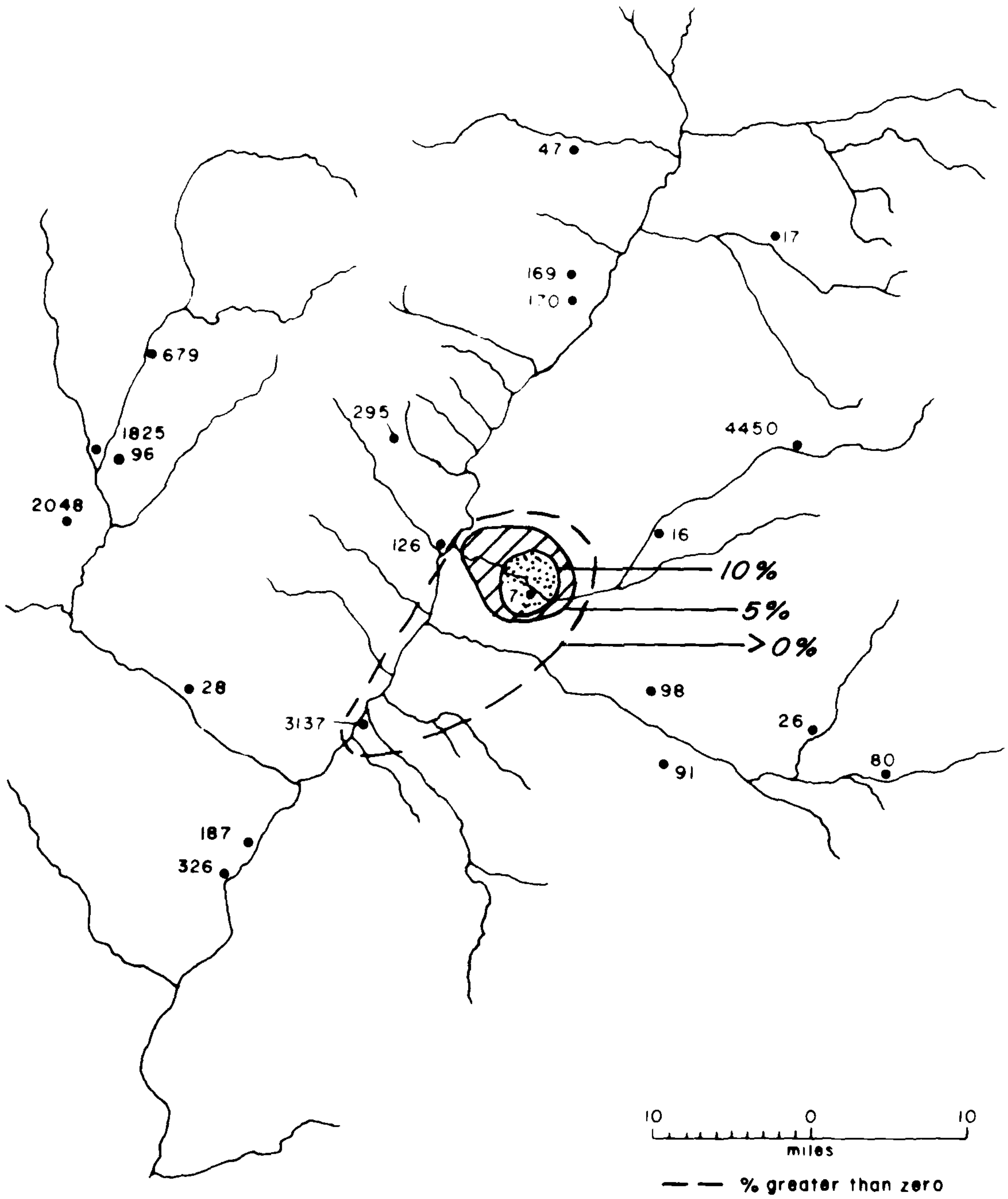

Fig. 10.8 Glaze A red sites (Isopleths denote percentages of crystalline basalt tempered sherds per site)

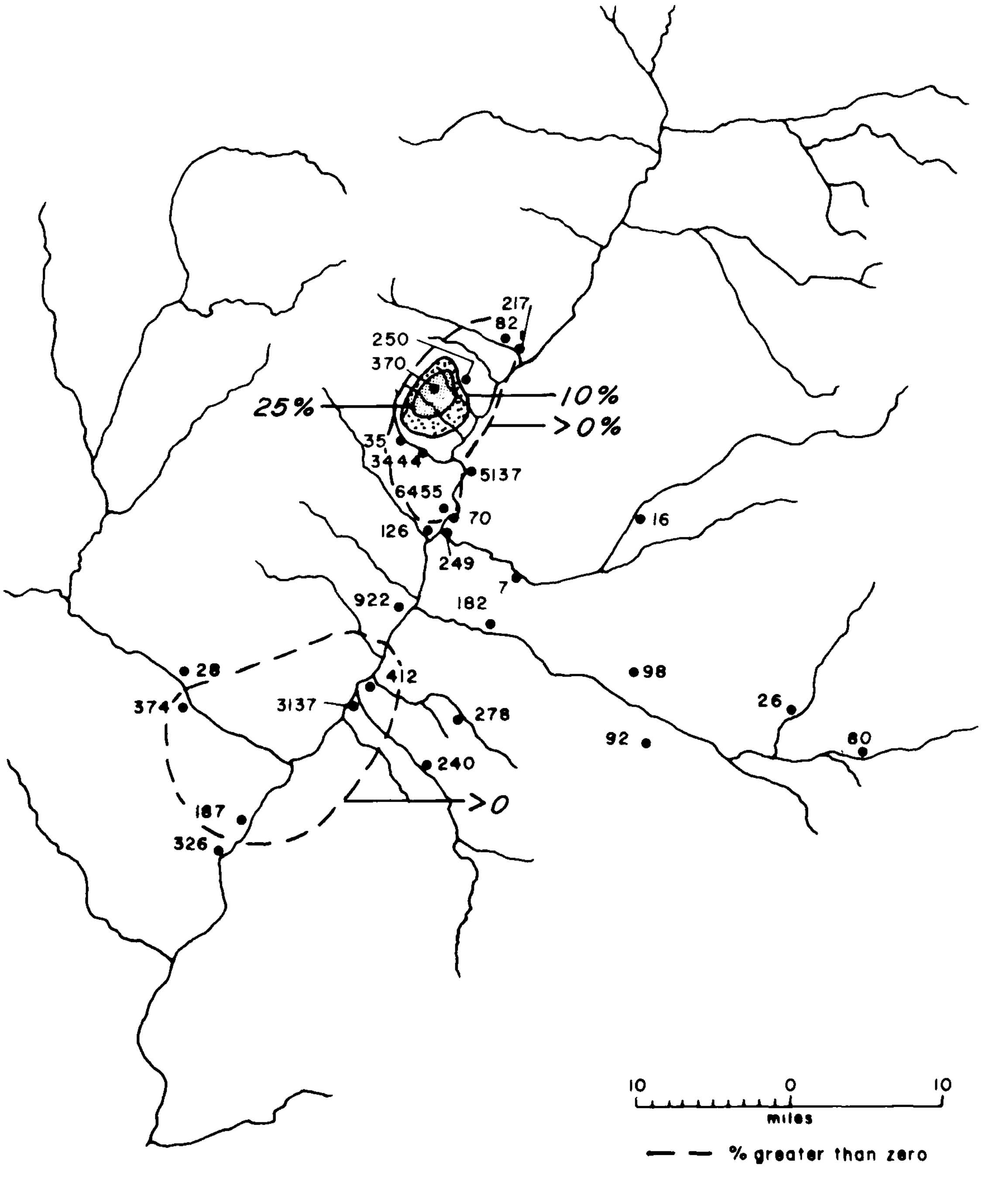

Fig. 10.9 Glaze C sites (Isopleths denote percentages of crystalline basalt tempered sherds per site)

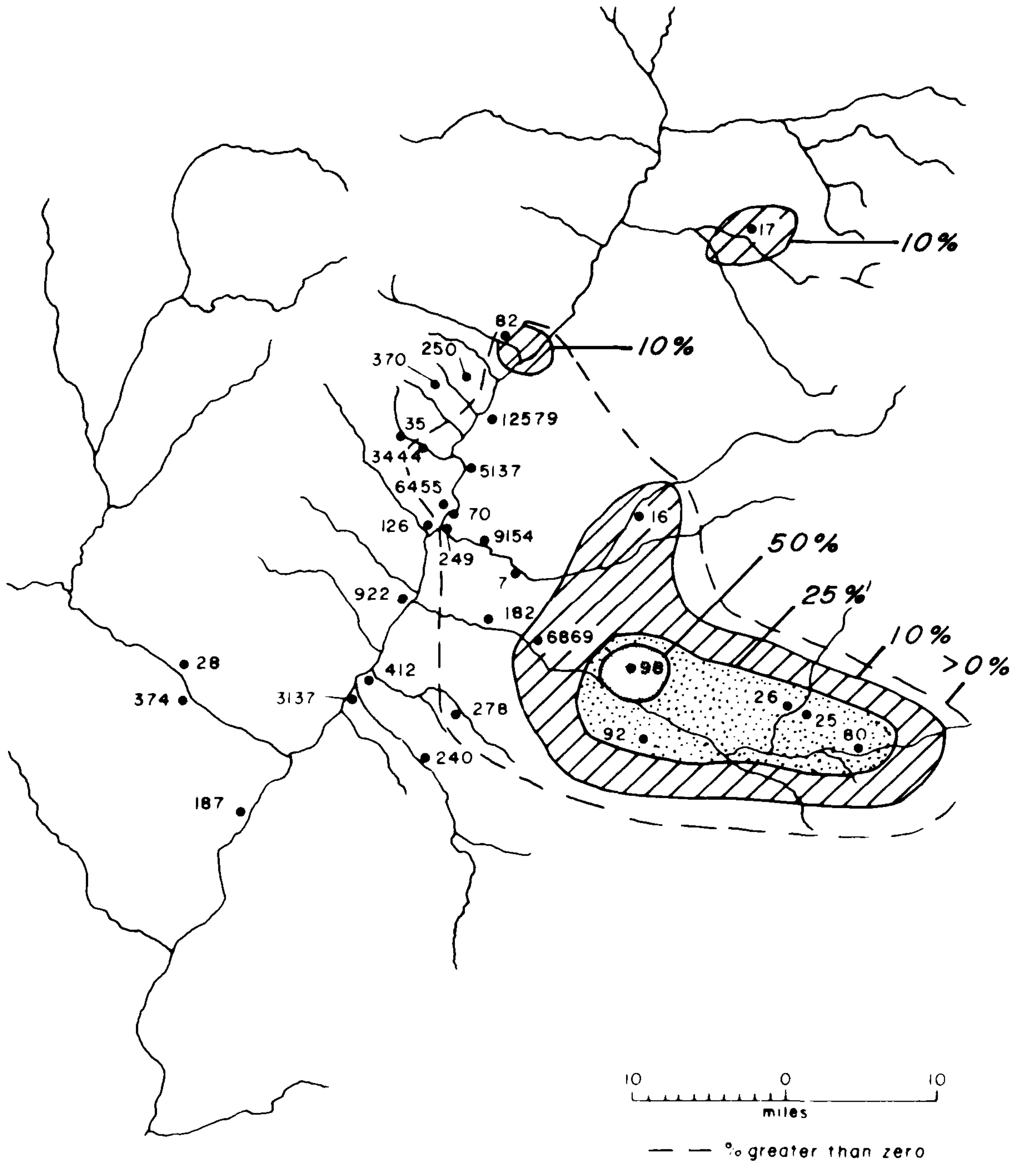

Fig. 10.10 Glaze A red sites (Isopleths denote percentages of augite latite tempered sherds per site)

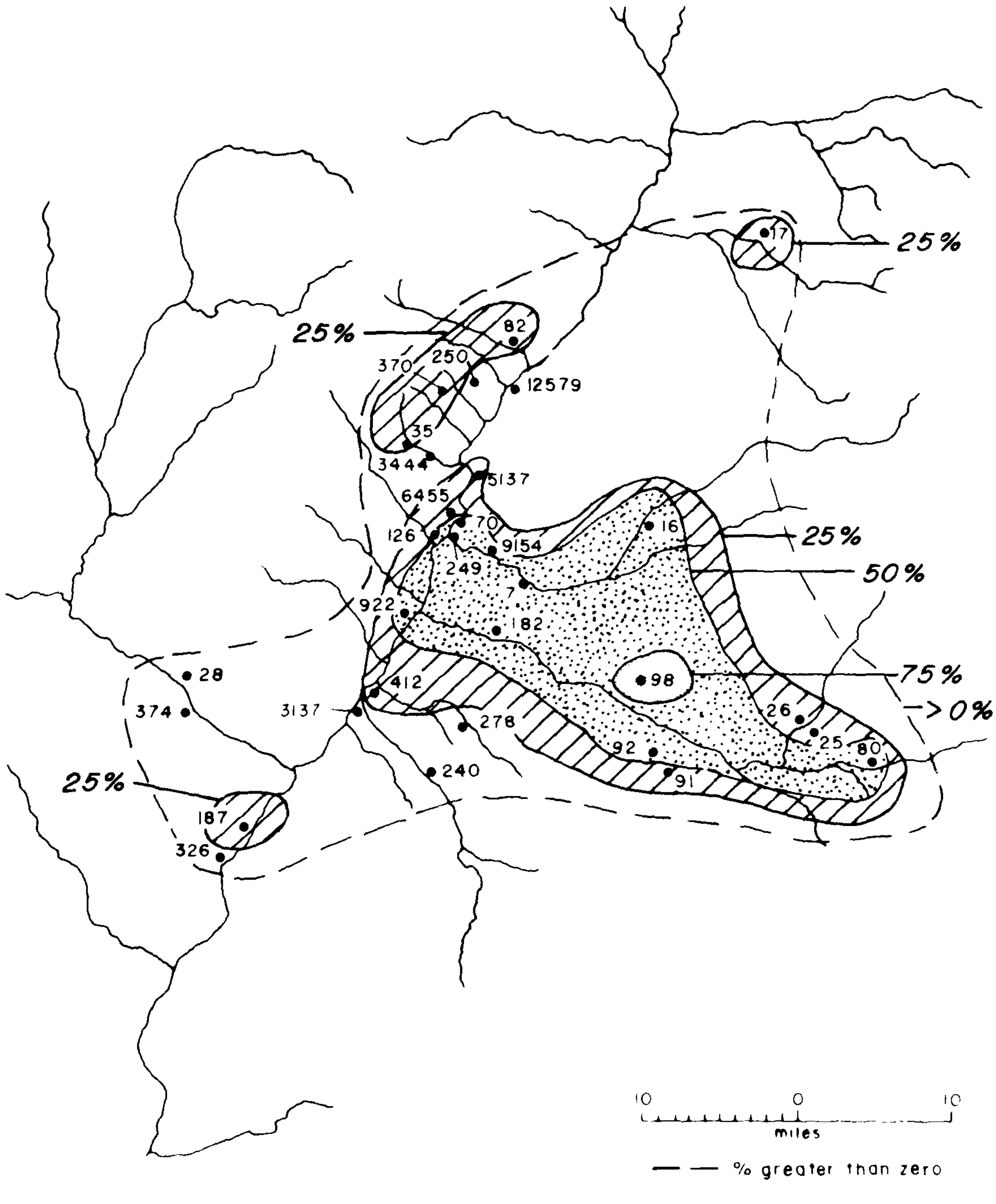

Fig. 10.11 Glaze A yellow sites (Isopleths denote percentages of augite latite tempered sherds per site)

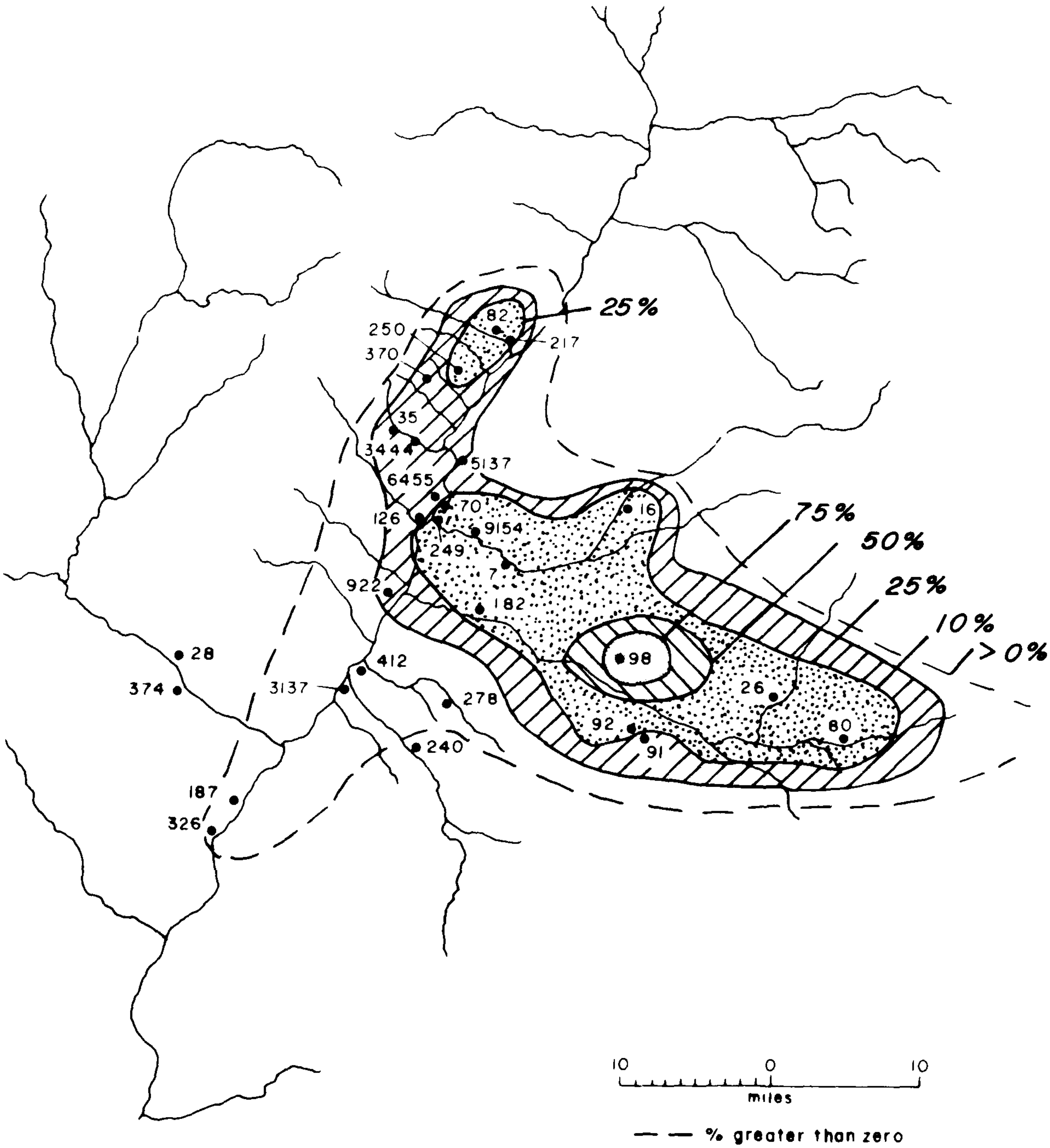

Fig. 10.12 Glaze C sites (Isopleths denote percentages of augite latite tempered sherds per site)

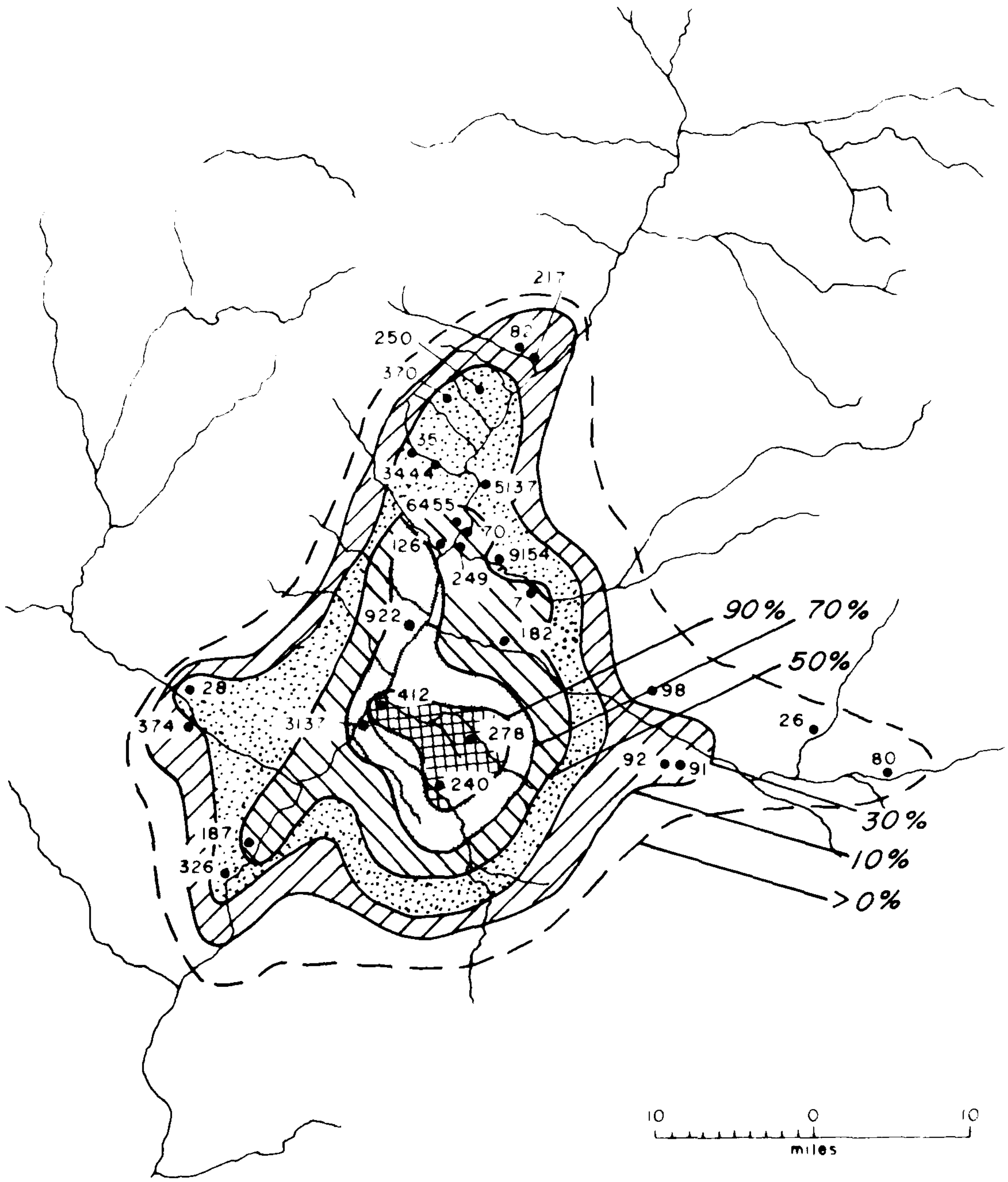

Fig. 10.13 Glaze C sites (Isopleths denote percentages of hornblende latite tempered sherds per site)

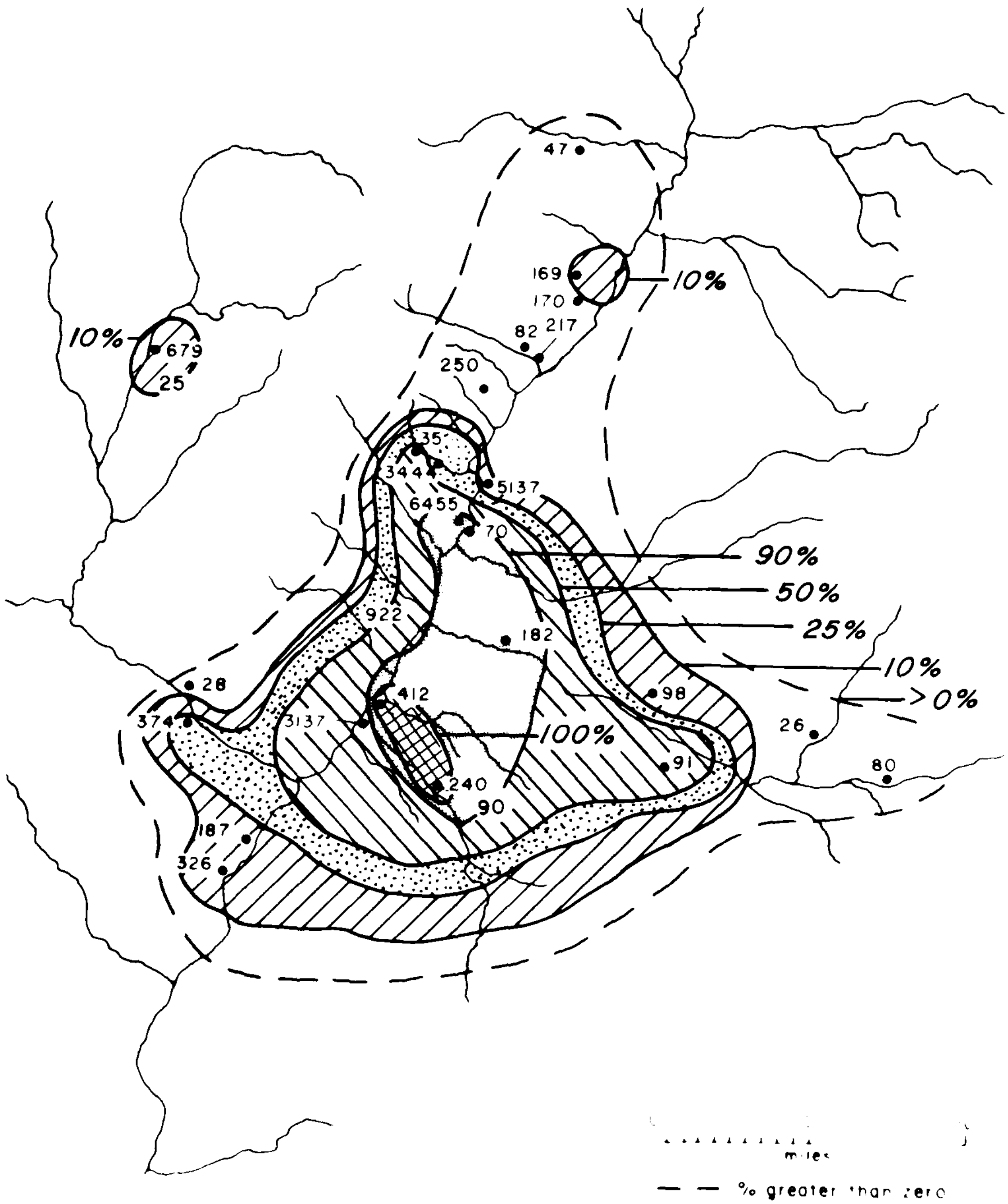

Fig. 10.14 Glaze E sites (Isopleths denote percentages of hornblende latite tempered sherds per site)

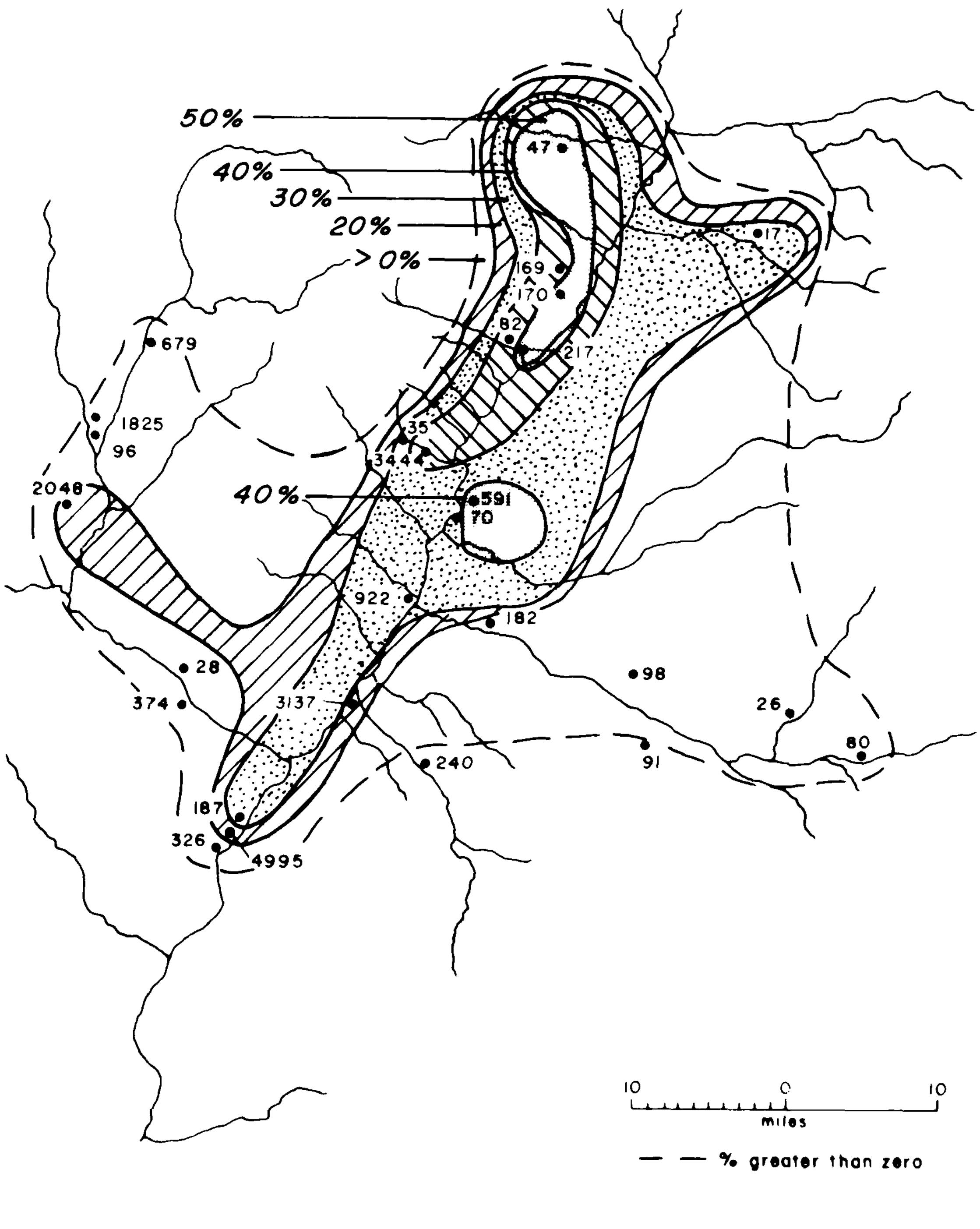

Fig. 10.15 Glaze F sites (Isopleths denote percentages of hornblende latite tempered sherds per site)

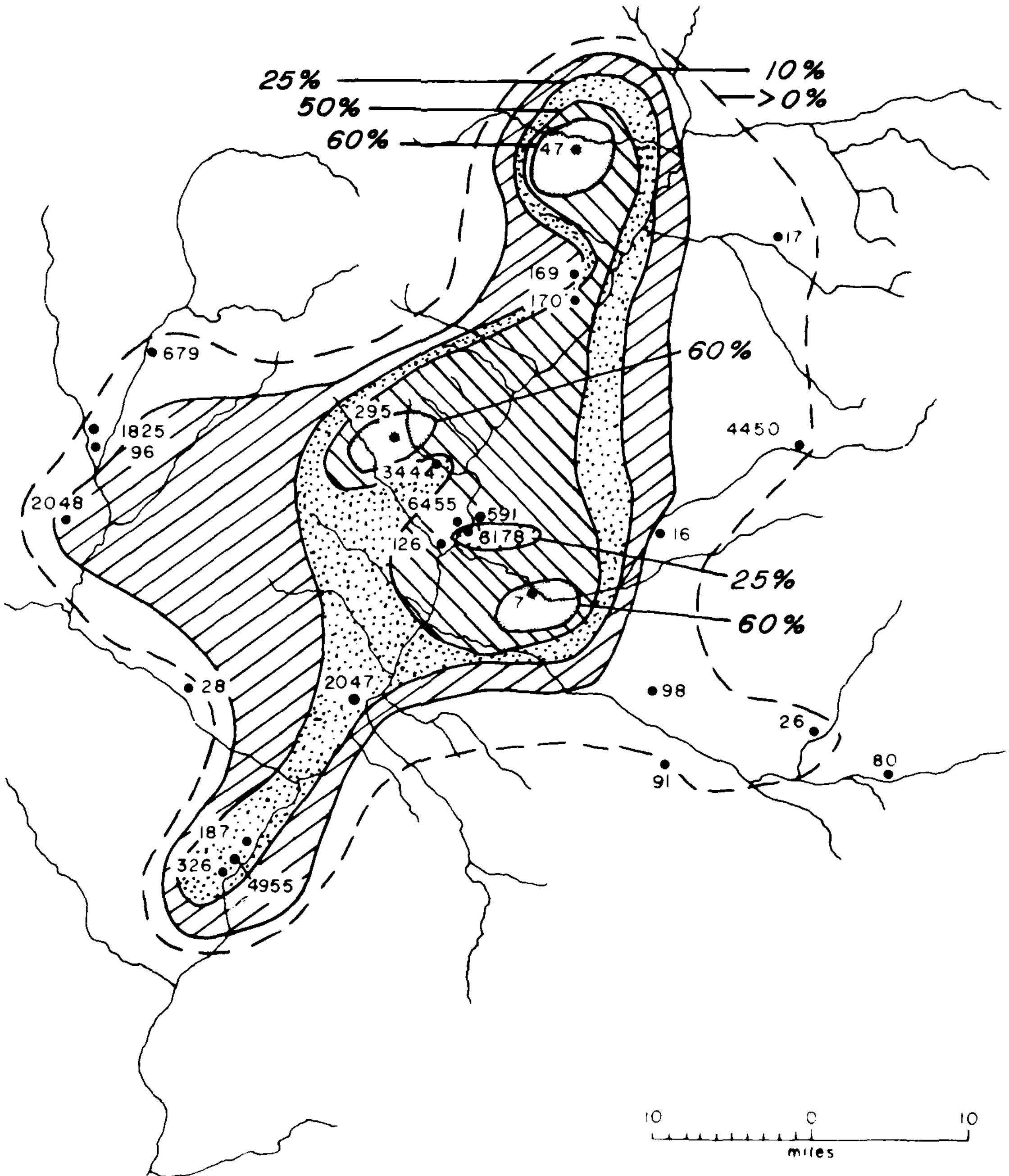

Fig. 10.16 Glaze F sites (Isopleths denote percentages of rhyolite tuff tempered sherds per site)

Chapter 11

THE EVOLUTION OF A FRONTIER: AN HISTORICAL INTERPRETATION OF ARCHEOLOGICAL SITES

Cordelia Thomas Snow

INTRODUCTION

I first became acquainted with the historic sites in the Cochiti Reservoir District as the result of the excavations undertaken by the Laboratory of Anthropology of the Museum of New Mexico at LA 34, 70, 591, and 6178. As will be seen in the following discussion, however, these four sites represent only a portion of the historic spectrum in the Cochiti area, and as such, when considered as representative of the whole, skew any interpretation that might be attempted of the historic period. It was not until the Office of Contract Archeology of the University of New Mexico had the opportunity to excavate another series of historic sites in the area that the very unintentional bias intoduced by the Museum was alleviated in large part, and more accurate assessment made possible of the archeological record.

Admittedly, gaps remain in our knowledge and understanding of the historic period in the Cochiti area. It would aid immeasurably, for example, if one or more of the 18th century *ranchos* in the Canada de Cochiti Grant along the Rio Chiquito could be excavated and the results published for comparative purposes. Moreover, intensive survey of the entire Santa Cruz Tract is of the utmost importance if the identification of sites and their occupants is to be attempted on anything other than a speculative basis. Finally, consideration must be given to the problem of the Navajo who are documented as having been active in the area but of whom little else is known.

Gaps notwithstanding, it has been my opinion for some time that the historic sites in the Cochiti Reservoir area reflect primarily the development and growth of a herding--sheep, goat, and cattle—economy; an adaptive response no longer operative in the area—in large part, as the result of Anglo technology and intervention. During most of the historic period, New Mexico has existed as a frontier—first to Spain and Mexico, and since 1846, to the United States. In fact it might be said that, the train and improvements in communication notwithstanding, New Mexico did not lose its frontier status until the impact of World War II and the subsequent energy boom were felt throughout the state.

In such a frontier situation, adaptive responses are as frequently effected by the indigenous cultures in the area as by the newly arrived groups. This often produces a frontier culture that is a combination of both parent groups but which develops on its own. Such a situation is found in the Cochiti Reservoir area, in the combination of Spanish-European and Indian traditions. By the last half of the 18th century, sites that were neither wholly Spanish nor Indian had developed in response to the conditions imposed by the frontier. Once developed the frontier culture remained homeostatic even after New Mexico gained territorial status (and thus, static economic traditions persisted until well into the 20th century).

Far more than a geographic frontier, New Mexico functioned as an economic frontier. Until shown to have potential for more than the most minor input into the larger system (whether Spanish, Mexican or Anglo), the subsystem was, to all intents and purposes, prevented from all but the most inconsequential change.

As a result, it is possible to view the historic occupation of the Cochiti area on the level of a micro-frontier in which the initial attempts by the Spanish at change were unsuccessful. Once the responses were altered, even only slightly by the elimination of the *encomienda* among others, a new system evolved. Thus, in the discussion which follows, I have briefly described each of the sites excavated, in addition to a brief review of the survey data, in order to emphasize the temporal and spatial patterns found in the Cochiti Reservoir area. Following each group of site discussions is a review of a portion of the available historic documentation of the area during which the sites were occupied. Included in this section are occasional suggestions for alternative interpretations of several of the sites under consideration. Such alternatives, for which I assume full responsibility, are based, for the most part, on data not available at the time the sites were excavated and the results analyzed and reported upon. They are in no way intended to reflect adversely upon the quality of the original work.

In the concluding section, I have attempted to bring the whole together in such a way as to provide a basis for future work, not only in New Mexico, but in other areas where similar adaptive responses may be found. The success or failure of my attempts, and any errors or omissions in the text are my own, and certainly not tne fault of any one of the numerous individuals who have worked in the Cochiti Reservoir area. All of those individuals, however, are to be thanked for the wealth of information they gathered and so readily shared, and for allowing me the opportunity to present my views.

SEVENTEENTH CENTURY SITES

Only three of the historic period sites excavated as the result of the construction of Cochiti Dam date to the 17th century; however, the actual period of occupation of one of those is doubtful because of the almost complete lack of cultural remains found in it. These early historic sites varied in size from one to more than 12 rooms, and show evidence of degrees of utilization that range from temporary and seasonal, to permanent, year-round habitations. Two of the 17th century sites were definitely constructed for use by the Spanish who settled the area, while the occupants of third site cannot be determined. The two definite Spanish sites were located on the east bank of the Rio Grande and the indeterminant site on the west bank of the river.

Three additional sites of possible 17th century date were located in White Rock Canyon during the archeological surveys of the area; two on the east side of the Rio Grande, and the other on the west side. While one of those sites consisted of only an artifact scatter, the others contained architectural components—one a single room and the other, two contiguous rooms. However, any determination of affiliation or the actual dates of occupation must remain uncertain because of the lack of otherwise identifying cultural material.

Although one-half of the 17th century sites located within the survey area were excavated, the sample must still be viewed as biased because of the nature of two of those sites, in that they represent some of the earliest strictly nonreligious and/or administrative Spanish remains in New Mexico. This bias is not without its own impact, however. While the individuals who occupied those sites almost certainly were involved with the *encomienda* (and thus, were admittedly more closely associated with the State than the Church), the sites were totally domestic in nature. As such, they are of considerable importance to an understanding of the socioeconomic development of the New Mexican colony. Perhaps of even greater importance, however, is the fact that all three of the sites excavated contained either features and/or cultural remains which indicated that the process of acculturation was already well underway at the time of their construction and occupation.

LA 34 - The Cochiti Springs Site partially excavated by the Museum of New Mexico (Snow 1971). The site is situated on the west bank of the Santa Fe River on a knoll overlooking Cochiti Springs. The largest of all the historic sites excavated in the area, the structure is rectangular in plan and consists of from 12 to 18 rooms arranged around a central plaza. Corrals, constructed of basalt boulders, are located immediately below the site on the flood plain of the river. The dwelling was apparently constructed entirely of adobe bricks laid on adobe and cobble foundations, and many of the interior wall remnants retained traces of white wash over layers of adobe plaster. A corner fireplace with a raised hearth was uncovered in one room, while firepits located near room corners were found in two other rooms. In addition to a basalt metate, a comal was found in association with the corner fireplace. While native wares accounted for the majority of the ceramics recovered from the site, 20 sherds representing four different types of Mexican Majolica were also found.

Although not completely excavated, and only a portion of the cultural remains returned to the Museum of New Mexico for analysis, it would seem that the Cochiti Springs Site had been constructed for occupation on a permanent rather than seasonal basis. Moreover, the size and the plan of tne site suggests occupation either by an extended family whose members occupied separate areas within the structure, or perhaps by several discrete but unrelated groups. Finally, while the site was apparently intentionally abandoned prior to the Pueblo Revolt in 1680, portions of it were later reused for herding activities.

LA 591 – The Las Majadas Site excavated by the Museum of New Mexico (Snow 1973a). This site was located on the east bank of the Rio Grande near the mouth of White Rock Canyon. The main structure consisted of five rooms arranged in an *L* shape. An extensive corral and a three room outbuilding were definitely associated with the larger structure. Although not found in place on the wall foundations, the fact that some adobe bricks were recovered during the excavation indicates their use in construction. A bilevel, adobe lined fireplace located in the northwest corner of one room was connected by a channel to an unusual raised, possibly once covered, firebox in the adjacent room. A third room contained an adobe rimmed firepit in the southwest corner in addition to an oval firepit near the center of the floor. A broken comal and a set of three stone andirons were found in association with the bilevel fireplace discussed above. In addition, a mealing bin was located along the south wall of the same room. A cubicle, possibly intended for storage purposes, was found in another room.

The three room outbuilding was apparently constructed entirely of adobe bricks. Also arranged in an *L* shape, the long east wall of the structure adjoined the corrals. A single firepit was found in the center of one room. Two additional hearths were located in the exterior work area formed by the *L*. The corral, which measured 40 x 70 m, was constructed of large cobbles. The same materials were used to divide it into three units. A gap in the wall adjacent to the outbuilding may indicate the former location of a gate opening into the corral.

Like LA 34, the majority of the ceramics recovered from LA 591 were of pueblo manufacture. Both those and the two types of Mexican Majolica found indicate that the site was occupied during the mid 17th century. Fragments of chain mail, a straight pin, several varieties of forged nails, and other tools attest to predominantly Spanish rather than Indian occupation of the site.

The faunal remains recovered from LA 591 show an unusually high dependence upon the use of domesticates rather than nondomesticates. Only one deer, a minimum of two rabbits, and a fish were identified as compared to the remains of five *Equus*, 14 *Bos/Bison* and 23 sheep/goat (*Ovis/Capra*).

Because of the plan of the main dwelling at LA 591, Snow (1973a) suggested that it had been occupied by either an extended family or by a single family with servants or slaves. If the outbuilding had been used as a dwelling -the firepits would indicate at least some use as a habitation—a minimum of two, and perhaps more, groups may have occupied the site. In any case, like LA 34, the Las Majadas Site was also apparently purposefully abandoned by its occupants prior to the Pueblo Revolt. The outbuildings, however, were reused at a later date.

LA 5013 – Excavated by New Mexico State University (Laumbach et al. 1977). The site was located on the west bank of the Rio Grande above the mouth of Medio Canyon. The site consisted of a single, more or less rectangular room, and was constructed of locally available basalt. An adobe lined fireplace was located in the southwest corner of the room. Four andirons or pot-supports were found in association with the fireplace.

While some lithic debitage was found at the site, no tools were recovered. In fact, the only other artifact found was a sherd of Tewa Polychrome. It is because of the paucity of cultural remains associated with LA 5013, that its inclusion with the other definite 17th century sites in the Cochiti Reservoir area may be in error. That the site was not occupied for any appreciable length of time seems certain in any case.

Discussion

Aside from the priests and other religious personnel who were responsible for the Mission of San Buenaventura at Cochiti Pueblo, there are few references to Spaniards living in the area prior to 1650. Further, there are even fewer data concerning who may have actually occupied any of the 17th century sites discussed above. However, the following individuals are known to have either had connections with, or lived on or close to, Cochiti lands during this century.

Scholes (1937a:94) lists Francisco Lujan as *Teniente* of Cochiti Pueblo in 1643. In this capacity Lujan would have acted, more or less, as an assistant to the Alcalde Mayor of the Pueblo. While Lujan is known to have died before 1663 (Chavez 1973:63), his house was described as being one half league east of the Rio Grande and without a roof (Snow 1968). As a result the location makes LA 34 a possible candidate for Lujan's house, but none of the other sites described above.

By 1661, Jose Telles Jiron held the *encomiendas* of Cochiti and San Felipe (Chavez 1973:106). It may be that he never did more than to visit the area, as *encomenderos* were forbidden by law to live in the pueblos where they received tribute (Scholes 1937b:388). More importantly, however, in the same year (1661) the *Alcalde Mayor* Juan Varela de Losada was described as *the only Spanish person at Cochiti* (Chavez 1973:111). Since LA 34 and 591 are both within the old Cochiti league, Varela de Losada could have been living at either. In view of the fact that it was the duty of the *Alcalde Mayor* to collect the tribute (mantas, hides, pinyons, etc.) owed the *encomendero* (Scholes 1937b:390), it is not impossible that Varela de Losada had quarters in the Pueblo.

Within two years, Cristobal Fontes held the position of *Alcalde Mayor*. In addition, he owned the La Majada Grant on the east side of the Rio Grande across from the Pueblo, and is further documented as having borrowed land from Cochiti for cultivation (Brayer 1939:112; Twitchell n.d.:No. 822). In short, Fontes almost certainly lived in the area. Further, Chavez (1973:30) lists Fontes' wife as *Maria Ramos 'alias' Varela, twenty-two years old and a native of New Mexico*. Whether Maria Ramos *aka* Varela was, in fact, Varela de Losada's daughter is not known; however, such a familiar tie might explain how a relative newcomer to the area could be given not only the La Majada Grant but also borrow land from the Pueblo.

While the foregoing does not answer the question of who occupied either LA 34 or 591, the fact that Fontes borrowed land from Cochiti for cultivation is of no little importance. Neither of the two major 17th century sites in the area was located where irrigation agriculture was feasible except on the flood plains below the respective sites, and, in both cases, that land was in limited supply. Further, since runoff from snow-melt at the higher elevations often lasted (without the aid of modern dams) until mid or even late June (Domínquez in Adams and Chavez 1956:7-8), the use of the flood plain for agricultural purposes could not always be assured. Moreover, if planting were delayed by high runoff, there was always the possibility that crops would be killed before maturation by late summer frosts.

Dry farming, on the other hand, would be of equal risk if summer rains did not occur at the proper times for plant growth. Even the use of such water control devices as terraces would not ensure crop growth and maturation without adequate water. Furthermore, while terraces, checkdams and the like are found in some abundance in the area, particularly on the east side of White Rock Canyon, there is no indication whatsoever that such water control devices were used by the Spanish settlers at this or any other time.

Since Cochiti Pueblo owned virtually all of the irrigable land in the area, Spanish settlers were limited then either to borrowing land in order to ensure the desired crop production or, alternatively, to relying upon other means of support whereby goods produced could be used for sale or trade. For the most part, the Spanish chose the latter alternative and thus instituted what was to become the major source of economic support in the Cochiti area during the 18th and 19th centuries—herding.

The raising of livestock was also fostered by the institution of the *encomienda* system whereby, in addition to the tribute owed the *encomendero* in return for military protection, a labor force was available for those in charge. While theoretically paid for their work, the Indians were, in many cases, little more than slaves (*cf.* Scholes 1937b:393-396). Shepherds and herdsmen were, of course, an important part of this labor force (Scholes 1937b:399-400).

The corrals and faunal remains found at LA 34 and 591 leave no doubt that herding was among the activities undertaken by those Spanish who occupied the sites. Further, that the occupants of the two sites were involved with the *encomienda* is suggested by the recovery during excavation of such items as Mexican Majolica and glassware—material requiring importation and, thus, sufficient means for payment.

Within the subsystem, however, LA 34 and 591 functioned on a level only slightly above that of the much smaller, and admittedly less complex site, LA 5013 that is, on the level of the individual. Far removed from Santa Fe, they could be described as representative of a micro-frontier with the two major sites analogous to frontier towns (*cf.* Lewis 1977:151-201), but on a far smaller scale. Living in close association with Cochiti Pueblo, the 17th century Spanish settlers in the area were forced to rely either upon themselves and or the natives in selecting the proper responses to their particular situations.

If a loss of cultural complexity on the part of the intrusive group (Lewis 1977:155) is combined with an even less complex sociocultural organization on the part of the indigenous group (Lewis 1977:163), the development

Table 11.1
Seventeenth Century Sites

LA Number	Location	Type of Site
Sites Located on the East Side of the Rio Grande:		
34*	Santa Fe River	Rancho. 12-18 rooms, corrals.
591*	Rio Grande below White Rock Canyon	Rancho. 5 rooms; corrals with 3-room outbuilding
12452?	White Rock Canyon	2-4 contiguous rooms; artifact scatter; actual date of occupation uncertain.
13300?	White Rock Canyon	Artifact scatter. Actual date uncertain.
Sites Located on the West Side of the Rio Grande:		
5013*	White Rock Canyon	Single room with corner fireplace.
5017	White Rock Canyon	Single room.

*excavated or tested

of a frontier may proceed. If, however, given the micro-level of the Cochiti area (and others at the same time), the sociocultural organization of the indigenous group was more complex (in this case an entire pueblo) and much less extenuated than the tiny fragment of the system represented by the Spanish settlers in the same area, the subsystem might be expected to become unbalanced and eventually cease to operate.

Both LA 34 and 591 were abandoned, apparently peacefully, and as such, the micro-frontier ceased to exist in the Cochiti Reservoir District. Concomitant with the abandonment of this and other micro-frontiers in New Mexico were a series of droughts and an increase in raids on settlements by the Apaches and others; the result of which was the collapse of the entire system with the Pueblo Revolt of 1680. On the other hand, however, unsuccessful as the development of the frontier may have been during the 17th century, the impacts were such that, with the elimination of such intrusive features as the *encomienda* and the substitution of the *Partidario*, the frontier was permitted to redevelop during the 18th century.

LA 5017, 12452 and 13300 (the possible 17th century sites located during survey but not excavated) and LA 5013 (discussed above) become lost with the scope of the micro-frontier, however. As relatively uncomplex architectural manifestations and an artifact scatter, the sites are representative of an unknown aspect of Spanish frontier culture. The reason for the scatter or the construction of the sites--whether to provide shelter for farming, herding or other activities--and the identification of the occupants—whether Spanish or Indian or both—simply cannot be determined from the data at hand. As such, however, the sites are of no little importance. Until that portion of the subsystem they represent is identified, explanation is not possible and the ramifications of the 17th century frontier remain unclear.

EIGHTEENTH CENTURY SITES

The bulk of the historic sites excavated in the Cochiti area are 18th century in date. Of the 18 such sites located during survey, five of the nine excavated sites are located on the west side of the Rio Grande—a reversal of the 17th century pattern where the majority of the sites were located on the east side of the river. Three of the four excavated sites located on the east side of the Rio Grande are within the old Cochiti league, and one of those is a reoccupation of another site.

The character of the sites changed radically during the 18th century. Instead of relatively compact homesteads like LA 34 and LA 591, the architectural manifestations have fewer units, are considerably smaller, and are more widely dispersed throughout the area. Corrals, stock pens and the like were found in association with several of the sites that were occupied during this time. Finally, the cultural inventory, with a few exceptions, becomes smaller and less varied than in the sites occupied during the 17th century. Whether the decrease in variability is the result of task specialization or due to the lack of the availability of certain items is not certain; however, in view of the available historical documentation, the former seems to be the more plausible of the two explanations.

LA 70 – Pueblo del Encierro, excavated by the Museum of New Mexico (Snow 1976). This prominent site was located on the east side of the Rio Grande less than one mile downstream from LA 591. Although primarily a prehistoric pueblo, three noncontiguous groups of rooms were remodeled and occupied sometime during the last half of the 18th century. Group A consisted of four rooms, one of which had a fireplace in the southwest corner, and another which had an adobe rimmed D-shaped firepit centered along the north wall. Doorways had been constructed and provided access to all rooms in the group. Two rooms made up the group B component. Connected by a door, the rooms had corner fireplaces which had been placed back to back. In addition, one of the rooms had a storage bin.

Group C also consisted of two rooms. In both, the original floors had been removed and new floors prepared below the level of prehistoric occupation. Corner fireplaces with adobe rims enclosing the hearth area were found in both rooms. A doorway which had once connected the rooms was found sealed with cobbles. The reason the door was sealed, and when that might have been done, is unknown.

The artifacts associated with the historic occupation of Pueblo del Encierro included fragments of metates and manos, although no mealing bins were found in situ. Worked selenite was recovered, indicating the presence at one time of windows in several of the rooms. Other artifacts included hammerstones and other stone tools; native ceramics, including locally made wares from Cochiti Pueblo, and Mexican Majolica; and fragments of glass and metal.

Because of the extensive prehistoric occupation of LA 70, it was difficult to differentiate between the prehistoric and historic faunal remains. As a result, only the domesticates and those remains found in direct association with the historic rooms, were considered to have been related to the 18th century reoccupation of the site. When compared to the other historic sites in the area, it is interesting to note that the only domesticates recovered were either *Bos/Bison* or *Ovis/Capra*. On the other hand, the remains of fish were recovered in both prehistoric and historic contexts.

While it is difficult to assess the nature of the historic occupation at LA 70, the extensive remodeling of the prehistoric rooms, the presence of multiple fireplaces, metates and the like suggest that the occupation was intended to be a relatively permanent one. Further, the presence of Mexican Majolica, glass, and metal indicate the means available to obtain such imports and suggest that the occupants may have been Spanish rather than Indian. Because the reoccupied rooms were not contiguous, it is possible that three separate groups may have lived at the site.

LA 6178 -- The Torreon Site excavated by the Museum of New Mexico (Snow 1973b). The site was situated on the east bank of the Rio Grande approximately 100 meters west of LA 70. A multicomponent site originally believed to have been first occupied during the late 17th century (Snow 1973b), new data (Warren, this volume) suggest that the site was probably occupied wholly during the 18th century. In either case, severe erosion and the subsequent mining of the site during the 20th century by CCC crews prevented disclosure of the full architectural, and hence occupational, sequence of the site. As a result, it is uncertain whether the remains uncovered represent a continuous occupation of the area or two discrete occupations --one early in the century and one later.

Problems aside, LA 6178 was intensively occupied during its existence. Rectangular in plan, the site—with the exception of an associated trash deposit located in a nearby arroyo—was completely enclosed by walls constructed of locally available basalt. Whether those enclosing walls were associated with the earliest architectural remains found at the site--that is, two rooms associated with stock pens or enclosures--is not clear; although the historical documentation discussed below suggests that possibility. In any case, defensive towers (torreones) were located in the southwest and northeast corners of the enclosure. While the towers were large enough to have been divided into rooms, the site had been eroded to the point that no such indications remained—if they ever had existed. Small, rectangular rooms were found located in the remaining corners of the quadrangle, however. What may have been a firepit was located near the west end of one of those rooms. No hearths, firepits, or fireplaces could be identified for the initial phase of construction at the site.

To compound the confusion that existed at LA 6178, the site lay downslope from Pueblo del Encierro and there had been considerable wash from that site. As a result, the lithic assemblage at the Torreon Site could not be distinguished from material which may have come from the pueblo. However, since virtually all of the bone recovered from the trash deposits at LA 6178, both within the quadrangle and from the arroyo, had been butchered with metal rather than stone tools, it may be that the use of stone had been of minor importance to those who had occupied the site, and therefore, the lithic assemblage was originally quite small.

The ceramics, while equally mixed by erosion, could be differentiated. Since there was no identifiable prehistoric component at LA 6178, those sherds were eliminated from the final analysis as having originated from LA 70. Further, it was found that the ceramic assemblages themselves differed between the historic occupations of the two sites: for example, Ogapoge Polychrome was the predominant decorated ware recovered from the Torreon Site while locally manufactured copies of Tewa and Zia ceramics were found in greater abundance at LA 70. Other items of material culture found at the site were five different types of Mexican Majolica, Chinese porcelain, glass, and metal.

As at the 17th century site of LA 591, the faunal remains recovered from the Torreon Site were primarily domesticates, including a minimum number of 61 *Bos*, 58 *Ovis/Capra*, eight *Equus*, and two domestic pigs. Nondomesticates included one rabbit, one deer (represented by an antler fragment only), and possibly some antelope.

The defensive nature of the Torreon Site combined with the unusually large number of butchered domesticates and early 18th century ceramics strongly suggest that this site was the quarters for the Cochiti garrison ordered into the area by Governor Cuervo y Valdes during the first years of the century. While the troops were stationed in the area as a result of the tremendous increase in Navajo raids after the reconquest of New Mexico by the Spanish in 1696, they were returned to Santa Fe within two years (Bancroft 1889:227-229). That the site continued to be occupied is shown by the later ceramics recovered during excavation, but it may be that the site was only used during times of unrest as a place of refuge.

LA 9138 – excavated by the Office of Contract Archeology, University of New Mexico (Chapman et al. 1977). The site was situated on the west side of the Rio Grande. A multicomponent site, two rooms had been occupied prehistorically while the remainder were occupied during the 18th century. The historic portion of the site consisted of four noncontiguous roomblocks with a total of seven rooms arranged in no discernible pattern, and an extensive network of low walls constructed of basalt. While the majority of the rooms were rectangular in plan, one was oval and another circular in outline. At least one room in each group had a corner fireplace and, although most had been constructed of slabs and adobe, one had been made using adobe bricks in part. Several of the structures at LA

9138 showed evidence of short-term abandonment and reoccupation.

While a wide variety of ceramics were recovered from the site, ollas far outnumbered bowls (63 ollas represented versus 30 bowls represented). The preponderance of the ollas suggests an unusually high dependence upon, or need for, temporary storage. In view of the lack of such food processing items as metates or mealing slabs, it would seem that the occupants relied heavily on readily available foods or upon those which could be transported and stored easily—such as previously prepared grains and the like. And, while extremely limited in quantity, the vegetal remains (pinyons, unidentified nut shell fragments and peach pits) recovered from the site tend to substantiate portability.

Expediency is visible in the faunal remains recovered from LA 9138 in that nondomesticates were apparently consumed as readily as domesticates. Further, the fact that fish vertebrae were recovered may conclusively identify the occupants of the site as Spanish rather than Indian. Although as noted above, fish were recovered from prehistoric contexts at LA 70, their use appears to have increased during the historic period, perhaps as the result of precedent set by the Spanish. That the Spanish made intensive labor investments using dragnets and as many as 30 individuals at a time to procure fish, particularly during March and after heavy summer rains, is certain (Adams and Chavez 1956:7).

The lithic assemblage at LA 9138 possibly substantiates the above speculation concerning the identity of the occupants of the site, in that it has been described by Chapman et al. (1977:157) as reflecting the technological behavior of individuals who are relatively unfamiliar with manufacture or usage of stone tools but . . . who had no access to metal implements.

While somewhat more extensive than the majority of the 18th century sites under discussion, LA 9138 appears to have been intended for periodic, seasonal occupation by individuals almost certainly involved with the raising of livestock. Because the site contained several discrete units, it may be that the site represented a gathering place for herds prior to sale or movement elsewhere.

LA 9139 – partially excavated by the Museum of New Mexico (Snow 1976); reexcavated by the Office of Contract Archeology, University of New Mexico (Chapman et al. 1977). Located on the east side of the Rio Grande 200 meters west of LA 70, the site consisted of a single rectangular room. A raised adobe hearth was found in the southeast corner of the structure. In addition, what may have been a slab-lined firepit was found in the west central portion of the room.

Two sherds of Mexican Majolica were the only imported ceramics found in an otherwise almost completely locally made ceramic assemblage. No lithics were found in either excavation.

Snow reported the recovery of *Ovis/Capra* and *Bos/Bison* bones from the excavations carried out by Museum personnel, while Chapman and others reported a scapula fragment from an otherwise unidentified artiodactyla. A fragment of a peach pit constituted the total vegetal remains from the site.

Tree-ring dates obtained by the Museum of New Mexico indicate that the occupation of the site was contemporaneous with that of the historic occupation at nearby LA 70 and, therefore, Snow suggested that LA 9139 may have been an isolated component of the larger site.

LA 10110 – partially excavated by the Office of Contract Archeology, University of New Mexico (Chapman et al. 1977). This site was situated on the west side of the Rio Grande slightly more than 1 km below LA 9138. A multicomponent site with basalt walls, modern hearths and scatters of lithics, glass, and metal artifacts, only the purported structure was tested. Whether a dwelling or habitation unit ever existed at this site is not known. However, the suggestion that the walls found on the site were extensions of those found at LA 9138, and in my opinion LA 10110 as well, seems plausible in view of the lack of any data to the contrary. That the site was not intended for more than periodic use is obvious.

LA 10111 – partially excavated by the Office of Contract Archeology, University of New Mexico (Chapman et al. 1977). This site was situated on the west bank of the Rio Grande just upstream from LA 10110. Also a multicomponent site, LA 10111 consisted of corrals, a lithic scatter and probably associated rock art; no dwellings were located, however. All of the corral walls were constructed of locally available basalt. Although no cultural remains were recovered from the area tested, the site was determined to be possibly 18th century because of the similarity of the walls to those at LA 9138. There seems to be little doubt that the site was not intended for use on other than a temporary, periodic basis.

LA 12161 – excavated by the Office of Contract Archeology, University of New Mexico (Chapman et al. 1977). Also situated on the west bank of the Rio Grande, LA 12161 was located north of the mouth of Medio Canyon. The site consisted of a single room and an associated trash deposit. A hearth, constructed of adobe and basalt, was located near the northeast corner of the room. A small, circular subfloor cist was uncovered to the west of the hearth.

Although extremely small in size, a wealth of cultural remains was recovered from LA 12161. As such, the site presents something of an anomaly for the majority of the 18th century excavated sites in the Cochiti area: for example, that as many as 107 ceramic vessels, including several bisque or unfired pieces, were represented in the midden alone, is awesome. However, for the site as a whole, as at LA 9138, olla or jar forms were found in greater numbers than bowls; again suggesting a need on the part of the occupants for temporary storage. Unlike LA 9138, on the other hand, fragments of ceramic comales and soup plates were recovered in greater frequency. It should be noted, that the comal fragments were the only item that related to the preparation of food, other than meat, that were recovered.

Also, unlike LA 9138, the lithic assemblage showed evidence of familiarity both with the natural resources in the area and the manufacture and use of stone tools. Similar specialization is evident in the variety of bone tools recovered from the site. That as many as four activities were represented by the bone implements (skinning, hide preparation, cutting or punching, and sewing), suggest that either repair was undertaken and/or that complete items were being manufactured. Since the majority of the tools were found in the midden, the completion of tasks with subsequent purposeful disposal of the tools, evidently regardless of their condition, is suggested. If, on the other hand, the activities for which the tools were used had been undertaken frequently, or were of long duration, tool curation should have been evident.

The recovery of 13 whole or fragmentary spindle whorls and 14 circular, undrilled ceramic discs (presumably spindle whorl blanks) suggest that either spinning took place at the site, or that those items were being manufactured for use elsewhere. Although spinning is frequently considered a woman's activity, there is good evidence that Spanish males were equally involved in this task (cf. Bloom 1927:233-238; Boyd 1974:200, 218).

In other words, although the data are admittedly ambiguous, women need not have been present during the occupation of LA 12161. The range of activities, encountered via the cultural remains recovered from the site, could have been carried out solely by men. In any case, however, the size of the structure (6.7 m^2 of floor-space) precludes the presence of more than two or three individuals (at the very most) if required for shelter for any length of time. Therefore, although intensively occupied, it is my opinion that the site was not intended for permanent habitation, but was used periodically.

LA 12438 – excavated by the Office of Contract Archeology, University of New Mexico (Chapman et al. 1977). The site was located on the east side of the Rio Grande below the mouth of White Rock Canyon. Although surface remains indicated the presence of two rooms, excavation failed to yield further evidence of architecture. There were two occupations of the area, however, one prehistoric and the other 18th century.

All of the ceramics found at LA 12438 were of native manufacture, and neither metal nor glass was recovered. Although no bone artifacts were found, the faunal remains

Table 11.2
Eighteenth Century Sites

LA Number	Location	Type of Site
Sites Located on the East Side of the Rio Grande:		
70*	Rio Grande below White Rock Canyon	Three noncontiguous groups of rooms remodeled within confines of prehistoric pueblo. Rancho?
6178*	Rio Grande below White Rock Canyon	Rectangular enclosed structure with two torreones in opposing corners.
9139*	Rio Grande below White Rock Canyon	Single room; corner fireplace
12438*	Rio Grande below White Rock Canyon	Two occupations—one prehistoric. Two rooms?
12452	White Rock Canyon	Two to four contiguous rooms.
12466	Basin No. 6	One masonry room in addition to indeterminant number of possible rooms.
12469	Basin No. 3	Single masonry room.
13391	White Rock Canyon	One to two possible habitation units; seven to nine small storage structures: isolated wall.
Sites Located on the West Side of the Rio Grande:		
9138*	White Rock Canyon	Two occupations–one prehistoric. Seven structures and extensive network of basalt walls.
10110*	White Rock Canyon	Multicomponent. One to two indefinite rooms; extensive walls.
10111*	White Rock Canyon	Multicomponent. One possible room, extensive corrals.
12160	White Rock Canyon	One masonry room.
12161*	White Rock Canyon	Single masonry room, associated trash.
12162	White Rock Canyon	One room (?), possible corral.
12472	White Rock Canyon	Multicomponent. Campsites, scatters and walls.
12507*	White Rock Canyon	Single masonry room.
13055?	White Rock Canyon	Multicomponent; one to three masonry rooms, terraces, rock art. Date of occupation uncertain.
13381	White Rock Canyon	Two contiguous rooms.

* excavated or tested

indicated consumption on the site of a minimum of two sheep/goat, as well as a possible *Bos* among two other individuals.

The recovery of four cores of various local materials suggest that some manufacturing of stone tools was done at the site. Additional intrasite activity is indicated by the utilization of some of the debitage found during the excavation. In any case, it is clear that the site was not occupied for more than short periods of time.

LA 12507 – excavated by the Office of Contract Archeology, University of New Mexico (Chapman et al. 1977). The site was situated on the west bank of the Rio Grande downstream from the mouth of Bland Canyon. This site consisted of a single rectangular room and associated sheet trash. A slab-lined hearth was located in the northeast corner of the room. Constructed of basalt clasts, the room had 10.5 m^2 of floor space.

Unlike LA 12161, LA 12507 contained relatively little in the way of cultural remains. A minimum of six ceramic vessels of native manufacture was recovered with bowls and ollas equally represented. Only one bone artifact –a possible flesher–and five lithic artifacts were recovered—all of which suggest that minimal amounts of time had been spent at the site by those who used it.

The faunal remains, also few in number, included one sheep/goat, a small mammal, and one fish of unidentified species. No *manos*, metates, or comales were found to indicate on site preparation of any foodstuffs other than meats.

The paucity of cultural remains at LA 12507 indicate that the occupation of the site was temporary in nature. Since the sheep/goat remains were immature, they may indicate that the site was occupied primarily after the spring lambing season. Certainly, the presence of the corral-like structures approximately 140 m southwest of the main portion of the site suggest that herding was among the activities that took place at LA 12507.

Discussion

With the initial reconquest of New Mexico by the Spanish in 1692-93, and then final reconquest of 1696, the northernmost frontier of Mexico was permitted to redevelop. Among the differences that marked the 17th and 18th century occupations was a rapid increase in the number of Spaniards who wished to settle in the colony and, as a result, much of New Mexico, including the Cochiti area, became involved with disputes concerning land ownership. While the documentation for this area is not complete, enough is available to provide some insight into the activities of those living there.

In 1695, the La Majada Grant, which had been owned by Cristobal Fontes prior to the Pueblo Revolt, was given by Vargas to a Captain Jacinto Pelaez (Brayer 1939:119). Although revalidated several times, the fact that the southern boundary of the grant was given as the northern boundary of Santo Domingo immediately placed the owners in conflict with lands owned by Cochiti Pueblo. Within the La Majada Grant was a tract of land known as El Ojo de Santa Cruz (Brayer 1939:121). This was the area in which were located LA 70, LA 6178, and LA 9139–the southern portion of which lay within the bounds of the old Cochiti league, and thus could not be legally owned by the Spanish.

After passing through a series of owners, who may or may not have occupied the land (Twitchell No. 822), Diego Gallegos, *Alcalde Mayor* or Cochiti (Twitchell No. 185), who is also known to have borrowed land from the Pueblo, petitioned for land at Santa Cruz in 1731. The boundaries of the tract requested by Gallegos were, a small stone house on the north, the mesa on the east, Cochiti lands on the south, and the Rio Grande on the west. According to the petition, the land had been abandoned since 1680 (Twitchell No. 319). While it is tempting to equate one of the sites discussed above with the small stone house noted in Gallegos' petition, such one room structures as that at LA 9139 would be too close to the Rio Grande to fit the description. In any case, the petition was denied.

By 1744, Lt. Juan Jose Moreno petitioned for the area around Santa Cruz that Gallegos had once requested and, in his petition, stated that his activities would not disturb the grazing of the royal horse herd then in the area (Twitchell No. 733). To compound the matter, however, Moreno received his request within weeks after a portion of the Santa Cruz had been sold back to Cochiti. Whether Moreno lived in the area on either a temporary or permanent basis is not certain, but in 1755 when the land was given to Moreno's brother-in-law, Santiago Roybal, a house and corrals were included. It was further noted that the land was then being used for pasturage for cattle and horses (Twitchell No. 773).

Meanwhile on the opposite side of the Rio Grande, Antonio Lucero had petitioned in 1728 for lands that were bounded on the north by the old Pueblo of Cochiti (i.e., Kotyiti, LA 295), east by the Rio Grande, south by Cochiti, and on the west by the Jemez Mountains (United States Government 1884). This was the Canada de Cochiti Grant, and by 1765, forty settlers were in residence (Twitchell No. 1352). In 1776, however, Dominquez (Adams and Chavez 1956:159) reported the presence of 52 families with 307 individuals in residence.

One of these settlers, Miguel Romero, had died at his home in the settlement of Our Lady of Guadalupe in 1771 (Twitchell No. 792). Although apparently a trader and obviously wealthy, Romero's will dispells in part the myth that virtually no metal of any sort was available in New Mexico at this time: for example, two lances, two swords, four old hoes, one ax, one addice and one chisel were listed in addition to one branding iron and 33 knives (Twitchell No. 792). While admittedly the foregoing does not indicate tremendous quantities of metal, in another case, that of the will of a *Coyota* (half-breed) woman from Cochiti Pueblo, were listed among other items: six axes, four plowshares or points, an adze, two spades and two swords (Twitchell No. 185). In short, while metal tools were available, they were highly curated and as a result probably should not be expected to be found in any quantity in archeological sites –and certainly not in structures intended primarily for temporary occupation.

Romero's will is also of interest because of his involvement with the system of *partidario* whereby an individual, Indian or Spanish, held the right to work out an agreement with a stockowner to care for a specified number of livestock for a stated length of time at a reasonable rate of return for both parties. Prior to his death, Romero had given a *partito* of 24 cows and calves and three bulls to one Antonio Gallegos. At the end of five years, Gallegos was to return 40 cows and five bulls (Twitchell No. 792). Any surplus, of course, would belong to Gallegos. The result of such arrangements kept the annual caravan from New Mexico to Chihuahua, and eventually Mexico City, well supplied with livestock both on the hoof and in the form of hides, fleeces and some woven goods throughout the 18th and 19th centuries.

So great was the need for trade with Mexico, however, that the *partidario* system was frequently abused. By 1777, the situation was such that so many head of cattle and sheep were being exported that the economy suffered. As a result, Governor Mendinueta prohibited not only the export of livestock but also of raw wool and, at the same time, stated that the *partidario* was contrary to the public good (in Bloom 1927:230-231).

Whether the edict had much effect on the populace is uncertain—the *partidario* did not cease in any case. For example, less than ten years later when Don Juan Fernandez, then owner of the La Majada Grant, died, apparently while in Chihuahua on business, he had ten cows on *partito* to *an Indian at Santo Domingo* (Twitchell No. 280). When Fernandez' herds were counted after his death, his shepherd, Miguel Ortiz, reported a total of *552 sheep* including *'goats,' wethers, ewes, and lambs* on the La Majada. A recount decreased the number of sheep to 500 because the lambing season was not yet finished, but added 20 cows, 15 calves and heifers, four oxen and one bull to the livestock on the Grant (Twitchell No. 280).

In view of the above, then, there seems to be no question that among the Spanish population of the Cochiti area the raising of livestock was of significantly greater importance economically than other pursuits. The 18th century sites excavated, in addition to those located during survey but not excavated, reflect that bias. Because the landowners were frequently not in residence, little substantial architecture was necessary so long as shelter was provided for the shepherds and herders as they cared for the livestock. Since the flocks and herds moved continuously in search of graze and water, such shelters would be used on a temporary basis only. Those sites in the area with clearly associated stock pens and/or corrals may represent, on the other hand, special use sites for lambing or shearing activities; times when some separation of the herds is desirable. In view of the fact that as late as the 1880's, Zuni shearing corrals consisted only of *small poles fastened with rawhide* (Bourke in Bloom 1936:120), walls constructed of locally available basalt, such as found in the Cochiti area, appear considerably more practical if for no other reason than that they would require less maintenance and, therefore, a smaller investment of labor over the long run.

This is not to say, however, that agriculture was not practiced using either limited irrigation or dry farming techniques; it clearly was. In fact, in the late 19th century, Bandelier (Lange and Riley 1966:147, 156-157) noted what appeared to be irrigation ditches on the north side of the Canada de Cochiti (Rio Chiquito) and on the flood plain of the Rio Grande below LA 70 and LA 6178. Although in ruins at the time Bandelier saw them, they could have easily been constructed and used during the 18th century. As noted for the 17th century sites discussed above, agricultural endeavors apparently were limited and Dominquez' description of such attempts at Canada de Cochiti in 1776 should suffice as an indication of its success:

> *It* [Canada de Cochiti] *is a settlement of ranchos throughout the canyon, with lands of good quality by nature, but since the very small river that runs through the middle of the said canyon . . . always fails at the best season, as a result the farming is usually in vain. This leads to scanty crops, and the people are obliged to seek grain elsewhere. . .* (Adams and Chavez 1956:159)

Although unlikely in my opinion, it is not impossible then that a site such as LA 9139, located above the flood plain of the Rio Grande, could represent a field house intended primarily for shelter for agriculturalists rather than as shelter for shepherds or herders.

While the majority of all the 18th century sites in the Cochiti Reservoir area would fit into the parameters outlined for temporary habitations, several sites such as LA 70, LA 6178 and LA 12161 fall outside that range of variability. Although it is not inconceivable that the 18th century reoccupation of LA 70 functioned as a headquarters for one or another absentee landowner of the La Majada Grant or Santa Cruz Tract, there are too few data to warrant more than speculation about whom those individuals may have been. Certainly, the occupation was more extensive, and apparently intensive, than at most of the sites in the area.

The Torreon Site, LA 6178, stands out from the remainder of the 18th century sites simply by virtue of its obviously defensive construction. Probably occupied by the Cochiti garrison during the first decade of the century, the site was apparently periodically reoccupied until about the middle of the century. As such, it is possible that it functioned as a blockhouse or place of temporary refuge for settlers in the area. The lack of interior features, erosion notwithstanding, argues against the use of the site on an extended basis.

While LA 12161 possibly should remain anomalous, in my opinion, the obvious concentration of the occupation represents not a dwelling occupied on a year-round basis, but a structure which was instead occupied recurrently on a seasonal basis over an extended period of time. Admittedly, a portion of my bias is the result of the singularly small size of the structure. Moreover, the lack of such items as metates combined with a seeming overabundance of ceramics, specifically ollas, and certain types of tools such as the bone artifacts and spindle whorls, leaves an impression of preoccupation on the part of the inhabitants with certain tasks only, and not the result of continual, daily routine over the period of a full year.

While it appears highly probable that LA 9138, LA 10110, LA 10111, LA 12161 and LA 12507 were utilized by the owners or employees of the ranchos at Canada de Cochiti, and not necessarily by individuals living on either the La Majada Grant or on the Santa Cruz Tract (simply because of proximity), any attempts to relate known settlers in the area with the sites would be pure speculation and, as a result, of little value to this study.

Finally, the nine 18th century sites located during survey, which were not excavated, were evenly divided between the east and west sides of the Rio Grande. Of those sites, only two were not located in White Rock Canyon. Ranging in size and composition from scatters and campsites to sites of one to two rooms (in one case, perhaps as many as four rooms), the unexcavated sites are virtually identical to those discussed above. Taken as a whole then, the 18th century sites in the Cochiti Reservoir District reflect the successful redevelopment and stabilization of the Spanish frontier and its eventual extension via herding activities, into areas not known to have been utilized by the Spanish during the previous century.

NINETEENTH CENTURY SITES

Four of the sites excavated as the result of mitigation required for the construction and filling of Cochiti Dam have been identified as 19th century in date. Similar in many respects to the majority of the 18th century sites discussed above, the site elements are just as small and as frequently dispersed. All of the sites were apparently used for a continuation of the herding activities initiated during the 18th century. The fact that more of the 19th century sites located during the archeological surveys of the area were found on the east side of the Rio Grande (ten sites on the east side versus seven on the west), may reflect the fact that, while the Navajo continued to raid the area until mid-century at least, new settlements such as Pena Blanca may have provided an increase in protection for those not living in the rough terrain of the foothills of the Jemez Mountains. It is also just as possible that the difference in location of the sites reflects a seasonal use of the area not readily visible in the archeological record, with the east side being preferred for winter grazing.

LA 10114 -- excavated by the Office of Contract Archeology, University of New Mexico (Hunter-Anderson, Enloe and Binford 1979). This site was situated on the west side of the Rio Grande between Medio and Sanchez Canyons. A multicomponent site, LA 10114 consisted of a single room, isolated wall fragments, and a series of petroglyphs, some of which were definitely historic. The room was subrectangular in plan and a probable firepit was located along the west wall. An ash deposit over the floor suggests that the structure had burned. An exterior hearth and possible storage units were found in the talus around the site.

While prehistoric ceramics found at the site indicate probable prior usage of the area, the primary occupation occurred during the historic period. In fact, because of the preponderance of Ogapoge and Puname Polychromes (seven and three vessels represented, respectively); types usually considered not to appreciably post-date 1800 (Warren 1977a:100) LA 10114 is, in my opinion, probably 18th century in date rather than 19th century.

In any case, the lithic assemblage was varied and contained a mano and milling slab in addition to five cores and two complete unifaces and incomplete bifaces. With the exception of one core, all of the larger artifacts were recovered from the area outside the structure indicating an exterior work area and either intentional disposal or loss during periodic cleaning.

The faunal remains recovered from exterior test trenches suggest, along with the prehistoric ceramics, that there had been an earlier occupation of the site. In addition to the remains of the three sheep goat found at the site, large to small artiodactyla and other mammals were also recovered. All were apparently butchered and consumed on the site. Thirteen bone tools included in the faunal remains found at LA 10114 suggest that skinning, hide preparation and sewing were among the activities carried out by the occupants.

In short, except for the quantity of the cultural remains recovered, LA 10114 and LA 12161 are similar in most respects and possibly represent identical roles within the sphere of the Spanish frontier in the Cochiti area.

LA 12449 – excavated by the Office of Contract Archeology, University of New Mexico (Chapman et al. 1977). The site was located on the east side of the Rio Grande approximately 1.5 kilometers north of Medio Canyon. This site consisted of a single structure (in an excellent state of preservation), a trash deposit, and associated corrals.

A beehive-shaped fireplace was located in the southwest corner of the room. Shelves were found in the northwest and southwest corners of the structure while a cupboard (made of a packing box) was hung along the north wall of the room. In addition, several nails with wire or leather on them were found in the bond beams, thus indicating further storage.

Virtually all of the historic artifacts found at the site indicate occupation from the last decades of the 19th century to as recently as the first decade of the 20th century. Included in the inventory were square, wire, and cut nails; one tobacco can; a cartridge case and percussion caps; fragments of leather including footgear; a lard bucket; pocket knives; and sheepshears. The faunal remains included sheep goat and possibly antelope bones. All butchering had been done using metal tools.

No food processing items were recovered and, in view of the cans found, probably were not required by the occupant(s). That the site was intended for periodic occupation, probably by a shepherd, seems certain.

LA 12465 - partially excavated by the Office of Contract Archeology, University of New Mexico (Chapman et al. 1977). The site was situated on the east bank of the Rio Grande downstream from the mouth of Bland Canyon. A multicomponent site with possibly associated corral-like structures, the primary (?) habitation unit was constructed to utilize a natural overhang. No interior features were found in the shelter.

While the majority of the ceramics recovered were historic, fragments of two prehistoric ollas and one bowl were also found. Of the nine fragmentary historic ollas, all date to the 18th century. Other cultural remains included a Spencer Carbine Winchester cartridge, a four-hole metal button, a four-hole button made of milk glass, a domed copper button, what may have been a spring from a flintlock rifle, and fragments of an amber beer bottle. The faunal remains were scanty but included *Bos/Bison*, sheep/goat or antelope, and woodrat. The latter, of course, need not have been directly related to the human occupancy of the site.

While LA 12449 and 12465 are potentially at least partially contemporary, the cultural remains recovered from the two sites varied considerably which suggests that the activities that took place within the sites also may have differed considerably. Certainly LA 12465 appears to have been occupied less frequently and for shorter periods of time than the more substantial structure. The specific difference in the activities which may have occurred at either is not certain, however.

LA 13291 – excavated by the Office of Contract Archeology, University of New Mexico (Schutt 1979c). The site was located on the east side of the Rio Grande east and slightly south of LA 12449. The site consisted of four noncontiguous rooms and a series of short walls. All of the rooms had been constructed to utilize the available overhang provided by a number of large boulders – a situation similar to that found at LA 12465. Firepits were found in two of the rooms, but not in the others. Rodent activity was encountered throughout the area.

The ceramics recovered from the site represented a minimum of 43 vessels although only 195 sherds were found. The sherds included types in use in the area from ca. 1325 to 1920, with the majority being late 18th early 19th century in date. Jars were more numerous than bowls.

The lithic assemblage included two manos and one unshaped mano fragment; however, no metates or milling slabs were recovered. Two hammerstones, an abrader, four cores and seven facially retouched tools, including three bifaces, were recovered in addition.

The faunal remains consisted of more than 700 bones primarily representative of medium to large mammals in addition to small rodents and rabbits. A minimum of three deer was also found. The domesticates consisted of a minimum of three *Bos/Bison* and four sheep/goat. Butchering marks indicated that both stone and metal tools had been used at the site. Included in the faunal assemblage were seven bone tools, types which suggest that skinning, hide preparation and sewing were among the activities which had taken place at the site.

Flotation samples taken from the two rooms contained *Portulaca*, *Amaranthus*, *Chenopodium*, *Euphorbia* and *Opuntia* seeds in some quantity. However, because of the rodent activity at the site, in my opinion, the sample may not actually reflect the foods consumed by the human occupants of the site.

LA 13291, is, then, not dissimilar to many of the late 18th/early 19th century sites excavated in the area and, as such, probably represents a continuation of the earlier 18th century herding activities in the area.

Table 11.3

Nineteenth Century Sites

LA Number	Location	Type of Site
Sites Located on the East Side of the Rio Grande:		
12433	White Rock Canyon	Artifact scatter: some material 20th century.
12449*	White Rock Canyon	Single room. Continued use in early 20th century.
12453	White Rock Canyon	Single room possibly used in 20th century.
12458	White Rock Canyon	Artifact scatter, some 20th century material.
12465*	White Rock Canyon	Seven masonry structures; corral.
13291*	White Rock Canyon	Four noncontiguous rooms, short walls, probably primary occupation in late 18th century.
13304	White Rock Canyon	Two corrals constructed of masonry, juniper and wire; hearth.
13309	White Rock Canyon	Single masonry room; corral; occupation continued into 20th century.
13320	White Rock Canyon	Corral.
13360	White Rock Canyon	Corral constructed of masonry, barbed wire.
Sites Located on the West Side of the Rio Grande:		
10114*	White Rock Canyon	Single room, isolated wall fragments. Probably occupied during the 18th century.
12485	White Rock Canyon	Sheep pen, artifact scatter.
12489	White Rock Canyon	Masonry structure.
13046	White Rock Canyon	Masonry corral.
13367	Ancho Canyon	Masonry room; corral.
13369	Ancho Canyon	Masonry room.
13377	White Rock Canyon	Artifact scatter.

* excavated or tested

Discussion

During the 19th century, the Cochiti area was the scene of considerable activity, particularly so after New Mexico gained territorial status in 1846. What is more interesting, however, is that the sites excavated reflect relatively little of that activity. Throughout most of the century, herding was to retain its position as the leading industry of the area even though new pursuits were eventually introduced.

In April of 1800, Paulo Montoya, then owner of a portion of the La Majada Grant, filed suit against Miguel and Manuel Ortiz for the destruction of his property and the exhaustion of springs by having too many head of livestock in the area (Twitchell No. 603). The Ortiz's replied that their sheep were not under their control but on *partito* and, as a result, their care was the concern of the herders. In this case, the Governor found in favor of Montoya stating that, since only 1400 varas of land were under discussion, the large number of livestock pastured there could not help but cause damage (Twitchell No. 603).

Miguel Ortiz had purchased his portion of the La Majada in 1785 from the heirs of his old employer, Don Juan Antonio Fernandez (Twitchell No. 663). His parcel contained 200 varas of cultivated land and 500 varas of uncultivated land and was located on the banks of the Santa Fe River as it left the mouth of the canyon near La Bajada. As the result of the location of the Ortiz tract, it is tempting to speculate that either Ortiz or one of his shepherds was responsible for the reuse of the 17th century site of LA 34 as a corral. However, because of that site's proximity to the 19th century town of Pena Blanca and herders there, any such speculation would be just that.

In 1803, the Governor of New Mexico received a royal order from Mexico City stating that, because too many sheep were being exported (between 25,000 and 26,000 per annum), other pursuits were being neglected. As a result, master weavers were sent to New Mexico with modern looms and other implements in order to promote that industry (Bloom 1927:234). Whatever the impact these master weavers may have had--Boyd (1974:200) suggested that it was probably minimal--the industry was to change anyway with the opening of the Santa Fe Trail in 1821.

The first major opportunity for change in over a century came with the opening of the Santa Fe Trail when New Mexico became exposed to the effects of the industrial revolution via the goods offered for sale by Anglo traders. While this force had immediate, tremendous impact on one level--that is, within the towns of Santa Fe and Albuquerque--drastic change was not to be felt in the more rural areas for decades. At least initially such items as bleached and unbleached cotton yard goods *enjoyed the greatest sale* (Carrol and Haggard 1942:119; Quaife 1926:105-106). The increasingly widespread availability of cotton fabric, of course, lessened the demand for locally produced woolen goods. While the large scale raising of sheep by private entrepreneurs for meat and export continued well into the 20th century, the long range effect of the Santa Fe Trail was to cut the size of the local herds and eventually alter a major portion of the rural economy. This reduction was to lag in such regions as the Cochiti Reservoir area, however, because of an apparent lack of alternative economic strategies.

Of even greater importance, however, was the change in ownership status of many lands which occurred as a consequence of the ratification of the Treaty of Guadalupe Hidalgo in 1848. This treaty formally transferred governmental jurisdiction of the area from Mexico to the United States with the consequence that many lands formerly available for grazing were withdrawn from public or private use and placed under the control of the Territorial government. In some cases, such lands were transferred to corporate control as well, such as ownership by the Santa Fe Railroad (*cf.* Brayer 1939:20-31; Swadesh 1974:68-72; Weigle 1975:213).

A major result of these jurisdictional changes was the effective loss of grazing land which played a fundamental role in producing economic change, particularly in rural areas such as the Cochiti Reservoir region.

In addition, those newcomers to New Mexico introduced new strategies: for example, during the latter part of the 19th century, a portion of the Santa Cruz Tract along the Rio Grande became known as the Boom where, during the summer, logging activities took place (Harrington 1916: 441). Also, about the same time, there was a renewal of interest in mining which had resulted in large part from technological advances offered by the Anglos. The results of such interest can be seen in the development of such short-lived communities as Bland and Abermarle located in the Jemez Mountains north and west of Cochiti Pueblo. Finally, the extension of the railroad into New Mexico provided not only a tremendous improvement in communication, but also the impetus for an increase and diversification in merchantilism and other forms of economic specialization.

It must be noted however, that all of the above potential was not only introduced by representatives of the new government, but also was controlled by them. Thus, the indigenous population of the Territory, which now included the Spanish, was forced to adopt a new role--in essence, that formerly held solely by the Indians during the previous effort at colonization. The result was to renew the evolution of the frontier. Therefore, the fact that the majority of the 19th century sites found in the Cochiti Reservoir area exhibited virtually none of the impacts or change briefly discussed above is not without precedent. Until the indigenous populations became integrated into the sociocultural milieu of the newly intrusive group, major change would not be evident in those sites occupied by members of the former group, particularly if they had relatively little to offer on an economic basis.

Were it not for the fact that the Cochiti area became part of a new frontier, the area may have remained culturally stable indefinitely. With the exception of the few recent artifacts recovered from LA 12449 and 13291, the 19th century sites are virtually identical to those occupied during the 18th century. Moreover, except for the quantitative differences in the cultural remains found, the sites continue to reflect activities primarily related to herding.

From survey documentation, the unexcavated 19th century sites appear to be identical in most respects to those sites selected for excavation. Although it cannot be absolutely determined in all cases whether the unexcavated sites represent the herding subsystem, their content and location leads to speculation that they reflect such seasonal use of the area.

Admittedly, the sample is biased by the constraints imposed by the boundaries of the survey area. Because all but two of the sites were found in White Rock Canyon, however, suggests that their location was not fortuitous. The fact that corrals were found in association with several of the sites--both excavated and unexcavated--leads to further speculation that they were sites intended for special uses. That more corrals were found on the east side of the Rio Grande than on the west side may reflect topographic or other considerations, such as the Navajo who were known to frequent the area. While the data at hand do not allow more than speculation, these and other such questions should be considered for future work in the area or for work done in similar situations.

TWENTIETH CENTURY SITES

Although two of the 19th century sites which were excavated during the Cochiti Reservoir Project contained materials of 20th century manufacture, no sites that were purely 20th century in date were dug. However, 22 such sites were located during survey and, while few definitive statements are possible, some observations about them may be of interest.

There appears to be a definite difference between the types of sites located on the east and west sides of the Rio Grande. Of the fourteen 20th century sites found on the west sides of the survey area, eight, and possibly nine, represent campsites. Only one such site was located on the east side of the river. The difference can almost certainly be attributed to (1) the presence of Bandelier National Monument and recreational facilities provided by the National Park Service, and (2) the very obvious environmental differences between the two sides of the river. The location of Bandelier can probably also be used to explain a cairn and trail found in White Rock Canyon.

The fact that fewer 20th century sites (a total of eight) were found on the east side of the Rio Grande, and the fact that they tended to be somewhat earlier in date, can probably be attributed to numerous boundary disputes that have occurred in the area (*cf.* Brayer 1939:118-122), and the fact that much of the east side of the river is now administered by the United States Forest Service.

While it is possible that the number of sites on the east side of the Rio Grande will increase in the future as the result of recreational use of Cochiti Lake, in my opinion, the predominant use of the west side of the river will continue—simply because of the scenery and recreational potential offered by Bandelier National Monument.

Table 11.4
Twentieth Century Sites

LA Number	Location	Type of Site
Sites Located on the East Side of the Rio Grande:		
12435	Rio Grande below White Rock Canyon	Campsite -- 1950-1975.
12437	Rio Grande below White Rock Canyon	Leanto – 1950-1975.
13011	Santa Cruz	Artifact scatter/Boom?
13059	White Rock Canyon	Cave site with masonry dividing wall.
13306	White Rock Canyon	Semisubterranean room; ovens -- 1900-1915.
13357	White Rock Canyon	Possible corral.
13359	White Rock Canyon	Five hearths, corral -- 1950+.
13451	White Rock Canyon	A-frame; leanto; corral -- 1950+.
Sites Located on the West Side of the Rio Grande:		
12472	White Rock Canyon	Multicomponent. Campsites, scatters, isolated wall.
12473	White Rock Canyon	Campsite – 1950-1975.
12474	Bland Canyon	Isolated wall.
12475	White Rock Canyon	Campsite – 1950-1975.
12476	Sanchez Canyon	Campsite -- 1950-1975.
12477	White Rock Canyon	Campsites.
12484	White Rock Canyon	Campsite.
12487	White Rock Canyon	Campsite.
12488	White Rock Canyon	Structure, masonry.
12493	White Rock Canyon	Campsite.
12500	White Rock Canyon	Artifact scatter; fire-cracked rock.
13289	White Rock Canyon	Cairn, trail – 20th century.
13366	Ancho Canyon	Artifact scatters.
13458	Capulin	Juniper and barbed wire corral.

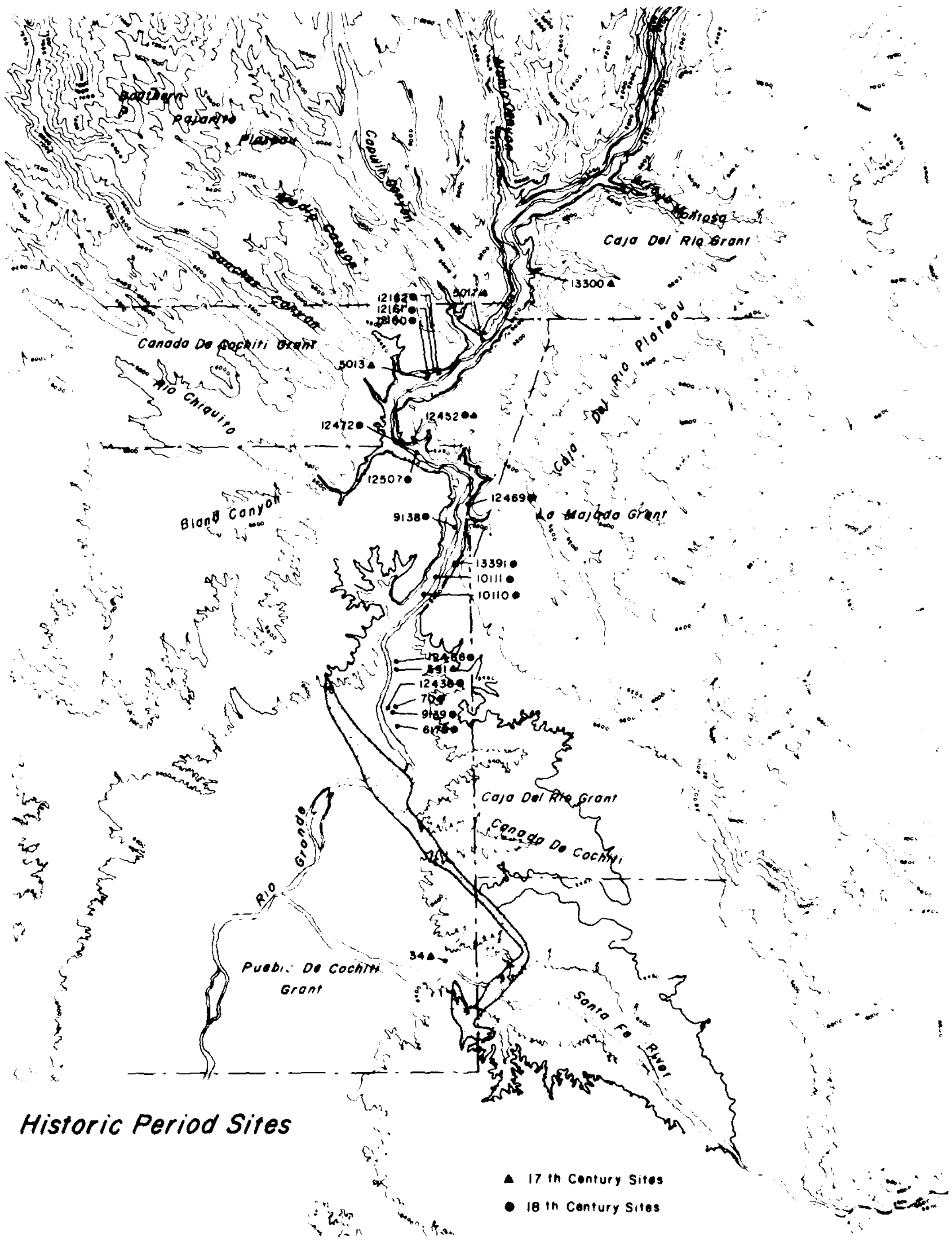

Fig. 11.1 Location of 17th and 18th century sites in the southern portion of Cochiti Reservoir (Santa Fe River to Alamo Canyon)

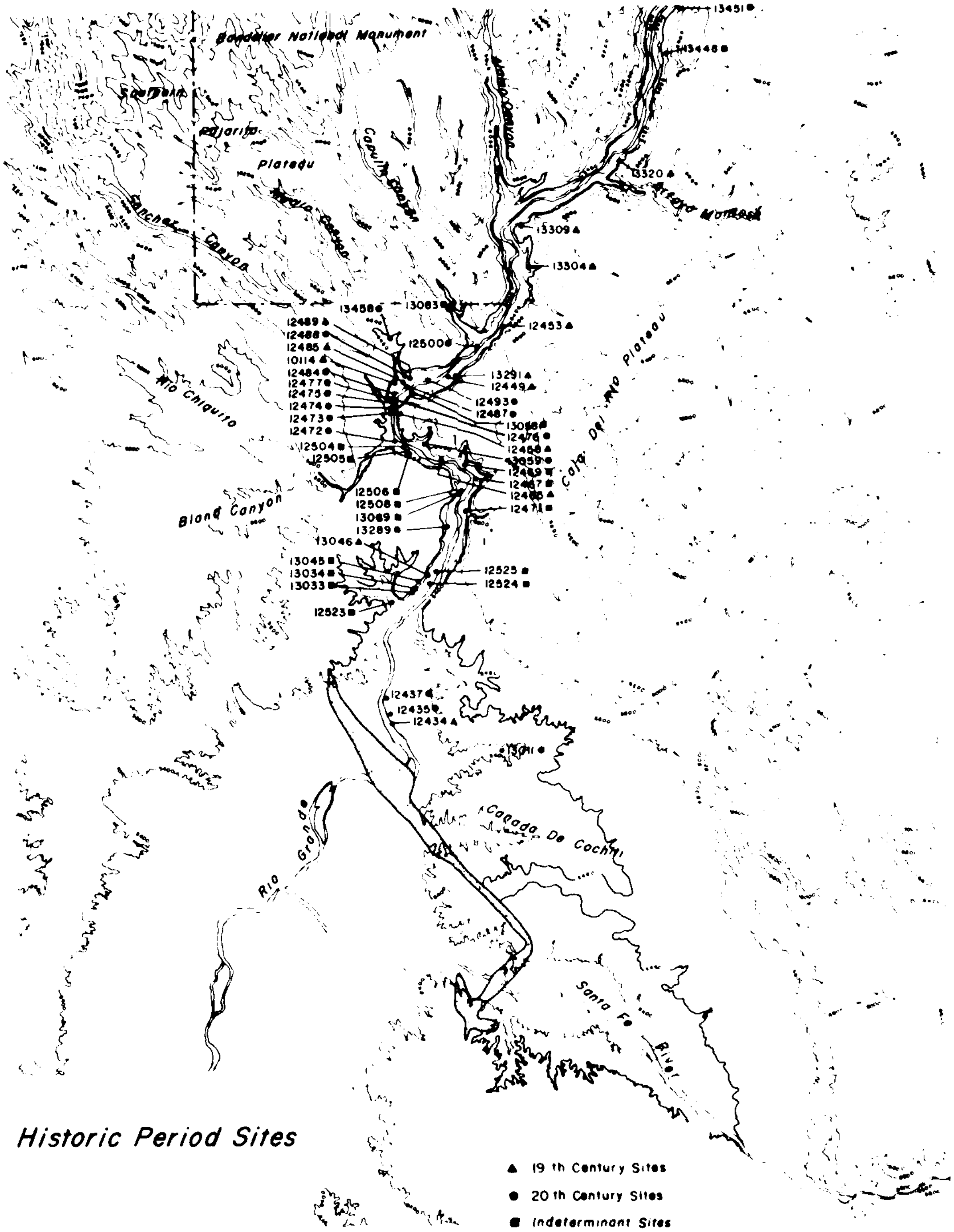

Fig. 11.2 Location of 19th and 20th century sites in the southern portion of Cochiti Reservoir (Santa Fe River to Alamo Canyon)

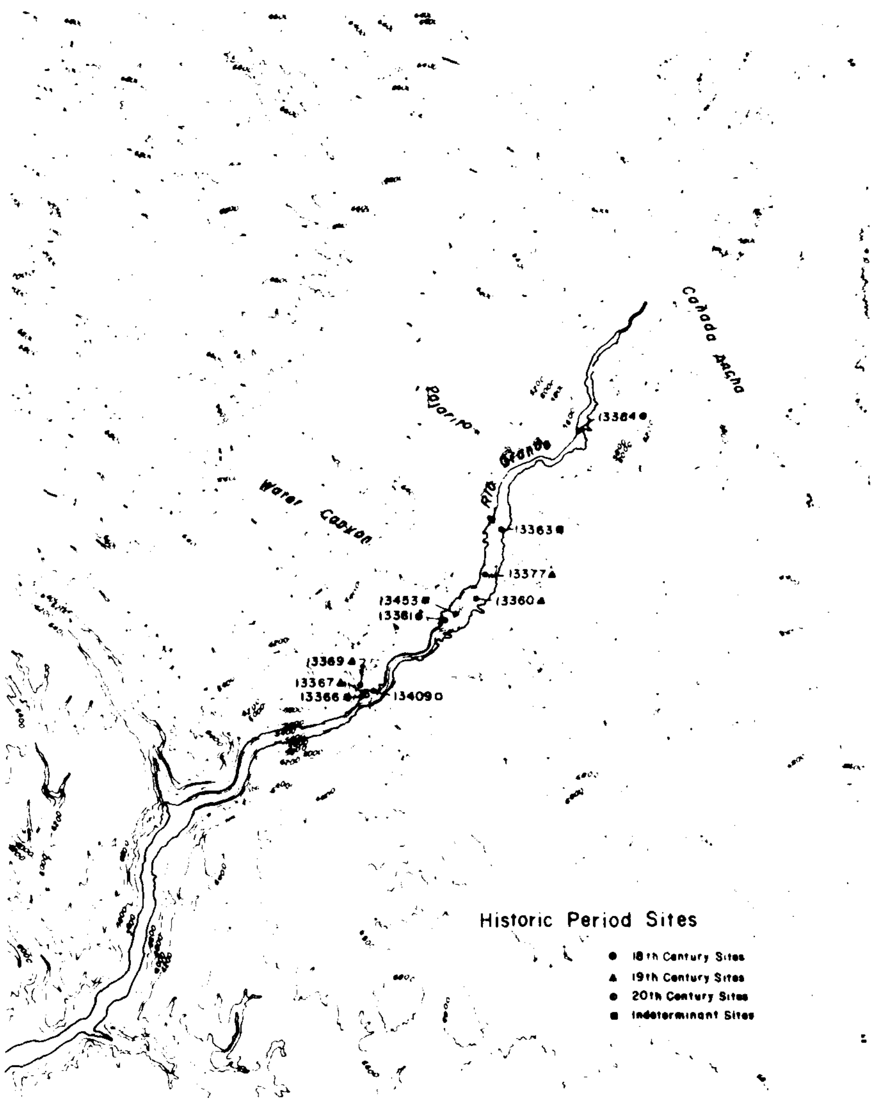

Fig. 11.3 Location of 18th, 19th and 20th century sites in the northern portion of Cochiti Reservoir (Ancho Canyon to Canada Ancha)

MISCELLANEOUS SITES

Twenty sites were located during the archeological survey of the Cochiti Reservoir District which, while probably historic in date, must be placed into an indeterminate category because of the lack of any otherwise positively identifying characteristics. One of those sites was excavated.

LA 12524 – excavated by the Office of Contract Archeology, University of New Mexico (Chapman et al. 1977). The site was situated on the west side of the Rio Grande north of the mouth of White Rock Canyon. The architectural remains at the site consisted of five non-contiguous, essentially circular structures constructed of locally available basalt boulders and clasts. Although interior features were not found in the majority of the rooms, a burned area was present in the corner of one unit.

No ceramics or bone artifacts were recovered during the excavation, and the lithic assemblage consisted of a total of three pieces of unutilized debitage. The faunal remains were limited to a small mammal, one sheep/goat and one positive goat—the first such identified in the Cochiti Reservoir area. The presence of the latter two individuals are responsible, for the most part, for the determination of the period of occupancy of the site.

While Chapman et al. speculated (1977:359) that "*the*

Table 11.5
Sites of Indeterminant Date

LA Number	Location	Type of Site
Sites Located on the East Side of the Rio Grande:		
12459	White Rock Canyon	Brush corral.
12467	Basin No. 4	Semicircular walls.
12471	Basin No. 3	Two contiguous masonry rooms.
13058	White Rock Canyon	One room; hearth.
13363	White Rock Canyon	Masonry and brush corrals.
13448	White Rock Canyon	Corral; two noncontiguous structures; one subterranean structure.
Site Located on the West Side of the Rio Grande:		
12504	White Rock Canyon	Corrals.
12505	White Rock Canyon	Masonry structure.
12506	White Rock Canyon	Wall -- 40 m in length.
12508	White Rock Canyon	Single room, two corrals.
12523	White Rock Canyon	Corral.
12524*	White Rock Canyon	Five noncontiguous structures.
12525	White Rock Canyon	Two contiguous rooms, walls.
13033	White Rock Canyon	One room; two ovens (?).
13034	White Rock Canyon	Two rooms.
13045	White Rock Canyon	One structure; wall.
13069	White Rock Canyon	Isolated wall.
13083	Capulin	Masonry structure.
13409	Ancho Canyon	Single room.
13453	Water Canyon	Two contiguous rooms; one isolated room; terraces.

* *excavated or tested*

shape and construction of the features are suggestive of 'Navajo' structures documented elsewhere in northern New Mexico", that must remain conjectural. There is no doubt that the Navajo were active in the area as late as the mid 19th century (Lange and Riley 1966:139,158, 165-166) but, evidently, most of their time was spent raiding, and not herding or practicing agriculture as other groups of Navajo were doing elsewhere at the same time. In fact, the raids were such that they caused the La Majada Grant to be temporarily abandoned after 1818 (Brayer 1939:118).

While the appearance of a camp designed for activities preparatory for, or used as the result of, a raid upon a pueblo or other settlement is not well documented, structures appear, to me, to be unnecessary. In fact, unless previously abandoned structures were used, the act of constructing anything more than the most rudimentary shelter appears too time consuming in view of the desired results of the planned activity—that is, to get into and out of an area as quickly as possible in order to avoid detection and perhaps failure of the raid.

OTHER SITES – The majority of other miscellaneous sites assigned to the Historic period are represented by a range of isolated corrals, isolated structures which may have been used for temporary habitations or camps, and occasional locales characterized by both corral features and possible habitation structures. While it is obvious that the corrals represent special use sites, much less can be said of the isolated structures which do not occur in conjunction with corrals. Whether they were used by herders, agriculturalists, Navajo raiders, or for some entirely different purpose simply cannot be determined at this time.

REVIEW AND DISCUSSION

To review briefly, of the 83 historic sites located within the Cochiti Reservoir District, two were definitely occupied during the 17th century while four other sites may have been utilized during that time. Eighteen sites, on the other hand, were inhabited or used during the 18th century. Of the four excavated sites occupied during the 19th century, three represent continued use from the late 18th century. Thirteen additional 19th century sites were located during the archeological survey of the area. Twenty-two sites were determined to be 20th century in date. Finally, 20 sites exhibit evidence of construction and/or possible use during the historic period but must remain indeterminate as the result of their lack of otherwise identifying features or remains.

Of the total of the seventeen sites excavated, dwellings ranged from single room structures with no hearths to a homestead of from 12 to 18 rooms with multiple hearths. Other interior architectural features included, in some but not in all cases, mealing bins, storage bins and cists, shelves and a cupboard. Exterior architectural features consisted of occasional hearths and associated activity areas, stockpens and/or corrals—in two cases with associated structures--and occasional isolated walls.

The cultural remains consisted largely of ceramics where, in the majority of cases, ollas outnumbered bowls. Lithic assemblages varied in both quantity and content and showed evidence of a range of degree of familiarity with the natural resources of the area. The two definite 17th century and one late 19th century site which were excavated exhibited the widest variety in their cultural inventories, while the 18th century sites, for the most part, showed the least variety in the items recovered. Faunal remains consisted of both domesticates and non-domesticates, the majority of which evidently had been butchered and consumed on the sites. While both stone and metal tools had been used for butchering, only two sites, one 18th century the other other 19th century, showed evidence of almost total dependence upon the use of metal tools for that task.

With the exception of three sites, two of them 17th century and the other 18th century, obviously constructed with the intention of permanent, year-round occupancy, the excavated sites appear to have been intended for temporary habitation. Only one site in the Cochiti Reservoir area evidently was constructed for purely defensive purposes.

It is when the sites are considered in relation to the known historical documentation for the area that an adaptive response of a culture to the environment becomes most readily apparent, however. As noted above, land suited primarily for agricultural pursuits was not to be had in the area under consideration. Located well south of the mouth of White Rock Canyon, Cochiti Pueblo held virtually the only (and certainly the best) arable lands in the vicinity. In fact, even today Cochiti maintains its fields, for the most part, south and east of the Pueblo, and while irrigation ditches were noted by Bandelier on the north side of the Canada de Cochiti Grant and in the vicinity of LA 70 and 6178, in both cases they were situated on the respective flood plains rather than on terraces above the streams. In short, while agricultural pursuits were certainly undertaken by the Spanish, they could not be a primary means of support, particularly for those sites situated above the flood plain and away from permanent water. As a result, herding and associated activities became the leading in an otherwise limited choice of activities.

The problem then becomes one of the definition of the parameters of a herding economy in a frontier situation over three centuries. During the 17th century, there is evidence that some landowners and administrators maintained residences on their holding or close to the pueblos where they held positions. As a result, their homesteads, while they varied in size, were compact, more or less self-contained units frequently with corrals in direct association. Had the Pueblo Revolt not occurred and the *encomienda* been allowed to continue, such homesteads would probably have formed the nucleus of haciendas and an extension of the system of peonage found in Mexico. However, because the level of the frontier culture at Cochiti —and in similar areas throughout the colony—was less complex than that found within the Pueblo, a true frontier could not develop and the system eventually collapsed.

With the Pueblo Revolt and the subsequent reconquests of New Mexico by the Spanish, the *encomienda* ceased to exist and a land grant, and somewhat more equitable *partidario* system, took its place. At the same time, raids by the Navajo, Apache, Utes and others increased throughout the colony and, as a result, the character of the settlement pattern changed. Instead of more or less isolated, self-contained *ranchos*, habitations were frequently clustered—such as the settlement along the Canada de Cochiti—for defensive purposes. With a more equitable system, an increase in the number of settlers, and a common enemy, a new frontier began to develop.

Herds cannot be contained, however, and an adjunctive pattern emerged in the special use sites required for the protection and shelter of the shepherds and herders as they cared for the livestock in their charge. Multiroom dwellings were unnecessary as the herds and flocks were under the care of individuals, not family groups. Because the structures were not intended for permanent occupation, only the bare necessities of shelter and warmth were required. On the other hand, because of the movement required by the livestock, the number of such temporary structures proliferated, in part, in response to the increase in herd size and number of individuals required to care for the flocks.

With the development of the second frontier, the economy, while it did not exactly prosper, began to stabilize; that is, until the opening of the Santa Fe Trail and subsequent territorialization of New Mexico. With the new political subordination, a third frontier began to develop. Because the resource base of the Territory was seemingly limited, the evolution of this frontier was delayed until modern technological advances permitted the culmination of the process of colonization.

The herding economy of the territory state began slowly to assume less and less importance as the third frontier developed until it was almost completely replaced by an agrarian economy. As a result areas like the Cochiti Reservoir District were more or less abandoned until new uses could be found for them. While no longer a part of a frontier, one wonders, with the increased emphasis on recreation in the area, what will happen to the Cochiti area in the future.

Chapter 12
HISTORIC POTTERY OF THE COCHITI RESERVOIR AREA

A. H. Warren

INTRODUCTION

New ceramic traditions have been noted in historic pottery from archeological sites in the Cochiti Dam and Reservoir areas during the past decade. Pottery from the 17th, 18th, and 19th centuries were recovered during surveys and excavation of numerous historic sites in the region. Fieldwork was conducted by the Museum of New Mexico within the dam site between 1962 and 1966, and by the Office of Contract Archeology, University of New Mexico from 1975 to 1977, in the reservoir area, mainly within White Rock Canyon. Archeological investigations were under the supervision of the National Park Service.

The innovations in historic ceramic traits included pottery comales, flange bowls, ring-base vessels, fiber tempered pottery, mold-made vessels, mica slipped utility wares, as well as new vessel forms and decorative styles. The pottery was recovered from archeological sites believed to have been built and occupied by Spanish colonists according to historic records and archeological evidence. Analysis of the historic pottery of the Cochiti study area during the past ten years suggests that Spanish settlers introduced varied ceramic traits showing Mesoamerican influences and produced pottery for a period of almost 300 years.

Although Mesoamerican influences on the pottery of the historic Southwest have long been surmised, the nature of diffusion of new traits and their impact upon Puebloan pottery making in the Rio Grande have not been traced. Many questions remain to be answered concerning the historic pottery of the Cochiti study area. In this report, an initial chronological framework is suggested, based in part upon assemblage seriation and associations with dated pottery. A review of earlier work and a discussion of the possible importance of the archeological data is included, in hope of establishing background information for future research in this field.

PREVIOUS STUDIES OF HISTORIC POTTERY IN THE RIO GRANDE

In the centuries since A.D. 1540, there have been written accounts of the Pueblo peoples and their cultures, of the entradas and settlements of the Spanish explorers and colonists from the south, and more recently of the conquest of the American Southwest by the United States. There have been many gaps in our knowledge of day to day activities of those years and, for over a century, historians, ethnographers, and archeologists have been studying existing and former cultures of the Southwest. The ceramic record of former inhabitants of the Rio Grande region is rich and a good deal of attention has been given to the forms, the decorative styles, and the chronological sequences of the prehistoric pottery of the area.

In 1916, N. C. Nelson described *modern painted ware* that had been found on archeological sites dating in the 17th and 18th centuries. He recognized that the pottery was replacing the degenerative glaze decorated ware of that period. In the Cochiti area, he found it in considerable abundance at Pueblo Kotyiti (LA 295), which he excavated in 1912, and at the nearby ruins of Kuapa (LA 3444) along the Rio Chiquito.

The Modern painted ware at Pecos Pueblo was discussed in detail by A. V. Kidder (1931). The historic painted vessels were never common at Pecos, but contemporary bowls and jars of *Polished red*, *Polished black*, and *Plain gray* were plentiful.

In the 1930s, H. P. Mera named and described the matte paint (Modern painted) historic pottery of the Middle and Upper Rio Grande regions. Pottery made before the Pueblo Revolt of 1680 included Sankawi Black-on-cream, Potsuwi'i Incised, and Tewa Polychrome (Mera 1932, 1934, 1939). Pottery types produced after 1680 included Ogapoge Polychrome, Posuge Red, Pojoaque Polychrome, Kapo Black, and Puname Polychrome. Historic glaze paint wares described by Mera (1933) included late Puaray Polychrome, Kotyiti Polychrome, Cicuye Polychrome, and San Marcos Polychrome. Sherds and complete vessels from sites with tree-ring dates in the 17th and 18th centuries were studied and a chronology established for the various historic classes (Mera 1939). Mera found that Tewa Polychrome was primarily a 17th century ware, but that it did continue into the early 18th century. Ogapoge Polychrome appeared in the early 18th century and occasionally included red matte paint in the designs. Both were produced in the northern Tewa villages. Puname Polychrome, a mineral paint ware, was produced in the Zia villages from the 17th century into modern time.

More recently, F. H. Harlow has described in greater detail the macroscopic characteristics of the historic pottery of the Rio Grande Pueblos and has established several new classes, including Kiua Polychrome, a carbon paint polychrome of the Cochiti area made between A.D. 1750 and 1900 (Harlow 1970, 1973; Frank and Harlow 1974). All the historic wares discussed by Nelson, Kidder, Mera, and Harlow were believed to have been made by Indians of the Rio Grande Pueblos.

Pottery made in the Spanish colonial villages of the Rio Grande was studied and described by Hurt and Dick (1946), and later renamed by Dick (1968). These included Powhoge Polychrome, Casitas Red-on-brown, Carnue Plain, Kapo Black, and El Rito Micaceous Slip.

An overview of the history of the Middle Rio Grande from A.D. 1540 to present has been written by Abbink and Stein (1977) and provides a cultural and economic framework for the discussion of the historic events of the Cochiti study area. At least four unpublished manuscripts dealing with the historic pottery of the Cochiti study area were prepared and are on file at the Museum of New Mexico (Warren 1967a, 1967b, 1968, 1974a), and a summary of previous findings appeared in Pottery Southwest (1977d).

REGIONAL SETTING

The Rio Grande flows through White Rock Canyon, a gorge cut in high plateau country on the eastern edge of the Jemez Mountains; for 14 miles its channel has cut canyons from a few hundred to nearly a thousand feet deep, separating the rhyolitic rocks of the Pajarito Plateau on the west from the basalt mesas of Cerros del Rio on the east. Along the river and its western tributaries, narrow valleys edge the channels. The general aspect is one of desolate and inhospitable country. Only at the mouth of White Rock Canyon, near the modern pueblo of Cochiti and along the Rio Chiquito below Canada, are there tree-lined floodplains, agricultural fields, and gentle grassy slopes.

In this rugged country, the prehistoric and historic inhabitants built their homes and lived for many centuries. Foot trails, that are still used today, were built throughout the area, crossing mesas and contouring narrow canyons. Trade wares found at the ruins in the area attest to frequent contact with the peoples to the north and south, while local potters made their wares for domestic use.

The arrival of the first Spanish expeditions during the 16th century had very little impact upon the Cochiti study area. As far as we know, Kuapa (LA 3444), on the Rio Chiquito, and Tuyuoni (LA 82) on Rito de los Frijoles, were the only villages occupied during the early entradas, according to ceramic evidence available. The location of Cochiti Pueblo, which is listed by Onate as one of the Rio Grande pueblos in A.D. 1598 (Hammond and Rey 1953) is uncertain, for no pottery dating to this time period has been found at the modern site of Cochiti Pueblo. There is historic evidence that some of the Mexican Indians, who accompanied the Spanish expeditions remained behind in the Rio Grande area (Reilly 1974), but what cultural effect these had upon the Pueblos is subject to speculation only.

Colonization of the Rio Grande in 1598 was to bring numerous changes in the pottery of Middle and Upper Rio Grande region during the next 80 years. Glaze paint potters of the Middle Rio Grande began to make Salinas Redware, basically an undecorated glaze paint vessel (Toulouse 1949). Many of these vessels were used in Spanish colonial homes and missions. The glaze paints became increasingly runny, a characteristic of the Group F pottery of the second half of the 17th century. In the northern Tewa villages, potters began to produce polychrome and smudged wares, as well as plain redwares. Rare mineral painted polychrome vessels were being made in the Middle Rio Grande. In the Cochiti area, the ceramic assemblages of two Spanish homesteads dating to the mid 17th century, Las Majadas (LA 591) and Cochiti Springs (LA 34), reflected most of the innovations of this period.

During the Pueblo Revolt period (1680-1696), many changes in population distribution occurred within the Rio Grande. Many refugees joined the Navajos in the north. The Tanos of the Galisteo resettled at Santa Fe. The Cochiti moved up to *Old Kotyiti* (LA 295) on Potrero Viejo, where they were joined by other Pueblo Indians of the Galisteo. The ceramics of this period include the Group F glaze paint vessels, Salinas plainwares, and some Tewa polychrome.

Following the Reconquest, Spanish colonists settled in the Rio Grande region under a new land use system for New Mexico (Abbink and Stein 1977). Colonists included Mexican Indian families who emigrated from Mexico. Lands east and north of Cochiti Pueblo were settled shortly after A.D. 1700, on five separate land grants, including the Canada de Cochiti Grant on the Rio Chiquito. By A.D. 1750, there were at least six Spanish households in the area, and 40 families by 1760 (Adams 1954). The Cochiti had moved from their home on Potrero Viejo to the Rio Grande valley by 1696. Legend relates that they first settled on the east side of the river at Tipute and later obtained permission to move to the west side away from the flood danger (Benedict 1931).

METHODS OF INVESTIGATION

Historic pottery from sites in three geographic divisions of the Cochiti study area was examined. Three historic sites were on the La Majada Mesa, the open plains area south of Mesa Negra and east of the Rio Grande; five sites were in lower White Rock Canyon; and eight sites were along Rio Chiquito. Pottery from several historic Puebloan sites in the upper Middle Rio Grande have also been examined for ceramic types present, place of manufacture, vessel form and other attributes.

The ceramic assemblages came from excavated sites and from surface collections, and with one or two exceptions, all available material was analyzed. The analyses were by no means complete or comprehensive, being limited by the archeological data present. The 16 sites spanned a 200 year period, and individual sites often had unique features that were not evident at other sites. Since the ceramics from excavated sites have been discussed in detail elsewhere (Warren 1967a, 1967b, 1974a, 1977d), the present discussion will concentrate on the highlights of the studies.

Typology

During the initial studies of the historic pottery from the Cochiti study area, it soon became apparent that the existing classification for historic pottery of the Rio Grande would not provide an adequate framework in all cases; it has been necessary to use tentative descriptive categories during the analysis and interpretation of the sherd lots. Existing type names were used where applicable, and possible synonyms are noted; in other cases tentative groups or type varieties are used, until such time that ceramic, cultural, or chronological data is adequate to place the groups into a more formal typological framework (Table 12.1).

Temper Classes

Temper classes first established during the initial studies in 1967 have been used for subsequent studies, with new classes added as needed from time to time. The volcanic rocks of the Jemez Mountains provided a wide variety

Table 12.1

Formal Types of Historic Pottery

Type Name	Est. Dates	Description
	Glazewares	
Kotyiti G/Y, G/R, G-P (Glaze F)	1650-1700+	Duochromes more common than polychromes; long, parallel sided rims with exterior carina; ollas with sharply everted rims; shouldered bowls; soup plate forms; glaze paint runny; slips streaky.
	Carbon Painted Wares	
Tewa Polychrome	1675-1720	Fine line designs on polished white slips; red underbody; carinated bowls; vitric tuff temper, also crystal pumice.
Posuge Red	?1675-?	No designs; well-polished; vitric tuff temper, also sandstone.
Tewa Black-on-red	1680-?	Black carbon paint on red or pink surfaces; forms like associated historic wares; temper varied.
Kapo Black	?1650-?	Polished gray or black surfaces; vitric tuff or sandstone temper; if red slipped, then smudged.
Potsui'i Incised	?1450-1550	Geometric fine line incised designs, on smoothed tan surfaces; may have mica slip; vitric tuff temper.
Ogapoge Polychrome	1720-1800+	Carinated bowls, ollas; red matte designs; vitric tuff, crystal pumice tempers.
	Mineral Painted Wares	
Puname Polychrome	1680-1780+	Carinated bowls; jars; red, black paint; basalt, crystal pumice temper; rounded forms post 1780.
Casitas Red-on-buff	1740-1900?	Broad red line designs on polished buff surfaces; temper crystal pumice, sandstone, etc. -coarse-grained.

of suitable tempering materials. Intrusive wares from outside the study area added to the variety of temper types present. Usually, the temper groups were based upon mineral or rock identification using a stereomicroscope. Petrographic descriptions of slides were completed on numerous major historic temper types.

Analytical Methods

The steps undertaken during the analyses of the various sherd assemblages had four procedures in common:

1) Through use of mineral or petrographic analyses, observations concerning temper inclusions for each ceramic classification were made. Other pertinent attributes of each sherd or vessel were also monitored, including form, design, surface treatment, etc., depending upon the nature of the specimen.

2) Sherd lots, regardless of size, were considered to be random samples of a total original sherd or vessel population; no selective measures were used and sherd populations included either (a) all sherds from an excavated site, or (b) all surface sherds, with two exceptions which will be noted.

3) Similar measurements of attributes were obtained for each sherd within a class and frequencies of attributes determined.

4) Inferences concerning the distribution patterns of the ceramic attributes were made from the resultant data.

Subsequent research included literature searches which provided additional explanatory data. All archeological inferences are based upon the results of the current studies and upon previous archeological, historical, and ethnographic information available at this time.

HISTORIC POTTERY OF THE EXPLORATION AND COLONIZATION PHASES

Little is known of the pottery of the earlier Exploration Period (A.D. 1540-1598) in the Cochiti study area. The diagnostic pottery of this time period was Puaray Glaze-polychrome (Group E) which changed very little in appearance throughout the 16th century. However, the relatively low frequencies of this type at sites in the southern part of the area suggests that the Pueblo Indians there had left their homes, perhaps moving to sites on the northern Pajarito Plateau. This may have been part of a region wide exodus of the Pueblos from the upper Middle Rio Grande to villages at higher locations on the Pajarito, in the Jemez Mountains to the west, and the foothills of the Sandia Mountains to the east, during the late 1500s and early 1600s.

Historic records list Cochiti Pueblo as one of the Keresan Pueblos in 1598 (Hammond and Rey 1953), but no pottery of this period could be found either at the modern Cochiti Pueblo (LA 126) or at other Cochiti area sites. The Puaray Glaze-polychrome (G-P) pottery at Pueblo del Encierro (LA 70) is associated with tree-ring dates clustering around A.D. 1515-1520. Only Kuapa (LA 3444), located on the Rio Chiquito, appears to have glaze paint wares which might date to the turn of the 17th century; but to my knowledge, there are no Pueblo village ruins in the study which have produced late Puaray G-P (late Glaze E) pottery of the early decades of the 17th century except the Spanish homestead, Las Majadas, and possibly the Cochiti Springs settlement.

The absence of late Puaray G-P in the study area is curious, when we consider that the small Spanish homesteads on the east side of the Rio Grande may have been obtaining pottery made at a nearby Pueblo village during this period.

The Pottery of Las Majadas

One of the 16 historic sites in the Cochiti study area was occupied during the Colonization phase (A.D. 1598-1680). Las Majadas (LA 591), a Spanish homestead, dates to ca. A.D. 1620 to 1680. It was located on the east side of the Rio Grande, across from the present day Cochiti Pueblo. Las Majadas was excavated by the Museum of New Mexico in 1966. In the autumn of 1967, I began an analysis of the sherds recovered during the excavation. This was my first look at historic pottery in the Cochiti area although I had just completed analysis of the glaze paint wares of the Alfred Herrera site, a prehistoric site west of the river (Warren 1968).

The Las Majadas Site (LA 591) had a high percentage of 17th century glaze paint pottery, undecorated polished wares, and plain surfaced utility wares with polished interiors. A variety of exotic tradewares were also present. But of main concern here were a number of new or unusual ceramic forms, forerunners perhaps of the wares that were to become popular in the Rio Grande Valley after A.D. 1700, and other pottery types that were to appear only briefly.

Flange bowls, or *soup plates*, were common culinary vessels at Las Majadas. Made with the same clay and temper material as the Glaze F pots, these were named *Salinas Red*, and are believed to be made by Pueblo potters (Toulouse 1949:14-16). Some archeologists have thought the form to be of European or Spanish inspiration, but the flange bowl also occurs prehistorically in Mesoamerica (Rattray 1966) and could be a Mesoamerican Indian tradition. Flange bowls were also made with white slips, as at Pecos Pueblo, or with polished, smudged surfaces. Some were decorated with glaze paint, others with matte paints in the Tewa tradition.

Ring base or footed vessels. Fragments of two ring-base vessels were recovered at Las Majadas. One of these was decorated with carbon paint, similar to Sankawi Black-on-cream, and the other had an overall green glaze. Toulouse (1949:19) described a footed vessel from the 17th century mission at Abo. The cup or *chalice* had a mineral paint design on a white background and was classified as Tabira Black-on-white. Ring-base vessels appeared in Preclassic time in Mesoamerica and are a common bowl form in the Coyotlatelco pottery of the Classic period, A.D. 300-900, in the Valley of Mexico (Rattray 1966:117). The form is also characteristic of Thin Orange, a ware from Mixteca, and has been found in burnished monochrome at Amantla of Classic time, and been reported from the middle Archaic (Tolstoy 1958:25). The earliest reported occurrence of ring-base vessels is on the coast of Equador ca. 1500 B.C. (Ford 1969:117).

The Sankawi B/C ring-base vessel was tempered with crystal pumice, a frothy volcanic glass common in the Jemez Mountains, and was probably made in the Cochiti area. The green glazed vessel was tempered with rhyolite tuff which might be of local origin; however, rhyolite tuff was also used as temper by potters making Mexican green glaze in Chihuahua, and no petrographic slides were made to distinguish mineralogical varieties.

In addition to the ring-base green glaze vessel, sherds from an overall green glaze pitcher were found at Las Majadas. This was also tempered with rhyolite tuff, so its origin is uncertain. Green glaze vessels were common in Northern Mexico from about A.D. 1680 to the mid 1800s. Gerald (1968) reports that the glazes were made locally at many presidios in the border region.

Plain polished redwares, including locally made Salinas Red carinated bowls, *soup plates*, jars, and pitchers, first appeared in the Middle and Upper Rio Grande in the 1600s. The undecorated redwares are found to be most common at Spanish Colonial homes or missions in the Middle Rio Grande, but may have been made by Pueblo potters. It is possible that potters among the Spanish settlers used local clays and temper, however.

Other redwares intrusive to the Cochiti area included a small olla or jar from the Acoma area. The well polished red vessels from the Acoma area have occasionally been mistaken for the intrusive redwares of the Valley of Mexico. Also present were Posuge Red and San Juan Tan-on-red vessels, which were made in the Tewa country during the 17th century.

Several vessels of Sankawi Black-on-cream, an historic Tewa ware, had been present at the site. At least two had crystal pumice temper and were probably made locally. Other 17th century Tewa wares included a possible Tewa Polychrome olla and Kapo Gray vessels.

Exotic forms included a *soup plate* from Hopi and a black-on-red vessel from the Valley of Mexico.

The utility wares of the Rio Grande also saw changes in style and technology during the Colonization Period. Interiors of jars were polished, sometimes slipped or smudged. Exteriors were occasionally striated, as those described by Kidder (1936) at Pecos. About 10% were mica slipped. Hayes (in press) described the development of plain utility wares at Gran Quivira and named it Corona Plain. Temper changes from earlier corrugated utility wares were also noted. Except for the presence of mica slips on some vessels, the utility wares of Las Majadas are indistinguishable from the Corona Plain vessels at Gran Quivira, a contemporary village abandoned in the 1670s. The plain and striated utility wares at Las Majadas are tempered mainly with andesite vitrophyre but the mica slipped wares are usually tempered with fine-grained metamorphic rock, although a small percent contain local andesite temper.

The presence of numerous pottery spindle whorls at Las Majadas is one more indicator of innovation in the Rio Grande during the 17th century Colonization Period.

Approximately 10,000 potsherds were recovered during excavation of the Las Majadas site; of these, over 1,500 rim sherds were examined and classified by pottery and temper types. The frequencies of pottery types within the rim counts differed slightly from a traditional count of all sherds from the site; in particular, there was a higher percent of utility sherds in the total assemblage, with a concomitant decrease in frequency of sherds of polished plainware. It is possible that the rim counts give a more accurate estimate of vessel ratios, while total sherd counts reflect total vessel capacity. Since glaze classification and chronological refinements are based primarily upon rims, analysis of rims only was selected as a sampling method.

In summary, the Colonization Phase brought new ceramic traditions to the Rio Grande region, many of which were to continue into the next century or two of pottery making in the Southwest. These included (1) *soup plates* or flange bowls; (2) ring-base bowls and cups; (3) carbon paint and mineral paint polychrome vessels; (4) polishing of utility vessel interiors and occasional exterior mica slips; (5) smudged wares; (6) undecorated polished plainwares; and (7) numerous form changes. On the other side of the scale, the technique of decorating pottery with lead glaze paint was about to disappear from the ceramic traditions of the area after nearly 400 years of production.

HISTORIC POTTERY OF THE *PUEBLO REVOLT AND RECONQUEST PHASE*

The Pueblo Revolt of 1680 resulted in the complete abandonment of many of the Rio Grande towns. Some of the Pueblos, like the Cochiti, built homes on high plateaus, in defensive positions. As the attacks of unfriendly nomads and repeated punitive expeditions of the Spanish from the south continued, some of the Pueblos fled to the northwest and joined the Navajo Apache. A few rooms in ruined pueblos that had been unoccupied for 100 or more years were renovated, perhaps as field houses, for crops had to be planted and tended in the valleys below. No sites of this period were found in White Rock Canyon, but several were occupied along the Rio Chiquito and on La Majada Mesa.

The Puebloan pottery of the Revolt and Reconquest period was varied. At Kotyiti Pueblo (LA 295) on the Potrero Viejo, Glaze F vessels, mainly of local production, constituted almost one-half of the ceramic assemblage. Nearly as many were undecorated Salinas Redware, indicating that glaze paint was falling into disuse. Some intrusive wares from the Zia, Galisteo Basin and Pecos pueblos were present; possibly some had been brought by refugees from the Galisteo villages who joined the Cochiti on the Potrero after the Revolt. Sherds of Tewa Polychrome, Tewa Red, and Kapo Black were also present at Kotyiti, suggesting contact with the Pueblos to the north. According to historic record, the site was abandoned in 1693, after having been burned by De Vargas, and its occupants returning to their former home along the Rio Grande.

Basalt Point Mesa (LA 2047) at San Felipe was built ca. 1693, and was abandoned shortly after A.D. 1700. The plain polished wares at the site predominated over the glaze wares. Glaze F from Pecos, Cochiti, and the Galisteo, and Tewa Polychrome and Kapo Black were the main intrusives. Plain and mica slipped utility wares were locally made. An occasional *soup plate* form was noted.

The Canjilon Pueblo (LA 2049), reported to be an ancestral home of the Santa Ana, was probably contemporary with Basalt Point Mesa. Plain polished sherds from bowls and ollas predominated. Glaze sherds present were all from intrusive vessels from the Cochiti, San Felipe (?), and Galisteo Pueblos. Plainwares were probably made locally and contained a very fine-grained, light to medium grained basalt temper.

Production and use of glaze paint pottery continued throughout the Revolt period in the Cochiti study area, but had probably ceased around the turn of the century. By the time Spanish settlers had moved into the area shortly after 1700, local production of glaze paint pottery had ceased.

HISTORIC POTTERY OF THE COLONIAL, MEXICAN, AND TERRITORIAL PHASES

During the early decades of the 18th century, Spanish colonists settled along the Rio Grande in White Rock Canyon and along the Rio Chiquito in the Canada de Cochiti settlement. By 1760, there were at least 40 households totaling 140 Spanish citizens in the area north of Cochiti Pueblo (Adams 1954:65). Bishop Tamaron, who visited the area in that year, speaks of *Europeanized mixtures* who lived on the west side of the Rio Grande.

These settlers brought with them new and varied pottery traditions that were to continue in the area for nearly 200 years. Temper studies of the pottery from historic sites in the Cochiti study area have revealed that pottery related to the Tewa ceramic traditions of the northern Pueblos and the Zia ceramic traditions in the Jemez River valley was

Table 12.2

Frequencies of Historic Pottery Types and Selected Attributes at Archeological Sites in the Cochiti Study Area, Shown in Percentage
(X = present)

Pottery Type Form or Attribute	LA 591	LA 12210	LA 12161	LA 6178	LA 9819	LA 9818	LA 10114	LA 70	LA 12438	LA 9138	LA 9836	LA 9878	LA 3452	LA 9880	LA 3444	LA 13291
Comales	—	X	X	—	—	—	—	X	—	—	—	—	—	—	—	—
Spindle Whorls	—	X	X	—		—	—	X	X	—	—	—	—	—	X	
Bisque Ware (fiber temper)	—	—	X	—	—	—	X	X	X	—	—	X?	—	—	—	
Carbon/Red (%)	—	1	1	X	—	2	—	4	—	—	—	—	—	1		—
Casitas Red/Brown	—	X	—	—	—	—	X	X	X	—	—	X	—	X		
Glaze F (late) (%)	41*	11	2	8	14	4	—	—	1	1	—	1	—	—	—	
Micaceous Utility (%)	X	6	3	11	—	1	5	9	4	1	—	2	1	X		—
Carbon/White Polychromes (%)	1	27	12	48	26	31	18	25	25	15	16	20	28	21	17	41
Mineral/White Polychromes (%)	X	5	1	8	30	12	2	4	22	47	31	19	20	9	13	17
Kapo Black (%)	1	11	2	3	—	3	2	X?	6	4	6	2	12	20	6	9
Kapo Black "Ironstone"	—	—	—	—	—	—	X	—	—	—	X	—	X	X	X	X
Carinated Bowls	X	X	X	X	—	—		X	—	—	—	—		—		
Black Rims	—	X	—	—	—	—	X	—	—	—	—	X	X	X	X	X?
Ring-Bases	X	—	X	—	—	—	—	—	—	—	—					
Soup Plates	X	X	X	X	—	—	X	—	X	—	—	X		X		
China (pre 1880)	—	—	—	—	—	—	—	—	—	—	X					
China (post 1880)	—	—	—	—	—	—	—	—	—	—	—				X	X

* 17th century

being produced using local cla··s and rock temper. Sherd assemblages from 15 sites dating between A.D. 1700 and 1900 have been studied; two of the sites on La Majada Mesa and five in White Rock Canyon were excavated. The results of the analyses are summarized in Table 12.2.

18th Century Sites of La Majada Mesa

The Torreon Site (LA 6178) was separated from Pueblo del Encierro (LA 70) by about 100 meters, but the differences in the pottery assemblages indicate that they were not occupied at the same time. The Torreon Site was a fortified structure believed to have been occupied during the early decades of the 18th century (Snow 1973b). Eight rooms of the prehistoric pueblo, Pueblo del Encierro, had been reconstructed and occupied probably during the second half of that century.

At the time the historic pottery of the Torreon Site was analyzed, in 1967, it was thought that the Glaze F sherds present dated to the late 17th century. More recent studies of historic pottery from Rio Chiquito and White Rock Canyon sites indicate that late glaze wares were still being produced during the early decades of the 18th century. Tempering material in these 18th century vessels is mainly a sandy hornblende latite, believed to have been used by potters at the Galisteo Pueblo, perhaps after reoccupation of that village in 1706. However, about 10% of the Glaze F sherds contained rock temper indigenous to the Cochiti area, and more than 70% of the associated Salinas Red pottery was locally made.

The decorated wares were mainly Ogapoge Polychrome intrusive from the Tewa area in the Upper Rio Grande, with only a small percentage made locally or imported from the Zia villages. Tewa Polychrome, dating to the late 17th and early 18th century, was also present.

Hemispherical bowls were the most common vessel of the decorated wares, a form which appears to be an 18th century innovation. *Soup plate* and carinated bowl forms were also common in the carbon paint polychromes.

Several aberrant or unusual vessels were noted at the Torreon Site. A locally made olla had a carbon paint design on a red slip. A hemispherical bowl had a deep pink slip. A fragmentary Pojoaque Polychrome olla was decorated with red matte outlined in black, in the tradition of Ogapoge Polychrome, and was apparently locally made.

Kapo Black vessels, which had underlying slips, are the earliest known occurrence of the ware in the area. About 20% of the Kapo sherds contained local tempering material.

Culinary vessels with coarse grained volcanic sand temper and polished or smudged interiors are also new to the area. Some of the utility vessels are similar to the 17th century Corona Plain, which was common at the 17th century Spanish homestead of Las Majadas. The surface colors of the sandstone tempered utility sherds tend more to reds or tan, in contrast to the blackened utility sherds of the 17th century. The sandstone tempered utility wares may be classed as Carnué Plain, a type described by Dick (1968). Nearly half of the utility sherds were slipped with mica, in the same tradition as Vadito Micaceous Slip, a type described by Dick at Picuris (1968:84).

Tr..-ring dates from an historic room at Pueblo del Encierro were mainly from the period between 1766 and 1790, all noncutting dates (Robinson et al. 1972). Dates suggesting an early 18th century occupation were also obtained, but these may have come from reused timbers at the nearby Torreon Site. Encierro may have been the home visited by Bishop Tameron in 1760. On June 20, he visited "*a large house belonging to a settler opposite the pueblo* [Cochiti] *on the east side of the river* . . ." (Adams 1954: 65). Only one other historic building, LA 6170, is recorded in this area, but no data on the pottery is available.

The carbon paint polychrome vessels from Encierro tend to have heavy, solid black design elements, fitting the description of Powhoge Polychrome (Dick 1968); however, red matte may occur in the designs, as in the earlier Ogapoge Polychrome. More pottery was made locally than at the Torreon Site, probably more than 30%. Red-surfaced vessels with carbon paint designs made up 4% of the historic wares. The majority of these were made locally.

Mineral painted polychrome bowls at Encierro had been produced in the Cochiti area. Most had an exterior carina and designs painted on an exterior white slip above the angle. Designs included framed triangles, chevrons, zigzags, and framed dots or X's. Mineral paints are red, brown, and black, with a preference for reddish brown. Lines of equal width are often used to create the design elements. No sherds of this type were found at the Torreon Site.

Plain red, plain black, and red-on-buff wares were of local origin. The red-on-buff vessels are similar to those described by Dick (1968:80) as Casitas Red-on-brown; however, the bowls with everted rims are deeper than the *soup plate* or flange plates. White slipped bases appeared on two vessels. Only two *soup plates* were noted. No Kapo Black was recognized, although some vessels may have been smudged in part.

Fiber temper was noted in 12% of the plainware sherds from Encierro. Coarse-grained volcanic sandstone occurred in 44% and crystal pumice in 23%.

Forms of the historic plainwares included hemispherical, carinated or everted rim bowls, flared bowls, ollas or jars, *soup plates*, and possibly pitchers. Fiber temper occurred only in bowl sherds.

The rim of a ceramic comal was found in one of the rooms at Encierro. This was tempered with pumice and is presumably made locally. Comales are common in Mexico, prehistorically and historically, but the fragment found at Encierro may be the first reported occurrence in the Rio Grande.

Several methods of pottery making noted at Encierro have not been reported previously in the Rio Grande. The fiber tempered vessels had a laminated appearance and were probably molded from a pancake of plastic clay. Some of the larger vessels which contained coarse sandstone temper were also mold made, although others were coil constructed. In a few sherds there was evidence that a broad fillet of clay may have been added to form a rim by doubling it over and fastening it to both the interior and exterior of the bowl.

Large globular utility vessels may have been formed by two-piece vertical molds, as no weld marks or coiling were obvious. This method of mold construction has been described by Foster (1948:356) as a modern pottery-making technique in Michoacan, Mexico.

The base of one olla or pitcher had been constructed by pressing a small pancake of clay on another and welding them together with finger pressure.

In summary, the two 18th century sites near Cochiti Pueblo appear to be of two time periods and to have distinct ceramic traditions. Some of the traits that first appeared in the 17th century (such as flange plates, mica slipped utility, and smudged wares) carried over into the 18th century but after 1700 many new traits appeared as well.

Historic Pottery of White Rock Canyon

Five historic sites in White Rock Canyon (LA 9138, LA 10114, LA 12161, LA 12438, and LA 13291) all appear to have been Spanish Colonial occupations. All, except LA 13291, can be dated to the late 18th and possibly early 19th century. Associated ironstone sherds indicate that LA 13291 was occupied during the late 19th century.

Two of the earlier sites, LA 12161 and LA 12438, had similar pottery assemblages including carbon paint polychromes, Carnue Plain, mica slipped utility ware, and late Glaze F. Also present were Kapo Black, Puname Polychrome and *bisque* ware. Comal fragments, carbon paint red ware, soup plate forms, and a ring-base Kapo Black bowl fragment were found at LA 12161. At least one vessel of Casitas Red-on-brown was present at LA 12438. The pottery types and traditions are commonly found at sites with high frequency of carbon paint polychrome wares and are particularly reminiscent of the historic ceramics of Pueblo del Encierro (LA 70). Both assemblages included small percentages of late Glaze F, which was not present at Encierro.

Puname Polychrome was the predominant decorated ware at LA 9138, constituting 47% of all sherds recovered. Almost all of the mineral paint vessels were jars or ollas and were produced in the Zia area, although at least a few Puname vessels with crystal pumice temper had been made locally. The Puname Polychrome vessels were characterized by white slips, thin walls (ca. 5 mm), and red painted rims suggestive of 18th century production. Carnue Plain was the predominant utility ware at LA 9138. Carbon paint polychrome sherds constituted 15% of the assemblage; accessory were Kapo Black, late Glaze F, and mica slipped utility. Absent were the miscellaneous pottery types and forms characteristic of contemporary carbon paint assemblages.

Fragments of transfer print ironstone and a yellow ironstone mixing bowl dates the historic occupation of LA 13291 to the last two decades of the 19th century (C. Snow, personal communication). Carbon paint pottery made in the Cochiti area is predominant. At least two utility vessels might be classed as *brickware* and are red, thick-walled, and heavily tempered with sandstone grains. Puname Polychrome, Kapo Black, and red and tan plainwares complete the assemblage.

LA 10114, a one room site, had a ceramic assemblage similar to LA 12161 and 12438, but with a few trait differences that indicate a slightly later occupation. Late Glaze F, comales, and spindle whorls are absent at LA 10114. A carbon paint polychrome vessel with a black rim and Kapo Black *ironstone* sherds are believed to be characteristic of the 19th century. A high percentage of local crystal pumice temper in the carbon paint polychromes is also suggestive of a post 1880 date. Solid black triangle design motifs on carbon painted wares are consistent with pumice tempered vessels. In all probability, this site was occupied in the late 19th or early 20th century.

Pottery of Rio Chiquito Sites, Canada de Cochiti

Analysis of surface collection of sherds from eight sites along Rio Chiquito indicates a similar dichotomy in ceramic traits as noted in the White Rock Canyon sites. Sites with higher frequencies of carbon paint polychromes included LA 12210, LA 9818, and LA 9880. LA 12210 has one of the highest ratios of late Glaze F in the area and may be one of the earliest sites in the study area. One of the Puname Polychrome jars had a black rim, but three others had red rims. One unusual sherd found was from a red-on-buff bowl. Fine red lines, less than 2 mm wide, framed a series of solid red scallops. The crystal pumice temper indicates that the vessel was locally made.

Both LA 9818 and LA 9880 have higher percentages of locally produced carbon paint wares and may have been occupied in the late 19th or even into the early 20th century. However, the presence of Ocate Micaceous at LA 9880, a thin walled micaceous utility ware, and a wide variety of other ceramic traits, such as soup plate forms, carbon-on-red pottery, and Casitas Red-on-buff sherds, suggest a middle to late 18th century occupation. Gunnerson (1969) estimated the dates for Ocate Micaceous between A.D. 1550 and 1750. However, the ware has not been noted in the Rio Grande area prior to 1680. Ocate is characterized by thin walls, 3-5 mm, and inclusions of mica in the clay body, generally giving a laminated appearance parallel to the walls.

Five other sites along Rio Chiquito had frequencies of mineral paint historic pottery equal to or greater than the carbon paint pottery. Two sites, LA 9819 and LA 9878, included late Glaze F sherds and probably date in the 18th century, while three other sites (LA 9836, LA 3452, and LA 3444) are dated in the 19th century. A fragment of Chinese porcelain, probably predating 1870, was found at LA 9836. The late historic occupation at Kuapa (LA 3444) produced carbon paint vessels with black rims, although one Puname Polychrome sherd had a red painted rim. A sherd of white china found here probably dates post 1880.

Intrusive wares from the Tewa area to the north had decreased in frequency at the 19th century sites, probably making up no more than 10% of the ceramic assemblages. Both carbon and mineral painted wares continued to be made locally with crystal pumice temper, probably until 1900. The slips of the Puname vessels had a definite yellowish cast in contrast to the white slips of the 18th century vessels. Plainwares, both red and black, often took on high luster and slips sometimes looked glazed, taking on the appearance of commercial ironstone. Overall slipping of redware was noted at one site (LA 9836).

There was a general trend toward uniformity in the 19th century and a decrease in decorated vessels. Miscellaneous or aberrant vessels of the 18th century were generally absent at the 19th century sites.

POTTERY CLASSIFICATIONS OF THE COCHITI STUDY AREA: SUMMARY

Carbon Painted Polychrome Wares

Carbon painted polychrome vessels were the predominant decorated ware at the majority of site assemblages examined. Ollas were the predominant vessel form, but hemispherical bowls, carinated bowls, and flange bowls or *soup plates* were common. Three major source areas for the carbon paint pottery were identified through temper analysis and included the eastern Tewa villages along the Nambe and Tesuque Rivers, the western Tewa villages in the Espanola Valley, and the Cochiti study area. The frequency of carbon paint pottery made in the Cochiti area increased through time and toward the close of the 19th century, trade from the Tewa country had apparently ceased.

Pottery from the eastern Tewa was tempered with vitric tuff. Designs include fine line elements; cream colored slips are usually finely crazed; flakes of white and gold colored mica may be noticeable on the vessel surfaces.

Trade vessels from the Espanola Valley were tempered with vitric tuff containing black glass sherds; in addition to the fine line designs, heavier solid black triangles and broad lines were also present; white slips were crazed.

Locally made carbon paint polychromes were tempered with crushed crystal pumice fragments containing clear quartz phenocrysts; solid black designs predominate; the slips are smooth, white or cream, and glossy; red matte paint appeared occasionally in all three carbon paint types.

Tewa Polychrome sherds were mainly found at a Revolt Period site, *Old Kotyiti*, and at the Torreon site. An early Tewa jar was found at the pre-Revolt site of Las Majadas. Production of Tewa Polychrome probably ceased early in the 18th century.

Ogapoge Polychrome, which dates to the early and mid 18th century, is characterized by the presence of red matte paint in the designs, although duochromes are predominant. Ogapoge Polychrome was common at the Torreon site but not at sites post-dating A.D. 1750. Most of the Ogapoge Polychrome was intrusive from the Tewa country, although red matte did appear rarely on local carbon paint polychrome.

Powhoge Polychrome is characterized by solid black design elements, usually in exclusion of fine line design. Almost all of the locally produced pottery would be classed as Powhoge. However, the named varieties of the carbon paint polychromes were not used for comparative analysis of the ceramic assemblages due to the fragmentary nature of most of the sherds.

Carbon-on-Red Wares

The carbon-on-red tradition was present at six of the 16 sites. This ware first made its appearance at the Torreon site (LA 6178) dating to the early 1700s. The carbon-on-black pottery appeared at several other 18th century Spanish sites in low frequencies. Forms usually were the same as contemporary carbon paint wares and included both ollas and hemispherical bowls. Occasionally a polychrome effect was achieved by using both pink and red slips with black carbon paint designs. The carbon-on-red tradition did appear in the Tewa country about the same time as in the Cochiti study area, according to temper studies; most of the Tewa vessels were produced in the Espanola Valley. The tradition persisted into the 20th century at the pueblos of San Ildefonso and Santo Domingo according to Chapman (1970).

Mineral Paint Polychrome Wares

Several different mineral paint traditions were noted in the study area, including both the early white slipped Puname Polychrome and a 19th century cream-to-buff slipped ware. The majority of the mineral paint vessels in the Cochiti study area were intrusive from the Zia villages to the south, but local production utilizing crushed crystal pumice temper was noted at sites dating from the mid 1600s to the end of the 19th century.

White slips were used during the 18th century but some time after A.D. 1800, cream to tan slips became more common. Both red and black painted rims were present during the 18th century, with red predominant; black painted rims were more common in the 19th century. Puname Polychrome became a major trade ware during the latter part of the 19th century in the Rio Grande region. The ware was present at all the 16 sites included in this analysis and was predominant in three or four. Ollas were the predominant form in the mineral paint polychromes in the Puname tradition. However, carinated bowl forms were common at Pueblo del Encierro; designs were usually in a reddish brown paint on a white slip. At least one soup plate form was found at Pueblo del Encierro and a ring-base bowl sherd was noted at a site in the Canada de Cochiti Grant.

One unusual red-on-buff vessel of local manufacture was found at LA 12210, a Canada site. The interior of the hemispherical bowl was well polished and was decorated with red matte paint in a framed scallop design. The site probably dates to the early 1700s.

Red-on-Buff and Polished Plain Wares

Polished plain wares were common at some of the sites in the study area, particularly during the 18th century. Various ceramic traditions were undoubtedly present. One centered around hemispherical bowls with red slips and vitric tuff temper. Bands of red slip paint were often used to decorate buff colored surfaces. Two or more ceramic traditions might be included here. One developed in the Tewa country to the north during the 17th century and usually includes hemispherical bowls. The other ware has been named Casitas Red-on-buff (Dick 1968) and includes flange bowls. It is not known at this time if there is a cultural tie between the two wares.

Another division is indicated at Pueblo del Encierro (LA 70), where hemispherical bowls are absent in crystal pumice tempered plain wares, but common in the sandstone tempered pottery. Olla forms rarely occur with sandstone temper, and fiber temper was found mostly in bowl forms. This type of division within the plainwares suggests that either individual potters are making only certain forms, or that different temper is used for different forms.

Kapo Black and "Ironstone" Ware

Polished, smudged black wares were found at all sites except one or two of the 16, and included locally made and trade wares from the Tewa area. At LA 12161 fragments of a ring-base or footed vessel, which was apparently intrusive from the Tewa area, were found. The smudged black wares have collectively been designated as *Kapo Black* although made in different areas. Both bowl and olla forms may occur.

During the 19th century, a ware resembling Kapo Black appeared as late as the 1880s or 1890s. The reddish brown to black surfaces of these were fired to a subglaze, much resembling commercial ironstone of similar color. These contained crystal pumice temper and were probably made in the study area.

"Bisque" Wares

A group of plain polished wares that contain varying amounts of fiber temper and fine to coarse grains of sandstone have been designated as *bisque* ware. Workmanship is generally poor, walls are friable and sandy giving the appearance of *bisque* or unfinished pottery. With one exception, only bowl forms were present. The laminated appearance of vessel walls indicates construction over or in a mold. One miniature jar or *ollita* was probably finger modeled from two pancakes of clay. The fiber tempered wares appear to grade into sandstone tempered wares, but the sample was small. Possibly two ceramic traditions are represented.

Glaze Paint Wares

Post 1700 glaze paint wares were present at eight of the historic sites, and 17th century late Group E and Group F pottery was found at Las Majadas (LA 591). The occurrence of overall green glaze vessels at the latter site may be one of the earliest in the Rio Grande. The sherds were tempered with rhyolite tuff, but the source of manufacture was not determined. An unusual pitcher made at Pecos Pueblo had an overall glazed interior, undecorated exterior, and a ring base.

The post 1700 glaze wares are generally tempered with a sandy hornblende latite and are believed to have been made at the Galisteo Pueblo (LA 26). Bowls usually have typical Glaze F rims with an exterior carina, although one hemispherical bowl might be represented. Jar sherds were also noted. One sherd of undecorated *Salinas Red* bowl, also from the Galisteo, was found at LA 12161.

The Historic Utility Wares

New trends in the utility wares included interior polishing and smudging, which appeared first in the 17th century; mica slips; and exterior scoring. The 18th century utility wares were tempered mainly with coarse volcanic sandstone or crushed pumice, materials not used by 17th century or earlier potters. Laminated walls and absence of coil junctures in some of the partially restorable vessels of Pueblo del Encierro suggest manufacture by two-piece vertical molds, of some of the utility wares. Coil construction was also evident. Occasionally a utility jar would have some polishing on the exterior of the vessel; others had application of mica flakes on the exterior. One sherd of Ocate Micaceous(?) in the tradition of the Jicarilla Apache ware was found at LA 9880.

Smudging of the interior of utility vessels was a common trait in the Mogollon utility wares dating back into preColumbian time, and was not uncommon in the Middle and Upper Rio Grande in association with Rio Grande glaze paint wares. A possible cause of smudging in historic wares is suggested by Bandelier, who described chimneys made of large jars at Cochiti, and noted "*smoked pottery indicating chimneys*" at Mexican ruins on the road to La Bajada (Lange and Riley 1966:208).

Pottery Comales

Comal fragments were recovered from at least three 18th century sites in the study area. All sherd fragments were tempered with coarse volcanic sandstone (2475) and were produced locally. The comales have slightly upturned rims, a roughened base, and appear to be circular in form. One large rim fragment from LA 12161 indicates a circular form ca. 30 cm in diameter. Its base was encrusted with coarse sand grains, probably for insulation. Another fragment had a central weld line, suggesting construction with pancakes of clay. In general, the comales resemble those reported from prehistoric and historic sites in Mexico (Tolstory 1958:39). Pottery comales are rare in the Rio Grande region, and in the Cochiti study area, did not appear at any 19th century sites. Fragments of a comal that may have been made at Zuni Pueblo were found at a site near Peach Springs, on the Navajo Reservation, but is of unknown date.

TECHNOLOGICAL INNOVATIONS IN RIO GRANDE HISTORIC POTTERY: DISCUSSION

During the 17th century, numerous changes in the pottery of the Cochiti Reservoir District reflect influence of Spanish colonists, including Mesoamerican Indians who were often members of Spanish households. Flange and ring-base bowls made in the Cochiti area are reminiscent of prehistoric pottery traditions that date back to 1500 B.C. Mica slips appeared at the mid 17th century Spanish homestead of Las Majadas, as a new trait in utility wares; mica slips also occurred in the 16th century on Posui'i Incised and Kapo Gray vessels produced in the Tewa area to the north.

Other new ceramic traditions to appear during the pre-Rebellion period include carbon and mineral paint polychrome vessels; carbon paint redware; smudged wares, plain polished ware (Salinas Red), spindle whorls, and various form changes.

Following the Reconquest in the late 17th century, a number of Mexican families moved into the area east and north of Cochiti Pueblo. In 1760, Bishop Tamaron referred to these Spanish colonists as "*Europeanized mixtures*" (Adams 1954). The settlers were soon making pottery in the area but were selecting tempering materials that differed from those that had been in use in the previous century. Earlier traditions that did carry over from the 17th century included mica slips, smudging, ring bases, flange plates, and spindle whorls. For the first time, ceramic comales with upturned rims and roughened bases were produced. Carbon and mineral painted pottery made in the area soon replaced the 17th century glaze paint wares. Polished redware decorated with black carbon paint continued to be made in small quantity, but with slightly different vessel form from the 17th century pots. Broad-line red-on-buff bowls were produced in the Cochiti area for the first time. Hemispherical bowl forms became popular, replacing to some extent the earlier carinated bowls of the 17th century.

Mold-made pottery was a new method of construction introduced after A.D. 1700, and included pancake molding and two piece vertical molds, both traits suggesting Mesoamerican techniques. The presence of fiber temper in some of the mold-made vessels is suggestive of a long-lived prehistoric tradition of pottery making in Mexico.

Two or more separate ceramic traditions may have been present in the Cochiti Reservoir District during the 18th century. Subsequent changes within these ceramic assemblages and adoption of many traits by the Pueblo potters of the Cochiti and Tewa area need additional studies before the various factors influencing the adoption and development of new pottery tradition in the upper Middle Rio Grande can be traced or understood. Much of the new data obtained in the Cochiti area were a direct outgrowth of the mineralogical studies. Perhaps in the future additional studies in the Cochiti and other areas in the Southwest will help resolve some of the unanswered problems pertaining to the diffusion of ceramic traits into New Mexico during historic time.

Chapter 13

SPATIAL PATTERNING AND CONTENT VARIABILITY IN FOUR HISTORIC FAUNAL ASSEMBLAGES

Martha R. Binford

INTRODUCTION

Faunal remains have traditionally been treated superficially, often to the extent of only listing species present. This trend has been changing as archeologists become increasingly aware of the potential information carried in faunal remains. The problem now, however, is one of interpretation. Accurate interpretation of faunal remains requires an understanding of the variables and processes which condition the formation of faunal assemblages. At this time, we are ignorant of both, making accurate interpretation extremely difficult. We cannot expect to gain any understanding until we become aware of the variability we are actually dealing with, raise questions about the observed variability, and seek answers to these questions. As archeologists, we should be more concerned with realizing the extent of what we do and do not know, rather than attempting explanations based upon unjustified assumptions.

The goal of this paper is simply to document variability in faunal assemblages from four 18th and 19th century sites, and to raise questions about them as they reflect human behavior.

Faunal assemblages from four Historic period sites (LA 12161, LA 9138, LA 10114, LA 13291) in the Cochiti Reservoir area will be examined in regard to spatial organization and content variability. These sites were chosen because: (1) they have been posited to represent the same basic adaptation (see Snow, this volume); (2) they are located in the same area; and (3) they have relatively large faunal assemblages. All four sites are located in the Cochiti study area where similar faunal resources are available. Although their combined occupation spans a 200 year time period, all indicate a reliance on domestic sheep or goat. It was felt, due to these similarities, that variability in faunal remains would reflect behavioral rather than faunal resource differences. A brief description of the sites follows. For a detailed summary of each site see Chapman et al. (1977:119-159, 167-192), Hunter-Anderson et al. (1979), and Schutt (1979).

SITE DESCRIPTIONS

LA 12161 (A.D. 1700-1750)

LA 12161 is located north of Medio Canyon on an alluvial bench on the west side of the Rio Grande River, in White Rock Canyon. The site is composed of a single rectangular surface structure with a corner hearth and subfloor cist and an associated trash midden. LA 12161 is the only site where an intact midden was recovered. An area of 206 m^2 was surface collected. Excavation occurred within the room and midden, in grids contiguous to these features, and in four test areas. A total of approximately 17.7 m^2 was excavated (8.6% of the estimated site extent). There appears to have been only one occupation of LA 12161. Large quantities of cultural material were recovered from the site including ceramics, lithics, bone, metal, and glass. Ceramic artifacts indicate a minimum of 102 vessels represented at the site. Many ceramic spindle whorls, spindle whorl blanks and disks were also recovered. Faunal remains consisted of 663 bones, most of which (52%) were recovered from the midden area. Despite the apparent small time investment in construction of the room, artifactual debris suggest a prolonged occupation with considerable diversity of activities.

LA 9138 (A.D. 1750-1800)

LA 9138 is located on the west side of the Rio Grande River, approximately 3.5 km above the mouth of White Rock Canyon, at the base of a talus slope. The site is composed of an Anasazi period component (which will not be discussed) and a Historic period component. The Historic component consists of four noncontiguous structures, trash scatters, and a wall network enclosing the entire site. The structural units include three freestanding roomblocks of two rooms each (Rooms 1 and 2, Rooms 3 and 4, Rooms 8 and 9) and one freestanding isolated structure (Room 5). The surface area collected totaled 1155 m^2. Excavated areas included the interiors of the seven rooms and grids outside and contiguous to each room, totaling about 191.7 m^2 (16.6% of the estimated site extent).

There appears to have been at least two historic occupations represented at LA 9138. The first occupation is marked by the construction and habitation of Rooms 1, 3, 4, 5, 8, and 9. The second occupation is marked by the construction of Room 2 and the reuse of Rooms 1, 3, and 4 as corrals. Corner fireplaces were located in Rooms 1, 3, 4, and 8. Rooms 2, 5, and 9 did not have formal hearth features; Room 5, however, contained a large charcoal stained area.

Faunal remains consisted of 104 bones, the majority of which (66%) were recovered from Rooms 1, 2, 8 and 9. Room 1 contained the greatest amount of bone within a single room. There appears to be little difference, in terms of faunal remains, between the two historic occupations. Despite the relatively large labor investment in construction of Rooms 1, 3, 4, and 5, the artifactual debris recovered from this site suggests a relatively short occupation.

LA 10114 (A.D. 1800-1850)

LA 10114 is located between Medio and Sanchez Canyons in White Rock Canyon. The site is located at the base of a talus slope on the west side of the Rio Grande. LA 10114 consists of one room, two small storage structures, and a number of wall fragments enclosing an area at the base of the talus. Room 1 includes an interior hearth. An ash stain, hearth and two storage structures are located in the excavated area outside the room. An area of 372 m^2 was surface collected. Excavated areas include Room 1, approximately 23 m^2 north of and surrounding the room, and two test areas south of the room (about 56 m^2, 15% of the surface collected area). One historic occupation is indicated at the site; however, ceramics recovered from test areas 1 and 2 indicate a possible prehistoric component. Ceramic artifacts represent a minimum of 39 vessels. Faunal remains from the site (629 bones) were recovered primarily from the room and within grids contiguous to the room. Little time was apparently invested in the construction of the room, but artifactual debris was prevalent.

LA 13291 (A.D. 1850-1900)

LA 13291 is located at the base of a talus slope north of Medio Canyon on the east side of the Rio Grande. The site is composed of four noncontiguous rooms. An area of 632 m^2 was surface collected. Excavated areas include the interior of all rooms and grids outside and contiguous to these rooms (totaling approximately 53 m^2 or 8% of the site's estimated area). The occupations of the rooms were probably contemporaneous, with the exception of an earlier, less extensive, occupation of Room 1. Room 1 included two interior features: a burned hearth area and an ash area. The ash area was probably a dump for material accumulating in the hearth. Exterior features around Room 1 include three ash areas outside the south wall. A burned area within the room is the only evidence of an occupation level. Room 4 contained no interior features. Ceramic artifacts from LA 13291 represent a minimum of 43 vessels, the majority of which are historic in time period.

The faunal remains (765 bones) were recovered primarily in the upper strata of Room 1, representing the second occupation of the room, although comtemporaneous with the main occupation of the site. All rooms at the site show little labor investment in construction; however, artifactual debris recovered from the site suggests a fairly long occupation with a variety of subsistence activities occurring at the site.

CONTENT VARIABILITY

Introduction

The examination of variability within faunal assemblages is critical in determining subsistence activities at archeological sites. Information regarding the species exploited, butchering practices, and the processing and consumption of faunal resources can only be obtained through the analysis of faunal assemblage content. Analysis of this type provides valuable data which can be used to infer broader aspects of culture. For example, inferences can be made about the domestication of animals, trade behavior, and the production of exportable goods (wool for instance).

In this chapter, faunal assemblages are discussed as they reflect the species exploited and the processing and consumption of faunal resources. Through focusing on these topics, it is felt the study provides a substantial amount of information about human activities at four historic sites.

At this time, it is helpful to present some general limitations of the data to be discussed. First, the descriptions of these assemblages are based on extremely fragmentary samples. Second, evidence of attrition is great. Many of the breaks documented for the assemblages are of post-occupational origin. Third, rodent disturbed areas are common and some bone fragments have been nearly destroyed by rodent gnawing.

Another limitation of this data is the reliability of the sample. All areas within the estimated site boundary were surface collected. Although the intensity of some artifact classes is often greater on the surface than subsurface (providing a fairly reliable sample from surface collection), this is not the case for faunal remains. In the study area, bone is generally recovered in larger quantities below the surface. For example, only 0.16% of the bone from LA 10114 was recovered from the surface. Thus, surface collection alone is not a very reliable sample of faunal remains. Unfortunately, excavation of the four sites was generally limited to features and grids contiguous to features. The average excavated area at the four sites was only 12% of the estimated site extent. We have no way of assessing the reliability of these samples. Without knowledge of what our sample is (representative or biased), we can only speculate about the behaviors and activities the sample may reflect. Speculation, not supposed explanation, will be presented in this paper.

The identification of bone to species and element was conducted by Arthur H. Harris. Broad nontaxonomic categories were created by Harris to identify bones when classification to species was impossible. For example, the term *medium-large mammal* is defined as any mammal ranging in size from a cottontail rabbit to a bison. Obviously, use of these classes limits any behavioral interpretation. These categories do, however, carry general information about the body size of the species exploited. Due to the fragmentary nature of these faunal assemblages, these categories were prevalent in Harris' classification of these remains, with the majority of the bones classified into the following categories:

Large Mammal: Any mammal ranging in size from a domestic sheep to bison.

Medium-large Mammal: Any mammal ranging in size from a cottontail rabbit to a bison.

Medium Mammal: Includes mammals ranging in size from a cottontail to *Canis* sp.

Small-medium Mammal: Any mammal ranging in size from a rodent to *Canis* sp.

Small Mammals: Primarily rodents.

Artiodactyla: Any artiodactyla.

Large Artiodactyla: Any artiodactyla ranging in size from an elk to a bison.

Medium Artiodactyla: Any artiodactyla ranging in size from a pronghorn to a deer.

Small Artiodactyla: The domestic sheep or goat size range.

Mammal: Any mammal of any size.

Although the bones in these categories could not be used in the determination of minimum number of individuals or species exploited, they were used in the discussion of body size (see Table 13.1). Body size data can be used in the interpretation of subsistence strategies.

It should be noted that the speculations offered in this paper are based upon element counts and estimates of the minimum number of individuals (MNI) represented per species or taxon. The MNI is calculated by utilizing not only species and element counts, but also age estimation. For example, one left femur from an adult sheep and one right femur from an immature sheep is calculated as two individuals on the basis of age. The MNI is a true minimum in the sense that they represent a minimum for the site as a whole. Calculations based upon either vertical or horizontal provenience would inflate the estimate. Any other method could not be justified due to the disturbed stratigraphic sequence of the sites and the lack of clearly defined occupation levels.

Table 13.1

Body Size Data

	Site Number							
	LA 12161		LA 9138		LA 10114		LA 13291	
Total number of Bones	663		104		629		765	
Total Number of Bones with Body Size Data	654		94		591		700	
	No.	%	No.	%	No.	%	No.	%
Large	564	(86%)	50	(53%)	147	(25%)	465	(66%)
Medium – Large	85	(13%)	21	(22%)	341	(58%)	177	(25%)
Medium	2	(.3%)	6	(6%)	71	(12%)	19	(3%)
Small – Medium	0		0		21	(3%)	22	(3%)
Small	3	(.4%)	17	(18%)	11	(2%)	17	(2%)

(Includes nonmammals)

The following section examines faunal assemblage content as it relates to the species exploited. Emphasis is placed upon comparing strategies of exploitation represented among the four sites.

Species Exploited

The range of species exploited by the inhabitants of LA 12161, LA 9138, LA 10114, and LA 13291 is very similar. Although a total of 25 species (or taxa) were exploited at the four sites, the number of species exploited at each individual site ranges from 9 to 10. Both domestic and nondomestic species are represented at each site. A comparative summary of the species represented at each site, with accompanying MNI figures, is presented in Table 13.2.

LA 12161 – The faunal assemblage from LA 12161 indicates a subsistence strategy which focused upon large mammal species. The heavy reliance placed upon these species is supported by both the MNI and bone count percentages. Of the eleven individuals represented at the site, seven (67%) are large mammal species; of the 663 bones recovered from the site, 86% are from large mammal forms (see Table 13.1). These percentages are higher than any other site analyzed. Of the 654 bones for which size could be determined, only two fragments representing two individuals are from the medium body size range and no bones are from the small mammal size range. However, three bird bones, representing two individuals, were recovered. It should be noted that 85 bones are classified into the medium-large mammal category. Although these bones have not been examined by the author, reexamination of medium-large mammal bones from LA 10114 indicate that, at least for this site, the vast majority of the bones lumped into this category are actually large mammal forms (all medium-large mammal bones from LA 10114 have been reexamined by L. R. Binford). Despite these medium-large mammal bones, it is clear that the faunal remains at LA 12161 are almost exclusively large mammal species.

The variety of both domestic and nondomestic species is greater at LA 12161 than at any of the other historic sites. Seven individuals representing five different species of large mammals are evident from the faunal remains. LA 12161 also exhibited the greatest variety of domesticate forms. Three domesticated species represented by five individuals are indicated by the minimum number of individuals. The fauna from this site included not only domestic sheep or goat (which is indicated at all four sites) but also domestic cow and burro. The possibility of domestic dog is also likely. One *Canis* sp. is represented at the site, and numerous canine gnawed bones were recovered from the midden. Although we cannot be sure that the *Canis* species is a domesticated form, the presence of canine gnawed bones in the midden lends support to this suggestion. It seems unlikely that nondomesticated dogs

Table 13.2

Minimum Number of Individuals

		LA 12161	LA 9138	LA 10114	LA 13291
Large Mammals:	Bos/Bison				2
	Bos/Bison/Cervus/Equus		1		
	Deer	1		1	3
	Antelope	1			
	Cow	1			
	Burro	1			
	Sheep/Goat	3	2	3	4
	Total Large Mammal Species	5	2	2	3
	MNI	7	3	4	9
Medium Mammals:	Canis	1		1	
	Beaver	1			1
	Cottontail Rabbit		1	1	2
	Jackrabbit		1	1	
	Total Medium Mammal Species	2	2	3	2
	MNI	2	2	3	3
Small Mammals:	Mouse		1	1	
	Woodrat		1		3
	Rock squirrel				1
	Gopher			1	1
	Abert's squirrel		1		
	Total Small Mammal Species	0	3	2	3
	MNI	0	3	2	5
Birds:	Raven			1	
	Perching or song bird		1		
	Duck		1		
	Anseriformes	1			
	Bird (Mallard size)	1			
	Mourning dove			1	
	Bird				1
	Total Bird Species	2	2	2	1
	MNI	2	2	2	1
Fish:	Fish		1		
	Total Fish Species and MNI	0	1	0	0
Amphibian:	Spade foot toad				1
	Total Species and MNI	0	0	0	1
Total Domesticates:	**Species**	3	1	1	1
	MNI	5	2	3	4
Site Totals:	**Species**	9	10	9	10
	MNI	11	11	11	19

would gnaw bones that were already in the midden, due to the close proximity of the midden to the living area. In general, wild dogs tend to stay away from people. It is possible that the presence of these bones in the midden represents a cleaning episode in which bones that had been gnawed by dogs at the site during the occupation were deposited into the midden. At this point, however, this is entirely speculation.

These data suggest a very selective hunting strategy and a reliance upon a variety of domesticated forms by the inhabitants of LA 12161. The selectiveness evident at the site suggests an ability to *choose* what meat sources to exploit, a luxury not evident at some of the other sites studied. It is interesting to note that LA 12161, is the earliest of the four historic sites studied, and that this pattern of heavy reliance on a variety of large mammal forms (including more than one domestic species) is not continued through time.

LA 9138 – The species exploited at LA 9138, unlike LA 12161, indicate a much less selective utilization of faunal resources. A wide range of different body sizes are represented at this site (refer to Tables 13.1 and 13.2). No other site discussed in this paper had such high percentages of smaller body size animals. This suggests a greater emphasis on exploitation of small, readily available animals. Aquatic resource utilization is also evident at LA 9138. Although fish bone tends to preserve poorly, one fish is represented in the MNI. This individual constitutes the only fish represented at any of the sites studied in this chapter, although fish have been recovered at other Spanish Colonial sites (see Snow, this volume).

In comparison to other sites, LA 9138 has little evidence for domestic sheep or goat. Although two domestic sheep or goat individuals are represented by the MNI, these individuals are only represented by six bone fragments.

All of these data suggest that the inhabitants of LA 9138 practiced a broader, less selective subsistence strategy, exploiting a wide range of faunal types (both species and body sizes). Rodents, birds, fish, beaver and both large domesticates and nondomesticates were exploited. It appears that the inhabitants of this site exploited whatever animals were readily available, applying few selective criteria in their hunting strategy. Unlike the inhabitants of LA 12161, they apparently could not afford the luxury of being able to *choose* a preferred type of animal to exploit. LA 9138 illustrates the least selective strategy of any of the historic sites studied.

LA 10114 – The faunal assemblage at LA 10114 indicates an exploitation of large species, supplemented by exploitation of a variety of medium and small body size animals. This suggestion is supported by both the MNI and bone counts (see Tables 13.1 and 13.2). As indicated in Table 13.1, only 25% of the assemblage is representative of large species. This is misleading. The majority of the 629 bones recovered from LA 10114 have been classified as medium-large mammals. Most of these bones have been reclassified by L. R. Binford as large mammal species (primarily sheep or goat). This inflates the large mammal category considerably. For the sake of consistency, the original classification of species and element are used in the analysis of all four assemblages. However, the author believes that the majority of these bones are in fact large body size species. Although the MNI's and the fragment counts indicate differing degrees of reliance on medium and small mammals, as well as other fauna, both support the suggestion that reliance upon large mammal species was great, and that smaller body size animals only supplemented the diet of the occupants of LA 10114. It appears that as body size decreases, the reliance on species with smaller body size also decreases.

Evidence of the domestication of animals is limited to three domestic sheep or goat individuals, represented by 41 bones. Although these counts may appear small, these three individuals represent 75% of the large body size species and 27% of the total MNI's for LA 10114. Also, L. R. Binford (personal communication) suggested that the majority of medium-large mammal bones are "*almost certainly sheep or goat*". It is likely that domestic sheep or goat played an important role in the subsistence activities at this site.

These data suggest that the inhabitants of LA 10114 were more selective in their faunal subsistence strategies than the inhabitants of LA 9138. They were not, however, as exclusive in their exploitation of large body size species as were the inhabitants of LA 12161. The occupants of LA 10114 probably relied primarily on domestic sheep or goat for their subsistence, but supplemented their diet with eight other species of various body sizes that were all readily available to them.

LA 13291 -- The faunal assemblage at LA 13291 is similar to LA 10114 in the apparent dependence placed on large body size animals, with supplementary additions to their diet. However, major differences, in both variety and numbers of individuals, exist between these two sites. As with the other sites, support comes from both the MNI's and bone counts (see Tables 13.1 and 13.2). Large mammals are represented by a greater number of individuals and a greater number of bones than any other body size range. Medium and small body size animals are represented, but it is evident that large mammal species were exploited more heavily than these small forms.

A variety of species were exploited in each body size range. Although LA 13291 did not have as many different large species as did LA 12161, the site did have more than LA 10114 and LA 9138 (see Table 13.2). As for small mammal species, only LA 9138 equalled the variety of small mammals represented at LA 13291. Also, this site has the only evidence, although extremely limited, for the exploitation of amphibians. One spade foot toad is represented by the MNI's (see Table 13.2).

Summary

In conclusion, the species exploited at these sites are similar in type but vary in variety and body size. LA 12161 stands out from the other historic sites in that it indicates an almost exclusive exploitation of large body size animals. These include nondomestic species as well as the most diverse range of domestic species represented at any of the four sites. LA 9138 is at the opposite end of the subsistence scale. This site is characterized by a very broad, less selective strategy of exploitation with almost equal emphasis on large mammals, medium mammals, small mammals, birds and fish. LA 10114 and LA 13291 fall in between these two extremes. Both of these sites indicate reliance on large mammals with supplements of other body size ranges. LA 10114 indicates a much greater reliance on domestic sheep or goat than evident at LA 13291. LA 13291 indicates a more diverse exploitation of large body size animals with less emphasis placed on domestic animals. The pattern for these two sites is, in general, one of decreasing reliance on smaller body size animals. Despite similarities in location and time period, it is evident that a variety of species were exploited, and to different degrees, by the inhabitants of these four historic sites.

Tables 13.3 and 13.4 presen[illegible] data and data which may be relevant to the proces[illegible] of faunal resources.

Table 13.3

Age Structure by Species*

Species	Site	Very Young	Immature/Young	Adult	Old
Sheep/Goat	12161	1 (8%)	7 (54%)	5 (38%)	0
	9138	0	2 (100%)	0	0
	10114	1 (6%)	7 (44%)	8 (50%)	0
	13291	2 (4%)	7 (13%)	42 (81%)	1 (2%)
Bos/Bison	12161	1 (100%)	0	0	0
	13291	0	3 (50%)	3 (50%)	0
Deer	13291	1 (33%)	1 (33%)	1 (33%)	0
Beaver	13291	0	0	1 (100%)	0
Jackrabbit	9138	0	1 (50%)	1 (50%)	0
	10114	0	1 (100%)	0	0
Cottontail rabbit	9138	0	1 (50%)	1 (50%)	0
	13291	0	1 (33%)	2 (67%)	0
Woodrat	9138	0	1 (50%)	1 (50%)	0
	13291	2 (50%)	1 (25%)	1 (25%)	0
Gopher	10114	0	1 (100%)	0	0
	13291	0	1 (100%)	0	0
Abert's squirrel	9138	0	0	1 (100%)	0
Rock squirrel	13291	0	0	2 (100%)	0
Raven	10114	0	0	1 (100%)	0
Passiformes	9138	0	0	1 (100%)	0
Sheep/Goat/Pronghorn	12161	0	5 (83%)	1 (17%)	0
Cervid	13291	0	0	1 (100%)	0
Artiodactyla	12161	29 (74%)	10 (26%)	0	0
	9138	2 (28.5%)	3 (43%)	2 (28.5%)	0
	10114	2 (100%)	0	0	0
	13291	8 (32%)	11 (44%)	5 (20%)	1 (4%)
Medium artiodactyla	13291	0	1 (100%)	0	0
Small artiodactyla	13291	0	0	4 (100%)	0
Large Mammal	12161	2 (33%)	4 (67%)	0	0
	13291	1 (8%)	8 (61%)	4 (31%)	0
Medium-large mammal	12161	14 (78%)	4 (22%)	0	0
	9138	2 (33%)	4 (67%)	0	0
	10114	0	1 (100%)	0	0
	13291	4 (12.5%)	28 (87.5%)	0	0
Medium mammal	13291	0	1 (100%)	0	0
Small-medium mammal	10114	1 (50%)	1 (50%)	0	0
	13291	0	2 (100%)	0	0
Mammal	9138	6 (100%)	0	0	0
	13291	1 (50%)	1 (50%)	0	0
Small vertebrae	13291	0	0	1 (100%)	0

*The percentages refer to total number of aged bones.

Table 13.4
Additional Data

Complete Bones

LA 12161 : 62 (9%)
LA 9138 : 17 (18%)
LA 10114 : 8 (1%)
LA 13291 : 30 (4%)

Unidentified Fragments

LA 12161 : 11 (2%)
LA 9138 : 5 (5%)
LA 10114 : 207 (33%)
LA 13291 : 173 (23%)

Long Bone Shaft Fragments*

LA 12161 : 169 (25%)
LA 9138 : 19 (18%)
LA 10114 : 125 (20%)
LA 13291 : 142 (18.5%)

Long Bone Fragments*

LA 12161 : 15 (2%)
LA 9138 : 1 (1%)
LA 10114 : 95 (15%)
LA 13291 : 29 (4%)

Articulator Ends of Long Bones*

LA 12161 : 5 (less than 1%) all are distal (3 tibia, 1 ulna, 1 humerus)
LA 9138 : 0
LA 10114: 3 (less than 1%) 2 are distal (tibia, metapodial); 1 is proximal (metapodial)
LA 13291 : 4 (less than 1%) all are distal (2 ulna, 1 radius, 1 tibia)

*These values include only mammal bones in the large and medium-large body size range.
Percentages are the percent of the total number of bones from the site.

SPATIAL PATTERNING: ISOLATING FAUNAL ACTIVITY AREAS

Isolation of faunal activity areas can be extremely valuable in the reconstruction of subsistence behaviors. Spatial analysis can provide information about the processing and consumption of faunal resources as well as numerous other factors. For example, a man sitting around a hearth cracking marrow bones will leave long bone shaft fragments as the debris from this activity. If this area is not later disturbed, this debris can provide valuable information. Spatial analysis will delineate this area and may clue the archeologist to the activity performed, the processing of faunal resources, and the man's use of space. Unfortunately, spatial analysis has often been dismissed by the analyst. Although limited sample sizes and disturbed sites make isolation of activity areas difficult, I hope that this paper will illustrate that valuable information can be gained from spatial analysis despite these problems.

Obviously, the most reliable spatial information is obtained when cultural material is piece-plotted, locating the artifact exactly in both horizontal and vertical space. Collection by grid always obscures the spatial patterning to some extent. The degree of distortion is influenced by both the size of the collection unit and the size of the activity area within the grid system. Collection by feature alone can obscure the patterning further. At LA 12161 and LA 9138, features were collected as units and exterior areas were collected by 2 x 2 meter grid squares. This made isolation of activity areas within the rooms impossible. Later excavation procedures at LA 10114 and LA 13291 facilitated a more extensive spatial analysis of faunal assemblages. Features were collected not only as units, but also as portions of 1 x 1 meter grid squares. This permitted isolation of distributional variability within features, making delineation of activity areas possible.

Three activities are discussed in this section: marrow extraction, soup making, and skull processing. All three activities are evidenced by fragments of particular elements.

Density contour lines were employed in an effort to isolate concentrations which would delineate faunal activity areas. The raw counts of the variable to be monitored (long bone shaft fragments, for example) were calculated for each 1 x 1 meter grid square. The center point of the grid square was then assigned that value, and density contour intervals were calculated. Contour intervals were calculated using the mean and standard deviation. No zero values were used in the calculation of contour intervals. Contour lines were then drawn. For a full description of this method see Spear (this volume).

Only two of the four historic sites (LA 13291 and LA 10114) were collected in a way which facilitated the use of this method. The site to be analyzed must have equal units of measure, which LA 12161 and LA 9138 did not. However, a number of density contour maps were generated for LA 10114 and LA 13291 (Figs. 13.1 13.12). Due to the large concentrations of bone within the rooms, and the small number of bones outside of the rooms, few discrete activity areas were isolated.

One problem with the application of this method to these sites was the problem of delineating structures. Since the 1 x 1 meter collection units occasionally overlapped interior and exterior portions of structural features, density contours often appeared to flow through walls, which distorted the picture of the site.

Marrow Cracking

The presence of long bone shaft fragments in substantial numbers at a site has been suggested as evidence of marrow extraction (Gilbert 1969:290). It is suggested by the author that the spatial isolation of long bone shaft fragments, from medium-large and large mammals, may indicate either an area where marrow cracking occurred or a *dump* area from cleanup of the original activity location. Spatial isolation of long bone shaft fragments occurred at LA 12161, LA 10114 and LA 13291.

LA 12161 – Although density contour maps were not generated for LA 12161, examination of the distribution of long bone shaft fragments proved valuable. As might be expected, the majority (54%) of the 171 long bone shaft fragments from medium-large and large mammals recovered from the site, were recovered from the midden. A substantial number (30%) of shaft fragments were recovered from the room. Of these shaft fragments, 84% were recovered from the occupation level (33% from stratum 3, and 51% from the subfloor cist). Long bone shaft fragments from exterior grids comprised only 16% of the total, the majority of which were recovered from just south of the southwest corner of the room.

These data suggest a number of possibilities. It is possible that the primary center of marrow extraction was within Room 1. This area has the greatest number of shaft fragments, with the exception of the midden. Marrow extraction may also have occurred outside of the room by the southwest corner. However, evidence is limited in this and all exterior areas. The large quantities of long bone shaft fragments in the midden are probably not evidence of marrow cracking in that area. It is more likely that these fragments represent debris from marrow extraction elsewhere which was transported into the midden during cleaning episodes.

LA 10114 – Figure 13.2 illustrates the density of the 125 long bone shaft fragments at LA 10114. It is evident that two loci of long bone shaft fragments occur. One high density epicenter (Concentration No. 1) is located immediately outside the east wall of the room.

The other high density epicenter (Concentration No. 2) is located within the room. These concentrations suggest that marrow cracking occurred within the room and possibly just outside the east wall.

On further examination of the long bone shaft fragments from Concentration No. 1, it is evident that more is happening than the spatial analysis revealed. Concentration No. 1 is 95% burned shaft fragments (67.5% from stratum 2 and 27.5% from stratum 1). Concentration No. 2 is only 16% burned (12% from stratum 2 and 2% each from stratum 1 and 3). The high percentage of burned bone from Concentration No. 1 suggest that this area is not where the original activity of marrow extraction was located. Some of the burned shaft fragments can be accounted for by the nature of stratum 2. Burning is evidenced by a grey ash and charcoal layer (stratum 2). However, this does not adequately explain the high percentages of burned bone. If this burning accounted for most of the burned bone in the area, we would expect fairly high percentages of burned bone throughout this area. This is not the case, in that other areas within stratum 2 do not have such high percentages of burned bone. We can speculate how this variability occurred. Marrow extraction may have occurred within Room 1, centered in the area of Concentration No. 2. As the long bone shaft fragments accumulated, they may have been dumped into the hearth during cleanup episodes. In my opinion, some cleanup is likely to have occurred if only because of the sharp nature of these bones. Later, as the formal hearth accumulated ash and bone, the hearth area may have been cleaned. If this were the case, we would expect a concentration of ash and burned bone in a dump area outside the room. As illustrated in Fig. 13.5, there is indeed an exterior concentration of burned bone in the area of Concentration No. 1, but there is no good indication that this concentration is associated with a localized ash deposit.

Because stratum 2, where most of the burned bone occurred, is comprised largely of ash and charcoal throughout, evidence of localized ash concentrations within the stratum could not be defined. It is possible, therefore, that the long bone shaft fragments in Concentration No. 1 are located in a dump area from the hearth in Room 1. The speculation that the marrow cracking occurred in Room 1 and the accumulation of long bone shaft fragments were deposited in the hearth and later into the dump area, is a possibility.

It is felt that the spatial distribution of long bone shaft fragments both inside and outside the room may well reflect marrow cracking by the inhabitants, and that marrow extracting occurred within, rather than outside the room. The possibility that the exterior concentration of long bone shaft fragments represents the end result of cleanup activities within the room has been raised, but cannot be fully resolved because of the general nature of fill comprising stratum 2 where the exterior concentration was located.

LA 13291 -- Evidence of marrow cracking at LA 13291 comes from two distinct areas: within and around Room 1 and within Room 2. The Room 1 area included 121 or 85% of the total long bone shaft fragments while Room 2 included only 21 or 15%.

Room 1: Figure 13.9 illustrates the density of long bone shaft fragments within, and in grids contiguous to Room 1. With only one exception, all shaft fragments were recovered from the second, more extensive occupation of Room 1. Although this area was disturbed by both rodent and water action, a concentration was located just north of the hearth within Room 1 (contour lines 18.5 and 27). Included in the 20 contour line are shaft fragments from the hearth and the ash area west of the hearth. Eleven burned long bone shaft fragments were recovered from the ash area.

It has been suggested (Schutt 1979) that this area was a dump for material accumulating in the hearth. Faunal remains from this ash area tend to support this suggestion. Of the 123 bone fragments located within this ash area, only 37 (30%) were burned. These data suggest that this ash area was not a hearth and that the burned bone located in this area was probably dumped there.

Through this spatial analysis, we begin to get an image of what may have occurred in the Room 1 area. It seems that the primary center of marrow cracking was located within the room, just north and contiguous to the hearth. The debris from this activity (long bone shaft fragments) fell to the ground and was preserved archeologically. Some of the fragments were probably deposited into the hearth and then later, during a hearth cleaning episode, were deposited into the ash dump. It is also possible that long bone fragments were pushed aside into this already established dump area. It is interesting to note that, although this dump area was located within the room, it was in a fairly out of the way place—in the corner where the west wall and numerous boulders meet. In summary, it appears that marrow cracking occurred within Room 1, and debris from this activity was transferred into the ash dump when accumulations of these fragments became a problem.

Room 2: Evidence for marrow cracking in Room 2 was considerably less tangible when compared to Room 1. A total of only 21 long bone shaft fragments, located in and around the burned area within Room 2, was recovered. All of the shaft fragments within the charcoal stained area were burned. On the basis of such a small and rodent disturbed sample, it is difficult to determine the extent of marrow cracking in Room 2. It can be suggested from these data, however, that some degree of marrow extraction did occur within Room 2. The burned shaft fragments located within the charcoal stained area may indicate that the debris from this activity either fell into this burned area, during its use, or were deposited there by the inhabitants of Room 2.

In conclusion, marrow cracking, as evidenced by long bone shaft fragments, occurred at LA 13291. The center of this activity was located within Room 1, immediately north of the hearth. A limited degree of marrow cracking may have occurred within Room 2, but this concentration by no means compares with the large concentration within Room 1.

Soup Making

Soup making, as I use the term, consists of the processing and boiling of bone in order to render a broth. Bones which are high in grease content will yield the richest broth, especially if these bones are smashed so that the majority of grease can be released. The result of this smashing is usually a large number of unidentifiable fragments. White (1953:162) has suggested that bone parts are actually destroyed beyond recognition as a result of smashing bones for bone grease.

Among the Nunamiut Eskimos, long bone articulator ends of caribou are selected for white grease rendering because of certain morphological properties inherent in the bones themselves. For example, bone density, grease quantity, and bone size condition selection of bones for grease among the Nunamiut (Binford 1978b:32).

It is assumed that these general properties of bone will be similar not only between sheep and caribou (see Binford 1978b:34) but also between other artiodactyla. We would expect long bone articulator ends of artiodactyla to be selected for soup making because morphological properties of these bones make them better for grease rendering than other anatomical parts. We would also expect these articulator ends to be smashed to release a greater quantity of grease.

It is suggested that spatial association of unidentified fragments and long bone fragments from articulator ends might represent the area where debris from soup making was dumped. We would expect these elements to be associated because: (1) smashing bones in the soup making process will produce unidentifiable fragments; and (2) long bone articulator ends would be more likely selected for soup making because of their high grease content. Spatial association of these fragments occurred at LA 10114 and LA 13291.

LA 10114 – Although spatial association of long bone fragments and unidentified fragments did occur at this site, there are some problems with the application of the above suggestion to these data. Figures 13.3 and 13.4 illustrate the density of both types of fragments at LA 10114. The centers of highest concentration overlap but are not spatially identical. Although it is possible that this concentration within Room 1 represents the dumping of smashed bone after the soup was stored or consumed, this does not seem likely. It is hard to imagine the occupants of this site dumping the debris from the soup making process within the room when it would appear to be more convenient to dispose of these fragments directly outside, or in an established dump area.

On further examination of long bone fragments and unidentified fragments, it is clear that a greater spatial association exists between burned fragments of these types (see Figs. 13.6 and 13.7). It is evident that the high concentration for burned bones of these types is located outside the east wall, just south of the concentration of burned long bone shaft fragments (see Marrow Cracking, LA 10114).

It is possible that these burned fragments represent the debris from soup making. It was suggested in the Marrow Cracking section that this area was a dump for material accumulating in the hearth. If this is in fact the case, the burned fragments in this area may have originally been dumped into the interior hearth and later, during a hearth cleaning episode, dumped on the opposite side of the wall outside the room. However, the reasoning which would result in dumping waste bone within the room still escapes me. These fragments would have already been collected in the soup pot for easy disposal, once the soup was consumed. It may be that the reasoning escapes me simply because of my personal late 20th century standards of cleanliness. In any case, until we have a greater understanding of the processes which will produce this kind of patterning, we cannot be sure what behaviors are reflected by these observations.

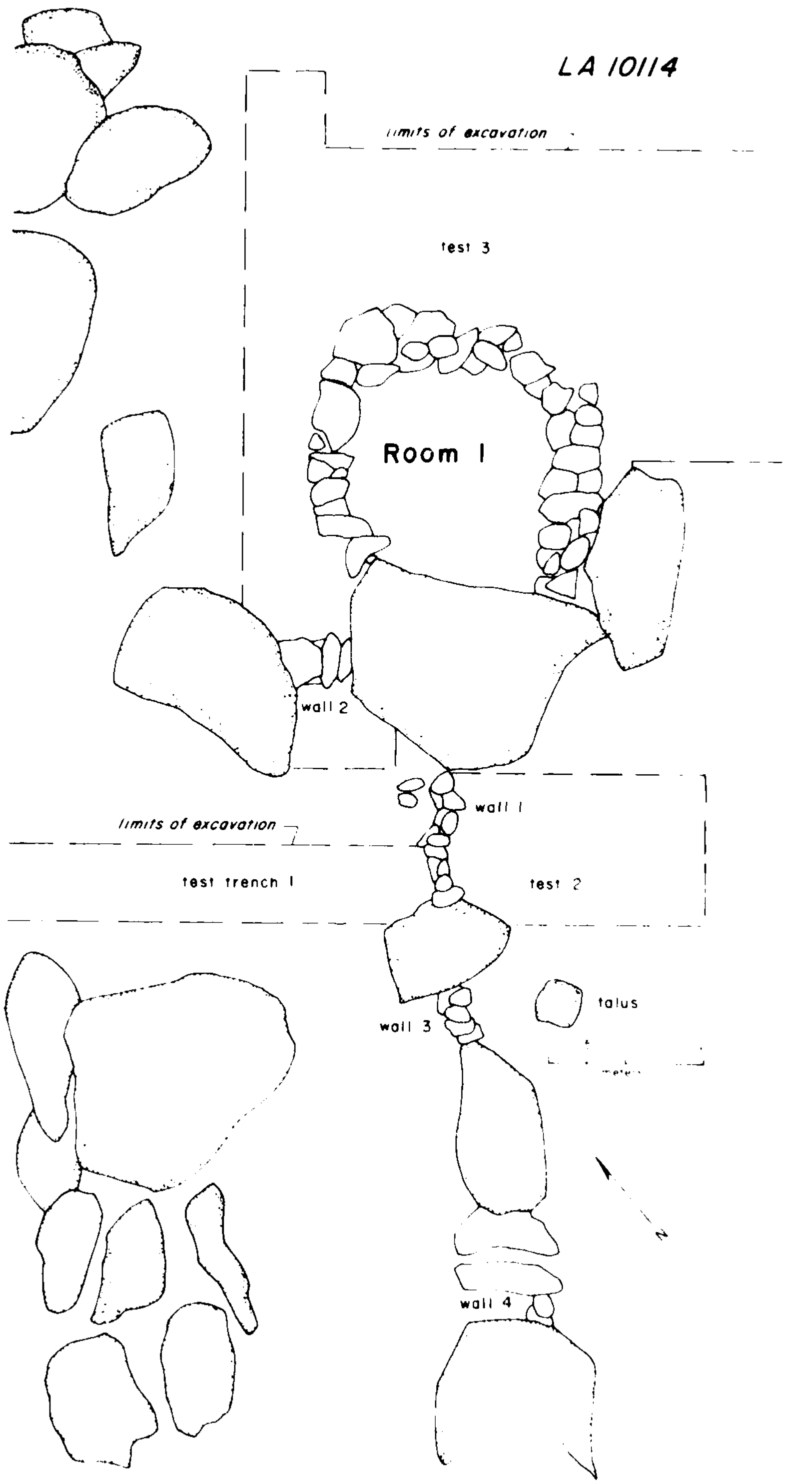

Fig. 13.1 LA 10114 Overview

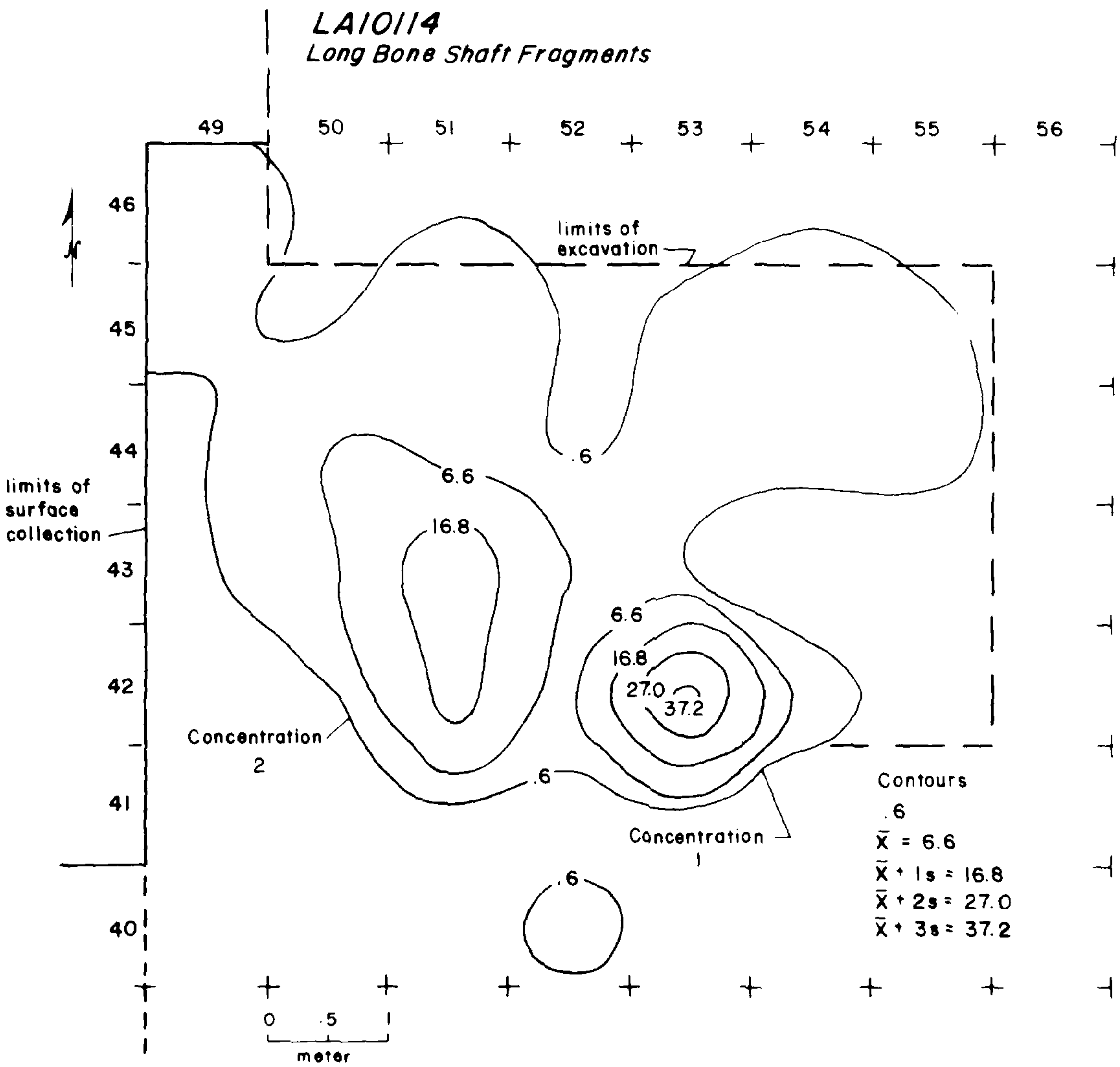

Fig. 13.2 LA 10114 – Long bone shaft fragments, all levels

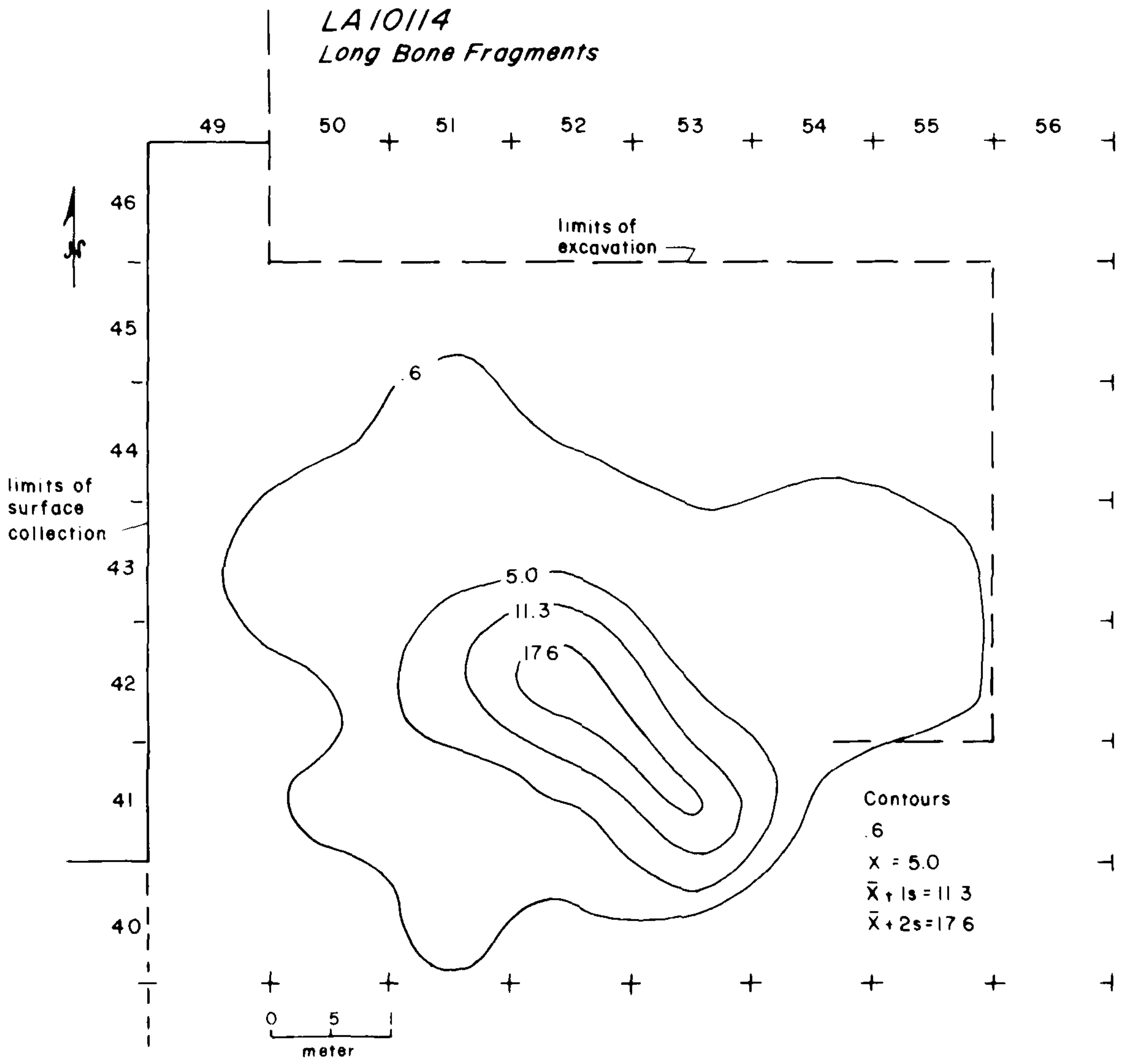

Fig. 13.3 LA 10114 -- long bone fragments, all levels

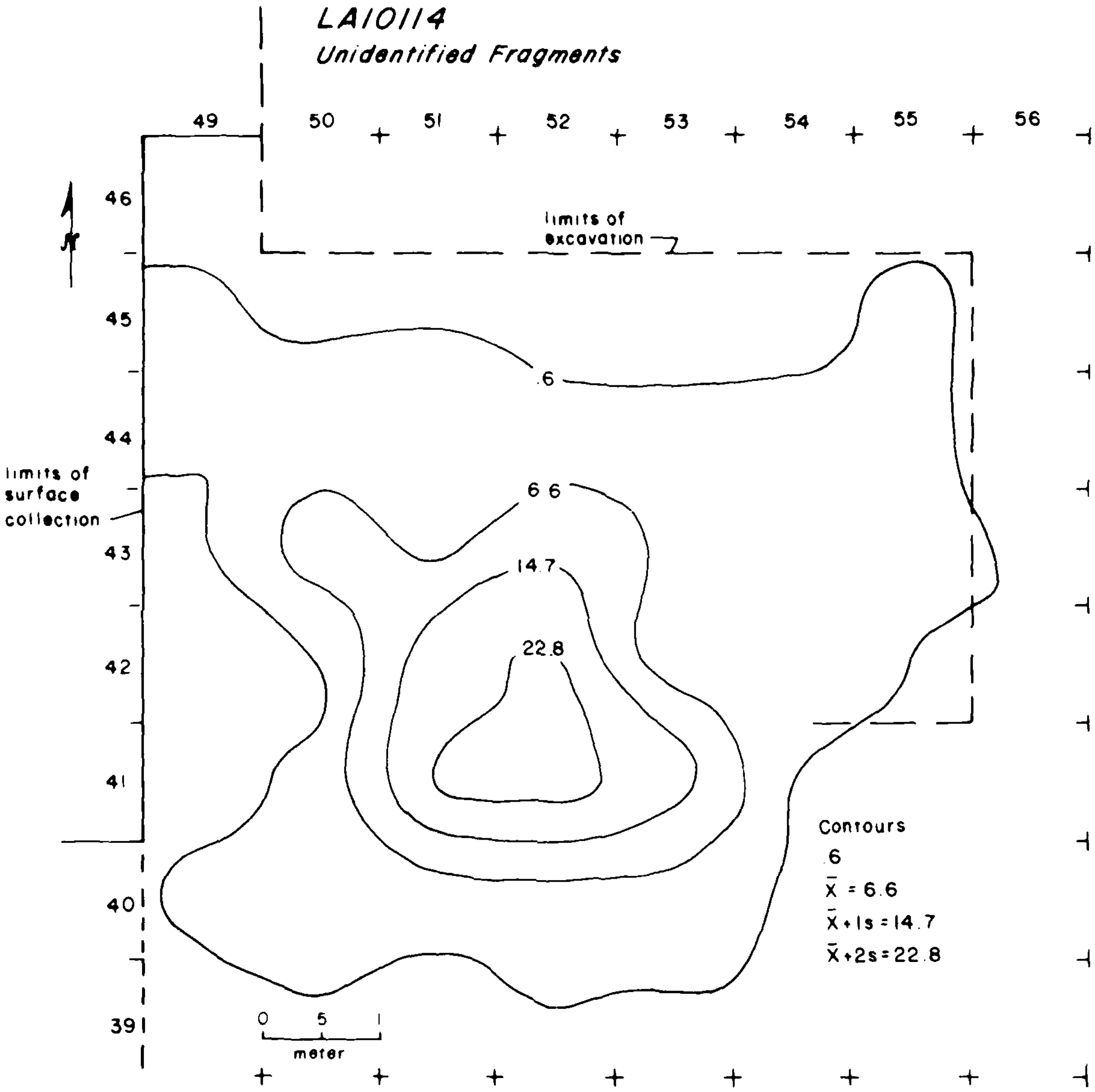

Fig. 13.4 LA 10114 – unidentified fragments, all levels

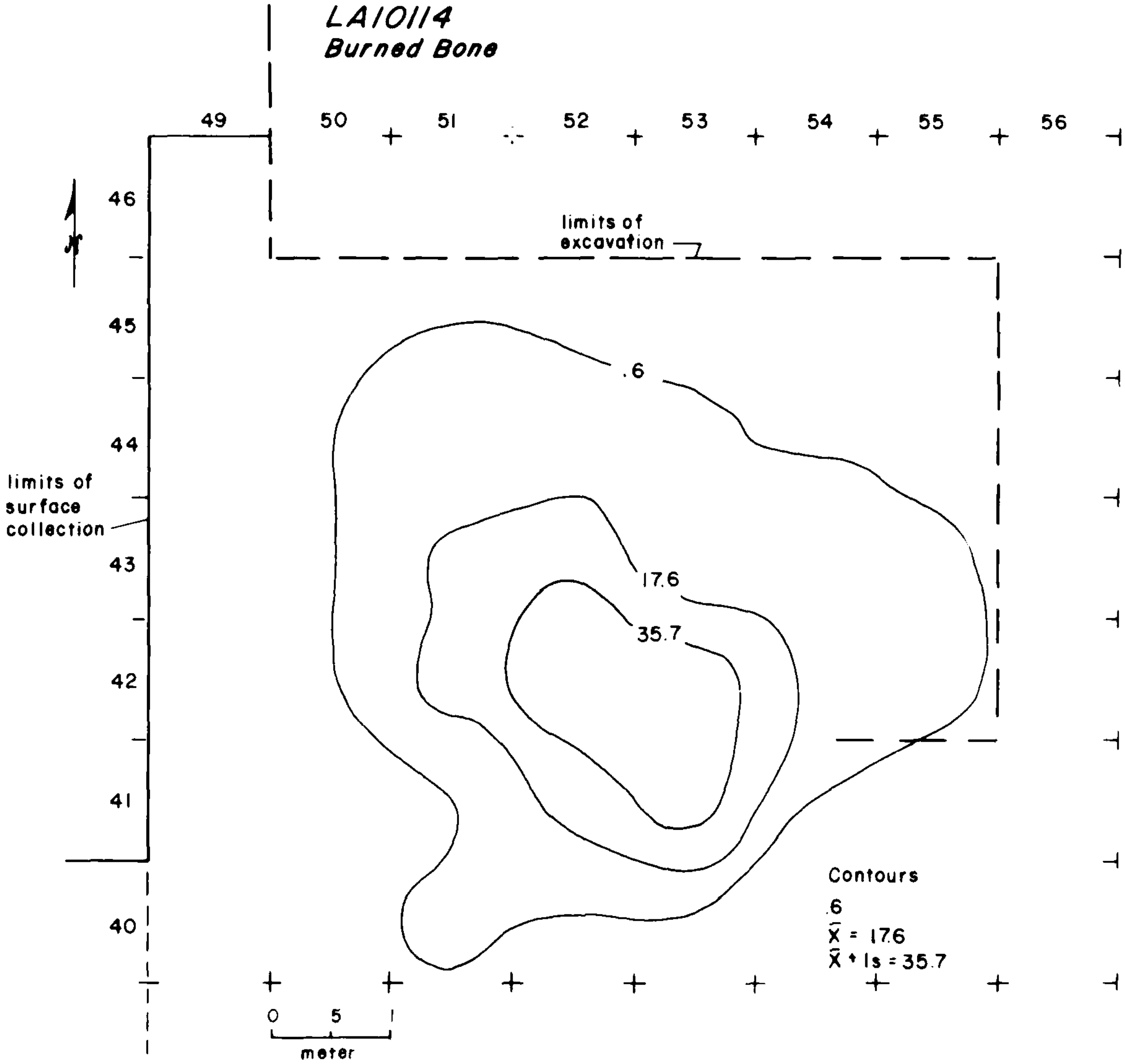

Fig. 13.5 LA 10114 — burned bone, all levels

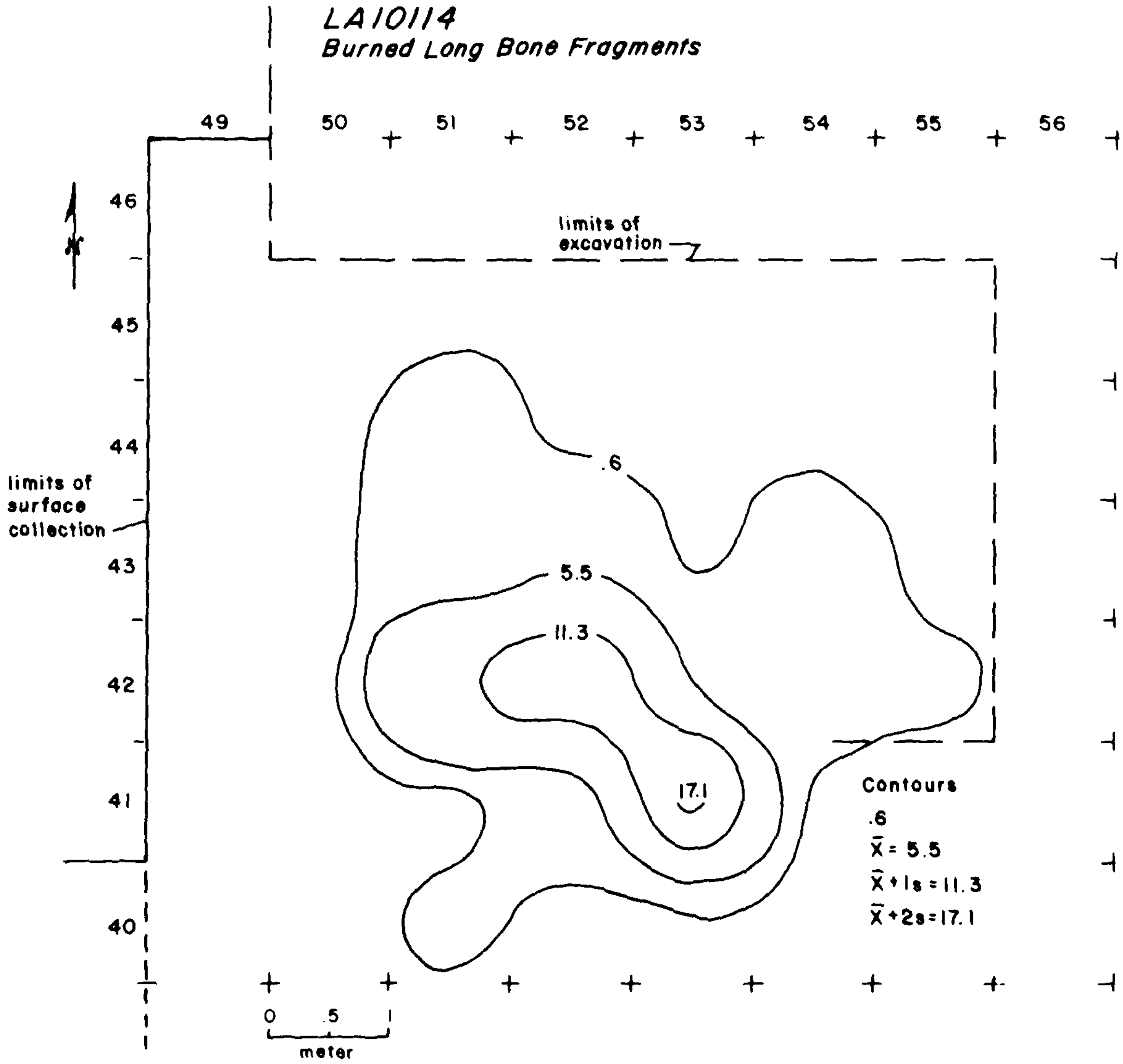

Fig. 13.6 LA 10114 – burned long bone fragments, all levels

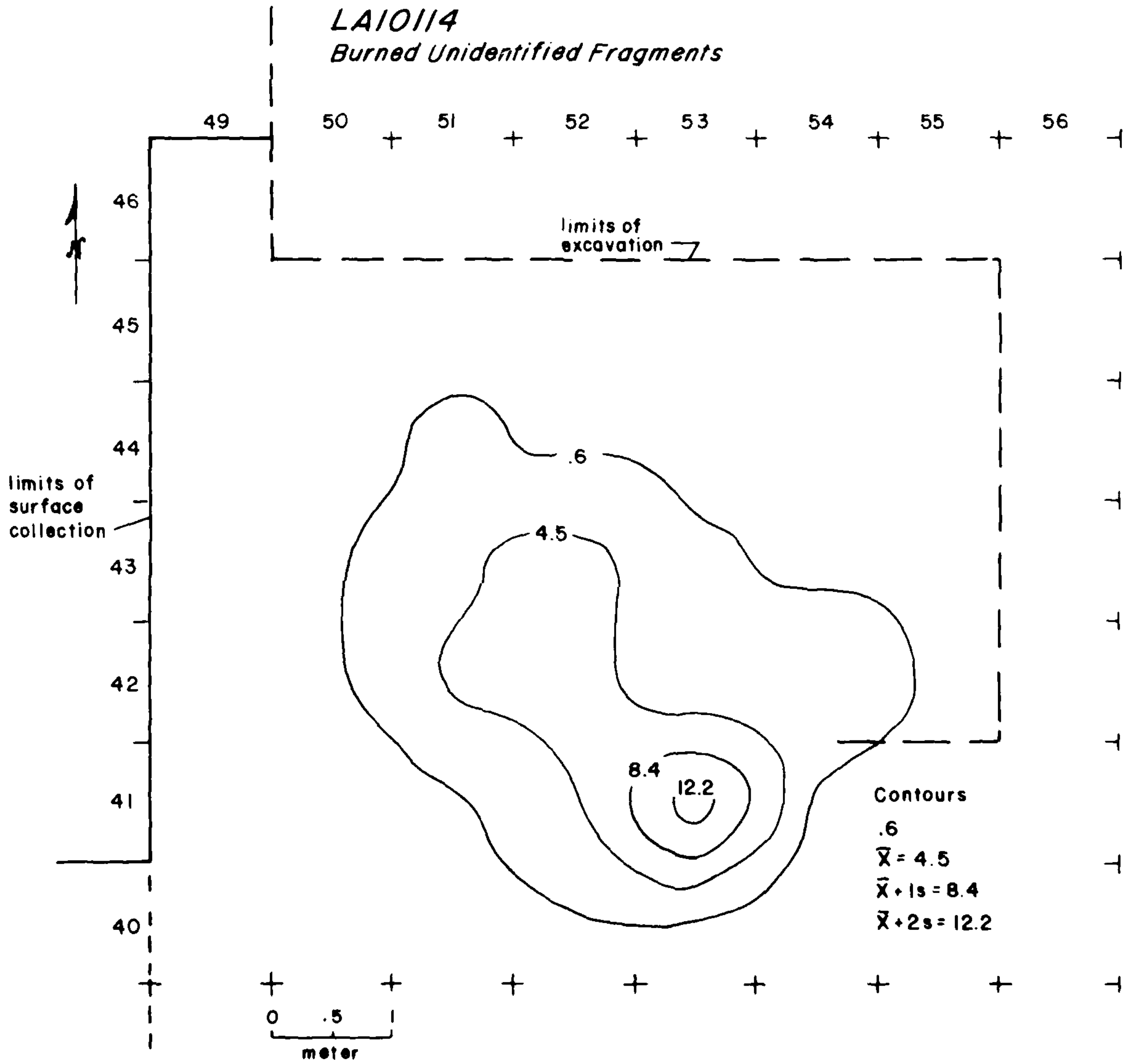

Fig. 13.7 LA 10114 — burned unidentified fragments, all levels

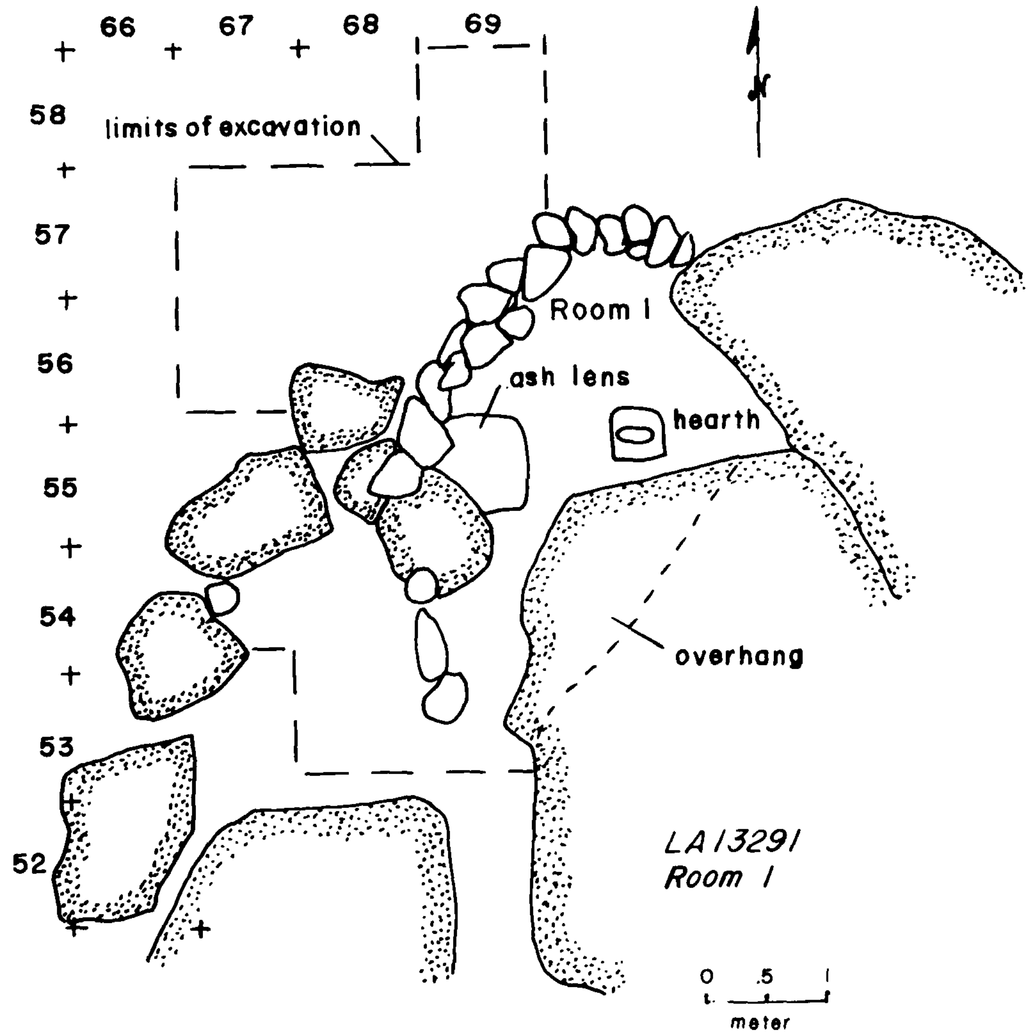

Fig. 13.8 LA 13291 Overview

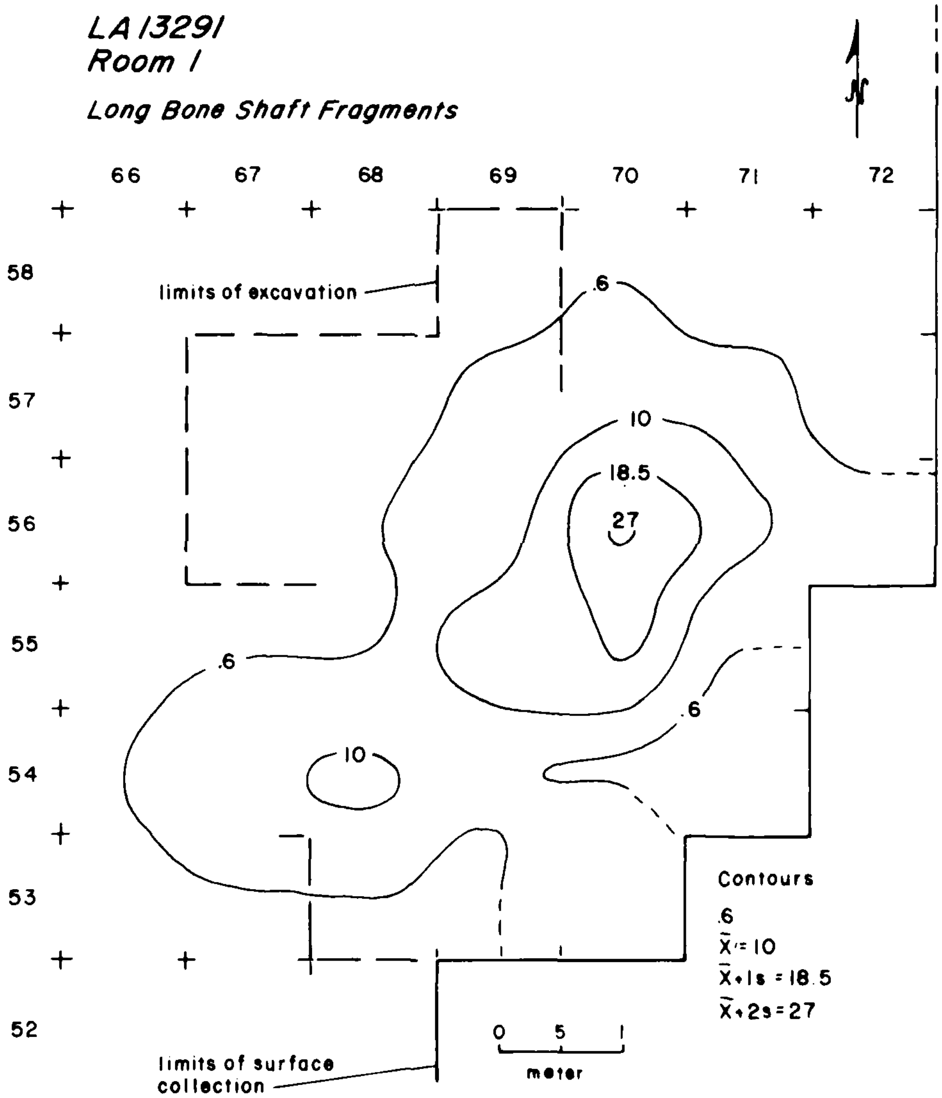

Fig. 13.9 LA 13291 – long bone shaft fragments, all levels

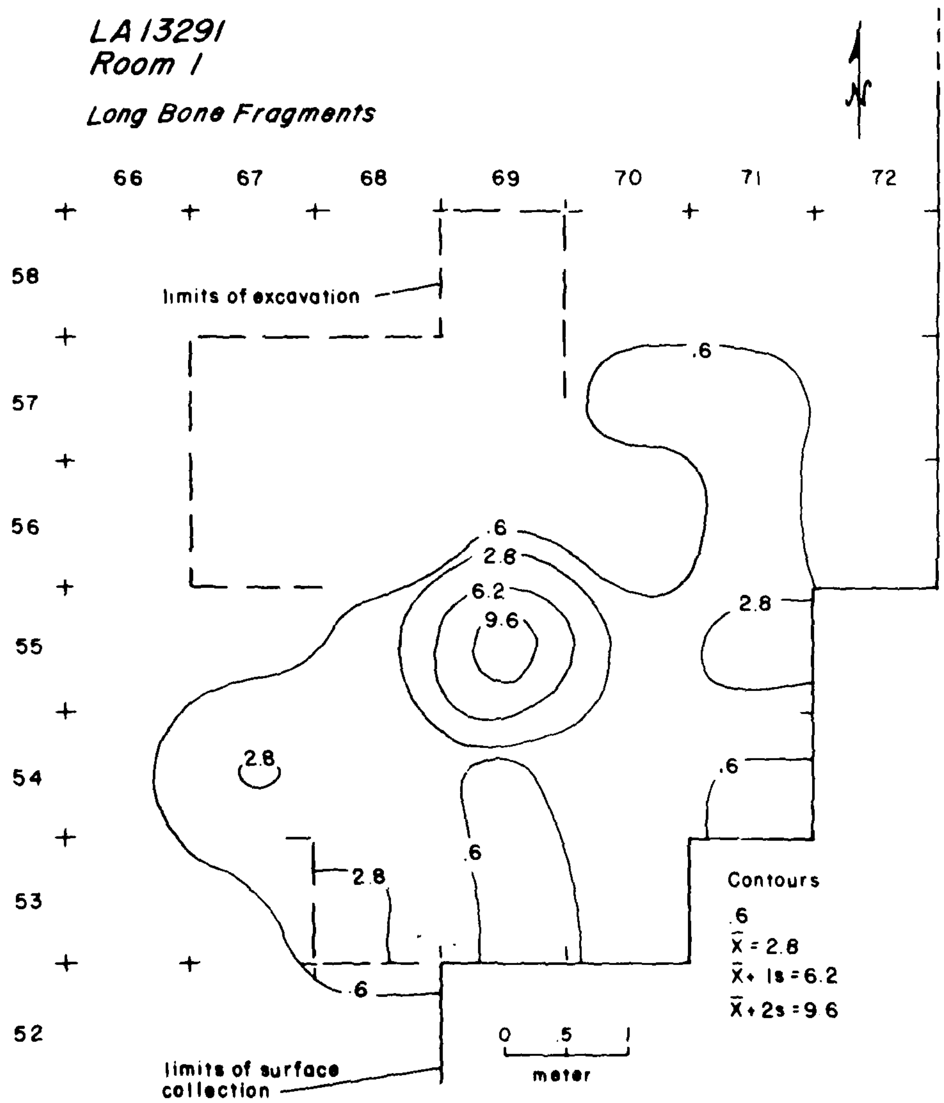

Fig. 13.10 LA 13291 — long bone fragments, all levels

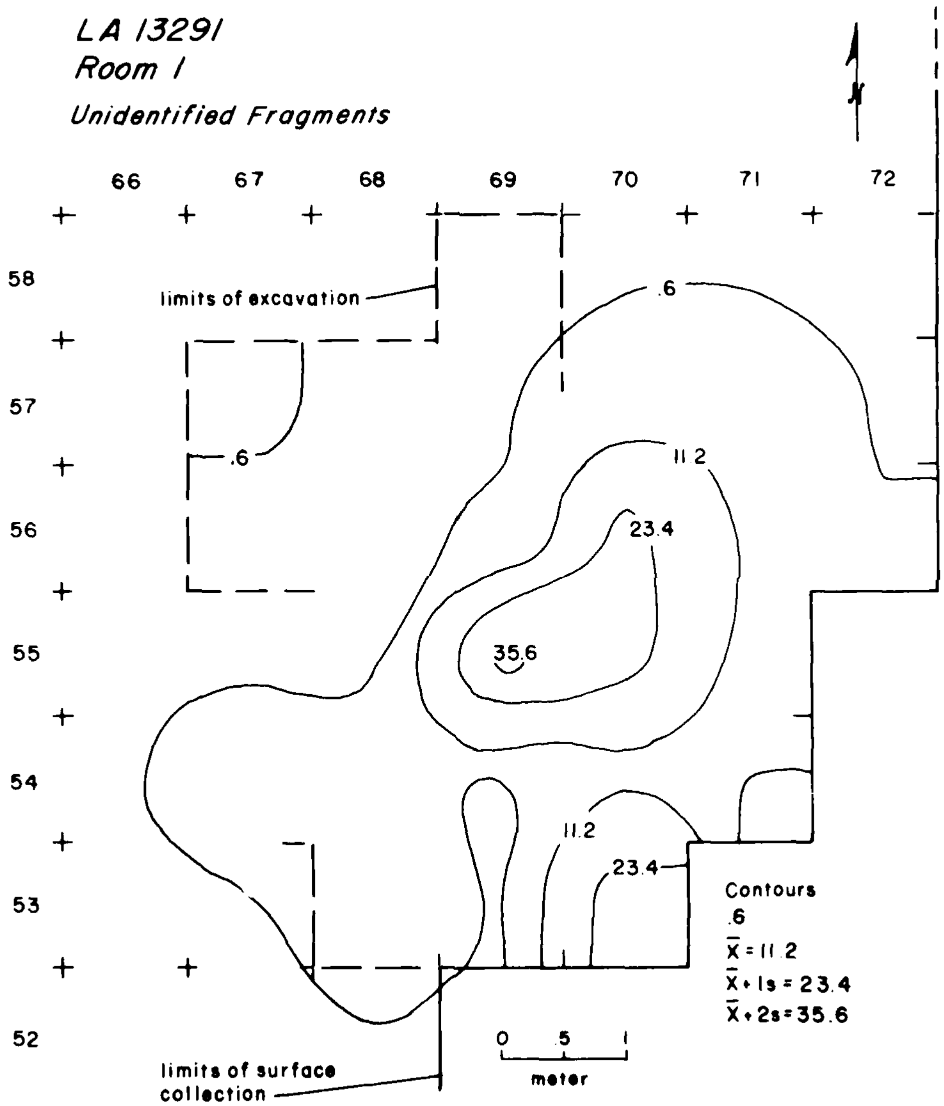

Fig. 13.11 LA 13291 — unidentified fragments, all levels

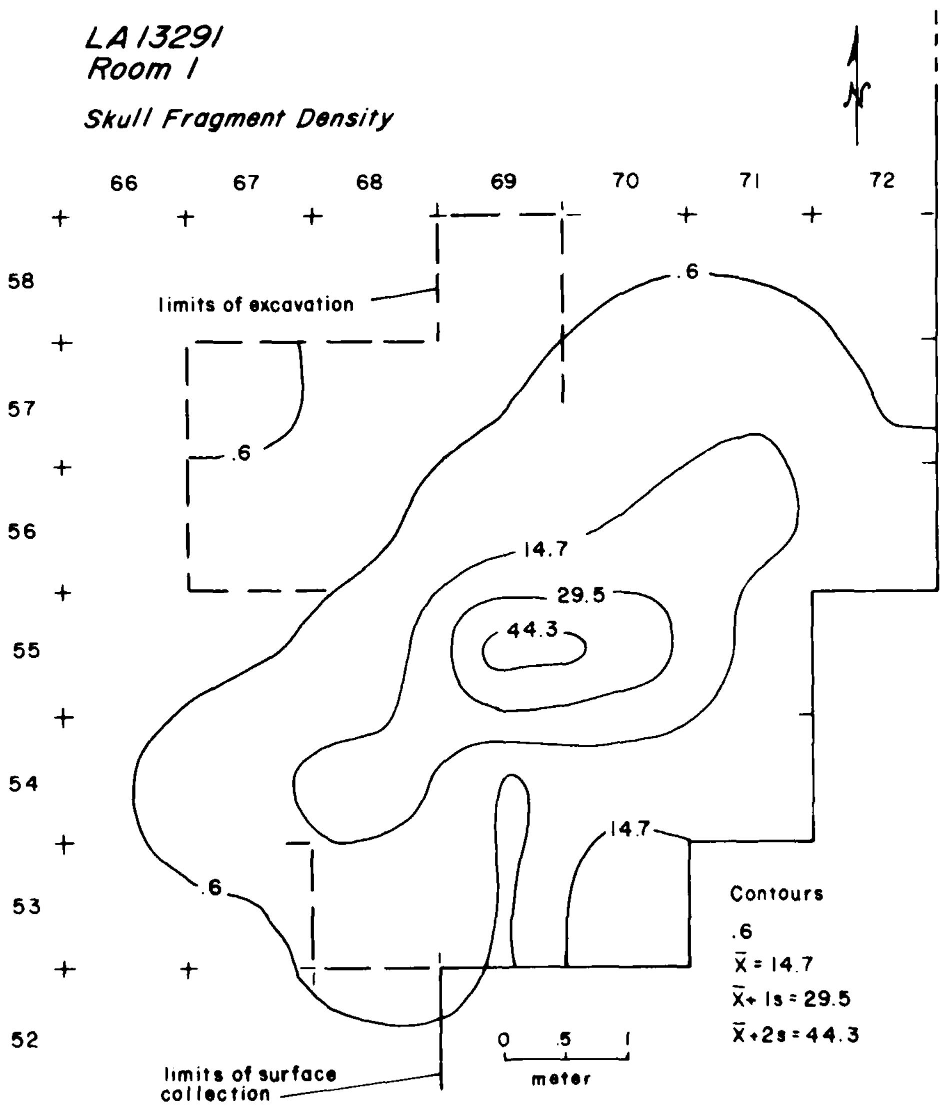

Fig. 13.12 LA 13291 -- skull fragments, all levels

LA 13291 – Figures 13.10 and 13.11 illustrate the densities of long bone fragments and unidentified fragments in the Room 1 area of LA 13291. All of the long bone fragments and 97% of the unidentified fragments were recovered from this area. The high concentrations for both types of fragments are located in and around the ash area discussed in the marrow cracking section. It is easy to conceive of waste bone, from soup consumption, being dumped into this already established dump area. Of these fragments located within the ash area, 67% were not burned. This suggests that these fragments were dumped directly into this dump area and not into the hearth previously.

These data suggest that a limited degree of soup making may have occurred at LA 13291. The center of this activity was within Room 1. Bone fragments remaining after the soup was consumed were deposited in the established interior dump (ash area), a conveniently out of the way location.

Skull Processing

The consumption of skull contents has been documented both ethnographically (Brain 1969:15; Binford and Bertrum 1977:94) and archeologically (Kehoe 1967: 69). The spatial isolation of skull fragments may not, however, reflect the consumption of brains. In order to determine if consumption of large mammal skull contents did occur, we must make certain assumptions about the use of space. The following assumptions were used in formulating logical speculations:

(1) Skulls would be transported from the butchering location into the living area only if use for them was anticipated.

(2) Skulls, due to their size, would not be stored in a habitation structure because this would limit the performance of other activities.

(3) Skulls would be brought into a habitation structure only if their use was not exhausted.

If we accept the above assumptions, spatial isolation of skull fragments within a habitation structure would most likely reflect the use of the skull within the room. Skull fragments would be the result of deliberate breakage since whole skulls would not be stored within the room for any length of time (thus eliminating the possibility of breakage of natural processes). It is suggested that spatial isolation of skull fragments within a room reflect consumption of skull contents. Spatial isolation of skull fragments occurred at LA 13291.

Figure 13.12 illustrates the density of skull fragments in the Room 1 area of LA 13291. This area contained 98% of all the skull fragments (240) recovered from the site. It is evident from the figure that a high concentration of skull fragments is located in and around the ash area (discussed in both the marrow cracking and soup making sections). This suggests that skulls were brought into the room after they had been roasted (there is no evidence of a roasting pit within Room 1) or were boiled in the room and consumed there. As with the long bone shaft fragments and the debris from soup making, the skull fragments left after the brains were consumed were pushed aside into the existing dump area (ash area). In support of these speculations is the degree to which skull fragments in this area were burned. The majority (76%) of the skull fragments in this ash area were unburned, suggesting that these fragments were deposited directly in the ash area and not into the hearth first.

In summary, it appears that consumption of brains occurred within Room 1 at LA 13291. Debris from cracking the skulls was pushed aside into the ash dump area. Although we cannot be sure that these speculations are correct, they do fit with the data.

Summary

This section has presented a number of speculations concerning the spatial structure of faunal remains. Although these speculations have been based on disturbed and limited samples, some interesting possibilities have been raised concerning the use of faunal resources. I hope that this section has shown that despite these problems, examination of spatial patterning is both informative and valuable. Continued spatial analysis is critical not only in determining activity areas, but also in increasing our understanding of the knowledge we must gain in order to accurately give meaning to the archeological record.

CONCLUSION

This paper documented the faunal assemblages of four historic sites in the Cochiti area. It also presented some speculations about behaviors which may be reflected by the data.

However, the value of this paper is that it demonstrates, despite limited sample size, disturbed sites, and the fragmentary nature of the assemblages, that valuable information can be gained through faunal analysis of both assemblage content and spatial distribution of bone.

Chapter 14

A COMPARATIVE STUDY OF ARCHAIC, ANASAZI AND SPANISH COLONIAL SUBSISTENCE ACTIVITIES IN COCHITI RESERVOIR

Meade Kemrer and Sandra Kemrer

INTRODUCTION

The archeological survey and excavation phases of the Cochiti Reservoir project were performed in the context of the methodological and theoretical biases established by White (1959), Binford (1964, 1968), and Flannery (1968). Consistent with this orientation, the major purpose of this study is to delineate aspects of the adaptive nature of the prehistoric and early historic cultural systems which operated within the Cochiti Reservoir study area. Answers to the following questions provided the framework for research:

1) How did the various human groups who occupied the Cochiti Reservoir study area articulate with the environment?

2) Did their adaptive systems exhibit different structural/organizational characteristics?

3) How can the outcomes of the systems be described in human behavioral terms?

In the process of reconstructing human adaptive systems, archeologists frequently deal with evidence which provides only indirect proof concerning their operation. In this paper, a number of human behavioral outcomes deemed important for the operation of energy procurement and transformation systems are examined. First, the types of stone resources selected by various cultural groups from the Cochiti study area for tool manufacturing purposes are analyzed. Relationships are sought between tool manufacturing properties and the kinds of tools that were made and used. Second, variability in flaked tool types within and between the cultural periods are examined to determine patterns in diversity of procurement and processing activities that may have taken place. A similar analysis is performed in terms of tools utilized for food grinding activities. Third, an examination of site settings and the activities performed in the various site contexts is conducted to evaluate past human articulations with their environment within the study area. Finally, a comparative analysis of plant and animal food remains, tool use, and environmental settings is performed to specify various elements in the adaptive systems which operated in the Cochiti Reservoir area through time.

THE DATA SAMPLE

The set of sites analyzed were excavated during the 1975-1977 field seasons (Chapman et al. 1977; Biella 1979). Not all of the excavated sites were utilized. Several conditions which could potentially skew or obliterate human behavioral patterns obtained at several sites. Some were eliminated on the basis of post-occupational disturbance. Sites which could not be assigned satisfactorily to a time period or to a particular cultural group were also eliminated from examination. A total of 27 sites or proveniences of sites was considered to be suitable for analysis and are listed in Table 14.1.

The cultural designation terminology used in the report requires explication. The term *Archaic* refers to the set of sites in the sample that were occupied by human groups who did not use ceramics. Obsidian hydration studies, and in a few cases, temporally diagnostic projectile points indicate that these sites predate the Puebloan period (Haecker 1977:111-114). The age of the Archaic sites may range between 5500 B.C. and ca. A.D. 400, or Basketmaker II (*cf.* Irwin-Williams 1973). The justification for enclosing these sites within one analytical unit is based upon the premise that the acquisition of nonagricultural food resources was of primary adaptive significance to human groups living in the Cochiti Reservoir study area within this time range. Six sites dating to the Archaic period were included in the study (see Table 14.1).

The term *Puebloan* refers, for the most part, to the Anasazi P-IV period (A.D. 1325-1600). Exceptions include the late P-III component at LA 9138A and LA 5011. Seventeen sites are included in this analytic unit (see Table 14.1).

The four sites labeled *Spanish Colonial* were occupied during the 18th century. The sites designated *Spanish Colonial* all contain features which are characteristic of Spanish culture, such as corner hearths and ceramic griddles (*comales*), contrasting with Southwestern Pueblo Indian culture.

DATA ANALYSIS

Patterns in the Selection of Lithic Materials

Materials extracted from the environment as a part of procurement and processing systems are likely to reflect the relationship between specific tasks to be performed and certain qualities of the material selected. The lithic resources within the Cochiti region exhibit a wide range of variability in those properties most likely to have been considered important by the prehistoric and historic inhabitants of the region. Variation in the physical properties of the lithics found at the sites selected for study had a demonstrable impact on the tools manufactured.

The size of raw materials varies with material type. Basalt is available in sizes ranging up to massive blocks and outcrops. Chalcedony occurs in nodules derived from the Totavi Lentil and exhibits a size range smaller than that of

Table 14.1
Site Sample Listed by Major Cultural Periods

LA Site No.	Cultural Affiliation	Brief Description
	ARCHAIC	
LA 12442	Archaic/BM-II	Open Campsite
LA 12456	Late Archaic/Early BM	Open Campsite
LA 12463	Late Archaic/Early BM	Open Campsite
LA 12494	Late Archaic	Open Campsite
LA 12495	Late Archaic/BM	Open Campsite
LA 12496	Late Archaic	Open Campsite
	PUEBLOAN	
LA 5011	Anasazi, P-III/P-IV	one room
LA 9138A	Anasazi, P-III/P-IV	2 noncontiguous rooms (6 and 7)
LA 12443	Anasazi, P-IV	one room?
LA 12447	Anasazi, P-IV	one room?
LA 12449	Anasazi, P-IV	one room?
LA 12454	Anasazi, P-IV	2 rooms
LA 12483	Anasazi, P-IV	Open Campsite
LA 12486	Anasazi, P-IV	Open Campsite
LA 12517	Anasazi, P-IV	one room
LA 12518	Anasazi, P-IV	2 rooms
LA 12519	Anasazi, P-IV	2 rooms
LA 13049	Anasazi, P-IV	one room
LA 13050	Anasazi, P-IV	one room
LA 13054	Anasazi, P-IV	2 noncontiguous rooms
LA 13076	Anasazi, P-IV	2 noncontiguous rooms
LA 13084	Anasazi, P-IV	5 noncontiguous rooms
LA 13329	Anasazi, P-IV	one room
	SPANISH COLONIAL	
LA 9138B	18th Century	2 noncontiguous rooms (8 and 9)
LA 12161	18th Century	one room
LA 12438	18th Century and Anasazi, P-IV	2 or 3? rooms
LA 12507	18th Century	one room

basalt and greater than chert and obsidian (see Warren, this volume). Obsidian nodules, locally available and derived from Jemez volcanics, generally occupy the smallest size range. By virtue of the fact that stone tool manufacturing is a subtractive process, the size of the raw materials will frequently have an effect upon tool size. This relationship is reflected in the size range of whole flakes derived from the major material types (Table 14.2). Basalt flakes exhibit the greatest range of size variation, with chalcedony, chert, and obsidian showing progressively narrower size ranges.

Further analyses were carried out to determine more specifically the nature of lithic selection patterns at the 27 sites. A tabulation of the raw and proportionate frequencies of each lithic material genus shows that considerable diversity obtains among the sites (Table 14.3).

The frequencies of lithic artifacts derived from the data from Table 14.3 were then ranked by material generic type within each site. The highest incidence of flaked materials of a given class of stone was assigned a rank value of 1, and so on. Sites sharing the same ranking order are shown as *clusters* in Table 14.4.

General lithic material preferences characterize each cultural period. Archaic groups (clusters 6, 9 and 10) tended to select either basalt or obsidian with chalcedony assuming a secondary or tertiary role. In contrast, P-III and P-IV groups (clusters 1-8) exhibit a wider range of preferences, with basalt or chalcedony tending to be selected over obsidian. During the 18th century Spanish Colonial period (clusters 11 and 12), the finer-grained materials such as obsidian or chalcedony were preferred over basalt. In all time periods quartzite, jasper, silicified wood, rhyolite, and andesite (grouped together in the material category *other*) tended to be the least preferred class of materials.

Another question posed was whether preferences existed regarding lithic taxa. To investigate this possibility, the relationship between the number of flakes versus the number of taxa represented at each site was analyzed by calcu-

Table 14.2

Size Variability in Whole Flakes*

Material Type	Flake Size in Millimeters 0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	100
Basalt	141	447	407	245	195	108	69	48	23	9	7
Chalcedony	90	435	320	179	90	30	10	3	–	–	–
Chert	6	12	3	4	3	2	5	–	–	–	–
Obsidian	112	411	259	81	15	5	1	–	–	–	–

* Data from only the first 20 sites analyzed are represented in Table 14.2. A visual inspection of the second set of sites showed the same pattern. Due to time limitations, these data were not compiled.

Table 14.3

Distribution of Flakes and Tools by Material Generic Type

LA Site No.	Period	Basalt	Obsidian	Chalcedony	Chert	Other	Totals
LA 5011	P-III/IV	87 (39%)	63 (28%)	41 (18%)	21 (9%)	12 (2%)	222
LA 9138A	P-III/IV	272 (66%)	4 (1%)	98 (24%)	36 (9%)	– (0%)	410
LA 9138B	Spanish Colonial	71 (17%)	34 (8%)	204 (50%)	84 (21%)	16 (5%)	409
LA 12161	Spanish Colonial	148 (13%)	448 (39%)	320 (28%)	174 (15%)	47 (4%)	1137
LA 12438	P-IV + Span. Colonial	11 (25%)	6 (14%)	11 (25%)	9 (21%)	6(14%)	43
LA 12442	Archaic	349 (29%)	719 (59%)	90 (7%)	37 (3%)	12 (1%)	1207
LA 12443	P-IV	158 (61%)	36 (14%)	28 (11%)	33 (13%)	5 (2%)	260
LA 12447	P-IV	187 (68%)	9 (3%)	57 (21%)	14 (5%)	8 (3%)	275
LA 12449	P-IV	107 (73%)	11 (7%)	22 (15%)	2 (1%)	4 (3%)	146
LA 12454	P-IV	175 (73%)	12 (6%)	12 (6%)	6 (3%)	– (0%)	205
LA 12456	Archaic	654 (67%)	118 (12%)	156 (16%)	26 (3%)	15 (2%)	969
LA 12463	Archaic	177 (53%)	85 (25%)	55 (16%)	17 (5%)	3 (1%)	337
LA 12483	P-IV	62 (33%)	45 (24%)	59 (32%)	3 (2%)	16 (9%)	185
LA 12486	P-IV	543 (63%)	83 (10%)	100 (12%)	55 (6%)	82(10%)	863
LA 12494	Archaic	1046 (46%)	358 (15%)	661 (29%)	137 (6%)	70 (3%)	2272
LA 12495	Archaic	262 (54%)	49 (10%)	124 (25%)	35 (7%)	16 (3%)	486
LA 12496	Archaic	156 (39%)	173 (44%)	46 (11%)	12 (3%)	10 (2%)	397
LA 12507	Spanish Colonial	– (0%)	– (0%)	4 (80%)	1 (20%)	– (0%)	5
LA 12517	P-IV	144 (28%)	14 (3%)	212 (42%)	50 (10%)	89(17%)	509
LA 12518	P-IV	137 (19%)	82 (11%)	388 (53%)	89 (12%)	30 (4%)	726
LA 12519	P-IV	19 (39%)	4 (8%)	17 (35%)	9 (18%)	– (0%)	49
LA 13049	P-IV	346 (34%)	155 (15%)	389 (38%)	92 (9%)	36 (3%)	1018
LA 13050	P-IV	210 (41%)	94 (18%)	163 (32%)	18 (3%)	25 (5%)	510
LA 13054	P-IV	150 (12%)	120 (10%)	744 (62%)	53 (4%)	137(12%)	1204
LA 13076	P-IV	1301 (94%)	21 (1%)	63 (4%)	1 (.01%)	3 (3%)	1389
LA 13084	P-IV	2565 (98%)	5 (2%)	28 (1%)	– (0%)	4 (2%)	2602
LA 13329	P-IV	25 (86%)	1 (3%)	3 (10%)	– (0%)	– (0%)	29

Table 14.4
Ranked Incidence of Flaked Lithics by Material Generic Type

Cluster No.	Cultural Period	LA Site No.	Basalt	Obsidian	Chalcedony	Chert	Other
1	P-IV	LA 12449	1	3	2	5	4
	P-IV	LA 12483	1	3	2	5	4
	P-IV	LA 13050	1	3	2	5	4
	P-IV	LA 13084	1	3	2	5	4
	P-IV	LA 13329	1	3	2	4.5	4.5
	P-IV	LA 12486	1	3.5	2	5	3.5
2	P-III/IV	LA 9138A	1	4	3	2	5
	P-IV	LA 12447	1	4	3	2	5
	P-IV	LA 12519	1	4	3	2	5
3	P-IV	LA 12518	2	4	1	3	5
	P-IV + Span. Colonial	LA 12438	1.5	4.5	1.5	3	4.5
4	P-IV	LA 12517	2	5	1	4	3
5	P-IV	LA 12443	1	2	4	3	5
6	P-III/IV	LA 5C11	1	2	3	4	5
	Archaic	LA 12463	1	2	3	4	5
7	P-IV	LA 13054	2	4	1	5	3
8	P-IV	LA 13049	2	3	1	4	5
	P-IV	LA 13076	1	3	2	4	5
	P-IV	LA 12454	1	1.5	1.5	4	5
9	Archaic	LA 12456	1	3	2	4	5
	Archaic	LA 12494	1	3	2	4	5
	Archaic	LA 12495	1	3	2	4	5
10	Archaic	LA 12442	2	1	3	4	5
	Archaic	LA 12496	2	1	3	4	5
11	Spanish Colonial	LA 12161	4	1	2	3	5
12	Spanish Colonial	LA 9138B	3	4	1	2	5
	Spanish Colonial	LA 12507	4	4	1	2	4

lating a Pearson's r correlation coefficient. The r coefficient value obtained was 0.82, indicating that a positive and significant relationship exists between these two variables. This probably means that the need for a specific tool could be met by more than one taxon and that there was little discrimination being made at the taxon level. Furthermore, a visual inspection of the data array reflected no clustering by cultural period. Rather, as the number of flakes increased the number of taxa increased in a roughly linear relationship consistent with the r correlation coefficient value.

Cross-cutting cultural preferences was the relationship between material selection and type of tool to be manufactured and used. Specific genera correlated with different classes of tools. Massive material such as basalt, quartzite, rhyolite and andesite dominated the categories of utilized large angular debris and utilized cores, whereas obsidian, chalcedony and chert, which occur in smaller nodules, were preferred for the manufacture of facially retouched tools. Utilized debitage and utilized small angular debris reflect no material selection bias, for the proportional incidence of tools in each material classification is similar to their total proportional frequencies. The actual and proportional frequencies of the major tool types are listed by lithic material in Table 14.5.

Tool Utilization

A general question important in isolating tool utilization patterns is whether the intensity of tool utilization is a function of the total amount of flaking activities at a site. Tools were defined as facially retouched artifacts, utilized large and small angular debris, utilized flakes, and utilized

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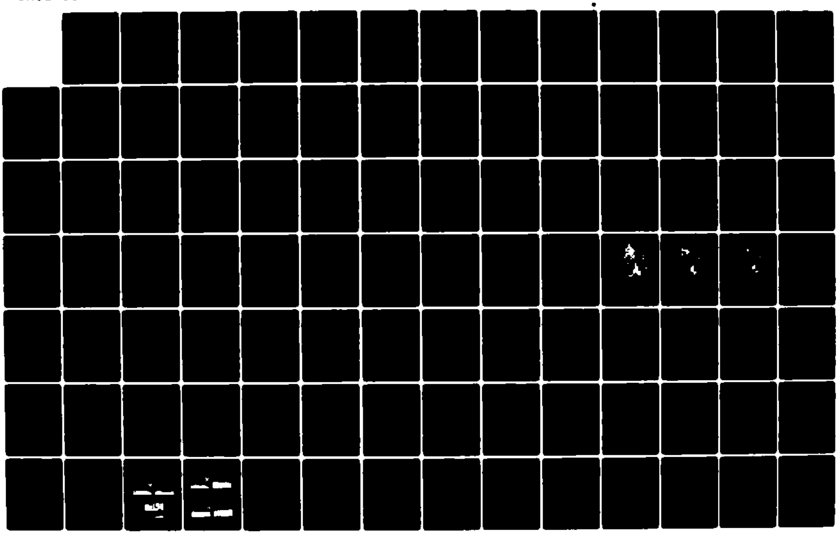
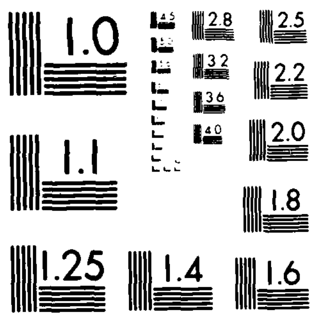




MICROCOPY RESOLUTION TEST CHART

Table 14.5

Tool Type Distributions by Material Type

Tool Type	Lithic Material Type: Basalt		Obsidian		Chalcedony		Chert		Other		Totals
Facially Retouched	10	(13%)	42	(53%)	13	(16%)	13	(16%)	1	(1%)	79
Utilized Cores	26	(74%)	1	(3%)	3	(9%)	1	(3%)	4	(11%)	35
Utilized LAD	32	(78%)	0	(0%)	4	(10%)	–		4	(10%)	41
Utilized Deb. + SAD	567	(48%)	357	(30%)	171	(14%)	70	(6%)	22	(2%)	1187
TOTALS	635	(47%)	400	(30%)	191	(14%)	85	(6%)	31	(2%)	1342

cores. Retouch and resharpening flakes from material taxa not represented among the facially retouched artifacts recovered from each site were also included, for it was considered likely that the actual tool from which these flakes were removed was modified at the site.

A Pearson's τ correlation was calculated between the number of tools and the total amount of flaked lithics recovered from each site. The τ coefficient value obtained was 0.68. Although this is a positive and significant correlation, the τ value indicated that a wide range of dispersal existed around the line of the estimating equation. The values for each site were therefore plotted and are presented in Fig. 14.1. Lines defining the boundaries of the tools versus lithics variability for each major cultural period are also drawn on Fig. 14.1.

Each time period is represented by a unique configuration of points. Archaic site lithic contents exhibit a greater range of variation than those found on Puebloan and Spanish Colonial period sites. Also, Archaic sites which contain fewer lithics tend to have a proportionately higher incidence of tools compared with the P-IV sites. The single P-IV site which falls within the Archaic range of variability (LA 12486) is a nonarchitectural manifestation where the procurement/processing activities may have been similar to those performed during the Archaic period. The Spanish Colonial sites form a discrete class with consistently higher numbers of tools per volume of lithics than either the P-IV or Archaic site categories.

Variation in tool manufacture and use also exists within each cultural period. Table 14.6 illustrates this by listing the ratio of the number of tools to the total number of lithics at each site. The Puebloan and Archaic values vary widely and overlap with each other. The Spanish Colonial ratios range consistently high compared with those derived from prehistoric sites. This pattern may indicate that the Spanish Colonial inhabitants of the Cochiti Reservoir Basin performed lithic manufacturing and use tasks on more of an *ad hoc* basis than the prehistoric groups.

The positive correlation between number of tools and total amount of flakes generated other relevant analyses.

Table 14.6

Flaked Tools and Lithic Distributions by Cultural Period

LA Site No.	Total No. Tools	Total No. Lithics	Tot. Tools / Tot. Lithics
ARCHAIC			
LA 12456	119	969	0.12
LA 12463	49	337	0.14
LA 12494	106	2,272	0.05
LA 12495	30	486	0.06
LA 12496	32	397	0.08
LA 12442	32	1,207	0.03
PUEBLOAN			
LA 5011	14	226	0.06
LA 9138A	8	410	0.02
LA 12443	37	260	0.14
LA 12447	6	275	0.02
LA 12449	0	146	0.00
LA 12454	29	205	0.14
LA 12483	3	185	0.02
LA 12486	43	863	0.05
LA 12517	30	509	0.06
LA 12518	4	726	0.01
LA 12519	5	49	0.10
LA 13049	121	1,048	0.11
LA 13050	20	528	0.04
LA 13054	125	1,204	0.10
LA 13076	71	1,408	0.05
LA 13084	189	2,665	0.07
LA 13329	14	30	0.47
SPANISH COLONIAL			
LA 9138B	54	409	0.12
LA 12161	182	1,137	0.16
LA 12438	13	43	0.30
LA 12507	1	5	0.20

The relationships among occupational intensity, tool manufacturing and tool use activities were compared in all cultural periods. The term *occupational intensity* is defined as a combination of behavioral outcomes which reflect the length of time or the number of times a site was occupied, and the number of individuals who may have occupied the site. This broad definition is necessary given the fact that group size, number of reoccupations, and occupational duration were generally indistinguishable.

Occupational intensity was measured by the amount of ceramic breakage that occurred at each of the Puebloan and Spanish Colonial sites. The assumptions made are 1) that ceramic vessels were employed in routine, repetitious tasks such as food and water storage, preparation and consumption, and 2) that vessel breakage rates during the performance of these activities was generally constant. For the nonceramic Archaic occupants of the Cochiti region, the amount of firecracked rock on each site was used to measure occupational intensity. Again, the assumptions are made that the accretion of firecracked rock is associated with repetitious food preparation activities, and the rate at which firecracked rock was produced at each site was generally constant.

Ceramic breakage at each Spanish Colonial or Puebloan site was measured in terms of the minimum number of broken vessels. Sherds from the same ceramic type (e.g. Santa Fe B/W), sharing the same vessel form (e.g. bowl), and composed of the same tempering material (e.g. vitric tuff) were considered to be from the same vessel regardless of the number of proveniences from which the sherds were recovered.

Firecracked rock volume was measured by combining the weight of all firecracked rock at each site.

All 20 components could not be included in these analyses. Postoccupational erosion or disturbance precluded the use of Puebloan sites LA 9138A, LA 12449, and LA 12483. The Archaic site, LA 12442, is a unique type of occupation in that hearths were not present. The data assembled for these evaluations are presented in Table 14.7.

Table 14.7

Firecracked Rock or Ceramics Versus Flaked Tools and Unutilized Lithics

LA Site No.	FCR (in Kg)	Min. No. Vessels	No. Tools	No. Unutilized Lithics
ARCHAIC PERIOD				
LA 12456	365.7	–	119	850
LA 12463	97.2	–	49	612
LA 12494	770.2	–	106	2,166
LA 12495	254.6	–	30	456
LA 12496	42.5	–	32	365
PUEBLOAN PERIOD				
LA 5011	–	21	12	208
LA 12443	–	23	37	223
LA 12447	–	10	6	269
LA 12454	–	13	29	176
LA 12486	–	13	43	820
LA 12517	–	1	30	479
LA 12518	–	10	22	704
LA 12519	–	5	5	44
LA 13049	–	15	118	887
LA 13050	–	25	20	490
LA 13054	–	18	107	1,088
LA 13076	–	15	70	1,338
LA 13084	–	8	182	2,411
LA 13329	–	3	1	28
SPANISH COLONIAL PERIOD				
LA 9138B	–	51	54	355
LA 12161	–	124	182	955
LA 12438	–	21	13	30
LA 12507	–	6	0	5

A series of Pearson's τ correlation coefficients was obtained between occupational intensity and tool manufacturing/use intensity. The results of these evaluations are presented in Table 14.8.

Table 14.8
Occupational and Lithic Intensity Covariation

Description of Variables	N	R
Archaic FCR vs. Tools	5	0.74
P-IV Vessels vs. Tools	14	0.00
Spanish Colonial Vessels vs. Tools	4	1.00
P-IV + S.C. Vessels vs. Tools	16	0.00
Archaic FCR vs. Unut. Lithics	5	0.95
P-IV Vessels vs. Unut. Lithics	14	0.00
S.C. Vessels vs. Unut. Lithics	4	1.00
P-IV + S.C. Vessels vs. Unut. Lithics	16	0.00

Flaked artifacts not exhibiting use attributes were assumed to be the outcomes of lithic reduction behaviors. Flaked artifacts showing shaping or use attributes were regarded as tools.

Tool use became sharply differentiated from tool manufacture in these analyses. During the Archaic period, a high correlation coefficient was obtained between occupational intensity and tool manufacturing episodes. Conversely, a lower coefficient was obtained with tool use, indicating that tool utilization varies more independently of occupational intensity than tool manufacturing. These conclusions are supported by the wide range of variability in all lithics versus tools illustrated in Fig. 14.1. One implication of this would be that certain exploitive and processing activities requiring tools were routinely performed in the context of firecracked rock production and, in other instances, tool using activities took place predominantly outside the site boundaries.

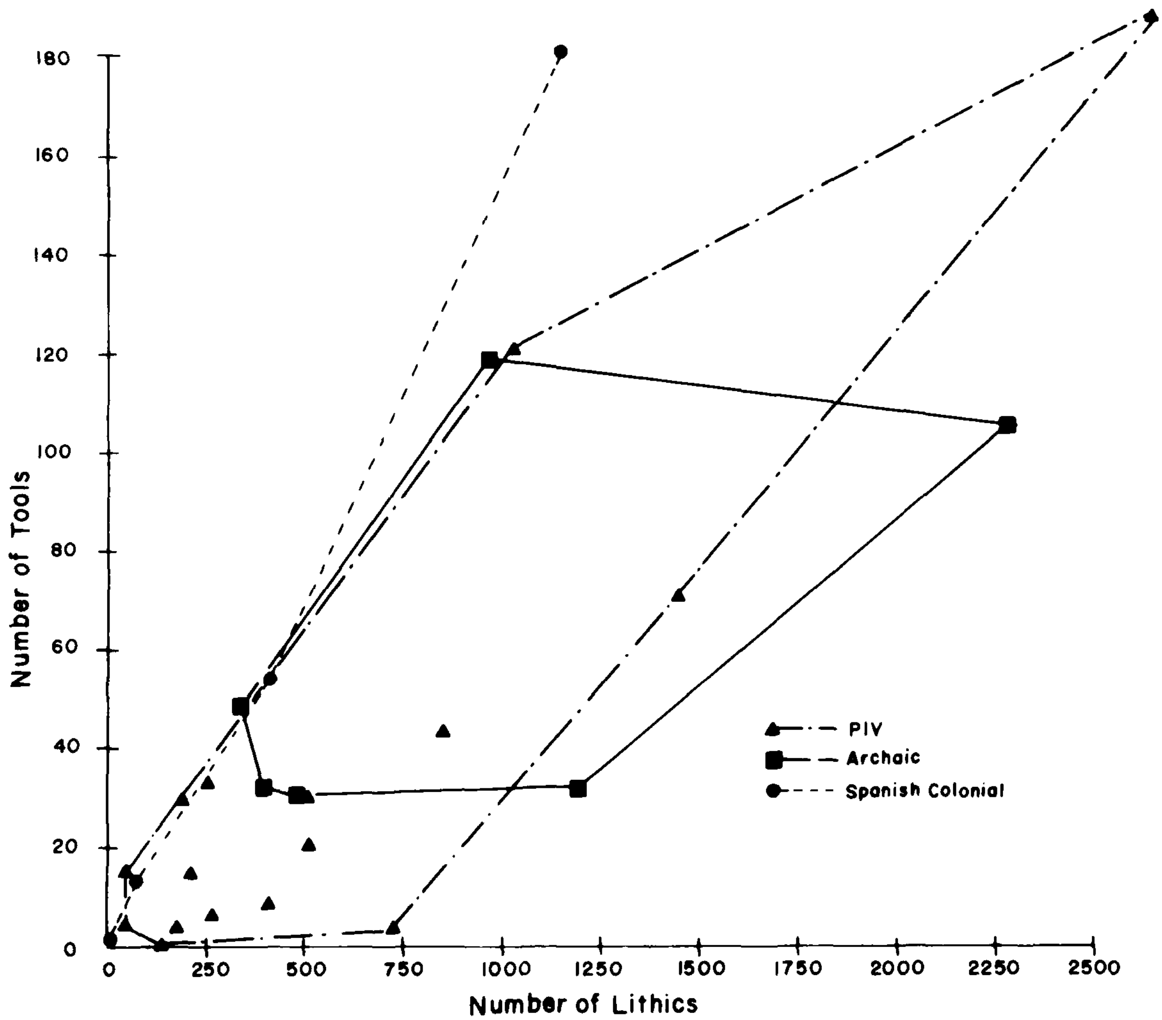


Fig. 14.1 Tools versus total lithics from sampled sites.

Table 14.9
Distributions of Major Tool Types by Cultural Period

LA Site No.	Debitage and Small Angular Debris		Utilized Large Angular Debris		Utilized Cores		Facially Retouched		TOTALS
ARCHAIC PERIOD									
LA 12442	30	(94%)	–	(0%)	–	(0%)	2	(6%)	32
LA 12456	92	(77%)	15	(13%)	2	(2%)	10	(8%)	119
LA 12463	42	(86%)	–	(0%)	4	(8%)	3	(6%)	49
LA 12494	96	(91%)	–	(0%)	5	(5%)	5	(5%)	106
LA 12495	29	(97%)	–	(0%)	1	(3%)	–	(0%)	30
LA 12496	25	(78%)	–	(0%)	–	(0%)	7	(22%)	32
TOTALS	314	(85%)	15	(4%)	12	(3%)	27	(7%)	368
PUEBLOAN PERIOD									
LA 5011	12	(86%)	–	(0%)	–	(0%)	2	(14%)	14
LA 9138A	6	(75%)	2	(25%)	–	(0%)	–	(0%)	8
LA 12443	32	(86%)	2	(5%)	2	(5%)	1	(3%)	37
LA 12447	2	(33%)	–	(0%)	4	(67%)	–	(0%)	6
LA 12449	–	(0%)	–	(0%)	–	(0%)	–	(0%)	0
LA 12454	25	(86%)	1	(3%)	2	(7%)	1	(3%)	29
LA 12483	3	(100%)	–	(0%)	–	(0%)	–	(0%)	3
LA 12486	34	(79%)	1	(2%)	2	(5%)	6	(14%)	43
LA 12517	30	(100%)	–	(0%)	–	(0%)	–	(0%)	30
LA 12518	20	(90%)	–	(0%)	1	(5%)	1	(5%)	22
LA 12519	5	(100%)	–	(0%)	–	(0%)	–	(0%)	5
LA 13049	118	(90%)	8	(6%)	–	(0%)	5	(4%)	131
LA 13050	20	(100%)	–	(0%)	–	(0%)	–	(0%)	20
LA 13054	107	(92%)	4	(3%)	–	(0%)	5	(5%)	116
LA 13084	182	(96%)	6	(3%)	–	(0%)	1	(1%)	189
LA 13076	70	(99%)	–	(0%)	–	(0%)	1	(1%)	71
LA 13329	14	(100%)	–	(0%)	–	(0%)	–	(0%)	14
TOTALS	511		18		0		12		541
SPANISH COLONIAL PERIOD									
LA 9138B	45	(83%)	–	(0%)	5	(5%)	4	(7%)	54
LA 12161	157	(86%)	–	(0%)	4	(2%)	21	(12%)	182
LA 12438	9	(69%)	–	(0%)	1	(8%)	3	(23%)	13
LA 12507	–	(0%)	–	(0%)	–	(0%)	1	(100%)	1
TOTALS	211	(85%)	–	90%)	10	(4%)	29	(11%)	250

The P-IV sites exhibit a different pattern. The correlation between occupational intensity and tool manufacturing is not significant, and tool use is weakly correlated with occupational intensity. Both correlations imply a wide range of diversity in the loci of tool manufacturing and the exploitive and processing behaviors.

In the Spanish Colonial period sites, high τ coefficients are obtained in both cases. These results are interpreted to mean that manufacturing and use activities were routinely and repeatedly conducted at each site and vary directly with occupational intensity. This interpretation is supported by the nearly perfect straight-line relationship between tools and lithics for Spanish Colonial sites shown in Fig. 14.1.

The significance of the high τ coefficient values required additional evaluation since the number of Spanish Colonial sites was low (N=4). In order to raise the total number of cases to eleven, the P-IV sites were added to the Spanish Colonial sites. Additional correlations were computed to evaluate the impact of the Spanish Colonial site data on the entire array. Occupational intensity versus both tool manufacturing and use yielded positive and significant τ values. The impact of the Spanish Colonial data on these relationships was obviously significant (Young and Veldman 1965:420).

The types of tools utilized are highly diversified both within and between the three major cultural periods. The porportional and raw frequencies of the four major tool types for each site are listed in Table 14.9.

Despite the diversity of tools, each cultural period exhibits unique characteristics. The Spanish Colonial period sites do not contain more than 86% utilized debitage and small angular debris, whereas this class of tools can range up to 97-100% on both Archaic and Puebloan sites. Utilized large angular debris are absent in Spanish Colonial sites, found on only one Archaic site (LA 12456), but were recovered from seven of the ten Puebloan sites. The proportion of facially retouched tools can range higher in Archaic sites than Puebloan, but are found in proportionately highest frequencies on Spanish Colonial sites.

Archaic sites cluster into sets possessing similar proportions of associated tool types. Sites LA 12496, LA 13352, and LA 13353 are similar in that they contain only utilized debitage, small angular debris, and facially retouched artifacts. Finally, LA 12456 is unique in that it contained the only utilized large angular debris from Archaic period sites excavated in the 1975 season.

Clustering can also be observed among the Puebloan sites. Utilized debitage and small angular debris are the only tool types recovered from five sites, LA 12483, LA 12517, LA 12519, LA 13050, and LA 13329. Facially retouched artifacts occur on Puebloan sites only when the total tool frequencies are relatively high. Intersite variability, however, appears to be highest among the Puebloan sites.

Spanish Colonial period sites exhibit the least amount of diversity in tool types. In effect, all four sites form a single cluster.

Assuming that the amount of variability in tool types is related to diversity in food procurement and subsistence-related activities, each cultural period has distinctive characteristics. The Puebloan adaptive system(s) exhibits the most variation, and the Spanish Colonial, the least. The Archaic would fall between the others in terms of food processing and procurement complexity. This interpretation is consistent with the analyses of lithic material selection and tool use described above, and will be further supported by the studies which follow.

Grinding Activities

Grinding activities, presumably associated with the processing of vegetal materials, occurred in all cultural periods. Close inspection of the grinding implement data and other activity-related features (Table 14.10) revealed patterns that may be significant in reconstructing settlement and food procurement systems that operated within the Cochiti Reservoir area.

Grinding tools were found in all of the Archaic sites. In addition, the quantity of manos and/or metates covaries with the number of activities represented on each site. This association is also illustrated in the site maps (Chapman et al. 1977) which show that grinding implements, particularly metates, are usually located near hearths or heavy concentrations of firecracked rock.

Different sets of patterns obtain on Puebloan and Spanish Colonial sites. Grinding artifacts are not present on all sites in either period (Table 14.10). Nevertheless, grinding activities may well have occurred at all sites in both the Puebloan and Spanish Colonial periods. Specifically, what is postulated is that grinding artifacts, particularly metates, were purposely removed by site occupants and constitute site abandonment-related behavior.

A number of patterns in the evidence supports this hypothesis. First, the presence of only manos at the Pueblo sites LA 12454, LA 12518, LA 13084, and the Spanish Colonial sites LA 9138B, LA 12161, and LA 12438, would suggest that their metate counterparts were removed. Second, a bin which may have held a metate was found at the Puebloan site LA 12454 (Chapman et al. 1977:244-5). Third, metates found at four Puebloan sites, LA 12486, LA 12519, LA 13054 and LA 13329 were actually metate *fragments*. This would suggest that *intact* metates are preferentially absent and were removed from the sites. Fourth, manos are more likely to occur on Puebloan and Spanish Colonial sites that may have been occupied or reoccupied for comparatively longer periods of time (see Tables 14.7-14.9). The inhabitants of the sites which possess few activity areas or where few tools were discarded, may have been performing milling activities, failed to break or wear out manos or metates, and thus removed them when they abandoned their sites.

The possibility of post-abandonment removal of grinding implements is unlikely. If such were the case, manos and metates should have been removed from Archaic period sites as well. Post-abandonment human visitation did occur at Archaic sites, for prehistoric and historic sherds and other artifacts were found at virtually all of the Archaic sites, yet intact metates and manos remained in place (Chapman et al. 1977).

The removal or nonremoval of manos and metates specified different types of settlement systems in operation through time. Archaic groups were mobile hunters-gatherers. In the context of such a settlement system, it would be less likely that heavy grinding equipment would have been transported, particularly if the distances between use areas were considerable. Manos and metates were abandoned, and the former Archaic occupants were willing to invest energy in remanufacturing these items.

The Puebloan groups, particularly the P-IV occupants of the Cochiti area, participated in a settlement system composed of a proportionately large number of 1-2 room sites, and a few large sites containing 30 to over 100 rooms (Biella and Chapman 1977b:305-9). None of the small sites examined in this sample show any evidence of long-term occupation. The inhabitants probably periodically shifted residence to nearby population aggregates. Viewed in the context of this type of settlement system, the removal of grinding equipment is not an unreasonable expenditure of energy.

Table 14.10

Distributions of Grinding Implements and Activity Areas by Cultural Period

LA Site No.	No. Manos	No. Metates	Activity Areas
		ARCHAIC PERIOD	
LA 12442	–	1	1 Lithic Concentration
LA 12456	1	10	6 or 7 Hearth Areas
LA 12463	1	3	2 or 3 Hearth Areas
LA 12494	22	14	7 or 8 Hearth Areas
LA 12495	5	6	3 Hearth Areas
LA 12496	3	11	7 or 8 Hearth Areas
		PUEBLOAN PERIOD	
LA 5011	–	–	1 Room, Scattered Trash
LA 9138A	–	–	2 Rooms, Scattered Trash
LA 12443	–	–	1 Room, Scattered Trash
LA 12447	–	–	1 Room?, Scattered Trash
LA 12449	–	–	1 Room?, Scattered Trash
LA 12454	2	–	2 Rooms, Scattered Trash
LA 12483	–	–	1 or 2 Hearth Areas
LA 12486	3	2	3 or 4 Hearth Areas
LA 12517	–	–	1 Room, Scattered Trash
LA 12518	2	–	2 Rooms, Scattered Trash
LA 12519	2	1	2 Rooms, Scattered Trash
LA 13049	–	2	1 Room
LA 13050	–	–	2 Rooms
LA 13054	1	2	2 Rooms
LA 13076	–	–	2 Rooms
LA 13084	1	–	5 Rooms
LA 13329	–	1	1 Room
		SPANISH COLONIAL PERIOD	
LA 9138B	1	–	2 Rooms, Scattered Trash
LA 12161	3	–	1 Room, Midden Area
LA 12438	5	–	1 Room, Scattered Trash
LA 12507	–	–	1 Room, Scattered Trash

The Spanish Colonial groups occupying the Cochiti Reservoir area may have occupied their sites for longer periods of time. One site, LA 12161, shows evidence of protracted occupational usage. Access to animal-drawn transportation may be the significant factor pertaining to the removal of grinding tools by Spanish Colonial groups.

Site Location Patterns

The sites examined constitute an excavation sample within a survey sample. The sites selected for excavation necessarily share certain locational and topographic attributes, for they were endangered by the flooding of the reservoir basin. All of the sites are located in the Upper Sonoran-Juniper vegetative zone. Similarly, all are located immediately adjacent to the Rio Grande in White Rock Canyon. The sites range in altitude from 5280 to 5460 feet above mean sea level (Biella and Chapman 1977a:209-23).

A listing of those environmental setting characteristics that may be more meaningful in terms of the locational criteria perceived and utilized by human groups occupying the area is presented in Table 14.11. The data were compiled from Biella and Chapman (1977a:209-23).

Alluvial benches were utilized in all cultural periods. Archaic groups frequently located their sites in sand dunes. All of the Spanish Colonial sites are located in elevated settings. Consistent with the prevous analyses, the Puebloan sites exhibit the greatest range of variability in physiographic setting.

All of the Archaic sites are located on southerly exposures. This may well have been a significant criterion for site location. Southern exposures receive more solar radiant heat and thus provide more comfort to the occupants. This would be particularly true for those groups living in open campsites. Note that the two Puebloan open sites are

Table 14.11

Site Environmental Settings by Cultural Period

LA Site No.	Physiographic Situation	Exposure	Side of Rio Grande	Distance to Rio Grande (m)	Site Characteristics
		ARCHAIC PERIOD			
LA 12442	Alluvial Bench	SW	E	60	Open
LA 12456	Sand Dune	SW	E	20	Open
LA 12463	Sand Dune	S	E	40	Open
LA 12494	Sand Dune	SW	W	100	Open
LA 12495	Sand Dune	SW	W	100	Open
LA 12496	Alluvial Bench	SW	W	100	Open
		PUEBLOAN PERIOD			
LA 5011	Sand Dune	E	W	70	1 Room
LA 9138A	Gravel Terrace	SW	W	80	2 Rooms
LA 12443	Alluvial Bench	W	E	160	1 Room
LA 12447	Alluvial Bench	NE	E	20	1 Room?
LA 12449	Alluvial Bench	W	E	40	1 Room?
LA 12454	Alluvial Bench	SW	E	120	2 Rooms
LA 12483	Sand Dune	SE	W	20	Open
LA 12486	Sand Dune	S	W	40	Open
LA 12517	Basalt Ridge	Open	W	40	1 Room
LA 12518	Base of Talus	SE	W	120	2 Rooms
LA 12519	Talus & Bench Interface	NW	W	40	2 Rooms
LA 13049	Ridge Top; Basalt Talus	S	W	60	1 Room
LA 13050	Sandy Bench	NW	W	140	2 Rooms
LA 13054	Gravel Ridge Top	Open	W	100	2 Rooms
LA 13076	Basalt Talus	n.d.	E	60	2 Rooms
LA 13084	Boulder Field	n.d.	E	100	5 Rooms
LA 13329	Gravel Terrace	Open	E	6800	1 Room
		SPANISH COLONIAL PERIOD			
LA 9138B	Gravel Terrace	SW	W	80	2 Rooms
LA 12161	Alluvial Bench; Talus Base	S	W	120	1 Room
LA 12438	Alluvial Bench	SW	E	180	1 Room
LA 12507	Alluvial Bench	W	W	20	1 Room

also located on southern exposures.

Environmental Exploitation Patterns

Floral and faunal remains recovered from each site that provide direct evidence of environmental exploitation are compiled in Table 14.12. Artifacts that are indirect indicators of procurement/processing activities are also listed in Table 14.12. Projectile points are assumed to reflect the presence of hunting activities, and grinding implements (manos and metates) are asuumed to be associated with plant food processing.

A comparison of projectile point distribution with that of faunal materials does not yield sharply defined patterns. However, the absence of projectile points does not necessarily mean that hunting activities or projectile point usage did not occur at a given site. Other conditions may be responsible for the absence of these artifacts. A site may have been occupied for such a short period of time that projectile point manufacture, repair, or disposal did not take place; or projectile point disposal behavior may have occurred outside of the immediate environs of the occupational zone; or different hunting methods may have been employed.

Despite potential difficulties in interpreting the evidence, the following observations can be made. When prehistoric sites do contain projectile points, animal bone is always present. When the same site yields identifiable faunal remains, the inventory in six out of seven cases includes large game animals. The presence of exclusively small animal bone at several Puebloan sites (LA 9138A, LA 12518, LA 12519) is associated with an absence of projectile points, indicating that other procurement methods, such as handcapture, clubs, or nets may also have been employed to acquire these species.

Table 14.12

Distributions of Floral and Faunal Remains by Cultural Period

LA Site No.	Floral and Faunal Remains Recovered	Projectile Points	Grinding Implements	Activity Areas
	ARCHAIC PERIOD			
LA 12442	Unidentified bone fragment	+	+	1 Lithic Concentration
LA 12456	Seed, large game, terrestrial snail	+	+	6/7 Hearths
LA 12463	Unidentified bone fragment	–	+	2/3 Hearths
LA 12494	Seeds, rabbit, deer, mollusk	+	+	7/8 Hearths
LA 12495	n.d.	–	+	3 Hearths
LA 12496	n.d.	–	+	7/8 Hearths
	PUEBLOAN PERIOD			
LA 5011	Seed, woodrats, large game, small game	+	–	1 Room
LA 9138A	Fish, rabbit, frog	–	–	2 Rooms
LA 12443	n.d.	–	–	1 Room
LA 12447	n.d.	–	–	1 Room?
LA 12449	n.d.	–	–	1 Room?
LA 12454	Seeds, large game	–	+	2 Rooms
LA 12483	Unidentified bone fragment	–	–	1/2 Hearths
LA 12486	Deer, antelope?, rodent, egg	+	+	3/4 Hearths
LA 12517	n.d.	–	–	1 Room
LA 12518	Rabbit, lizard	–	+	2 Rooms
LA 12519	Rabbit?, woodrat	–	+	2 Rooms
LA 13049	Seeds, small game	+	–	1 Room
LA 13050	Woodrat, gopher, mouse, landsnail, turtle, small game, large game	–	–	2 Rooms
LA 13054	Seed, small game, large game, fish(?)	+	+	2 Rooms
LA 13076	None	–	–	2 Rooms
LA 13084	Seeds, woodrat, lizard	–	+	5 Rooms
LA 13329	None	–	+	1 Room
	SPANISH COLONIAL PERIOD			
LA 9138B	Sheep/goat, deer/antelope, peach pits, cattle/bison, bird, jackrabbit, egg	–	+	2 Rooms
LA 12161	Sheep/goat, deer/antelope?, burro, cattle/bison, bird, goose, dog/wolf, beaver	–	+	1 Room
LA 12438	Sheep/goat, cattle/bison, deer/antelope	–	+	1 Room
LA 12507	Sheep/goat, deer/antelope, rabbit, fish	–	–	1 Room

Direct evidence for large game hunting is present in all but two of the Archaic sites. However, faunal inventories in only four out of seventeen Puebloan sites include large mammals. This could mean that large game hunting was a habitual mode of environmental exploitation during the Archaic period, and less significant during the Puebloan period.

Large game w... also procured during the Spanish Colonial period. Later Cochiti basin occupants may have used firearms exclusively. Evidence supporting this contention exists in the presence of gunflints and a gun fragment found at LA 12161 (Chapman et al. 1977:179-81).

The data from Table 14.12 show that riverine resources were exploited in all cultural periods. A freshwater mollusk was recovered from the Archaic site LA 12494. Fish bone and frog remains were found at the Puebloan site LA 9138A, and a possible fish vertebra at LA 13054. During the Spanish Colonial period, aquatic birds and fish were part of the procurement systems. Whether or not faunal type differences between the cultural periods specify differential riverine resource usage patterns is difficult to determine, for the amount of faunal materials from any single site is extremely low.

SUMMARY: ARCHAIC

Grinding activities, as previously mentioned, took place in all cultural periods. The fact that manos and metates were found in all of the Archaic sites indicates that vegetal food processing and presumably nondomestic plant seed procurement are activities that were habitually performed by Archaic occupants of the area.

Seed gathering, processing (grinding), preparation, and consumption was one identifiable activity sequence that took place at Archaic sites. Small game and molluscan/gastropod collection, processing, preparation and consumption constitute two additional activity sets. Large game hunting, processing, preparation and consumption constitute a fourth behavioral sequence which characterizes the Archaic occupations.

The analyses performed in this study provide more specific information pertaining to Archaic adaptations within the Cochiti basin. The activities performed at LA 12442 and LA 12496 appear to have been similar. Both sites are located on alluvial benches and contrast with the others which are located in sand dunes (see Table 14.11). The occupations of both sites differ from the remainder of the Archaic sites in terms of lithic material and tool preferences. The inhabitants of LA 12442 and LA 12496 preferred obsidian (see Tables 14.4 and 14.5), and used only small angular debris, debitage and facially retouched tools (see Table 14.9).

If the interpretations pertaining to resource acquisition and processing are correct, then the primary subsistence-related activities that took place at the first group of sites was large game hunting and processing, and seed procurement and processing. In contrast, wider ranges of resource acquisition are implied by the greater diversity of tool types and floral and faunal remains from the other Archaic sites, LA 12456, LA 12463, LA 12494, and LA 12495 (see Tables 14.3, 14.4 and 14.12).

SUMMARY: PUEBLO

Puebloan environmental exploitation strategies appear to differ markedly from those practiced during the earlier Archaic period. Consistent with previous lines of evidence, the Puebloan period is characterized by high diversification in resource usage patterns.

None of the sites show evidence of prolonged periods of occupation or of intensive seasonal reoccupation. Consequently, the amount of organic remains recovered from Puebloan sites is low and reduces the degree to which exploitation-related behaviors can be accurately specified. One characteristic of the P-IV adaptive system, however, is periodic short-term and diversified resource utilization within the area.

Nonagricultural resource acquisition appears to have been the primary activity conducted at the open campsites LA 12483 and LA 12486 (Table 14.12). Large and small game resources are represented among the biotic remains. The presence of mano and metate fragments would suggest that seed gathering activities took place. Although faunal and floral remains are represented by only one unidentified bone fragment at LA 12483, the proportion of tools to total lithics (Figure 14.1) falls within the range of variability for the Archaic period.

The paucity of organic remains from the Puebloan sites which contain architecture may well mean that the environmental exploitation activities included domestic plant maintenance and harvesting. However, the notion that all one or two-room sites are *farmhouses* is too simplistic. If this class of sites served one and only one purpose, then the activity patterns at all of the sites should be similar. As discussed throughout this paper, such is clearly not the case. Lithic resource types and tool types vary considerably between sites (Tables 14.4, 14.5, and 14.9). The site settings vary widely (Table 14.11). Finally, nondomestic biotic materials were exploited by the occupants of the architectural sites (Table 14.12).

What, then, is the evidence to support the performance of farming activities? The facts provide indirect proof. All of the sites are located adjacent to the Rio Grande where agricultural acitivites during the Puebloan period could be performed. The location of sites LA 12447 and LA 12519 on northern exposures, and LA 12517 exposed to the elements from all sides (Table 14.11), would indicate that these sites were occupied on a temporary basis, probably during the warmer months of the year.

Architectural features also provide indirect evidence for agricultural activities. The two-room site LA 12519 appears to be composed of a single habitation structure with an attached granary or storage chamber (Chapman et al. 1977:346-51). The habitation space contains a hearth which is absent from the adjoining structure. Other evidence supporting the notion of a storage unit is the fact that the structure is semisubterranean and the sides are slab-lined. This room may have served as a temporary storage place for crops being harvested from the alluvial flats below the site.

As discussed previously, the small Puebloan groups occupying the Cochiti area were participants in larger social and settlement systems. They were also participants in a regional system of exchange which undoubtedly is of adaptive significance. Evidence for the existence of the latter system is available in the ceramic inventories. Ceramics manufactured at various pueblo communities throughout the middle and northern Rio Grande basin were found in association with these sites (Warren 1977:362-74). The adaptive importance of the regional exchange was not pursued in this report, but remains a problem well worth investigating if we are to understand the cultural ecology of the Anasazi P-IV period.

SUMMARY: SPANISH COLONIAL

Human environmental usage during the Spanish Colonial phase appears to be similar between all sites in the sample. Interpretation is facilitated by the relative abundance of organic remains from each of the sites.

The use of pasturage resources for herding domestic animals is implied by the presence of sheep/goat remains at all of the sites (Table 14.12). Other domestic herbivores were also maintained. Cattle, horse and burro remains were also recovered from Spanish Colonial sites. The fact that sheep and goat bones possess butchering marks indicates that these species provided a source of meat for the occupants. This would contrast with other pastoralist strategies where only domestic animal *products* such as milk or blood are consumed.

Exchange for items related to energy capturing and transformation is an important feature in the Spanish Colonial adaptive system. All of the sites contain ceramics manufactured by Indian groups throughout the region. Evidence of guns and other metal trade items were recovered from the Spanish Colonial sites (Chapman et al. 1977).

Nondomestic animal resources were also exploited. All of the sites contain the remains of deer/antelope. The preference for large game species as a dietary constituent may indicate that these native species served as an alternative to sheep/goat in Spanish Colonial cuisine.

CONCLUSIONS

The results of these anlayses underscore the notion that there can be virtually limitless ways of surviving within any given environmental setting. Archaic or Basketmaker groups occupying the Cohciti area extracted a wide range of indigenous biotic resources. Similarly, Anasazi P-IV groups utilized native plants and animals perhaps in conjunction with farming activities. Both domestic and nondomestic animals provided an important aspect of the subsistence base for Spanish Colonial groups.

There is neither a trend towards increasing specialization nor generalization of resource usage through time. Behavioral diversity associated with subsistence as measured in these analyses is greatest within the Puebloan period and less so in the earlier Archaic and the later Spanish Colonial periods.

Many of the inferences pertaining to the various adaptive modes examined here must be regarded as tentative, given the small sample of sites available and suitable for analysis. Nonetheless, these results should be of heuristic value in explicating the prehistoric and historic adaptive systems which operated within the region.

Chapter 15

THE SPATIAL DISTRIBUTION OF ARCHEOLOGICAL SITES: A CLUE TO SUBSISTENCE BEHAVIOR

Alan Rogers and W. J. Chasko, Jr.

INTRODUCTION

Human populations depend for their survival upon resources which are dispersed in space, and generally exploit areas considerably larger than individual archeological sites. The subsistence activities conducted within an area may produce a variety of different kinds of archeological sites, including villages, temporary residential sites, field houses near agricultural land, and facilities for processing wild foods before carrying them home. The interaction of any human group with its environment is likely to be reflected in a variety of kinds of sites within the area exploited by that group.

These considerations suggest that archeological investigations of human ecology should deal with regions rather than single sites, and with all site types present rather than just a few. As Plog and Hill observe, however,

> *Through the history of archaeology, most surveys have focused on sites on which habitation structures were located, and often only the largest of these. But, prehistoric, and modern, settlement systems consisted of more than large habitation sites. There were both large and small habitation sites or settlements as well as sites where activities other than habitation took place.*
>
> (Plog and Hill 1971:8)

A variety of reasons could undoubtedly be adduced for this neglect of nonresidential sites in favor of larger, residential locations, but central among these is the problem of temporal control. The archeological record is the accumulated by-product of thousands of years of human activity. This time depth is at once the promise of and the problem with archeological data. When contemporaneous remains can be recognized and distinguished from material of different ages, archeological research can elucidate changes in patterns of human subsistence over long spans of time (Flannery 1968; MacNeish 1971). When such distinctions cannot be made, however, substantial portions of the archeological record must be ignored.

Conclusions concerning patterns of prehistoric subsistence behavior are generally based on a biased sample of the archeological record. Such conclusions should be viewed with a certain amount of scepticism. Flannery (1968) for example, bases inferences concerning changing patterns of adaptation in the Southern Highlands of Mexico solely on cave deposits. It is easy to imagine changes in subsistence patterns which would affect the number of caves used without affecting the contents of utilized caves. Such changes would be *invisible* to an archeologist who restricted his attention to caves.

The value of the enormous spans of time represented in the archeological record has been emphasized frequently. But the value of this time depth is somewhat limited unless contemporaneous sites can be recognized, and differentiated from those of different ages. Archeologists have relied heavily on formal similarities between assemblages in recognizing association between sites. This approach has led to a number of problems.

Many sites, for example, lack *diagnostic* artifacts. The archeological evidence produced during hunting, gathering and processing of wild foods is often meager and is likely not to include the items generally used in assigning sites to particular horizons. Although such sites may contain abundant information concerning the activities which produced them (Goodyear 1975), they are often difficult to relate to residential sites in the same region. Investigations of change through time in adaptive systems are generally restricted to those portions of the archeological record which can be reliably dated, and this restriction frequently excludes all but large residential sites.

In addition to their inability to recognize associations between related sites, traditional methods may be criticized for their tendency to make spurious distinctions. Contemporaneous sites which reflect different aspects of the adaptation of a single human group may have extremely dissimilar assemblages. When sites with dissimilar assemblages are assumed to represent different cultures it is impossible to recognize association between the diverse sites which may be produced by a single group. Binford (1972) has argued that such assumptions have led to erroneous interpretations of archeological sequences in Europe and Africa.

In summary, current archeological methods do not allow reliable inferences to be drawn concerning change in the structure of prehistoric adaptive systems. Studies of change in subsistence behavior involve comparison of materials of different ages. This would seem to require the ability to recognize contemporaneous sites and distinguish between sites of different ages. Such distinctions are often difficult to make in the case of small, nonresidential sites, making it necessary to rely primarily on data from residential sites. This emphasis on a single kind of site is unfortunate since the interaction of any human group with its environment is likely to be reflected in a variety of kinds of sites—residential as well as nonresidential. This study attempts to develop a different approach to the investigation of subsistence strategies.

THE POTENTIAL VALUE OF SPATIAL DISTRIBUTIONS IN STUDYING ADAPTIVE STRATEGIES

An ideal solution to the problem considered above would allow recognition of associations between each residential site and the nonresidential sites ancillary to it.

This is an extremely difficult task. Fortunately, it is possible to learn a great deal about the adaptive strategies which characterized a region without recognizing relationships between individual sites.

Archeologists commonly divide the sites in a region into several categories thought to represent differences in age or function. Measurement of association between the spatial distributions of such site types is a much easier problem than the recognition of relationships between individual sites. We will argue that a measurable association should exist between the spatial distributions of residential and ancillary nonresidential sites. Analysis of such associations may be of great value in the investigation of adaptive strategies.

For example, assume that the residential sites in some region have been divided into a set of temporal classes, and that nonresidential sites in this area are divided into a set of functional classes. A particular class of nonresidential site might reflect the exploitation of some resource. If this resource was important during only one of the time periods represented, we could expect the distribution of this site type to be strongly associated only with the distribution of residential sites on that period. The changing importance of a resource should be reflected in the association between the spatial distributions of sites reflecting its exploitation and residential sites of different ages. Thus, changing patterns of resource use may be discernible in the patterns of association between the spatial distributions of different kinds of sites.

The resolution of such an approach will be limited by our ability to date residential sites and to recognize functional categories of nonresidential sites. Although these are not trivial problems, they will not be dealt with in this paper. Our concerns here are: (1) how spatial distributions of residential and ancillary nonresidential sites can be expected to be associated; and (2) how such associations can be measured.

MODELING NONRESIDENTIAL SITE DISTRIBUTIONS

Spatial distributions of sites are modeled here as stochastic point processes in two dimensions. It is reasonable to specify that not more than one site can be located in the same place. In mathematical terms this means that

$$\text{prob (number of sites in an area of size } \Delta s) > 1) = o(\Delta s)$$

Points on a two dimensional surface will be referred to by their Cartesian coordinates, an ordered pair of numbers representing the east and north dimensions.

Consider an imaginary residential site, A, whose inhabitants are about to engage in activities which will produce a nonresidential site, B. A variety of factors will undoubtedly condition their decision concerning the distance and direction from A they will travel to perform these activities. It will be useful to consider a simple case in which all variables other than distance and direction are held constant. We assume, therefore, that the probability that B will be located somewhere in an area of size ds at a distance r in a direction θ from A is a function only of r and θ. In other words, we assume that the probability that B will be placed at this location is

$$p(r, \theta)ds$$

where $p(r, \theta)$ is a two dimensional probability density function. It will be convenient to represent distance and direction by a single letter so that the expression above can be written

$$p(s)ds$$

where s is a two dimensional vector.

If the inhabitants of A produce n sites of the same type as B, the probability that one will be produced at the distance and direction from A represented by the vector s is

$$np(s)ds + o((ds)^2) = np(s)ds$$

in the limit as ds approaches zero, assuming that the location of each nonresidential site is an independent random variable with probability density $p(s)$.

This model can be summarized as follows:

1. Each residential site produces n nonresidential sites.
2. The vectors connecting each *parent* residential site with each of its *offspring* nonresidential sites are independent random variables with probability density function $p(s)$.

FREQUENCY ANALYSIS OF SPATIAL DISTRIBUTIONS

Since this model is a simplification of reality, there is little hope that it will yield a complete description of the relationships between spatial distributions of archeological sites. It may, however, adequately describe some aspects of those relationships. We will argue that, while the model presented here does not describe patterning in archeological site distributions on the scale of small distances, it is a good model of relationships on the scale of large distances. To study such relationships it will be necessary to separate patterning on different scales of distance.

The appropriate tool for this task is *spectral analysis*, which partitions variance or covariance in site density according to frequency and direction, where

$$\text{frequency} = \frac{1}{\text{distance}}$$

High and low frequencies correspond to the scales of small and large distances respectively. A measure of the relationship between two distributions is the squared coherence spectrum. Squared coherence measures the proportion of variance in density at a particular frequency and direction in one distribution which can be explained by a model of the form

Input Distribution	→	Linear Operation	→	Output Distribution

Coherence, as used in this paper, is somewhat different than coherence as defined for point processes by Cox and Lewis (1972:421). The approach used here is justified in *the appendix to this paper.*

Analysis of the model outlined above (see appendix) indicates that squared coherence equals 1 when frequency equals zero, and approaches zero as frequency approaches infinity. This means that, if the assumptions of the model were correct, a linear relationship would exist between distributions of residential and ancillary nonresidential sites at low frequencies (large distances) but not at high frequencies (small distances). This linear relationship would be reflected in values of squared coherence near 1 at low frequencies. Before empirical squared coherence spectra can be meaningfully interpreted it will be necessary to evaluate the effects of these assumptions.

INDEPENDENCE OF SITE LOCATIONS

We have assumed that the vectors connecting each *parent* residential site with each of its *offspring* nonresidential sites are independent random variables. In behavioral terms, this means that decisions concerning the placement of nonresidential sites of a given type do not depend on the locations of other sites of that type. This assumption is a concession to convenience and may not be accurate. If residential site distributions were being modeled it would almost certainly be in error since there is evidence that a minimum distance is maintained between villages (Reynolds 1976).

This assumption is probably justified for many types of nonresidential sites, but may be inaccurate for others. It is conceivable, for example, that a minimum distance might be maintained between some types of nonresidential sites. Such inhibitory effects are conveniently studied through spectral analysis.

Spectral density is a measure of variance in the density of a distribution at a particular frequency and direction. Let us examine the relationship between spectral density and frequency in several site distributions from the Cochiti Reservoir. Five types of site are considered:

1. Lithic unknown: scatters of lithic debris of unknown cultural or temporal affiliation;
2. Small P-III: Pueblo III sites with 1-10 rooms;
3. Large P-III: Pueblo III sites with more than 10 rooms;
4. Small P-IV: Pueblo IV sites with 1-10 rooms;
5. Large P-IV: Pueblo IV sites with more than 10 rooms.

In each of Figs. 15.1—15.5, the spectral density of one type of site is plotted against frequency. At most frequencies a number of points are plotted representing spectral density in different directions. An 'A' represents a single value, a 'B' two superimposed values, and so on. For a purely random distribution the expected value of the spectrum is 0.3 for all frequencies and directions. The horizontal lines on each graph define a 99% confidence interval around this value. If the distributions were random, approximately 99% of the points should fall between these lines.

We have assumed that decisions concerning the placement of nonresidential archeological sites of a given type do not depend on the locations of other sites of that type. This assumption is likely to be false for some nonresidential site distributions and many residential site distributions: the presence of a site at one location may decrease the likelihood that another will occur nearby. Such phenomena tend to depress the spectrum (Bartlett 1975:11), and this effect is evident in the spectra of all site types considered. The spectrum of large P-IV sites, for example, has very low values at frequencies 0.5, 1.1, 1.3, 1.8, and 2.5. These low values indicate that an inhibitory effect exists between large P-IV sites at frequencies greater than 0.5, which correspond to distances less than 1/0.5 ≈ 2.0 km. The spectrum of large P-III sites is similar, but the low frequency portions of the spectra of other site types are somewhat different. The spectra of small P-III and P-IV sites reach low values at frequencies greater than 0.9, suggesting an inhibitory effect between small sites at distances less than 1/0.9 ≈ 1.1 km. At frequencies less than 0.6, however, all values are above the lower confidence limit. Inhibitory effects between these sites do not seem to affect the spectrum at frequencies below 0.6, suggesting that no such effects exist at distances greater than 1/0.6 ≈ 1.7 km.

This situation is even more pronounced in the spectrum of nonstructural lithic sites. Low values do not occur at frequencies much less than 1, suggesting that no inhibitory effects exist at distances greater than 1 km. At frequencies less than 0.9 the spectrum is well above the lower confidence limit. Inhibitory effects between lithic sites do not seem to affect the spectrum at frequencies below 0.9.

These results might well have been predicted. The maintenance of a minimum distance between activity loci will affect patterning on the scale of small distances: the presence of a site at one location decreases the likelihood that another will occur nearby. At more distant locations, however, the presence of the first site is unlikely to affect the probability that another will occur. Thus, variation on the scale of large distances (which correspond to low frequencies) is unaffected by the maintenance of a minimum distance between activity loci. Although inhibitory effects between sites should be considered in any model of high frequency aspects of archeological site distributions, they may be ignored in models of low frequency phenomena. This, at least in part, justifies our assumption that the placement of nonresidential sites is independent of the locations of other sites of the same type. We can expect coherence at low frequencies to be unaffected by inhibitory effects between sites.

THE EFFECT OF RESOURCE DISTRIBUTIONS

Our model also assumes that the location of residential sites is the only factor affecting the distribution of nonresidential sites. Since other factors, such as the distributions of resources, are likely to be involved, it will be necessary to investigate their effect. In Fig. 15.6 two examples of site and resource distributions are illustrated.

In both examples the distribution of nonresidential sites closely reflects the distribution of resources; clusters

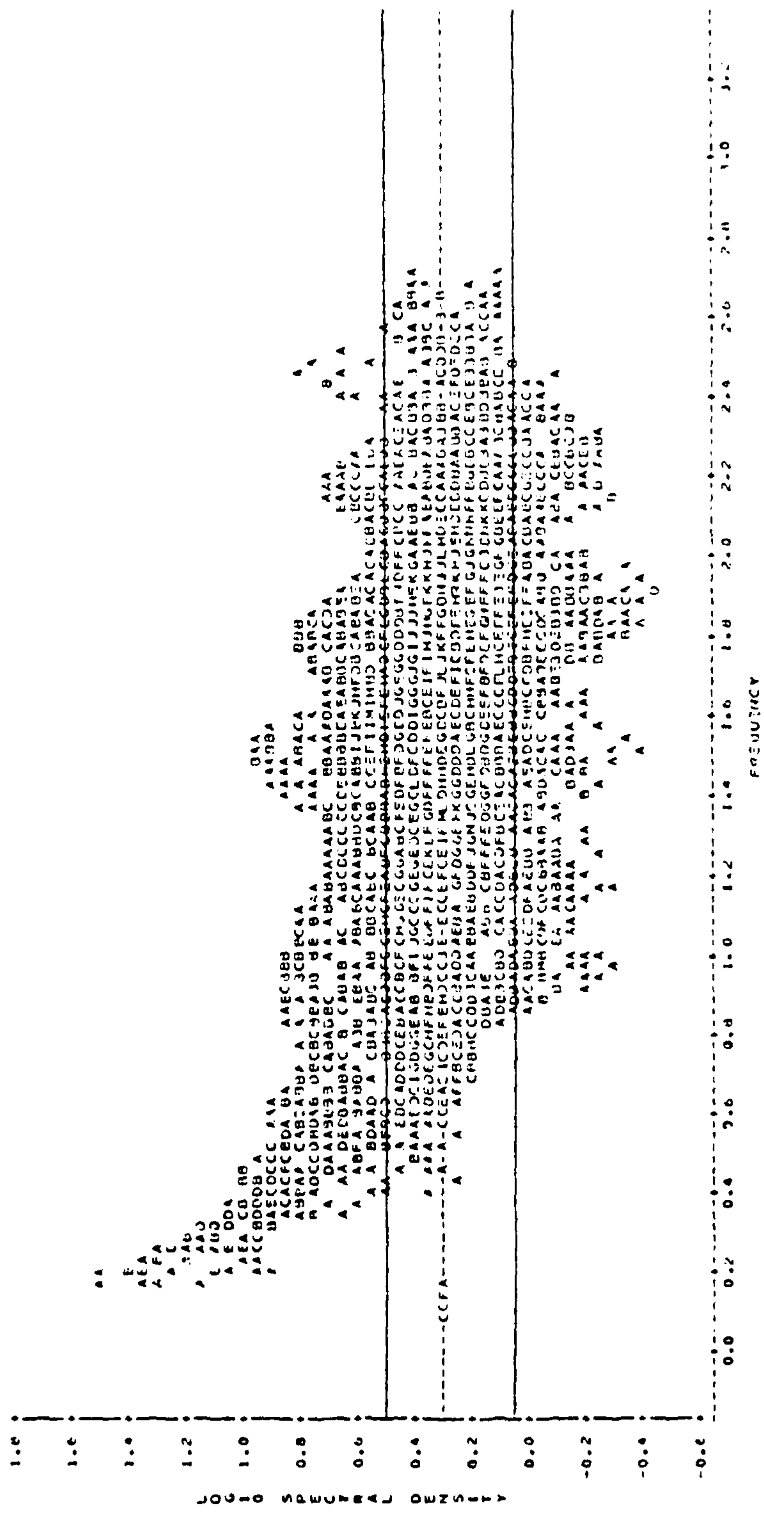


Fig. 15.1 Log_{10} of spectral density for lithic scatters

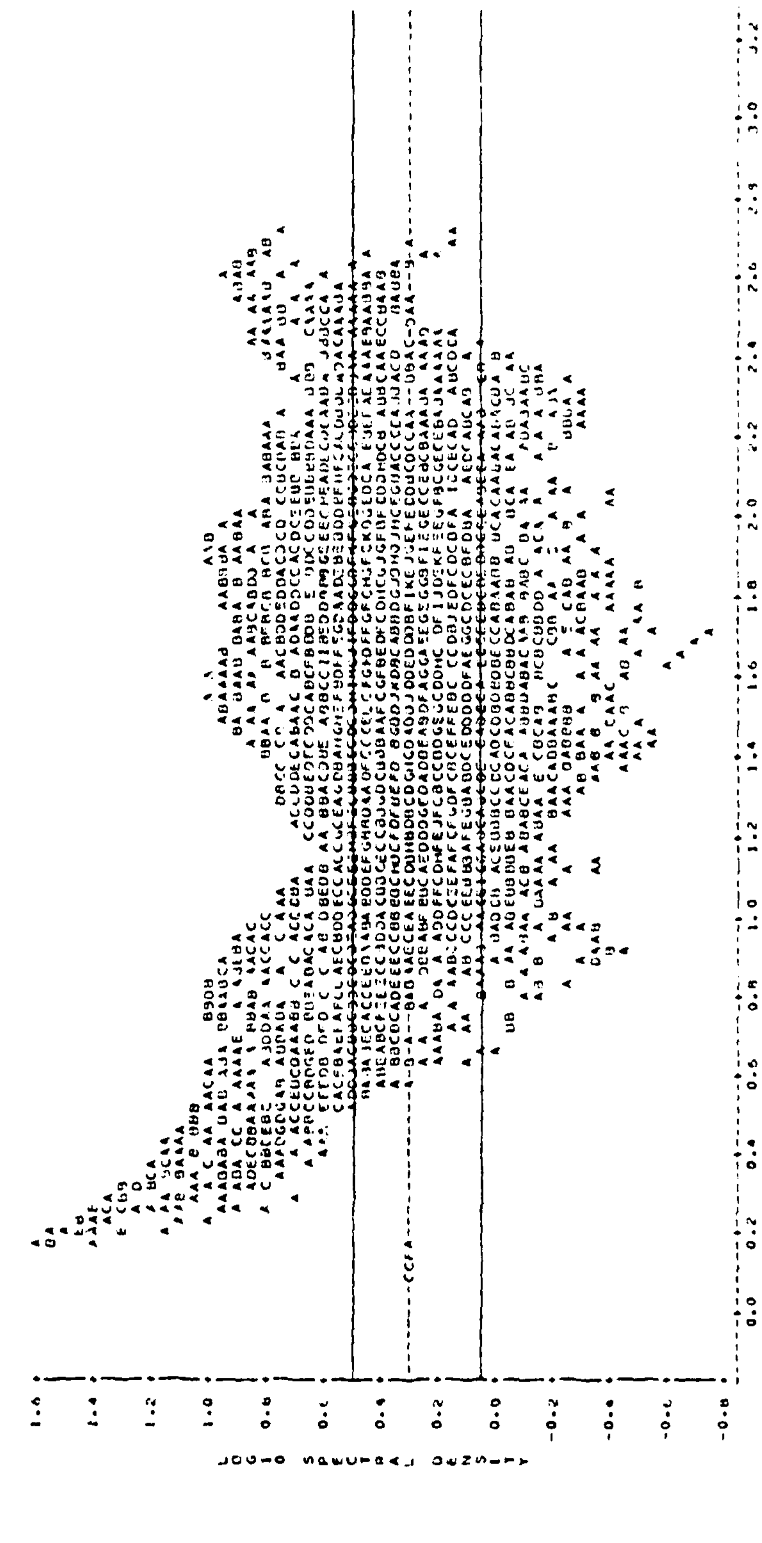


Fig. 15.2 Log_{10} of spectral density for P-III sites with 1-10 rooms

Fig. 15.3 Log_{10} of spectral density for P-III sites with more than 10 rooms

Fig. 15.4 Log_{10} of spectral density for P-IV sites with 1-10 rooms

Fig. 15.5 Log_{10} of spectral density for P-IV sites with more than 10 rooms

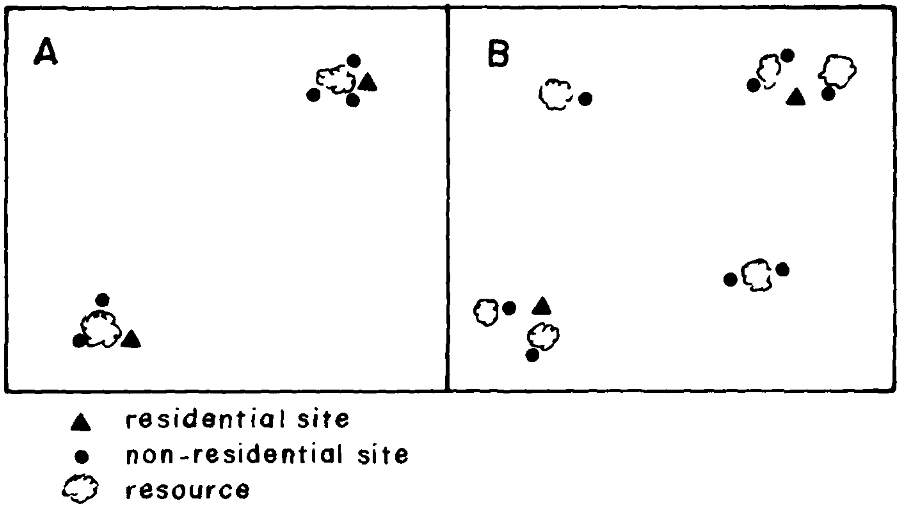


Fig. 15.6 Two examples concerning the distribution of resources and archeological sites

of sites occur near each resource location. But the coherence spectra of residential and nonresidential sites would be quite different in the two examples. In example A the effect of the resource distribution is the same for residential and nonresidential sites. Variance is not introduced into one distribution independently of the other. In this situation the distribution of resources would not tend to decrease the coherence of residential and nonresidential site distributions.

In example B on the other hand, nonresidential sites are associated with all resource patches while residential sites are associated with only two: the distribution of resources is more accurately reflected by nonresidential sites than by residential sites. Variance is introduced into the nonresidential site distribution independently of the distribution of residential sites. This will lower some portions of the squared coherence spectrum. In particular, since spacing between resources on the scale of small distances is reflected in the distribution of nonresidential sites but not of residential sites, squared coherence at high frequencies (which correspond to small distances) will be decreased. Conversely, since spacing between resources on the scale of large distances is reflected in both residential and nonresidential site distributions, low frequency coherence will not be decreased. In general, squared coherence will be decreased only at those frequencies at which variance in the density of resources is reflected in one but not both of the site distributions.

We claim that while high frequency variance in resource distributions may be reflected in the distributions of nonresidential sites but not in the distribution of residential sites, low frequency variance will affect the distributions of all site types. Thus, the effects of resource distributions will not tend to reduce coherence at low frequencies. From the argument presented above it is clear that the effects of resource distributions may decrease coherence at high frequencies. To substantiate our claim it is only necessary to show that resource distributions cannot have this effect at low frequencies. This contention will not be rigorously proved. Instead, we present an informal argument that it is plausible.

It is reasonable to assume that there is some distance, K_i, beyond which the occupants of a given residential site will not go to perform the activities which produce sites of type i. If site type 1 is an agave processing facility for example, and it is unprofitable to collect agave from locations more distant than 10 km, then sites of type 1 should be absent from locations farther than 10 km from residential sites. In this case, $K_i = 10$ km. In terms of our model this assumption means that for $|v| > K_i, p(v) \approx 0$.

Suppose that sites of type i reflect the exploitation of some resource. Variance in the resource distribution at frequencies less than $1/(2K_i)$ indicates that there is some tendency for concentrations of that resource to be spaced farther apart than $2K_i$ km. In the example above this would mean that concentrations of agave are sometimes more than 20 km apart. Since it would be impossible for a single residential site to be within 10 km of two such concentrations, both would not be exploited from a single residential site. Both could be exploited only if there were residential as well as nonresidential sites in the vicinity of each concentration of agave. In other words, both resource concentrations could be exploited only if the spacing in the resource distribution were reflected in the distribution of residential as well as nonresidential sites. Thus, variance at frequencies less than $1/(2K_i)$ cannot affect the distribution of nonresidential sites without also affecting the distribution of residential sites. The distribution of nonresidential sites should not vary independently from the distribution of residential sites at low frequencies. The effects of resource distributions will not decrease the low frequency portion of the coherence spectrum.

CONCLUSIONS

The effects of resource distributions and of inhibitory effects between sites seem to be restricted to high frequencies (i.e., to the scale of small distances). Thus, it is possible to use a simple model which ignores these factors in deducing expectations for low frequency aspects of relationships between site distributions. The model developed here leads us to expect high coherence at low frequencies between the distributions of residential and ancillary nonresidential sites.

These results should be useful in the interpretation of empirical coherence spectra, although some caution is necessary. High coherence at low frequencies may result from a variety of causes, of which we have considered only one. It would be unjustified to conclude that, since a pair of distributions are coherent, they must consist of residential and ancillary nonresidential sites.

Interpretation of low coherence at low frequencies is also somewhat ambiguous. Low frequencies correspond to large distances, but the largest distances in the present study are certainly no greater than the diameter of the survey area or 8.5 km. From low coherence at low frequencies we are justified in concluding that either (1) the distributions in question are not comprised of residential and ancillary nonresidential sites, or (2) the survey area is too small to exhibit the expected relationship. Analysis of low frequency coherence spectra will be most useful when the area surveyed can be assumed to be larger than the day range of its prehistoric inhabitants (perhaps a maximum of 12 km; see Chapman, this volume).

Archeologists often attempt to divide the residential sites in a region into temporal classes, and sometimes to divide nonresidential sites into functional classes. We have suggested that a great deal may be learned from studying spatial relationships between such categories. Change through time in the importance of some activity, for example, may be reflected in the association of the spatial distribution of a functional category of site with the distributions of residential sites of different ages. Thus, the spatial distributions of nonresidential sites may provide information about changing adaptive patterns even when none of those sites can be dated.

AN APPLICATION TO A PROBLEM FROM THE COCHITI STUDY AREA

Based on data collected during the Cochiti Reservoir surveys and other information from previous research in the area, Biella and Chapman (1977c:295-309) suggest that a major change in the organization of subsistence behavior occurred between the P-III and P-IV phases. Relying primarily upon the evidence from excavations and the number and distribution of room counts for the two phases, they infer that:

1. the human population increased slowly during the P-III phase and experienced a decline during the P-IV phase;
2. the settlement pattern was more dispersed and variable during the P-III phase than during the P-IV phase;
3. the P-IV phase exhibited a more aggregated settlement pattern, with a seasonal dispersion of population in very small units to production and procurement locales away from the large settlements.

If the small P-IV structural sites represent locations where agricultural activities were conducted and also served as bases for the procurement of wild foods, we might expect to find associated lithic and ceramic scatters representing the remains of procurement activities conducted in the neighborhood of small P-IV structural sites.

Most of the scatters found were lithic scatters and contained no diagnostic artifacts; consequently, it was not possible to assign the scatters to any temporal phase. Two dimensional spectral analysis has been employed to resolve this difficulty. It allows us to pose the question "*Does the distribution of lithic scatters allow us to reject the assertion that they were associated with the small sites of the P-IV phase?*" If the scenario outlined by Biella and Chapman is correct, we would expect to find high coherence at low frequencies between the distributions of the small P-IV sites and the lithic unknown sites.

To perform the analysis we stratified those structural proveniences assignable to the P-III and P-IV phases into four categories based on the total room count and the presence of diagnostic ceramic materials. They were: P-III with 1 to 10 rooms; P-III with 11 or more rooms; P-IV with 1 to 10 rooms; and P-IV with 11 or more rooms. We then computed coherence between the distributions of sites in these categories and the distribution of sites in the lithic unknown category.

An inspection of Fig. 15.7 reveals that the analysis sup-

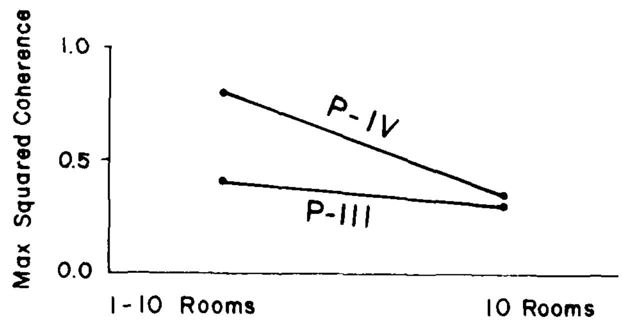


Fig. 15.7 Maximum squared coherence between lithic and residential site distributions for frequencies $\leq$1 cycle km

ports our expectations. In the frequency range from 0 to .25 cycles per km, we observe high values for squared coherence between the P-IV small category and the lithic unknown category. We do not observe high values for squared coherence between the lithic unknown category and any of the other three categories in this frequency range. We are thus not able to reject the assertion that the lithic unknown scatters are associated with the small sites of the P-IV phase.

We must add a caveat here: as is the case with correlation analysis, we cannot imply a causal relation between two distributions we have identified as associated. It is possible that some underlying variable conditions the distribution of both the lithic unknown sites and the P-IV small sites. A likely alternative explanation is that both P-IV small sites and the lithic unknown sites reflect the distribution of a particular resource or array of resources. We may speculate that the lithic unknown sites reflect an aspect of earlier Archaic adaptations and the P-IV sites are positioned to exploit the same resources as were being exploited by the makers of the lithic unknown sites. The results of our analysis would be consistent with such a scenario. We emphasize that both interpretations are consistent with the larger interpretation that the occupants of the study area during the P-IV phase reverted to increased dependence upon procured resources.

The methodology developed here was successfully applied and was able to detect and quantify relationships between several defined categories of Anasazi sites and the lithic scatters. It provided evidence supporting an interpretation of these data in the absence of any temporal information concerning the lithic scatters.

Any method which aids in the recognition of sites which functioned as parts of the same adaptation should be of great value to studies of human subsistence strategies. When the sites in a region can be divided into several functional categories, but the relationships between these categories are unclear, cross spectral analysis may succeed in elucidating these relationships. It is capable of dealing with a wide variety of models, and of recognizing relationships which are much too complex for other techniques.

Appendix
A MODEL OF ASSOCIATION BETWEEN TWO DIMENSIONAL POINT PROCESSES

I. DEFINITIONS

Let R^2 denote real, Euclidian, 2-space. The integral operator will represent integration over this entire space.

Define a counting process, $N^j(\cdot)$, by

$N^j(A)$ = the number of points of type j in the set A.

The differential of this process is itself a stochastic process

$dN^j(s) = N^j(ds)$, where s is an element of R^2

We assume that

$$\text{prob}\{dN^j(s) > 1\} = o(ds) \quad (1)$$

The density of $dN^j(s)$ is

$$\frac{E\{dN^j(s)\}}{ds} = \lambda^j \quad (2)$$

Covariance density is defined by

$$\mu_{jj}(\tau) = E\left\{\left(\frac{dN^j(s)}{ds} - \lambda^j\right)\left(\frac{dN^j(s+\tau)}{ds} - \lambda^j\right)\right\},$$

s, τ are elements of R^2

$$= \frac{E\{dN^j(s)dN^j(s+\tau)\}}{(ds)^2} - (\lambda^j)^2$$

$$= \lambda^j h_j^{(j)}(\tau) - (\lambda^j)^2 \quad (3)$$

Where

$$h_j^{(j)}(\tau) = \frac{E\{dN^j(\tau) \mid dN^j(0) = 1\}}{ds} \quad (4)$$

and second order stationarity is assumed. Notice that $h_j^{(j)}(0) = \frac{1}{ds}$, which can be interpreted as a two dimensional Dirac delta function. The cross covariance density between two processes, $dN^j(\cdot)$ and $dN^k(\cdot)$, is

$$\mu_{jk}(\tau) = \frac{E\{dN^j(s)dN^k(s+\tau)\}}{(ds)^2} - \lambda^j\lambda^k$$

$$= \lambda^j h_j^{(k)}(\tau) - \lambda^j\lambda^k \quad (5)$$

where

$$h_j^{(k)}(\tau) = \frac{E\{dN^k(\tau) \mid dN^j(0)=1\}}{ds} \quad (6)$$

and the joint process is stationary.

Spectral and cross-spectral densities are defined by

$$f_{jj}(\omega) = \int \mu_{jj}(\omega)\exp(-i\langle\omega\tau\rangle)\,d\tau,\ \omega \text{ is an element of } R^2 \quad (7)$$

$$f_{jk}(\omega) = \int \mu_{jk}(\omega)\exp(-i\langle\omega\tau\rangle)\,d\tau,\ \omega \text{ is an element of } R^2 \quad (8)$$

II. THE MODEL

Let each member of a parent distribution, $dN^a(\cdot)$, produce n offspring to form another distribution, $dN^b(\cdot)$.

In archeological terms, parents represent residential sites and offspring are ancillary nonresidential sites. The vectors connecting parents with offspring are independent, identically distributed random variables with probability density function $p(\nu)$. A similar model is discussed by Cox and Lewis (1972:419-422). Their model differs in that it is one dimensional and in that each parent produces only a single offspring.

We begin by investigating the conditional expectation density, $h_a^{(b)}(\tau)$. Because of (1), the conditional expectation of $dN^b(\tau)$ is equal to the conditional probability that $dN^b(\tau) = 1$. The probability density of a type b event at τ is equal to the sum over all ν's of the density of a type a event at ν times the density of an offspring occurring at $(\tau - \nu)$ from its parent.

Thus $$h_a^{(b)}(\tau) = \int (h_a^{(a)}(\nu))(np(\tau-\nu) + o((d\nu)^2))\, d\nu$$

$$= n \int h_a^{(a)}(\nu) p(\tau - \nu)\, d\nu \qquad (9)$$

Because of the delta function in $h_a^{(a)}(\nu)$, the contribution at $\nu = 0$ is $np(\tau)$. (9) is analogous to Cox and Lewis's (1972: 419) equation 3.26 except that they include the contribution for $\nu = 0$ as a separate term.

Since each parent produces n offspring, $\lambda^b = n\lambda^a$, and

$$\mu_{ab}(\tau) = n\,\lambda^a \int h_a^{(a)}(\nu)\, p(\tau-\nu)\, d\nu - n(\lambda^a)^2$$

$$= n \int \mu_{aa}(\tau)\, p(\tau - \nu)\, d\nu$$

Fourier transformation as in (8) gives

$$f_{ab}(\omega) = n\,\phi(\omega) f_{aa}(\omega) \qquad (10)$$

where $\phi(\omega)$ is the fourier transform of $p(\tau)$.

The spectrum of $dN^b(s)$ depends on $h_b^{(b)}(\tau)$. $h_b^{(b)}(\tau)$ is conditioned on the existence of a type b point at the origin. The probability density that its parent is located at u is $p(-u)$. Given that the parent is so located the probability density that it will produce an offspring at τ is $(n-1)\, p(\tau - u) + o((d\tau)^2)$, since we know that one of its n offsprings is located at the origin. Thus if only one parent existed we could integrate over all u's to get (ignoring higher order terms)

$$h_b^{(b)}(\tau) = (n-1) \int p(-u) p(\tau-u)\, du + \delta(\tau) \qquad (11)$$

The delta function reflects the fact that, for $\tau = 0$, $h_b^{(b)}(\tau) = 1/ds$.

For an unknown number of parents

$$h_b^{(b)}(\tau) \simeq n \int \int h_a^{(a)}(\nu) p(-u) p(\tau-u-\nu)\, du\, d\nu + \delta(\tau)$$

This is only an approximation because, for $\nu = 0$, the contribution is

$$n \int p(-u) p(\tau-u)\, du$$

This integral should be multiplied by $(n-1)$, as in (11), rather than by n. This discrepancy is corrected by subtracting so that

$$h_b^{(b)}(\tau) = n \int \int h_a^{(a)}(\nu) p(-u) p(\tau-u-\nu)\, du\, d\nu$$

$$- \int p(-u) p(\tau-u)\, du + \delta(\tau) \qquad (12)$$

Using (3) and (7) it can be shown that

$$f_{bb}(\omega) = n^2 |\phi(\omega)|^2 f_{aa}(\omega) - n|\phi(\omega)|^2 \lambda^a + n\,\lambda^a$$

$$= n^2 |\phi(\omega)|^2 \left(f_{aa}(\omega) - \frac{\lambda^a}{n}\right) + n\,\lambda^a \qquad (13)$$

where $\phi(\omega)$ is the fourier transform of $p(\tau)$.

For $n = 1$ (13) is equivalent to Cox and Miller's (1965: 366) equation 87 and to Lewis and Cox's (1972:422) equation 3.38. Cox and Miller point out that if the original process is a poisson process, $f_{aa}(\omega) = \lambda^a$, so that $f_{bb}(\omega) = \lambda^b$, and the offspring process is also poisson. It is interesting to note that this is not so for $n > 1$. For large n,

$$f_{bb}(\omega) \simeq n^2 |\phi(\omega)|^2 f_{aa}(\omega)$$

III. COHERENCE

We define squared coherence by

$$\rho^2(\omega) = \frac{|f_{ab}(\omega)|^2}{f_{aa}(\omega) f_{bb}(\omega)} = \frac{n^2 |\phi(\omega)|^2 f_{aa}(\omega)^2}{f_{aa}(\omega) f_{bb}(\omega)} \qquad (14)$$

It is convenient to rewrite (13) as

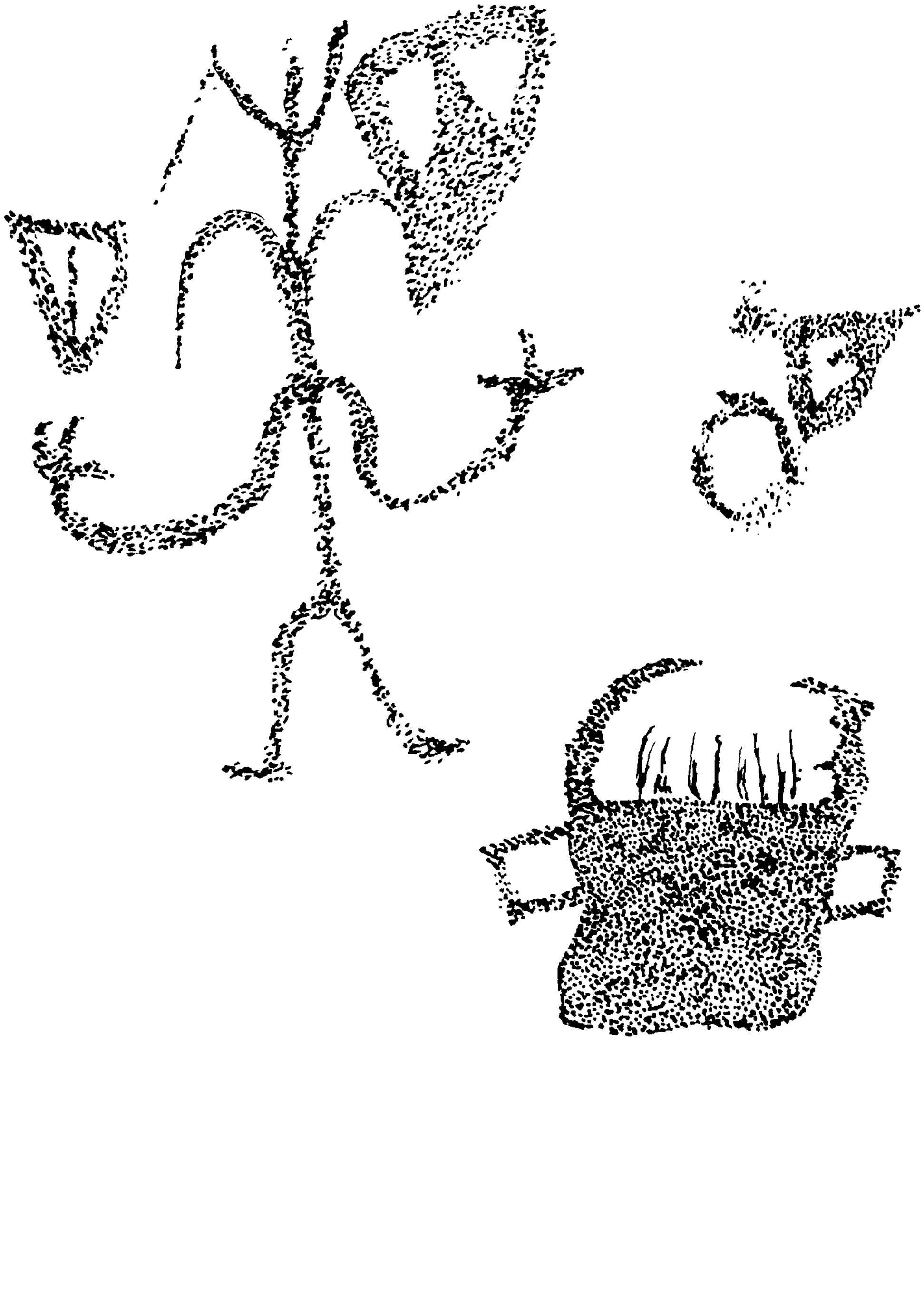
$$f_{bb}(\omega) = n^2 |\phi(\omega)|^2 \left[f_{aa}(\omega) + \frac{\lambda^a}{n}\left(\frac{1}{|\phi(\omega)|^2} - 1\right)\right]$$

This allows (14) to be written as

$$\rho^2(\omega) = \frac{1}{1 + \dfrac{\lambda^a}{n f_{aa}(\omega)}\left(\dfrac{1}{|\phi(\omega)|^2} - 1\right)} \qquad (15)$$

When the second term in the denominator is large, $\rho^2(\omega) \simeq 0$. When this term is small, $\rho^2(\omega) \simeq 1$. The second term will be small when n is large, $f_{aa}(\omega)$ is much larger than λ^a, or $|\phi(\omega)|^2 \simeq 1$. It is clear from computed spectra that $f_{aa}(\omega)$ tends to have large values near $\omega = 0$. Since $\phi(\omega)$ is the characteristic function (fourier transform) of a probability distribution, $|\phi(\omega)|^2 \leq 1$ for all ω. This insures that the second term in the denominator of (15) is always positive. Moreover, since $\phi(\omega) = 1$ when $\omega = 0$, and $\phi(\omega) \to 0$ as $\omega \to \infty$, $\rho^2(\omega)$ must equal 1 when $\omega = 0$, and approach 0 as $\omega \to \infty$ (see Feller 1971:498-530).

PART FOUR: METHODOLOGICAL STUDIES



Chapter 16

AN EVALUATION OF SURVEY STRATEGIES

David C. Eck

INTRODUCTION

This evaluation represents an attempt to assess the reliability of archeological survey data. Such an assessment is called for because of the use of survey data in mitigative planning, and because presentations of survey data are increasingly becoming the *de facto* final report for many site locations subsequently destroyed without further investigation. The results of this evaluation will be useful for planning of data collection policy for future surveys so as to allow more precise determination of the true nature of archeological remains, thereby minimizing potential information loss.

The accumulation of tremendous quantities of detailed archeological survey data is a rather recent development. Modern archeologists are conducting large-scale surveys and publishing extensive analyses of the resultant data sets at a rate surpassing that seen in any period of the past. Current emphasis in grant-supported research conducted by academically based archeologists on broad, regional studies often necessitates extensive surveys. The very nature of archeological contract work frequently requires coverage of extremely large areas, resulting in the production of extensive collections of survey data. This proliferation of survey data, and the wide usage made of such data, dictate the development of some sort of means by which to evaluate their reliability.

The Cochiti survey was typical of those surveys resulting from contract archeological investigations. The data generated were intended to be used in planning the mitigation program within the reservoir, and also to serve as usable data providing information about the operation of cultural adaptive systems within the project area (Chapman and Enloe 1977). The entire visible populations of ceramics, structures, features, etc. were documented, but the quantities of lithic artifacts present dictated a sampling procedure. The *no collection policy* sampling strategy for documenting lithic artifact variability as outlined in Chapman and Enloe (1977) was implemented as an experimental technique, and underwent modification in the field when obvious problems were encountered. However, "*The degree to which it provided information representative of artifact taxon or attribute variability within provenience locales is difficult to assess in the absence of controlled comparison between sample documentation and whole provenience documentation*" (Chapman and Enloe 1977: 177). Since the completion of the mitigation program at Cochiti has provided *whole provenience* documentation, we are now in a position to evaluate the reliability of the survey technique relative to documentation of lithic artifact variability. This paper, then, represents a partial evaluation of general survey strategies, and a detailed evaluation of the *no collection policy* sampling strategy in particular.

PREVIOUS RESEARCH

SURFACE/SUBSURFACE CORRESPONDENCE

The general question of the utility of information derived from the surface distributions of artifacts has often been considered. Since a number of inferences about the character of the entire assemblage are frequently made from the character of the surface sample, it has long been a serious concern for the archeologist. One of the first rigorous treatments of the question can be found in Binford et al. (1970), as part of their analysis of Hatchery West. They found that a controlled surface collection (a *total* collection) will permit a preliminary definition of the area of the site. Within the area so defined, variable densities and combinations of artifact classes can be used to define various subareas of the site. While these are useful applications of surface data, the authors emphatically state that densities of surface items cannot be used as guides to planning entire excavations, since at least two classes of data—artifactual items and archeological features—were found to be independently distributed at Hatchery West. They explicitly state that separate and specific sampling designs must be outlined for the excavation of each class of information that varies independently.

Redman and Watson (1970) conducted studies similar to those at Hatchery West and found that surface and subsurface artifact distributions are related in such a way that a description of the former allows prediction of the latter. In opposition to Redman and Watson's results, Schiffer and Rathje (1973) found no direct correspondence between surface material densities or distributions and subsurface artifact densities or distributions. Their article considers the effects of cultural (c-transforms) and noncultural (n-transforms) formation processes on the distribution of surface and subsurface assemblages, as does Binford (1964), though in more abstract language. In the particular case Schiffer and Rathje discuss, the Joint site, a single component site—they attribute the lack of surface/subsurface correspondence to aeolian deposition and downslope movement. This position implies, however, a demonstrated reason for expecting the two assemblages to correspond, in the absence of the n-transforms mentioned. Such an argument is not offered, and to my knowledge, none exists in the literature.

SAMPLING FOR DISTRIBUTIONS

Redman and Watson (1970) also experimented with sampling of surface distributions in order to look for patterns which were previously defined. Their first attempt utilized a 10% simple random sample, while a 10% stratified, unaligned, systematic sample was used in the second experiment. They concluded that the stratified, unaligned

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sample yielded somewhat *better* results. [Note that the use of probabilistic sampling for generating distribution maps is *not* in keeping with rigorous application of probabilistic sampling (Asch 1975), because it does not involve inferences about the characteristics of populations.] Furthermore, they *assumed* a 10% sample was adequate, leaving us with no basis upon which to further evaluate their conclusions.

Research similar to Redman and Watson has been conducted by Southern Methodist University at Cooper Lake, Texas (Hyatt et al. 1974; Hyatt and Doehner 1975). Since these investigators could not determine the size of an *adequate* sample, they opted for a total collection strategy. Analysis of the surface collections was not completed until after the excavation season, and did not constitute a part of the planning for excavation. In order to derive experimentally an *adequate* sampling strategy for collection and excavation, they conducted a sort of *post-mortem* on one of the excavated sites. Known surface distributions were recorded on maps to be used as standards of comparison. Three types of area sampling procedures were then implemented: simple random, stratified random, and systematic unaligned. The initial samples were drawn so as to comprise 10% of the total area, and subsequent samples were incremented at 10% intervals. Sampling continued until maps generated from the sample data approximated the distribution maps for the population. A minimum of 60% of the total area had to be sampled for an *adequate* approximation via simple and stratified random samples, while 50% was *adequate* for the systematic unaligned procedure (see the comment above concerning sampling and mapping). The authors argue that these percentages are required in order to say that an *adequate* surface sample has been taken, and in order to use it as a guide to excavation. They do not, however, offer any precise definition of what *adequacy* actually is. In a second part of their study, they determined that surface and subsurface density patterns generally correspond, but that surface densities and subsurface features are unrelated, which agrees with Binford et al. (1970), effectively preventing their use as a general guide to excavation.

Recently, spatial analysis of archeological sites has enjoyed significant advances (Hietala and Stevens 1977, for example), and some information relevant to the problem with which this paper deals should be forthcoming. For the present, however, spatial studies are confined to developing and applying means of quantifying and delineating patterning on a predominantly horizontal plane. They are not concerned with assessments of the correspondence of patterns in vertical dimensions, or with the reliability of sample or survey observations.

SAMPLING FOR CONTENT

This is the area with which this paper is specifically concerned, and it is also the area about which the least is known. Few archeologists have dealt with the problem of sampling to derive estimates of assemblage character and content. Since it is the content of the assemblage that affects our interpretation of function, it is vital that we have some degree of confidence in our data. One of the first archeologists to recognize the problem inherent in sampling (Binford 1964) pointed out that the sample size should be "*small enough to avoid unnecessary expense and large enough to avoid excessive error*", and noted that adequate sample size was related to the relative homogeneity of the population. He even went so far as to enumerate and describe sources of error in sampling various archeological populations and recommends systematic sampling designs, but failed to follow through in his hypothetical research design in which he *assumes* a 20% areal sample to be adequate. Brockington (1976) repeated the analysis of sources of error and bias in archeological samples, and also recommends systematic sampling procedures. He goes on to note that "*small-sample surface collections tend to confirm previously-held notions of artifact distributions*" on the surface, and thus recommends *maximum samples*. He also points out that the variance and correlation coefficient of the assemblage (with the entire population) are both reduced as sample size is reduced, indicating a loss of variability (information) and goodness of fit (reliability) with the total population.

Asch (1975) goes one step further in saying that archeological populations are largely nonnormally distributed, and are thus in direct conflict with the Central Limit Theorem, upon which probability and much of statistics are based. He does, however, make a case for the use of statistics in archeology, in spite of this discrepancy, and agrees with Brockington in stating that larger samples are needed for documentation of the diversity of cultural materials than for determination of central tendencies. (Note once again that using sampling as a tool for searching out the range of diversity within a population is also perhaps in conflict with the rigorous application of probabilistic sampling.)

What, then, constitutes an adequate sample, and what is the best procedure for choosing that sample? Mueller (1974) would have us believe that *simple nested cluster sampling* is the best strategy, and that 0.4 is the best sampling fraction, defined on the basis of economy and fewest significant variables. Thomas (1978) attacks Mueller on conceptual grounds, involving his measurements of economy and their use in choosing the sampling design. Plog (1978) presents serious criticism of Mueller's statistics, leading one to suspect that Mueller knows little about what his statistics actually do. Mueller (1978) acknowledges the validity of some of the points raised by these critics but steadfastly maintains his position on sampling procedure, although qualifying it to some extent by retreating within the confines of his study area and research problem. One additional criticism should be made: that there is no such thing as an optimum sampling fraction (from a statistical point of view) as Mueller would have us believe; rather, it is the absolute size of the sample that is of paramount importance (Cowgill 1975; Thomas 1978). The sampling fraction is defined *post hoc* as the relationship of the sample size to the population size, and that ratio has no direct bearing on statistical procedures or on reliability.

SAMPLING AND SAMPLE SIZE

Before proceeding to the present study, it is necessary to clarify certain issues raised in the short review of previous research presented above. First, let us consider the question of the proper applications of sampling. It was noted earlier in a parenthetical comment that probabilistic sampling used to generate maps of densities is not in keeping with rigorous application of sampling. Since mapping *does not* involve inferences about the characteristics of populations (Asch 1975), the use of probabilistic sampling designs is not justified. More simply stated, sampling is *not* intended to be used as a search procedure, but as means of gathering information. The use of sampling to estimate the content of assemblages is justified because it *does* involve inferences about population characteristics. It is such an application of sampling with which this paper will deal.

Second, we are faced with the question of determining an adequate sample size. The researchers mentioned above have done everything from assuming that a 10% sample is adequate to claiming that nothing short of total collection is sufficient. The fact that the sampling fraction has no bearing on a statistical definition of *adequacy* is one of the statistical mysteries that few archeologists have seen fit to attempt understanding. We would, of course, like to be able to inventory absolutely every member of the population under study, for then the reliability of our conclusions is maximized. The real world presents us with a problem, however: the vast majority of populations are so large that it is impossible to make a total inventory, given the time and cost constraints involved. The only acceptable compromise, then, is a sample of sufficient size to meet certain minimum standards of adequacy.

How, then, are archeologists to know whether or not their samples are of adequate size? Statisticians have long been familiar with this problem, and with its solution. Cornfield (1951) and others have dealt with this question and have developed formulae for estimation of adequate sample size, but nowhere is the problem dealt with more clearly than in *Sampling Techniques* (Cochran 1977). Specifying the acceptable range of error, the acceptable probability of having our estimate fall outside that range, and making an estimate of the proportion of the total population made up by that class of things that is of interest, the proper minimum sample size is defined as follows:

$$n = \frac{\frac{t^2PQ}{d^2}}{1 + \frac{1}{N}\left(\frac{t^2PQ}{d^2} - 1\right)}$$

Where:

- n is the sample size
- N is the population size
- d is the range of error (+ or −)
- t is the tabular value corresponding to the probability of a wrong estimate (from any t-table)
- P is the proportion of the population made up by one class
- Q is the proportion of the population made up by all other classes

when we are sampling for proportions of the population in question. In practice, we make an advance estimate of n (n_0) from an estimate of P (p):

$$n_0 = \frac{t^2pq}{d^2}$$

If the ratio n_0/N is negligible (less than 0.05), then n_0 is a satisfactory estimate of n. If not, then n can be found from:

$$n = \frac{n_0}{1 + (n_0 - 1)/N}$$

which formula is known as the finite population correction (fpc).

Since the value of pq increases to a maximum when p = 0.5, we are safest in making an estimation of the proportion of the population made up by the class of interest (P) that lies relatively nearer to 0.5. To be quite certain, we might estimate that the proportion is in fact 0.5, and thereby maximize the size of the sample and our confidence in our accuracy.

One further note: since these equations require some knowledge of the population size (N), and since we seldom know the actual size of archeological populations, it is obvious that some sort of estimate of population size is required. If such an estimate is not *available*, we *can still* be safe by assuming an infinite population which will effectively eliminate the population size as a relevant variable. If we were to do this as a matter of policy, n_0 would always be the best estimate of n; n_0 would, in fact, equal n for all intents and purposes; and we would find ourselves with a minimum sample size far larger than some of our archeological populations. It then becomes obvious that in some cases a total sample is called for since little time can be saved by applying the finite population correction (fpc) and arriving at a best estimate of n. It is also obvious in such a case that taking a total sample is a better estimate of the proportions within a population than any sample size derived by using the fpc. Each study, then, will have a uniquely defined sample size that will meet the requirements of the research design, and a threshold beyond which it is not economical in any sense of the word to continue sampling, when much more accurate estimates of proportion are available from recovery of the total population.

EVALUATION OF COCHITI RESERVOIR SAMPLING PROCEDURES

Let us now turn to a specific case—the Cochiti Project—for an evaluation of survey strategy and illustration of several of the points raised above. One of the first considerations is, of course, how to go about evaluating something so complex as an entire survey. Binford (1975) has pointed out that a sampling strategy must be evaluated with regard to the character of the target population to be sampled, and not in any sort of absolute terms. *This implies that we* have knowledge of the target population over and above that gained by the survey sample. The Cochiti Project presents us with just such a situation where quite a large number of sites are known from both survey and excavation observations.

Sample units at Cochiti were originally intended to be single quadrats placed within recognizable proveniences*, but transect sampling was initiated to compensate for the

*Proveniences were defined as spatial locales within site boundaries (see Chapman and Enloe 1977:174).

observed erosional sorting and downslope movement. Transects were oriented normal to the contours of the proveniences to control for variability due to these factors, and were oriented through the long axis of a provenience if it was on a level area. It was determined in the field that transect samples provided a more reliable estimate of artifact size variability than did quadrats, but whether the estimates of artifact taxon variability were better *"is a more difficult problem which can only be approached through analysis of completely collected or excavated locations"* (Chapman and Enloe 1977). Time, cost, and data limitations prevent an evaluation of this question at this time.

Field personnel also noted that certain low-count artifact taxa were often not accounted for by either quadrats or transect sample units. In view of the discussion above concerning the proper use of sampling, this is not a surprising observation. In order to recover information about low-count items (such as manos, projectile points, etc.), it is necessary to construct sampling procedures specifically intended to do so, and this is exactly the solution implemented at Cochiti: in fact, all visible items in such categories were monitored.

The determination of a proper sample unit size was a basic problem at Cochiti, as it is in most studies. *"A primary objective of sampling was to obtain a 'representative' description of artifact variability within the provenience locale, and a major problem resided in determining how large a sample would be documented"* (Chapman and Enloe 1977). Two solutions were proposed: sampling at a standard fraction of the total number of artifacts, and sampling at a standard fraction of the total provenience area. The first proved unfeasible because of unreliable estimates of the population size (see the discussion on sampling and the conclusions). The alternative was workable, since estimates of total provenience area were readily available, but fell short of the proposed 20% area sample due to time and cost parameters. In actual practice, the sample was as little as 5% of the area (which commonly yielded a less than 5% sample of the population of lithic artifacts—a serious problem when one considers the typically small populations observed at Cochiti).

The *no collection policy* was adopted in order to avoid impact on artifactual assemblages (since selective removal of certain taxa adversely affects the later research potential), and in order to save time in the logistics of transport and analysis. It was instigated as an experiment; an attempt to delineate research problems in such a way as to allow specification of relevant attribute variability and monitor it in the field. The data generated were intended to be useful for studying strategies of material selection, tool manufacture, and tool use within each provenience. A complete discussion of the study of these strategies can be found in Chapman and Schutt (1977), together with the definitions of attributes monitored and rationale for their selection.

STATISTICAL ANALYSIS

During the excavation phase of the Cochiti Reservoir Project, a number of the sites were found to be almost entirely surficial, a situation that made the survey observations representative of a sample from a population for which we subsequently gained more detailed knowledge. The situation can be conceptualized in two ways: first, we might wish to treat the excavation observations (still in fact a sample) as representative of reality—i.e. the excavation *is* the population targeted; or second, we could treat the excavation sample and the survey sample simply as two independent samples derived from the same unknown population. The first situation would best be tested using some statistical measure of the goodness of fit of the sample estimates to the target population itself, while the second case would call for some form of heterogeneity test intended to assess the probability that the two samples were indeed drawn from the same population.

A workable compromise might be the use of a statistical test that could fill both needs simultaneously. Chi-Square is one such test, but it suffers from some serious drawbacks that make its use in many archeological situations highly unreliable. For example, if the expected values are small, the Chi-Square calculated from them is biased in that the value of the statistic will be inflated artificially, and we will tend to obtain results which will lead us to consistently observe a poorer fit or greater heterogeneity than actually exists. The limitations typically imposed on Chi-Square are as follows: no expected frequency should be less than 1.0 and no more than 20% of the expected frequencies should be less than 5.0 (Zar 1974). There are two ways out of the dilemma that archeological data puts the statistician into: one can arbitrarily eliminate all those categories of information that typically result in low frequencies and proceed with the analysis using Chi-Square, or one can choose another statistic that suffers relatively less from these sources of bias.

In this study, it was felt that elimination of low frequency categories was undesirable because the loss of information that would result would be tremendous. The alternative strategy was adopted, in the form of the *log-likelihood ratio*. This statistic has advantages and disadvantages, as follows: its theoretical distribution is poorly known but twice the quantity approximates the Chi-Square distribution, and is applicable for goodness of fit and heterogeneity testing (Zar 1974). This statistic makes use of the logarithms of the actual frequencies and thereby eliminates a certain amount of the bias that low frequency data introduces into Chi-Square analysis. It tends to damp the distorting effects of low expected frequencies in such a way as to again approximate an unbiased Chi-Square distribution. Further, it is an easy statistic to compute, and makes use of the same table of degrees of freedom and significance levels as Chi-Square. It is derived as follows:

$$G = 2\Sigma f_i \ln \frac{f_i}{F_i} = 4.60517 \Sigma f_i \log_{10} \frac{f_i}{F_i} =$$

$$G = 4.60517(\Sigma f_i \log_{10} f_i - \Sigma f_i \log_{10} F_i)$$

where:

- f_i is the observed frequency (or survey observation) for category i
- F_i is the expected frequency (or excavation observation) for i
- ln is the natural logarithm

Σ is a symbol for the summation of values for all observations
$\log_{10}$ is the logarithm to the base 10
4.60517 is a constant

In brief, the statistic computes the summation of the products of the observed frequencies and their logarithms, subtracts from that total the summation of the products of the observed frequencies and the logarithms of the expected frequencies for each observation, and multiplies the remainder by the constant. The number of degrees of freedom is computed by counting the number of categories involved, then subtracting one. If the statistical value is greater than that specified in a table of Chi-Square for that number of degrees of freedom, then the probability of obtaining the observed frequencies purely by chance is less than the corresponding probability presented in the table. This gives us some measure of the accuracy of the estimated artifact variability, and some idea of the source of the bias, if any, from simple inspection of the observed and expected frequencies for each category of artifact.

Expected frequencies were derived from the ratio of total survey assemblage to total excavation (or provenience) assemblage times the observed frequency within each data class for the excavation assemblage. In this manner, excavation assemblages were expressed in terms of an assemblage identical in size to the survey sample, making the two comparable statistically. The actual computations were carried out on an HP-25 programmable calculator, computed at least twice as a check on accuracy, and each step in the calculations was recorded to minimize error.

Tables 16.1 and 16.2 present the statistical values computed for the surveys of the permanent and flood control pools, Surveys 1 and 2, respectively. The computations for each site are broken down into three categories: *all data classes*; that subset of classes informative about *morphological observations*; and that subset concerned with *material types*. For Survey 1, material types were obsidian, basalt, chert, chalcedony, and other. Morphological attributes include retouched, unretouched, cortical, noncortical, prepared platform, unprepared platform, and no platform. Computations for Survey 1 were performed using survey observations versus entire site observations (ws) for all sites and, in those cases where it was possible to establish correspondence in space, between survey observations and specific excavation proveniences. Such cases carry the designation *cp* under the site number in Table 16.1. For Survey 2, the designations *taxa* and *types* appear under the site number. If *taxa* is indicated, the material types were specific numerical taxon designations which refer to specific materials with known source areas (e.g. 3520—Jemez obsidian), while the *types* designation indicates that only gross categories of material were used, the same gross categories as Survey 1. It was not possible to establish corresponding proveniences for Survey 2, hence the different designations for Table 16.2. Morphological classes for Survey 2 include five separate size categories; presence or absence of utilization ± cortex; whether the cortex was waterworn; placement of cortex (platform, dorsal, platform and dorsal); angular debris; and ± of cortex on angular debris.

The first column in the tables gives the site number, and information relative to whole site (ws) or corresponding provenience (cp) assemblage data used in computations, and whether material taxa or types were used. The second column presents the actual size of the survey sample while the third column indicates the sampling fraction as computed from the ratio of column two to column four, which shows the size of excavation assemblage involved. The fifth column presents the sample sizes computed using the formula presented above, and the sixth shows what the sampling fraction would be. The sampling fraction is included in the table to illustrate that the fraction varies independently of statistical concerns. The next three columns present the statistical values computed for each group of data classes (including *morphology classes*, *material types* and *all data classes*). A single asterisk means that the probability of that outcome is less than 0.05; two asterisks mean the probability is less than 0.01; and three asterisks mean that the probability is less than 0.001. The designation *n.s.* means that the probability is greater than 0.05, and is therefore possibly due to chance. The *comments* column calls attention to the subset of data classes responsible for most of the statistical value, changes in value in different circumstances of comparison (i.e. whole site comparison versus corresponding proveniences comparison), and cases where the value is not significant (!). The parenthetical numbers refer to the associated degrees of freedom in each situation.

The sample sizes presented in column five were derived from the formula for sample size presented above, according to the following parameters: 1) ± 10% error is acceptable; 2) we are willing to get a wrong estimate (i.e. *outside the ± 10% range of error*) one in ten times; and 3) the worst possible situation holds, and the proportion of the population made up by a single data class is, in fact, 0.5. This yields an n_0 of 68 (i.e. *we must make 68 observations to have the reliability specified above*), *if* we have very large populations (in this case, greater than 1,362) or, if we assume infinite populations. If n_0/N was greater than 0.05, the value presented in the tables under the heading *sample size##* represents a revised estimate of n based on the fpc. It is easy to see by simple inspection that the sample size actually taken was adequate (within the above parameters) in only three cases, with most sample sizes falling far short of the requisite number. It is also obvious by inspection that *the sampling fraction has no meaning*—it freely varies from 0.02 to 0.67 in the examples presented in the tables.

Note here that the sampling unit in this case is the individual artifact. It is, of course, possible to have any sort of sampling unit, but each must be defined specifically for the class of information that is of interest. Therefore, in this case, a minimum sample of 68 pieces of debitage would have been sufficient to satisfy the above criteria. Neither are the criteria merely intended to serve as examples. Since the data concerning the proportions contributed by various classes of lithic artifacts is potentially critical in the characterization of the activities supposed to have taken place at each site, it becomes clear that error in estimation greater than ± 10% can have a devastating effect on the conclusions reached. The use of 0.5 as an estimate of the proportion made up by a single class of data is also justified, since almost exactly one-half the total population of artifacts at Cochiti is, in fact, basalt and being wrong more than one in ten times in estimation will surely cripple any analysis made of the lithic data.

Table 16.1
Statistical Data: Survey of the Permanent Pool (Survey 1)

LA Number	Sample Size	Sampling Fraction	Population Size	Sample Size **	Sampling Fraction**	Morphology Classes G=	Material Types G=	All Data Classes G=	Comments
5011 ws	11	.05	204	51	.25	3.25 n.s. (4)	14.73 ** (2)	22.05 * (11)	Material
9138 ws	22	.02	953	64	.07	9.99 n.s. (7)	52.68 *** (3)	133.83 *** (18)	Material
12161 ws	20	.02	1126	64	.06	20.03 ** (6)	13.12 * (4)	39.51 *** (16)	Morphology
cp	20	.05	366	57	.16	21.60 *** (5)	14.55 ** (4)	40.66 *** (16)	Worse!
12442 ws	34	.03	1185	64	.06	50.75 *** (4)	3.73 n.s. (2)	51.16 *** (11)	Morphology
12443 ws	19	.08	224	52	.23	20.40 ** (5)	9.21 ** (2)	43.56 *** (10)	Morphology
cp	19	.12	163	48	.30	22.80 *** (5)	6.77 n.s. (3)	39.33 *** (10)	Better?
12444 ws	14	.01	1544	68	.04	10.73 n.s. (6)	57.15 *** (1)	27.63 ** (10)	Material
12447 ws	17	.06	266	54	.20	36.10 *** (4)	9.62 ** (2)	61.53 *** (10)	Morphology
cp	17	.07	243	53	.20	31.55 *** (5)	6.95 * (2)	48.68 *** (10)	Better?
12448 ws	28	.49	57	31	.54	14.83 * (5)	2.44 n.s. (2)	30.03 ** (12)	Morphology
cp	28	.56	50	29	.58	9.62 * (4)	1.01 n.s. (2)	15.84 n.s. (12)	Better!
12454 ws	25	.13	189	50	.26	15.10 ** (5)	5.57 n.s. (2)	24.91 ** (8)	Morphology
cp	25	.15	168	49	.29	12.25 * (4)	5.57 n.s. (2)	20.54 ** (8)	Better?
12456 ws	24	.03	858	63	.07	30.21 *** (7)	0.00 n.s. (3)	28.87 *** (11)	Morphology
cp1	12	.03	385	58	.15	7.97 n.s. (5)	0.00 n.s. (2)	10.59 * (4)	Better
cp2	12	.07	183	50	.27	15.10 ** (5)	1.75 n.s. (3)	22.20 ** (8)	Better?

Some additional data presented in Table 1 are the results of experiments conducted by one of the survey archeologists, James Enloe. These results are presented with the evaluation of LA 12463 and are designated by the prefix *exp* and a percentage. The purpose of the experiment was to test both the limitations of the surveyors and their equipment, and to arrive at some estimate of a reliable sample size. Drawing 10%, 20%, 30%, and 40% areal samples from a known excavation population (LA 12463), he then performed the standard field analysis on the lithic artifact population. The areal samples were derived from transects spaced at a fixed interval from a randomly selected first transect. Inspection of the results reveals an interesting pattern: A sample size increases, the morphology classes contribute relatively more of the statistical value, perhaps indicating a source of bias in the observer or his equipment. Since the surveyor made his observations with a 10x hand lens, and the excavation assemblage was analyzed with the aid of binocular microscopes, the likely source of bias would seem to be the equipment. Another possible explanation for the increased statistical value could be the potential spatial correspondence of the sample transects with certain periodicities of the distribution of artifacts on the surface of the site, thereby yielding ambiguous results. Inspection of a density map showing artifact distribution at LA 12463 (Chapman et al. 1977:Fig.9.37) reveals that the 30% and 40% samples included relatively more of the central area of density of artifacts (10%—transects F & P; 20%—transects F, K, P, & U; 30%—transects F, I, L, O, R, & U; 40%—transects F, G, K, L, P, Q, U, & V). It is not surprising that the assemblage should vary so markedly in view of the fact that certain activity areas were emphasized in various samples.

If we now consider only those sites for which the sample sizes have been shown to be large enough to be reliable (as defined above), some support can be given

Table 16.1 (Continued)

LA Number	Sample Size	Sampling Fraction	Population Size	Sample Size**	Sampling Fraction**	Morphology Classes G=	Material Types G=	All Data Classes G=	Comments
12463	16	.05	314	56	.18	2.53 n.s.	12.99 **	47.11 ***	Material
ws						(5)	(2)	(10)	
cp	16	.11	146	47	.32	2.86 n.s.	10.73 **	40.89 ***	Better?
						(5)	(2)	(11)	
exp10%	15	.05	314	56	.18	0.32 n.s.	5.10 n.s.	10.15 n.s.	Material
						(4)	(2)	(10)	
exp20%	63	.20	314	56	.18	6.48 n.s.	3.42 n.s.	11.65 n.s.	Worse?
						(4)	(2)	(10)	
exp30%	109	.35	314	56	.18	18.47 ***	1.57 n.s.	30.40 **	Worse!
						(5)	(2)	(13)	Morphology
exp40%	150	.48	314	56	.18	6.03 *	5.56 n.s.	27.78 *	Better?
						(5)	(2)	(14)	
12465	9	.27	33	22	.67	8.15 n.s.	6.68 *	26.48 ***	Material
ws						(4)	(2)	(6)	
12468	21	.49	43	27	.63	24.45 **	6.03 *	32.14 **	Morphology
ws						(8)	(2)	(14)	
12483	15	.08	180	50	.28	15.75 **	30.49 ***	81.47 ***	Material
ws						(4)	(2)	(8)	
12486	32	.04	724	62	.09	29.93 ***	33.89 ***	118.91 ***	Material
ws						(8)	(3)	(13)	
12494	33	.01	2300	68	.03	29.52 ***	13.95 **	73.91 ***	Morphology
ws						(7)	(4)	(17)	
12495	18	.04	457	59	.13	27.72 ***	20.45 ***	58.90 ***	Material
ws						(7)	(3)	(11)	
12496	27	.07	370	58	.16	22.43 **	13.40 **	73.13 ***	Morphology
ws						(6)	(2)	(13)	
12517	20	.04	508	60	.12	2.12 n.s.	2.07 n.s.	18.56 n.s.	!!
ws						(4)	(3)	(13)	
12518	13	.02	712	62	.09	12.11 *	25.79 ***	74.70 ***	Material
ws						(4)	(2)	(9)	
12519	9	.18	49	29	.59	2.26 n.s.	3.36 n.s.	20.35 **	Material?
ws						(4)	(3)	(5)	

ws = whole site
cp = corresponding proveniences
** = derived from formula—theoretical minimum requirement for this study
n.s. = not significant

* = probability less than 0.05
** = probability less than 0.01
*** = probability less than 0.001
( ) = degrees of freedom
comments = denotes greatest contributors to statistical value, etc.

to the postulated bias due to equipment. These three sites (13049, 13086, and 13350) show a consistent pattern: morphology classes contribute the majority of the statistical value, indeed, in two of the three cases, the *only* significant component of the overall statistical value is the morphological subclass. Further confirmation of these observations can be found by comparing the observed survey frequencies for specific classes of data across all sites with the expected frequencies by means of a t-test. From this analysis it was found that only the morphological class of *no platform* was significantly biased for Survey 2. The category *no platforms* was underestimated while *utilization* was overestimated. In neither survey was any specific material type significantly biased. It is interesting to note, however, that basalt and the two morphology classes mentioned interact to produce the two most significantly biased classes in the entire population. Whether this is a chance occurrence, or is due to some inherent characteristic of basalt which makes it difficult to recognize those morphological attributes, is unknown.

While it is likely that there is at least some bias in the samples due to equipment limitations in the field, it is also possible that human bias in the form of preconceptions or lack of training also had an effect. If this were so, and since we know that additional training of survey crew members took place between the first and second survey seasons, we would expect an overall reduction in significance of the statistical value in the second survey. This is indeed the case, as we can determine by inspection of the tables. In the first survey, only one (5%) of the sites showed a nonsignificant difference between the survey sample and the excavation population;

Table 16.2
Statistical Data: Survey of the Flood Pool (Survey 2)

LA Number	Sample Size	Sampling Fraction	Population Size	Sample Size **	Sampling Fraction **	Morphology Classes G=	Material Types G=	All Data Classes G=	Comments
10114	12	.04	336	57	.17				
taxa						2.98 n.s. (6)	0.00 n.s. (3)	6.93 n.s. (11)	!!
types						10.34 n.s. (5)	6.30 * (2)	5.83 n.s. (6)	Morphology?
13049	79	.12	675	62	.09				
taxa						39.12 *** (12)	11.26 n.s. (6)	72.26 * (52)	Morphology
types						34.90 *** (12)	3.99 n.s. (3)	83.74 *** (35)	Worse!
13050	16	.06	280	55	.20				
taxa						36.51 *** (10)	4.97 n.s. (5)	2.54 n.s. (11)	!!
types						35.51 *** (8)	9.52 * (3)	3.57 n.s. (15)	Morphology
13054	14	.02	895	63	.07				
taxa						19.07 * (8)	4.19 n.s. (2)	6.02 n.s. (12)	!!
types						29.87 *** (7)	18.79 *** (3)	18.96 n.s. (11)	Worse Material
13076	65	.04	1561	68	.04				
taxa						47.10 *** (11)	0.00 n.s. (0)	47.10 *** (11)	Morphology
types						49.50 *** (10)	2.59 n.s. (2)	59.05 *** (16)	Worse
13084	18	.01	2933	68	.02				
taxa						12.74 n.s. (9)	0.00 n.s. (0)	12.74 n.s. (9)	!
types						12.74 n.s. (9)	0.00 n.s. (0)	12.74 n.s. (9)	No change Morphology
13086	84	.02	4381	68	.02				
taxa						25.18 * (12)	3.10 n.s. (1)	25.18 * (14)	Morphology
types						45.39 *** (13)	3.98 n.s. (2)	58.74 *** (21)	Worse
13292	43	.16	264	54	.20				
taxa						26.91 * (13)	27.90 *** (1)	2.83 n.s. (16)	!!??
types						16.17 n.s. (13)	13.87 *** (2)	73.39 *** (23)	Worse Material
13350	56	.20	280	55	.20				
taxa						25.76 * (14)	6.32 * (2)	41.21 * (24)	Morphology
types						24.06 * (14)	1.25 n.s. (1)	120.02 *** (22)	Worse
13351	17	.26	65	33	.51				
taxa						20.61 ** (8)	0.00 n.s. (1)	25.62 ** (10)	Morphology
types						42.87 *** (8)	10.73 ** (1)	169.78 *** (9)	Worse
13352	36	.16	228	53	.23				
taxa						30.96 ** (13)	0.96 n.s. (3)	11.29 n.s. (28)	!
types						19.58 n.s. (13)	4.34 * (1)	57.87 *** (22)	Worse Morphology
13353	5	.01	750	62	.08				
taxa						3.92 n.s. (6)	0.00 n.s. (0)	0.00 n.s. (4)	!!
types						6.70 n.s. (7)	1.39 n.s. (1)	1.39 n.s. (6)	!

ws = whole site
cp = corresponding proveniences
taxa = grouped by specific material types
types = grouped by gross material types
** = derived from formula—theoretical minimum requirement for this study

n.s. = not significant
* = probability less than 0.05
** = probability less than 0.01
*** = probability less than 0.001
( ) = degrees of freedom
comments = denotes greatest contributors to statistical value, etc.

while in the second survey, five (42%) of the sites showed nonsignificant differences. Note that the figures for types are used here instead of those for taxa. This is because the consistent improvement in statistical value for taxa versus types reflects the loss of information inherent in too finely subdividing one's categories. As the number of categories approaches the number of units in the sample, more and more of the categories will be represented by one or less items--useless for statistical comparison.

Beyond the postulated personal, training, and equipment-derived biases, it is possible that the physical properties of artifacts and their interactions with natural or cultural processes may also contribute biases. It has been shown, for example (Baker 1978), that the probability of any item being visible on the surface is directly proportional to its gross size. Baker argues that this can lead to later reuse of large artifacts, and a progressive accumulation of large artifacts on the surface of archeological sites. Given that utilized artifacts tend to be somewhat larger than their unutilized counterparts, this could result in just that sort of pattern observed in the second survey, where utilization was grossly overestimated. Isaac (1967), Johnson and Hansen (1974), and Cahen and Moeyersons (1977) have investigated a number of natural phenomena that can selectively sort artifacts according to size, and it was noted that one or more of these processes affected the surface distributions at Cochiti (Chapman and Enloe 1977). Rick (1976), Roper (1976), and Yellen (1977) have also dealt with cultural and noncultural sources of bias in surface data. One of the more intriguing such studies is that presented by Lischka (1969), finding that each material type may have a characteristic length/width ratio. If this is so, and there is a size bias on the part of the surveyors (due to perceptual limits in the field), there may be a related bias for material. If utilization and size are correlated to some extent, and if one considers that the second survey is biased for these categories, it is not surprising to find a strong bias for basalt. The first survey category of *no platform* (largely small angular debris--a hard to detect category), coupled with a slight bias against basalt (which produces notorious amounts of small angular debris), would also seem to support this, due to the fact that *no platform* is underestimated.

CONCLUSIONS

NO COLLECTION STRATEGY

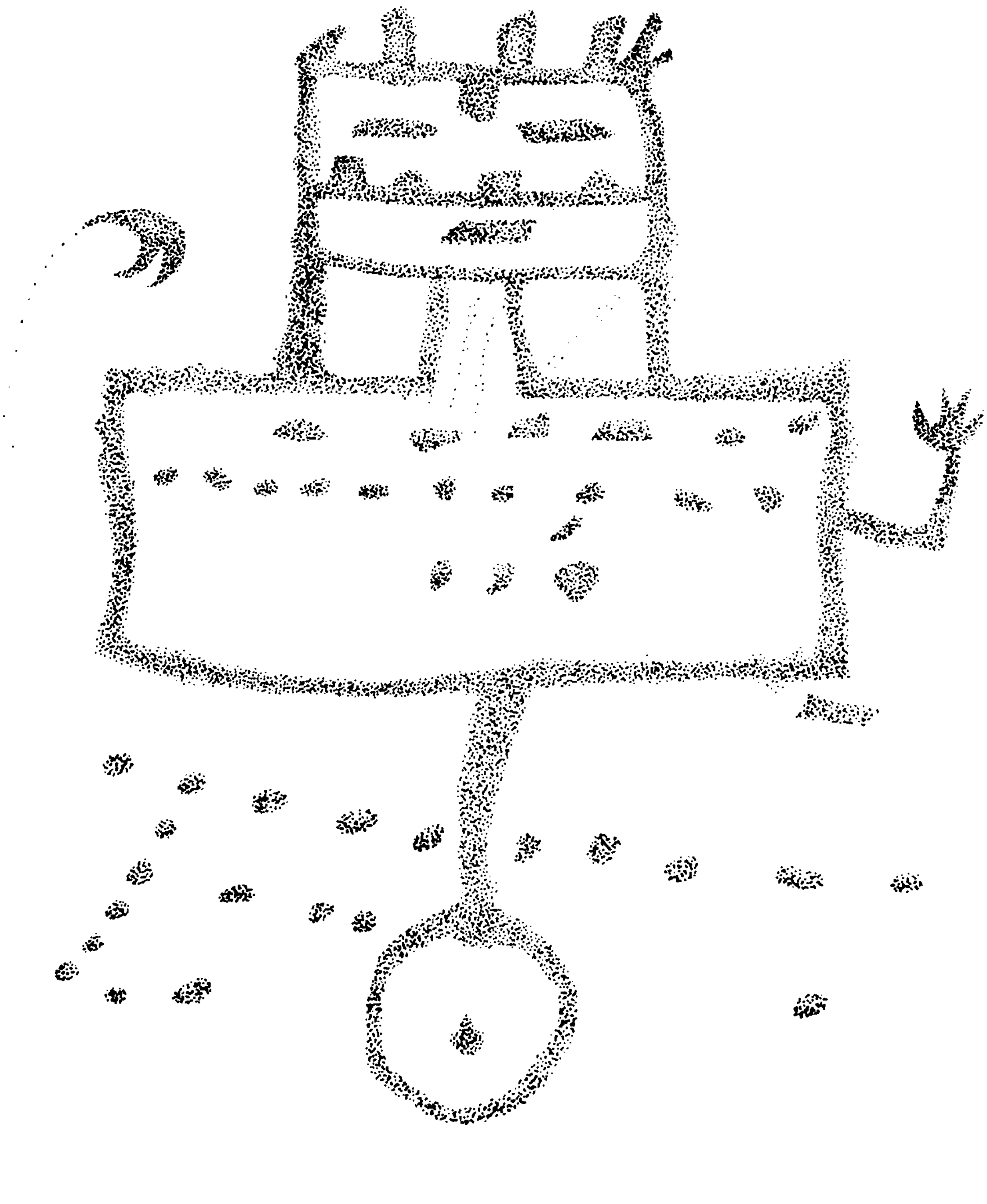
The strategy fulfilled the expectations which led to its formulation. Archeological sites were preserved in situ, with minimal impact on their utility for future research. Many of the sites would have been effectively destroyed if surface collections had been made, especially if samples large enough to be reliable statistically had been taken. Much time and energy were saved in logistics during the surveys since there was no need to transport large amounts of artifactual material back to the laboratory for analysis. The evaluation presented herein has shown that reliable estimates of assemblage content can be made and, with the proper training, analysis can be accurately done *in the field*. The actual analysis used in the Cochiti surveys could be made better perhaps by minimizing the number of categories involved, in order to insure sufficient frequencies for accurate estimates. Careful evaluation of human and equipment limitations would allow some sort of compensatory actions to insure accuracy. This analysis has pointed out the need to fit the sample unit to the research problem in this case the sample unit should have been the individual artifact instead of an areal transect unit that was employed. The samples actually taken at Cochiti were too small, in general, to allow for reliable estimates of the character of the populations involved. Finally, an awareness of the natural and cultural processes affecting artifact distributions would allow adjustments to be made in interpretations derived from the analysis, even as it was done at Cochiti.

GENERAL SURVEY IMPLICATIONS

As a result of this analysis, it is now known that statistically reliable estimates of population characteristics are obtainable from sample data. Careful definition of the target population and the requirements of the research design in terms of accuracy and reliability of estimates can be used to determine the minimum sample size necessary to accomplish the task. Much thought should be devoted to the reasons for sampling and what the resultant data are intended to provide information about. An awareness of the sources of error can help in planning and implementation of research based on survey samples, so that the return of useable data is maximized. It is hoped that this paper will provide some guidelines for planning and evaluating other research projects.

STATISTICAL APPLICATIONS

Lastly, this paper has presented a small amount of information which should help to clear up the confusion over sample size and sample fraction that has cropped up in archeology. It is hoped that this paper will serve as an example so that others can benefit from its discussion of the determination of proper sample size. It is also hoped that it will serve as an example of the proper use of statistical procedures--not as absolute measurements, but as tools to help point out sources of bias, error, and variance in our attempts to study the patterns of human behavior.



Chapter 17

PEDOLOGY IN THE SERVICE OF ARCHEOLOGY: SOIL TESTING AT LA 13086

Stephen Fosberg and John Husler

INTRODUCTION

This chapter is an outgrowth of a more general inquiry into the possible relationship between prehistoric Anasazi settlement strategies, agricultural practices, and variation in soils characterizing the Cochiti region of north-central New Mexico. In that paper, Fosberg (this volume) suggested five hypotheses which might account for a perceived change through time in location of small (1-10 room) sites from the Pueblo III phase (A.D. 1175-1325) throughout the Pueblo IV phase (A.D. 1325-1500). One hypothesis, which is the focus of this particular study, offered that *"If settlement pattern shifts over time were due to problems of salinity in the soil, then we would anticipate that the areas to be abandoned would be those with high clay contents and poor permeabilities"*.

An initial inspection of the patterning within the Cochiti Reservoir area appeared to bear out this hypothesis. A shift over time can be noted as an increasing proportion of small Pueblo IV sites (A.D. 1325-1450) of 10 rooms or less were based on the more marginal soils east of the Rio Grande. Soon after these soils supported over 27% of all P-IV sites, the area was abandoned. This Apache-Silver-Rockland association (No. 14) contains soils that are thin and that have been derived from basalt. The subsoil layers of stony loam to clay lying above impermeable basalts have moderate to slow permeability (Maker et al. 1971:27). Conditions appeared good for salt build-up within these fine-grained soils.

Such an accumulation could have been caused by a number of factors. First, if water had ponded up over the soil, either because of human terrace construction or the natural morphology of the land, evaporation may have deposited salts on top of the soil. Second, aeolian deposition may have laid down fine sediments laden with salt. Third, since the parent rock in the area is a calcium-rich basalt, the weathering of the parent material and the subsequent transportation of these fines into the field area may also have brought in abundant soluble cations.

Once the salts became established in the upper layers of the soil, the downward percolation of rainwater or trapped runoff would have transported them down into the clayey B soil horizon. In a semiarid environment, inadequate drainage of water through the soil horizons would not have permitted a thorough leaching of these salts through all the soil layers. Salt deposits would then increase in concentration in the B horizon until their presence began to affect adversely crops whose roots penetrated into this zone. Eventually, crop yields might have declined until the field would have had to have been abandoned.

In order to test this senario, an agricultural field adjacent to a small multicomponent P-III P-IV site (LA 13086) was examined. This field lies well within soil association No. 14 on the east side of the Rio Grande in White Rock Canyon. It is situated 500 feet to the southeast of the river and has a northwestern exposure.

METHODOLOGY

Soil Sampling

The site's location within its surrounding physiography permitted a relatively easy definition of the boundaries of the adjacent agricultural field. A landslide occurred, perhaps during the Pleistocene, in which the lip of the basalt mesa to the southeast collapsed. A bowl-like depression formed in back of the slide material which then slowly filled as weathering proceeded and fines either washed in from the higher slide deposits surrounding the depression or were blown in (Wells, personal communication). To the east and south, basalt cliffs come down to the edge of the site while to the west, a sharp drop off occurs beyond the slide material down to the river. Vegetation within the filled landslide basin is characterized by dense cholla and snakeweed stands. A marked relative lushness of cholla cacti has been noted at other archeological sites in the region (Biella, personal communication). Thus, because of the dense vegetation and because of the fact that the steep cliffs and slopes surrounding the site were unsuitable for agricultural usage, it was felt that the outlines of the field exploited by the Anasazi could be delineated fairly accurately.

Core hole 0 was located near the center of the field some 20 m southeast of the P-IV roomblock associated with Provenience 2, and approximately 18 m northeast of the P-III room in Provenience 3. Hole 1 lay only 5 m west of the talus boulders at the base of the cliff, 12 m east of hole 0. This represents a distance of 30 m east-southeast of Provenience 2. Hole 2 was sunk near the southern edge of the agricultural field, 36 m south of hole 0 and 55 m south-southeast of Provenience 2. The last core, hole 3, was taken close to the western periphery of the field. It was situated 22 m west of hole 0, or 10 m southwest of Provenience 2.

The field itself is basically rectangular in shape, some 550 feet northeast-southwest and 200 feet northwest-southeast. Because of time and fiscal restraints, sampling the field was not performed under the formal sampling designs suggested by Shackley (1975). Rather, the four areas sampled were deliberately selected in the belief that their position in the field would adequately reflect the variation within the soil body across its width from talus edge to the inside lip of the slide deposit. Lateral variability parallel to the cliff was not expected to be as great since conditions 100 feet from the cliff would probably be the same for all points 100 feet from the basalt mesa along a northeast-southwest line.

Collecting Samples

Soil samples were collected employing an auger equipped with a short extension which permitted sampling to a depth of approximately 40 inches. Layers that appeared to have distinct colors or textures were bagged separately in sterile, resealable plastic sacks. Homogeneous layers thicker than 6 inches were subdivided because of the restrictions on the amount of soil that could be withdrawn by the auger at any given time. In all, some 39 sample units were obtained: 11 from core hole 0, 11 from core hole 1, 8 from core hole 2, and 9 from core hole 3. All samples were sealed in air-tight plastic bags in the field, placed in a box, and then transported back to the laboratory where the following chemical tests were performed.

Analytical Techniques

The soil samples submitted to the laboratory were air-dried and screened through a 9 mesh sieve. The weight percentage of (+) 9 mesh and (-) 9 mesh fractions were recorded and analyses were then performed on the (-) 9 mesh fraction.

The pH measurements were performed by mixing a sample of soil with an equal volume of water. The paste was stirred intermittently for one hour and the pH measured after stirring the suspension well just prior to inserting the electrodes. This is the 1:1 (soil:water) ratio method suggested by Welcher (1963).

The water-soluble ions (sodium, potassium, calcium, and magnesium) were determined by atomic absorption spectrophotometry. A 10 g sample was stirred intermittently with 50 ml deionized water for one hour. The sample was gravity-filtered through a Whatman No. 42 filter and rinsed with 25 ml deionized water. In order to minimize ionization interferences, the sample solution was made to contain 1000 g/ml cesium when diluted to 100 ml. The Na and K were analyzed in an air-acetylene flame and the Ca and Mg in a nitrous oxide-acetylene flame.

The water-soluble phosphorus was analyzed on an aliquot of the same solution using an adaptation of the molybdenum blue method (see Chen 1956).

Total nitrogen was ascertained by an adaptation of the Kjeldahl Method. For details consult Prince (1945).

Organic matter was determined by reduction with potassium dichromate followed by back titration with ferrous sulfate. Richards (1954) elaborates on this method.

Costs

Despite the inevitable institutional variations and increases to be caused by inflation, this section is presented so that other archeologists can become familiar with the approximate costs of conducting similar research. As performed by the chemistry facilities at the Departments of Geology and Biology, University of New Mexico, the following costs were incurred: (1) for drying, screening, weighing of 39 samples — \$22.00; (2) for pH, Na, K, Ca, Mg, and P_2O_5 analyses of 39 samples — \$78.00 for each analysis; (3) for organic carbon (C) and N analyses of 39 samples — \$97.50 for each analysis. Thus the total amount spent to analyze the chemical variations throughout the stratigraphy of four cores from one field was \$685.00.

RESULTS

Tables 17.1-17.5 and Figs. 17.1-17.9 present the results in tabular and graphic form. An evaluation of these data is offered in the next section.

Table 17.1

Total Percent Nitrogen (N)

Hole 0		Hole 1		Hole 2		Hole 3	
Inches	% N	Inches	% N	Inches	% N	Inches	% N
0–2	0.0262	0–1.5	0.0367	0–3	0.0171	0–4	0.0343
2–4.75	0.0624	1.5–4	0.0275	3–6	0.0201	4–8.5	0.0234
4.75–6	0.0258	4–7	0.0202	6–9	0.0143	8.5–14	0.0217
6–9	0.0362	7–9	0.0199	9–13.5	0.0143	14–19.5	0.0183
9–11.5	0.0252	9–12	0.0203	13.5–24	0.0150	19.5–24	0.0185
11.5–13	0.0179	12–14.5	0.0237	24–32	0.0145	24–28	0.0165
13–17	0.0315	14.5–17	0.0227	32–36.5	0.0252	28–31	0.0166
17–22.5	0.0182	17–20	0.0209	36.5–39	0.0114	31–35.5	0.0145
22.5–25.5	0.0170	20–29.5	0.0160			35.5–38	0.0130
25.5–30	0.0125	29.5–36	0.0182				
30–35.5	0.0104	36–39.5	0.0147				

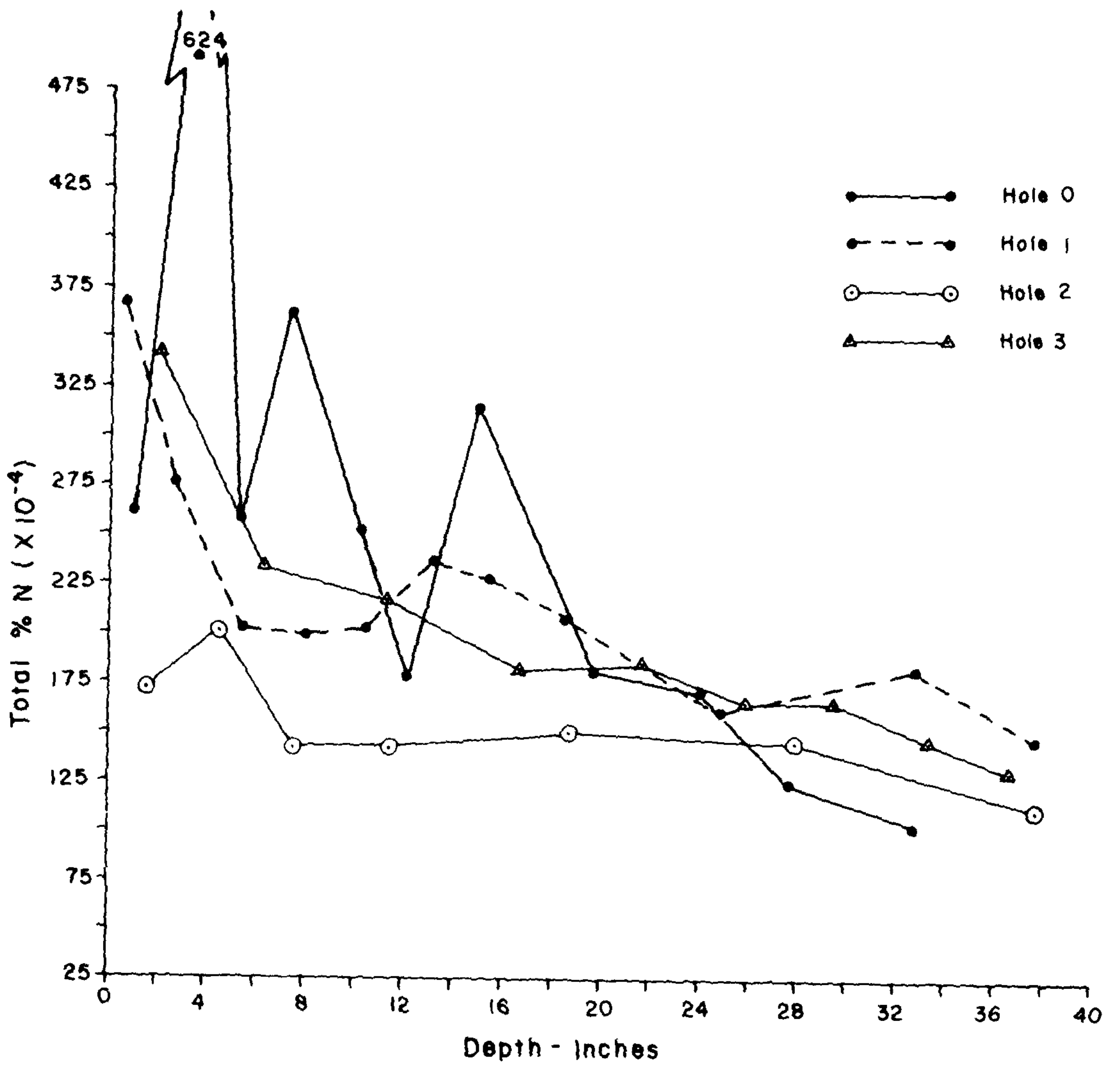


Fig. 17.1 Total percent nitrogen (N)

Table 17.2

Percent Organic Carbon

Hole 0		Hole 1		Hole 2		Hole 3	
Inches	% C	Inches	% C	Inches	% C	Inches	% C
0–2	0.82	0–1.5	0.96	0–3	0.52	0–4	0.71
2–4.75	0.64	1.5–4	0.65	3–6	0.51	4–8.5	0.58
4.75–6	0.59	4–7	0.53	6–9	0.47	8.5–14	0.55
6–9	1.05	7–9	0.50	9–13.5	0.40	14–19.5	0.51
9–11.5	0.56	9–12	0.54	13.5–24	0.39	19.5–24	0.40
11.5–13	0.49	12–14.5	0.53	24–32	0.36	24–28	0.41
13–17	0.66	14.5–17	0.53	32–36.5	0.35	28–31	0.36
17–22.5	0.43	17–20	0.46	36.5–39	0.45	31–35.5	0.33
22.5–25.5	0.35	20–29.5	0.42			35.5–38	0.37
25.5–30	0.28	29.5–36	0.38				
30–35.5	0.28	36–39.5	0.41				

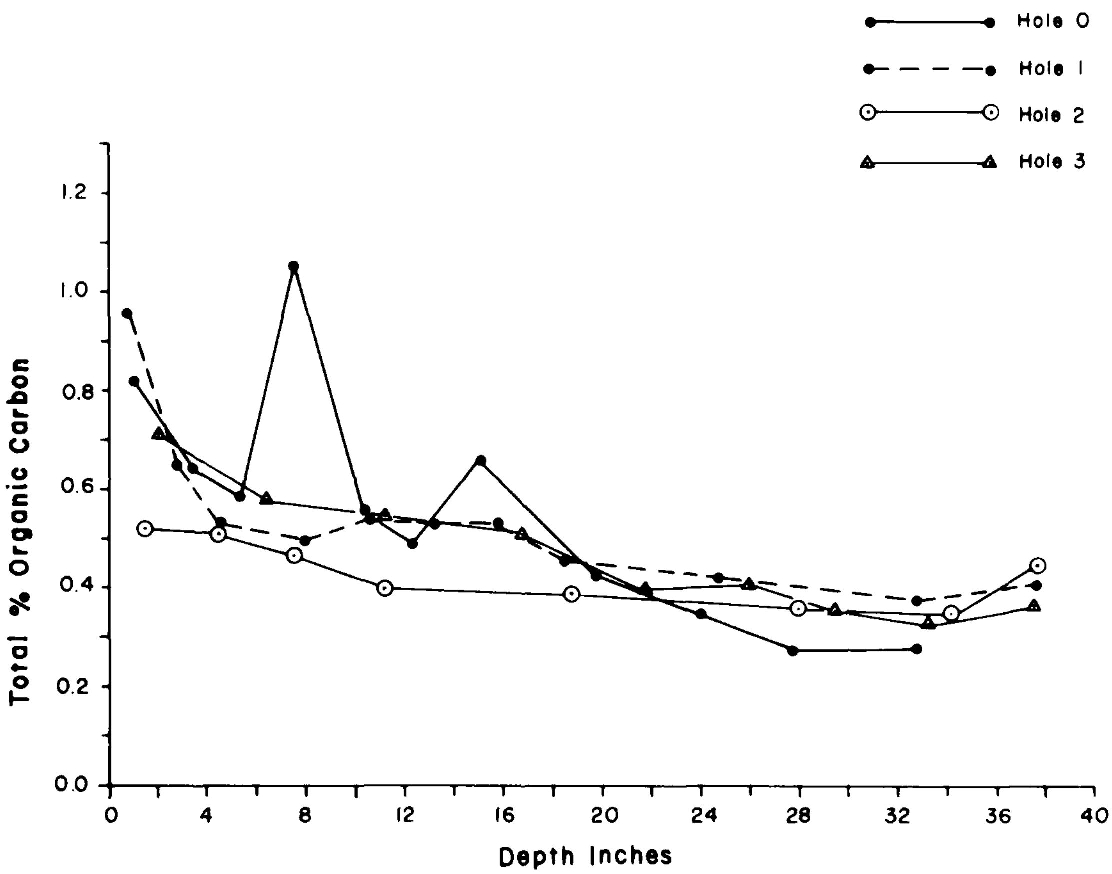


Fig. 17.2 Total percent organic carbon (C)

Table 17.3
Soluble Phosphorus (PPM)

Hole 0		Hole 1		Hole 2		Hole 3	
Inches	Soluble P_2O_5	Inches	Soluble P_2O_5	Inches	Soluble P_2O_5	Inches	Soluble P_2O_5
0–2	6.3	0–1.5	6.4	0–3	2.0	0–4	2.0
2–4.75	5.3	1.5–4	4.8	3–6	2.4	4–8.5	2.5
4.75–6	8.6	4–7	4.0	6–9	4.3	8.5–14	2.0
6–9	8.2	7–9	5.2	9–13.5	1.0	14–19.5	1.0
9–11.5	5.4	9–12	4.7	13.5–24	1.2	19.5–24	1.2
11.5–13	16.0	12–14.5	7.2	24–32	0.2	24–28	0.4
13–17	5.2	14.5–17	7.8	32–36.5	0.4	28–31	0.1
17–22.5	1.0	17–20	5.7	36.5–39	0.9	31–35.5	2.2
22.5–25.5	2.8	20–29.5	2.4			35.5–38	1.5
25.5–30	2.5	29.5–36	2.1				
30–35.5	0.7	36–39.5	4.0				

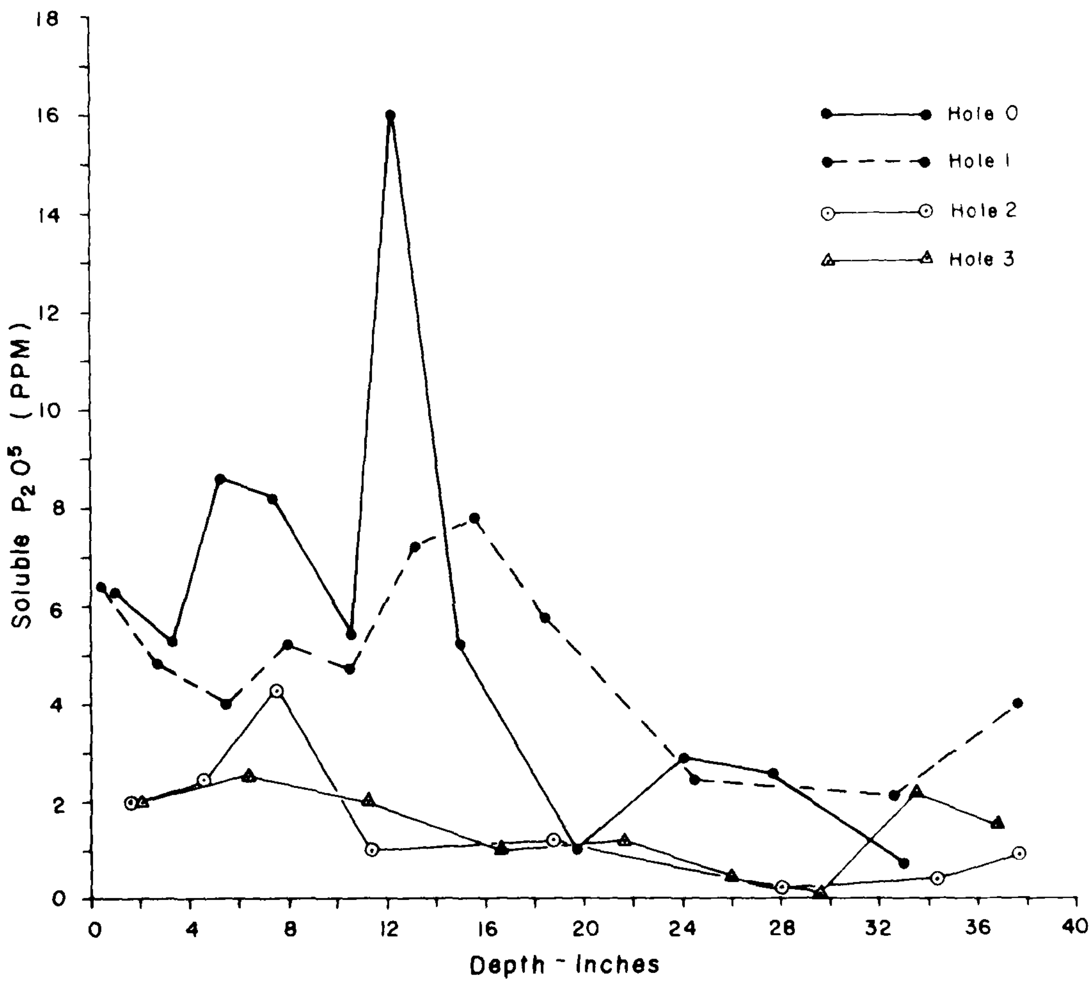


Fig. 17.3 Soluble phosphorus

Table 17.4

pH

Hole 0 Inches	pH	Hole 1 Inches	pH	Hole 2 Inches	pH	Hole 3 Inches	pH
0–2	6.83	0–1.5	7.07	0–3	6.98	0–4	7.31
2–4.75	7.99	1.5–4	7.30	3–6	6.99	4–8.5	7.60
4.75–6	7.15	4–7	7.42	6–9	7.30	8.5–14	7.66
6–9	6.91	7–9	7.70	9–13.5	8.16	14–19.5	7.80
9–11.5	7.60	9–12	7.54	13.5–24	8.20	19.5–24	8.17
11.5–13	7.80	12–14.5	7.61	24–32	8.10	24–28	8.25
13–17	7.38	14.5–17	7.63	32–36.5	8.15	28–31	8.30
17–22.5	8.10	17–20	7.88	36.5–39	7.80	31–35.5	8.21
22.5–25.5	8.31	20–29.5	8.05			35.5–38	8.19
25.5–30	8.38	29.5–36	8.30				
30–35.5	8.10	36–39.5	8.35				

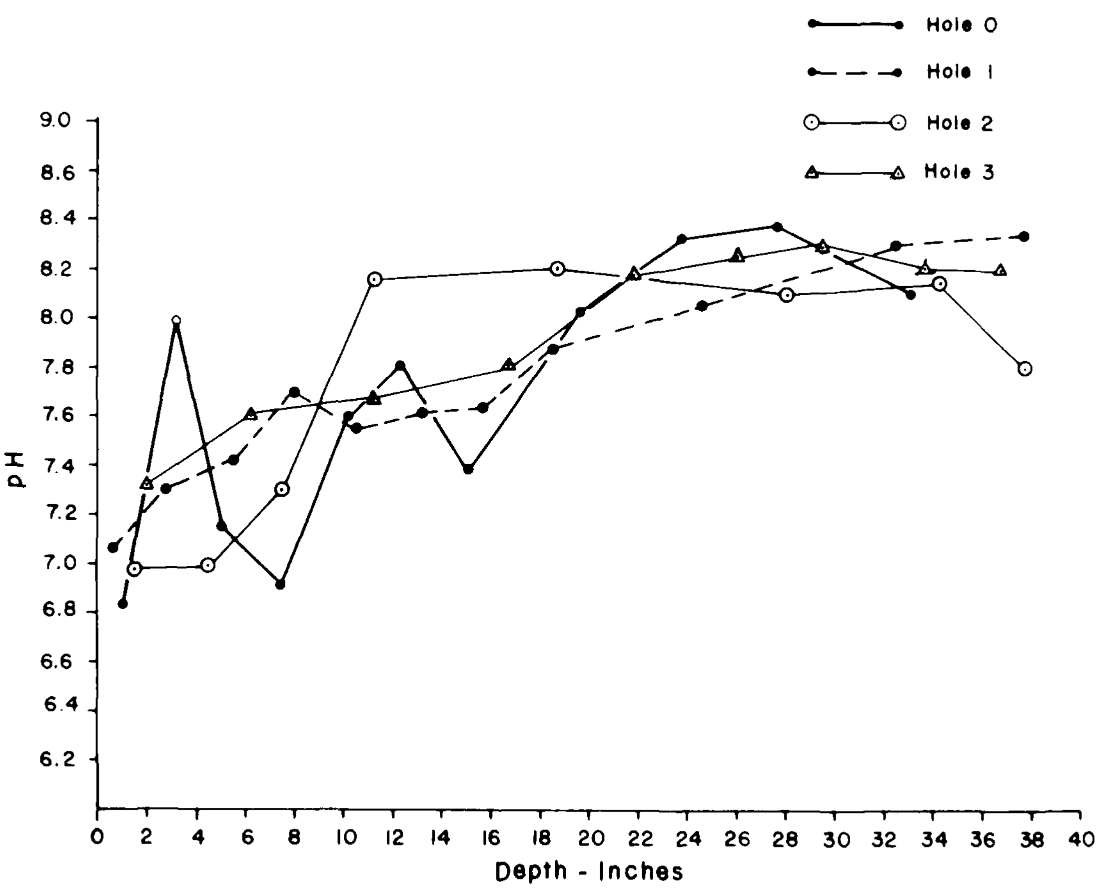


Fig. 17.4 pH

Table 17.5

Soluble Cations – (PPM)

Inches	Na	K	Ca	Mg	Total	Inches	Na	K	Ca	Mg	Total
Hole 0						**Hole 1**					
0–2	5.6	41	15	3.1	65	0–1.5	5.6	25	14	3.8	48
2–4.75	8.4	49	35	4.9	97	1.5–4	5.4	21	16	3.5	46
4.75–6	7.2	35	23	6.0	71	4–7	10	23	13	3.1	49
6–9	4.8	50	22	5.4	82	7–9	5.3	33	22	6.3	67
9–11.5	6.8	41	21	7.4	76	9–12	7.3	31	12	3.0	53
11.5–13	9.2	99	130	43	281	12–14.5	5.5	38	21	6.5	71
13–17	9.5	48	28	7.4	93	14.5–17	7.5	38	15	4.9	65
17–22.5	14	64	52	5.5	136	17–20	11	32	700	2.5	746
22.5–25.5	14	66	230	14	324	20–29.5	11	50	23	6.5	90
25.5–30	22	83	170	13	288	29.5–36	12	78	116	9.0	215
30–35.5	39	105	75	12	231	36–39.5	17	92	800	18	927
Hole 2						**Hole 3**					
0–3	7.8	44	16	3.5	71	0–4	5.7	13	15	2.5	36
3–6	12	19	21	4.8	57	4–8.5	8.3	19	58	5.5	91
6–9	11	19	17	3.5	51	8.5–14	10	18	16	3.8	48
9–13.5	12	37	73	4.1	126	14–19.5	11	20	11	2.8	45
13.5–24	19	46	88	6.0	159	19.5–24	17	43	100	7.5	168
24–32	25	39	68	6.6	139	24–28	16	40	165	7.5	228
32–36.5	37	38	94	6.0	175	28–31	19	37	73	5.6	135
36.5–39	21	30	80	7.4	138	31–35.5	20	42	210	11	283
						35.5–38	22	40	120	7.5	190

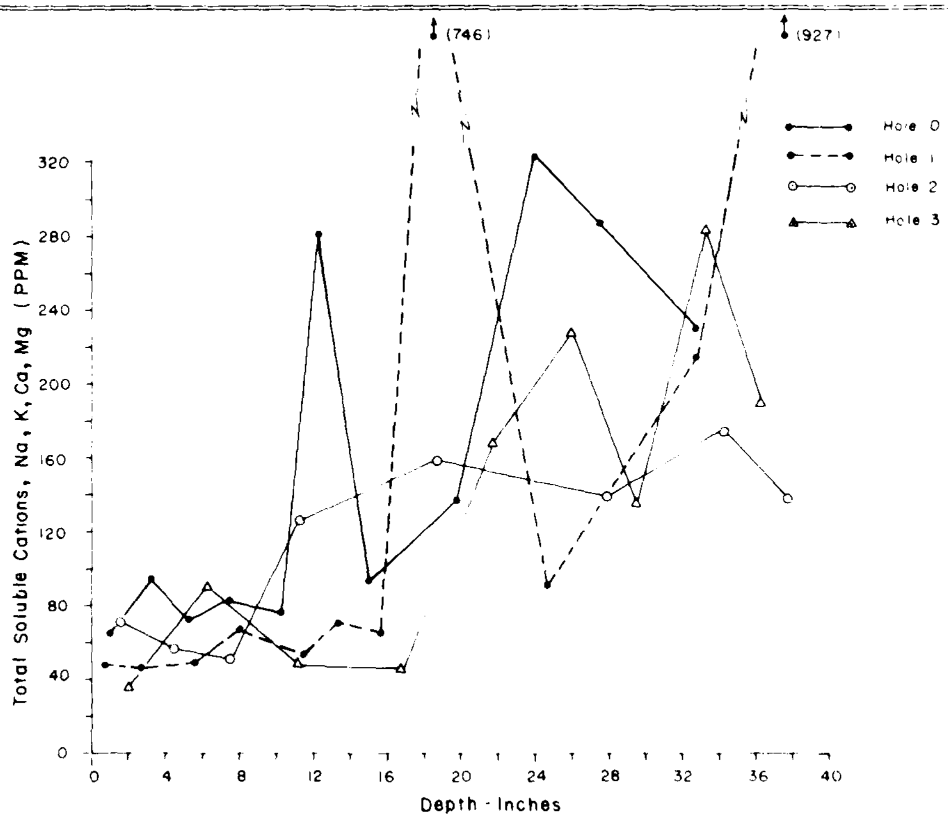


Fig. 17.5 Total soluble cations

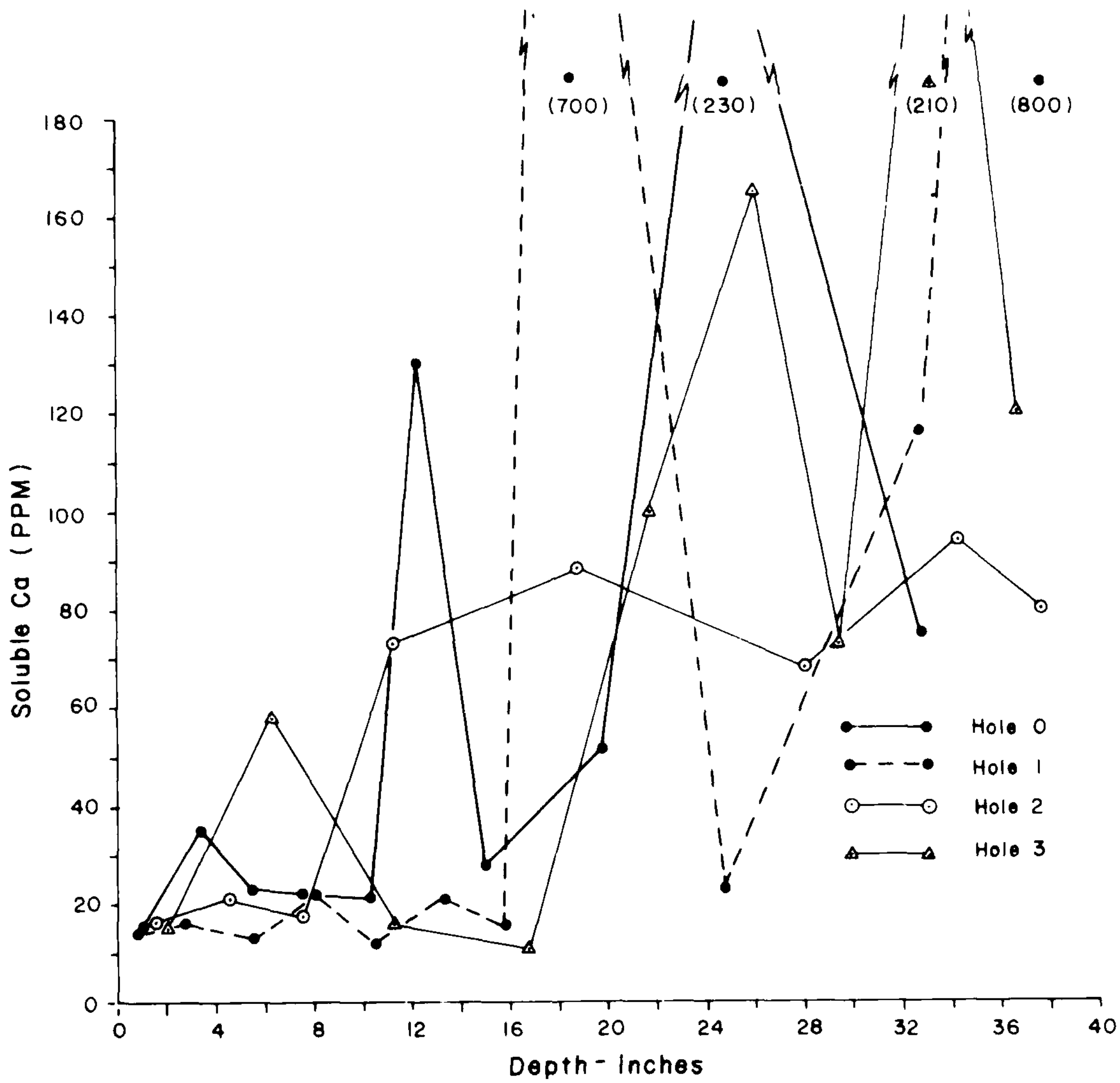


Fig. 17.6 Soluble calcium (Ca)

DISCUSSION

Chemical trends for each core vary according to its position within the field. Since the basin behind the initial landslide deposits dipped inward, moisture conditions would have been greater towards the center and erosional processes more effective around the periphery of the field. For these reasons, it is felt that holes 0 and 1, located closest to the middle of the field, have more accurately preserved the paleosol remains than holes 2 or 3. A glance at the graphs confirms this fact in that holes 0 and 1 feature the greatest variations throughout their profiles.

The data reveal an incipient soil sequence developing at a depth of approximately 0–6 inches. It is forming under modern conditions. Beneath this soil, however, appear two buried paleosols. The first is of primary interest since its vertical thickness from approximately 6 to 16 inches below the surface is assumed to represent the paleosol exploited by the Anasazi P-III and P-IV farmers.

Cultural deposits recovered from the associated field houses some 200 feet from the field were found at depths ranging from 0 to 30 cm (11.7 inches) below the surface. The structures were constructed on the stony rises at the

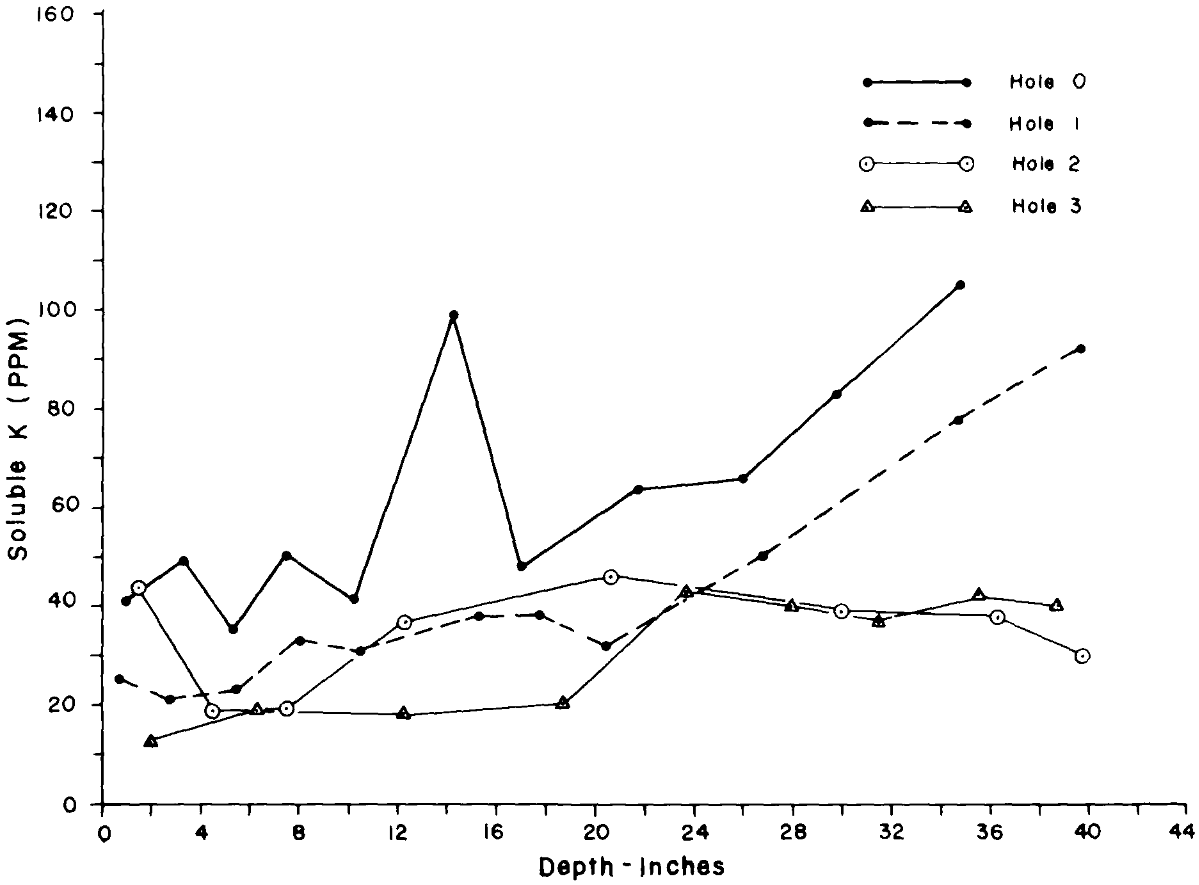


Fig. 17.7 Soluble potassium (K)

downhill edge of the slide deposits. Since agrable soils would have represented a scarce resource for the Anasazi, it can be assumed that they would have located their structures off the field on cobbley inferior soils. As a result, cultural remains on the thin rocky field house locations are largely surficial.

Although no cultural material was recovered directly within the field's stratigraphy, and no C-14 dates were taken from the field, several arguments can be made to justify the supposition that the upper paleosol represents the soil the Anasazi exploited. First, the upper six inches of soil contain chemical evidence to suggest that it is forming under current conditions. Its N and C percentages in the A horizon are quite high. Second, the lower paleosol occurs at a depth of some three feet below the surface. The depth is too great for the soil to have been partially buried, to have had a stable period set in and soil develop on it, to have been partially buried again, and finally to have stabilized to the point where another soil could begin to form all within 500 years after abandonment by the Anasazi. Third, phosphorus, which might indicate human disturbance of a soil through the introduction of bone matter in refuse scattered over the field, reaches it peak in each of the four cores within the 6 to 16 inch range.

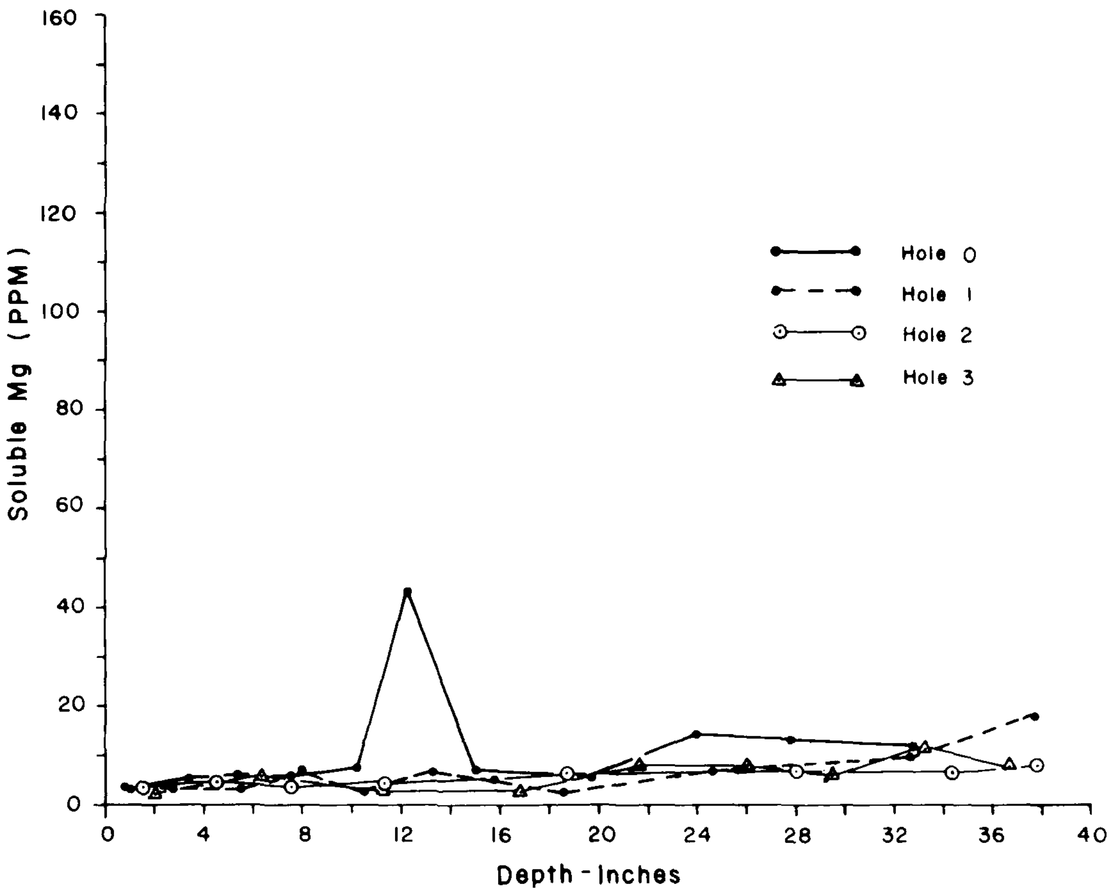


Fig. 17.8 Soluble magnesium (Mg)

Total percent N and percent organic C were measured as indicators of A soil horizons. Because the A horizon represents the zone of maximum biological activity, it is not surprising that organic material should be most concentrated here.

Tests were performed to determine the concentrations of four soluble cations (Ca, K, Mg, and Na). B soil horizons accumulate minerals and clays because of the downward percolation of clays in either a solutional or particulate form. The presence of leached Fe and Al serves to attract clays which precipitate out in their presence. Since the clay layer is relatively impervious to penetration by water, further downward leaching is inhibited and salts accumulate (Garner 1974:281). As an independent indicator of B soil horizons, pH was noted through the stratigraphy. The pH or the negative logarithm of the hydrogen ion activity should become more concentrated in B horizons as should most other bases because of leaching from the layers above.

Soluble phosphorus (P_2O_5) is important principally as an indicator of human disturbance of soil layers in the past (Arrehenius 1963:126). Since phosphorus might have been introduced to the soil by the spreading of human refuse over the field, P_2O_5 was expected to peak where human activities disturbed the soil to a maximum extent.

The results obtained from chemical testing are most encouraging. Hole 0 reveals three sharp A horizons at depths of 0–2 inches, 6.5–8.5 inches, and 14–16 inches. At these depths, total percent N and organic C peak. Just below these bands, three distinct B horizons can be noted at depths of 2–4, 8.5–15, and 16–30 inches. In the B horizons, pH measurements are at their highest. And most importantly in relation to the hypothesis, the total soluble cations jump dramatically in these clayey zones.

Hole 1 also produced fairly good results; however, evidence for the lower paleosol are generally lacking with this core. A surficial A horizon at 0–4 inches and a buried

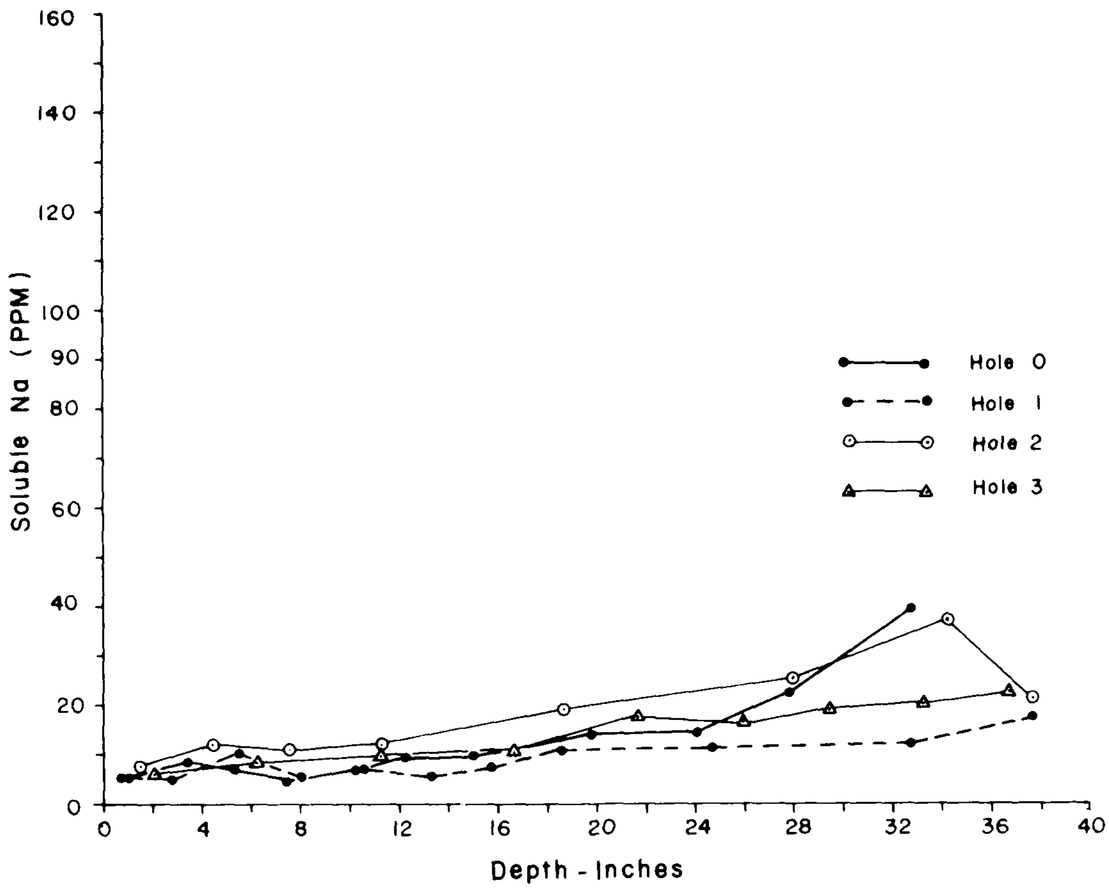


Fig. 17.9 Soluble sodium (Na)

A horizon at 9–16 inches both yield high amounts of total percent N and organic C. B soil horizons from 4–10 inches and 16–24 inches contain high salt contents and pHs. Below a depth of 24 inches pH measurements continue to climb and total cations peak at 37.75 inches. This suggests that the lower profile of the older paleosol survived while the upper section may have been destroyed by erosion before being buried.

Holes 2 and 3, lying close to the periphery of the basin, yield profiles that are not as well differentiated. This is not surprising since erosion would be expected to be greatest along the higher rim of the slight depression. Except for a surficial A horizon, total percent N and organic carbon are negligible throughout the cores. Evidence for B soil horizons is only slightly better represented. pH for hole 2 climbs sharply from 7.5 to 11 inches as would be expected, but then remains at a high plateau for the remainder of the core. In hole 3, the pH increases steadily until diminishing slightly at the bottom. Soluble cations in hole 3 peak at 18.75 inches and 34.25 inches while in hole 4 all three B horizons are evidenced by jumps in the salt contents at 6.25, 26 and 33.25 inches.

Overall, these chemical analyses provide strong evidence to support the hypothesis that soils of the Apache-Silver-Rockland association were abandoned because of salt build-up in their clayey horizons. The total soluble cations (especially Ca and K) increase geometrically in the dense B horizons. These salts become so concentrated that their presence may well have adversely affected crop yields.

CONCLUSIONS

This essay has attempted to familiarize those archeologists inexperienced in pedology with some of the basic procedures and costs involved in conducting research dependent upon detailed soil information. From the data presented above, it can be discerned that the cost of providing such precise descriptions of soil stratigraphy is high. The authors would maintain, however, that such an expense is justified since specific hypotheses, such as the one tested above, can be critically evaluated. Almost no predictions can be assessed using such traditionally pithy descriptions of soils as *brown loamy silt* or *reddish-brown clay*.

It obviously cannot be concluded that the hypothesis is conclusively proven by either the patterning noted earlier by Fosberg (this volume) or the results of the chemical analyses from the soils of one site. Nevertheless, the results are encouraging since the jump in salts in B horizons is so massive.

Hopefully, other workers in the region will begin to collect and analyze soil samples from their sites in comparable detail. Eventually enough sites will have been investigated to permit a statistical test on the significance of abandoned field house sites on saline fields. Another glaring need that future research must attempt to solve is a determination under field conditions of the precise levels at which particular cations within the soils of north-central New Mexico become toxic to plants. To date, several laboratory studies have been conducted but their conclusions are of little use because the specific cations tested and soil medium employed do not replicate the conditions present in the Cochiti area (Gauch and Wadleigh 1943; Haywood and Berstein 1958).

As archeologists become more knowledgeable in the fields of geology and pedology, they will be able to ask increasingly sophisticated questions concerning the dynamic relationships that existed between prehistoric farmers and the soils they exploited. The answers to many of the dilemmas concerning Anasazi settlement pattern shifts may well lie within the soils that most archeologists continue to dig through to get to the *real* artifacts.

Chapter 18

THE APPLICABILITY OF STATISTICAL MAPPING AS AN INITIAL STEP IN THE SPATIAL ANALYSIS OF ARCHEOLOGICAL DISTRIBUTIONS

Laurence M. Spear

INTRODUCTION

Research concerned with identification and analysis of spatial phenomena on archeological sites, in particular patterning in the distribution of artifact debris, has become an increasing focus of many contemporary studies. Much of this research, while primarily theoretically oriented, has experimented with quantitative methodologies often derived from other disciplines such as geography, meteorology or ecology. The nature of archeological data are such, however, that problems may be encountered when derivative spatial methodologies are employed. These problems are related to aspects of scale, numerical properties of measurement, and methods of data collection. The extent to which these types of bias are recognized and addressed by the archeologist profoundly influences the outcome and reliability of spatially oriented studies.

The development of methodologies which can be realistically employed in abstraction and analysis of archeological distributions should be a primary concern of initial research. Since a considerable body of literature in geography concerns the theoretical and methodological implications of different spatial techniques and analyses, an examination of the content of some of this work from a methodological point of view may prove useful in developing procedures appropriate for archeological studies.

As the validity of spatially oriented research depends heavily upon the initial measurement and abstraction of distributional phenomena, this paper will primarily focus upon certain of these important methodological steps which comprise the foundation of spatial analysis. Although an adequate understanding of the theoretical and conceptual environments from which these methodologies are derived is essential for critical examination and further application, the scope of this paper precludes a detailed review. The serious reader is encouraged to obtain Bunge (1962), Harvey (1969), and Amedeo and Golledge (1975), for a more in depth discussion.

A detailed examination of statistical mapping will comprise the main body of this chapter. Particular emphasis will be placed upon description of how these methods are employed, in conjunction with a critical review of their properties in terms of further applicability to archeological studies. The ability of these techniques to abstract, measure and present distributions in a format suitable for facilitating empirical conclusions will be a primary concern. Also some discussion of the suitability of these methods for providing numerical measurements amenable for use by more rigorous analytical techniques will be included.

FUNDAMENTAL SPATIAL CONCEPTS

An important decision faced by a researcher concerned with studying the distribution of phenomena in space is the choice of a conceptual framework in which to describe the relationships that are encountered. The most rigorously developed frameworks for depicting spatial relationships have been constructed by mathematicians. In essence, these formal languages, or geometries, specify sets of relationships between points, lines, surfaces and angles. The development of coordinate systems and analytic algebra has allowed comparisons or transformations of different concepts of space, as well as an extension of these relationships beyond the confines of two-dimensional relations.

Harvey (1969) discusses the importance of linking these well developed mathematical concepts of space with geographically oriented research. The advantage of such a linkage is the employment of a spatial language with the ability to measure relevant properties of distributions, to aid in the isolation of significant patterning and to facilitate the formulation of processual laws which govern distributions.

The most important aspects of geometries which make them a uniquely suitable tool for measuring distributions is the existence of a coordinate system governed by formal rules of relationships which can be expressed by means of analytic algebra. This allows the measurement of pertinent elements of a distribution to be put in terms of an abstract language that has the capability for further comparative or analytic procedures. In essence, this represents a formal spatial language because the relationships which comprise a particular distribution are summarized in a format which facilitates further analytic discussion.

In a geographic context, three general forms of geometries have been applied to a broad spectrum of problems. They are topology, projective geometry, and euclidean geometry. Each of these has a particular type of coordinate system governed by rules which specify relationships and allowable transformations.

This paper will only be concerned with methodologies of a euclidean nature. It is a simple, well developed geometry characterized by algebraic and trigonometric relations based on a cartesian coordinate system. Ability to assign phenomena a relative location in two-dimensional space by means of x and y coordinates serves as the basic measurement from which other relationships can be determined. Distance and direction are easily derived within a two-dimensional framework. The ability of analytic algebra to extend these relations into other dimensions allows the generation of a z coordinate (for frequency or volume).

Euclidean geometry will serve as the framework for assessing various methods of initial measurement or cartographic depiction. Cartographic depiction (analogue modeling) is suitable not only for solving problems by the direct (empirical) approach but is also suitable as initial translations or abstractions (symbolic modeling) that will facilitate a deductive approach. The degree of which statistical mapping edheres to euclidean relationships, along with its overall ability to measure and aid in pattern recognition and processual hypothesis formulation, will be the critical factors in judging the suitability of the following methodologies for archeological research.

THE STATISTICAL SURFACE

Understanding the concept of a statistical surface is essential in cartographic depiction. The statistical surface is composed of a three dimensional coordinate system that measures properties of certain phenomena in cartesian space, and simultaneously permits depiction of volume or frequency information. Certain initial considerations concerning the choice of a collective system (discrete or continuous) must be made. Since the collection system influences levels of generalization, it is best to employ a method offering the finest resolution whenever possible.

The benefits of discrete or continuous systems must be weighed against the initial empirical results that each offer and the ease of using their measurements in subsequent analytical studies. Basically, continuous collection systems offer finer resolution in terms of location and portray a better sense of gradient and form. Accuracy may be sacrificed, however, if a proper system of control points, total collection or actual continuous collection is not employed. Also, subsequent analytical procedures require complicated computations (Norcliffe 1969). Conversely, discrete measurement systems represent more generalization in original measurement and generally exhibit more limited empirical usages. On the other hand, they have the added ability to be used by more simple and better developed analytical techniques. These limitations and applications will be discussed in greater detail as appropriate.

The choice of a desired measurement or collection system results in the selection of one of two possible types of cartographic depiction: choropleths and isopleths (Robinson and Sale 1969). If the data are collected in a discrete manner (by means of quadrats of enumeration districts), the best representation is a choropleth map. Conversely, continuous recording of data by control points or total sampling will allow the generation of isopleth maps. Both of these techniques, if properly employed, can be used as empirical approaches for solving research problems, or for the generation of hypotheses that use these numerical measurements as variables.

Choropleth Mapping

If the data are collected by means of discrete units (as in the Cochiti Reservoir Project), a two-dimensional display will resemble that of Fig. 18.2. The original data are displayed within the cartesian coordinates (x and y) of its enumeration unit. The next step is to assign a third dimensional (z) coordinate to the data value (such as frequency of artifacts per grid). One graphic technique which displays distributional variability in multidimensional space is the choropleth method. Essentially, a choropleth map represents the use of an area shading technique to exhibit variations in frequency or volume over area (Jenks 1963). Different levels of gray tones are used to depict a continuum of classes, ranging from low value (light) to high value (dark). Fig. 18.3 is an example of a standard chorpleth map.

Cartographic generalizations of this type are important to enable the reader to gain a clearer understanding of the statistical information distributed in space than a tabular listing of the data would allow (Jenks and Coulson 1963). The ability to manipulate resolution by adjusting the number of classes and range of intervals contributes to the versatility of this method as a means of graphic depiction. Choice of classes and intervals are the most important consideration in the formulation of these maps since variability and number of class intervals directly affects visibility, accuracy, legibility and attractiveness of choropleth maps (Mackay 1955).

Many methods have been devised for determining numbers and intervals of classes. In general, the object of these techniques is to determine which manner of arranging the statistics will portray the most variability. Particular emphasis is placed upon the numerical rnage of the data. It is the application of these various techniques to the range which indicates the most suitable divisions.

Prior to the application of these techniques, a decision regarding the number of classes to be used is made. Since the goal is to elucidate the greatest variability, the largest possible number of classes is desirable. Seven classes is generally the maximum amount allowable, due to the difficulty in discerning more than that number of gray tones (Jenks and Coulson 1963).

After the number of classes to be used is selected, the following techniques can be introduced to dtermine the best choice of intervals. The results of the techniques can be graphically portrayed by means of frequency histograms. Unlike a gausian bell-shaped curve, the closer a rectangular distribution is approximated, the more variability that will be portrayed.

There are six basic techniques commonly used to determine class intervals (Mackay 1955; Jenks and Coulson 1963):

(1) In the *septiles method* the values per unit area are first ordered consecutively. Then the sum of the unit areas is divided by seven. This will yield the number of unit areas in each class. Then by referring back to the ordered ranking of values, assignments are made to a particular class.

$$\text{Septiles} = \frac{\text{Sum of unit areas}}{7} \quad \text{(Ordered data are then assigned to a particular class)}$$

(2) The *equal step method* is based on obtaining the range of the data and dividing by the number of classes desired.

$$\text{Equal step} = \frac{\text{Range of data}}{\text{\# of classes desired}}$$

(3) *Arithmetic class limits* are determined by a formula that compensates for the range of the data, and the number of classes desired.

$$A + X + 2X \ldots + NX = B$$

A is the lowest value, B is the greatest value, and X represents the classes. If 7 classes are desired, the summation of classes would be 28. Hence the formula would read:

$$A + 28X = B$$
$$28X = B - A$$
$$X = \frac{B - A}{28}$$

(Once substitution of the range values are completed, X will be the range of each class limit.)

(4) The *geometric method* is characterized by the transformation of raw data into logarithmic values. The difference of the logs (common) for the low (Y) and high (X) values are divided by the number of classes desired in order to determine the class range.

$$\text{Class range} = \frac{\text{Log}_{10} X - \text{Log}_{10} Y}{\text{\# of classes desired}}$$

(5) *Reciprocals* can also be used in the same way as logarithms to determine class intervals.

$$\text{Class range} = \frac{\frac{1}{X} - \frac{1}{Y}}{\text{\# of classes desired}}$$

X = high values
Y = low values

(6) The final method consists of using a *clinographic curve* to spot natural break (nick) points in the data. In this method volume or frequency values are plotted against their percentage of occurrence. The chief value of this method is the indication of sudden changes or breaks in the distribution (Monkhouse and Wilkinson 1963), and from this decisions regarding class limits can be made.

In order to describe the compilation of choropleth maps, one site from the Cochiti Reservoir Project (LA 13054) was chosen as a test case. The raw frequencies (counts) for certain lithic materials were chosen as the data base. This information was collected by a discrete system (1 x 1 meter grids) and, hence, served as a perfect example for this application. Only the information from the surface collections was used, as it represented a total areal sample of the site.

The first step of this procedure consisted of constructing a clinograph of the total number of lithics per grid in order to depict the distribution and aid in the choice of class ranges. Prior to this, a choice of seven classes was made in order to depict maximum variation. This clinograph is illustrated in Fig. 18.1. The *y* axis depicts the percentage of occurrence, and the *x* axis the range of frequencies. Notice the breaks in the continuum of occurrence up to the maximum of 71 flakes per grid.

Because of the pronounced skew of the distribution and a concern for illustrating a simple method where the curve could be transformed to approximate a more rectangular distribution, a modified equal step procedure was used in setting class ranges. This also allowed the data to remain in a measurement system more recognizable to the average observer (rather than logarithms, reciprocals or standard deviations).

A modified equal step procedure consists of compiling a series of histograms based on class intervals designed to span the portion of the distribution (as shown in the initial clinograph) having the greatest percentage of occurrence. This results in the final class of the histogram having all occurrences greater than a particular value. As the distribution consists primarily of relatively lower values per grid, this technique will exhibit maximum variability in the lower ranges while sacrificing resolution in the higher value grids. A technique of this type can easily be reversed or modified to exhibit variability in any area of the distribution. The skew of the distribution and the way in which the values are abruptly distributed makes this method a logical choice if a standard numerical system is to be retained.

Figure 18.2 illustrates the initial statistical surface, with the original raw counts for the total distribution of lithics. Figures 18.3–18.5 illustrate the application of the choropleth technique based on a modified equal step procedure with respective intervals of 1, 2, and 3. On each of the choropleth maps there is a key describing the class range (interval), starting with an integer and ending with a real number. This is done to ensure the distinctiveness of each class and to prevent overlaps. A histogram is located in the lower right hand corner of each map, which illustrates the amount of variability depicted.

Comparison of Figs. 18.3–18.5 indicates the variation of depiction due to different class intervals. When the goal is to depict maximum variation in the lower frequencies, the choice of Fig. 18.3 with an interval of 1 is the best, based on the closest approximation of a rectangular distribution by its histogram.

Further applications of this method are possible to depict any element of the distribution required. Specific material taxa, stages of lithic reduction, or sherd counts are easily accommodated. The ability to inspect visually variations in distributional characteristics of phenomena in addition to possibilities for adjusting the resolution, make this technique suitable for empirical conclusions and the generation of additional hypotheses. It should be emphasized, however, that the strength of these observations can be weak, due to the subjective nature of the methodologies and the possibility for differing interpretations by various observers.

Isopleth Mapping

The employment of a smoothed statistical surface, or isarithmic mapping, constitutes the other most widely used method of depicting a three-dimensional surface. Isarithm is a generic name for a wide variety of phenomena mapped by isolines. Isolines are line symbols that represent quantities assumed to be constant through the areas they pass

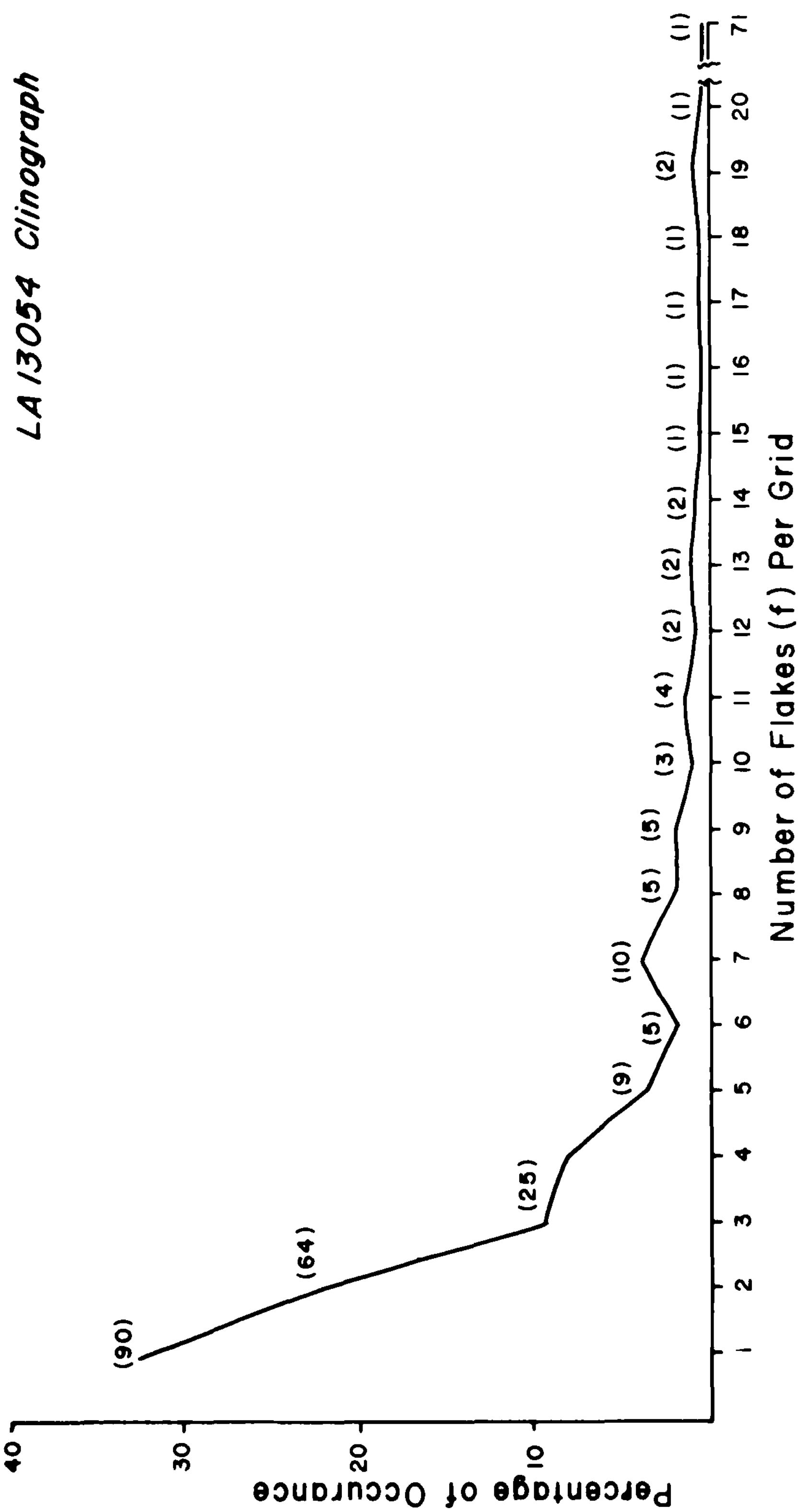


Fig. 18.1 Clinograph of total number of lithic material taxa flakes – LA 13054

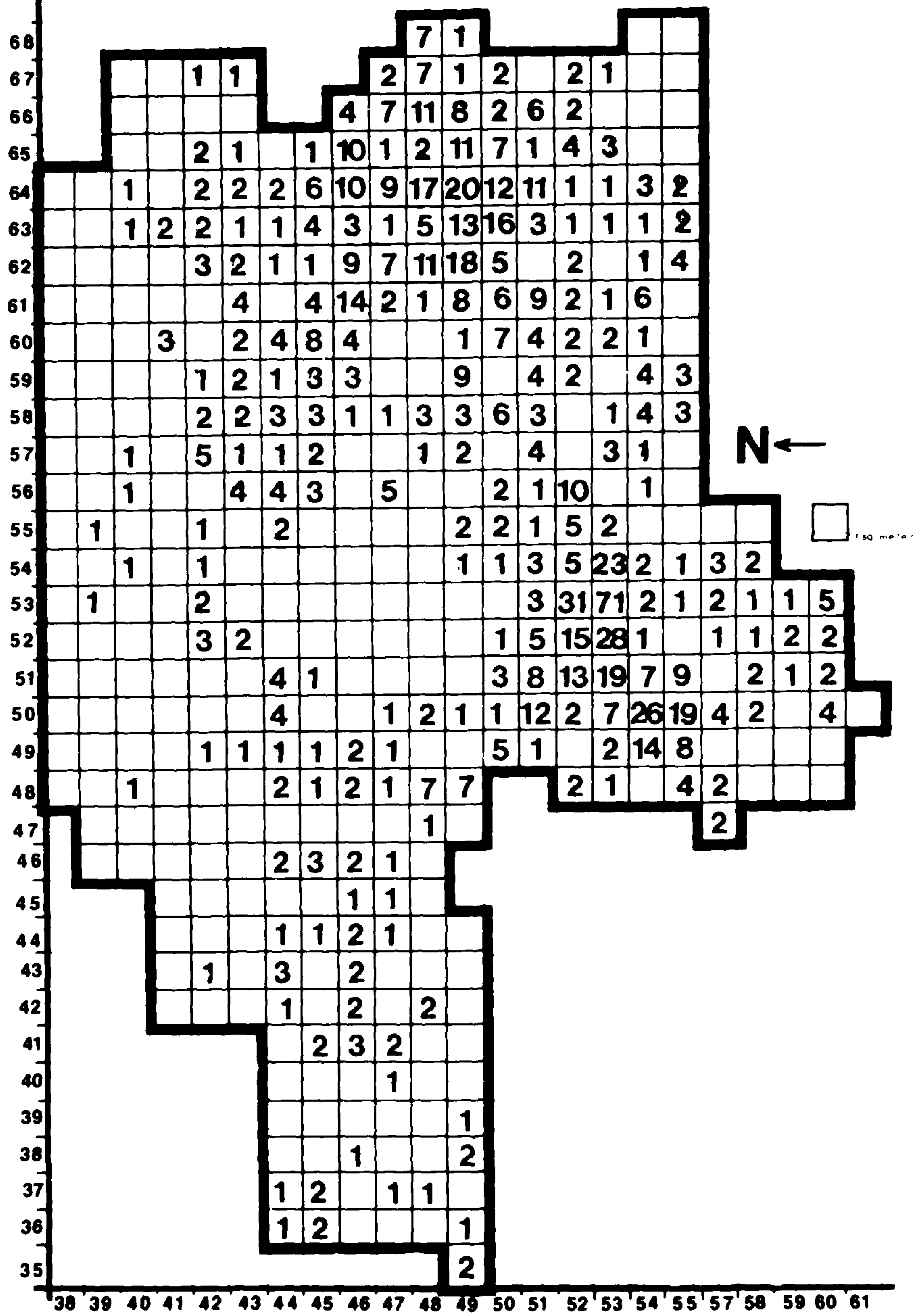


Fig. 18.2 Initial two-dimensional statistical surface LA 13054

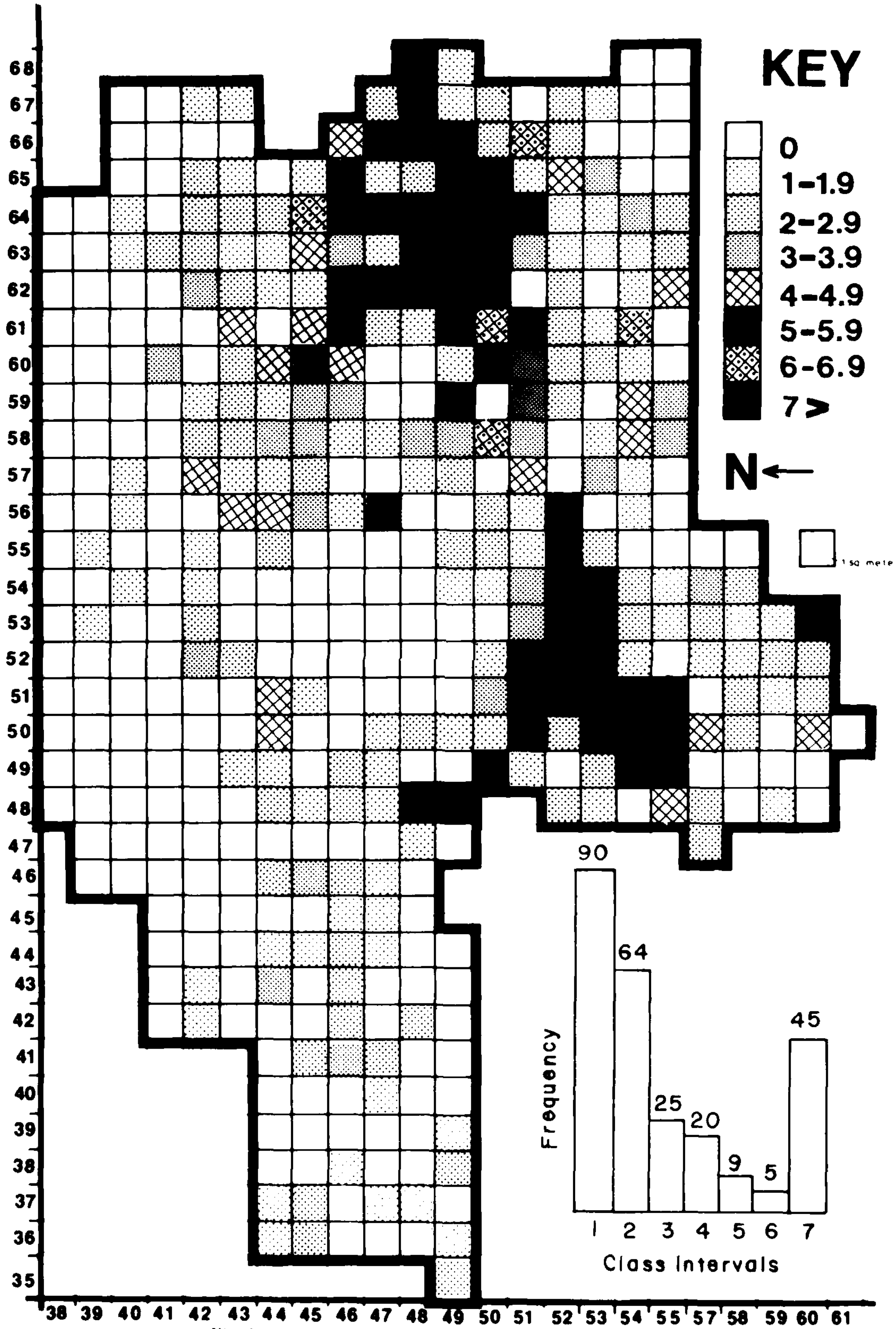


Fig. 18.3 Choropleth map LA 13054 interval 1

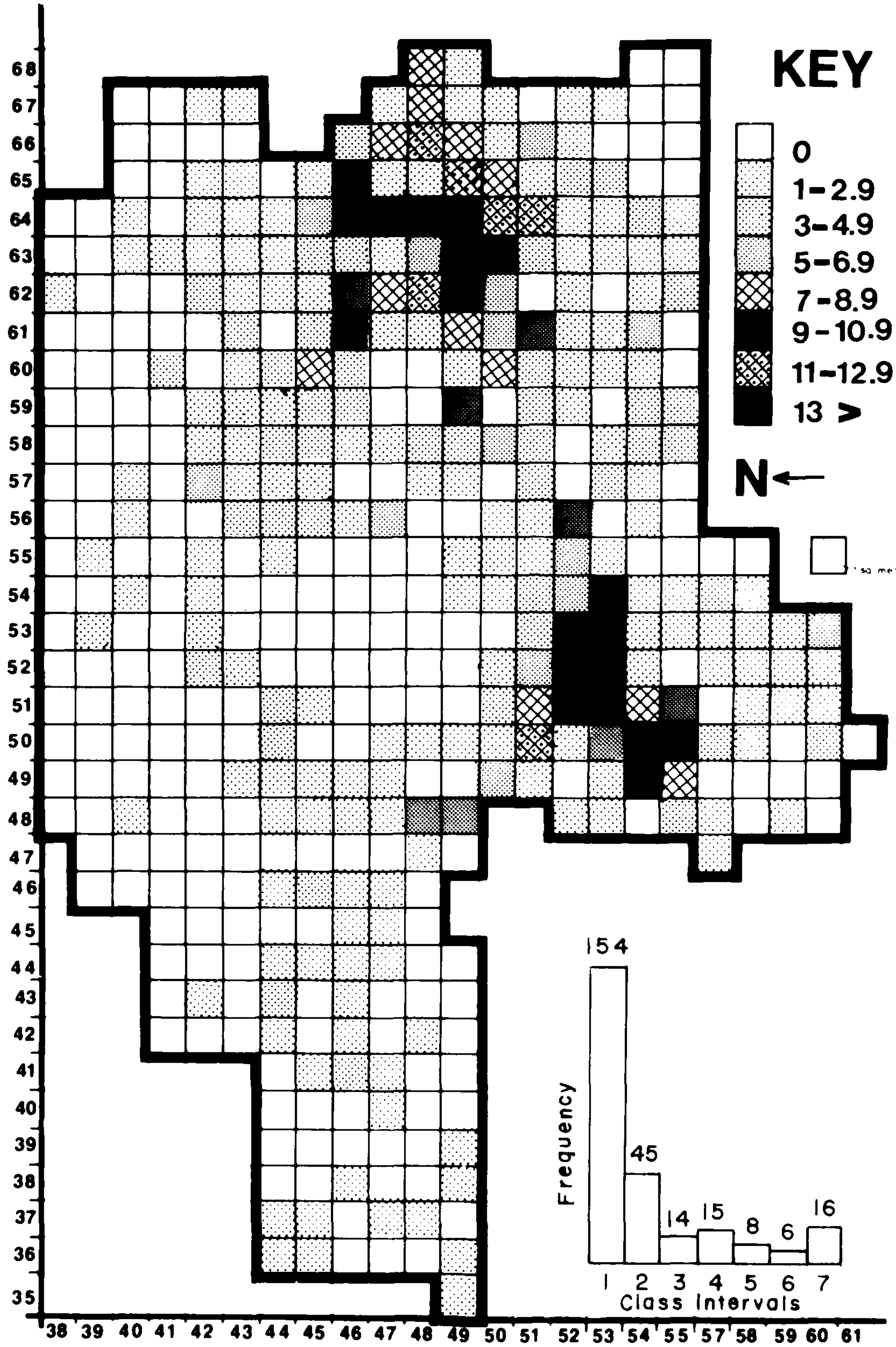


Fig. 18.4 Choropleth map LA 13054 interval 2

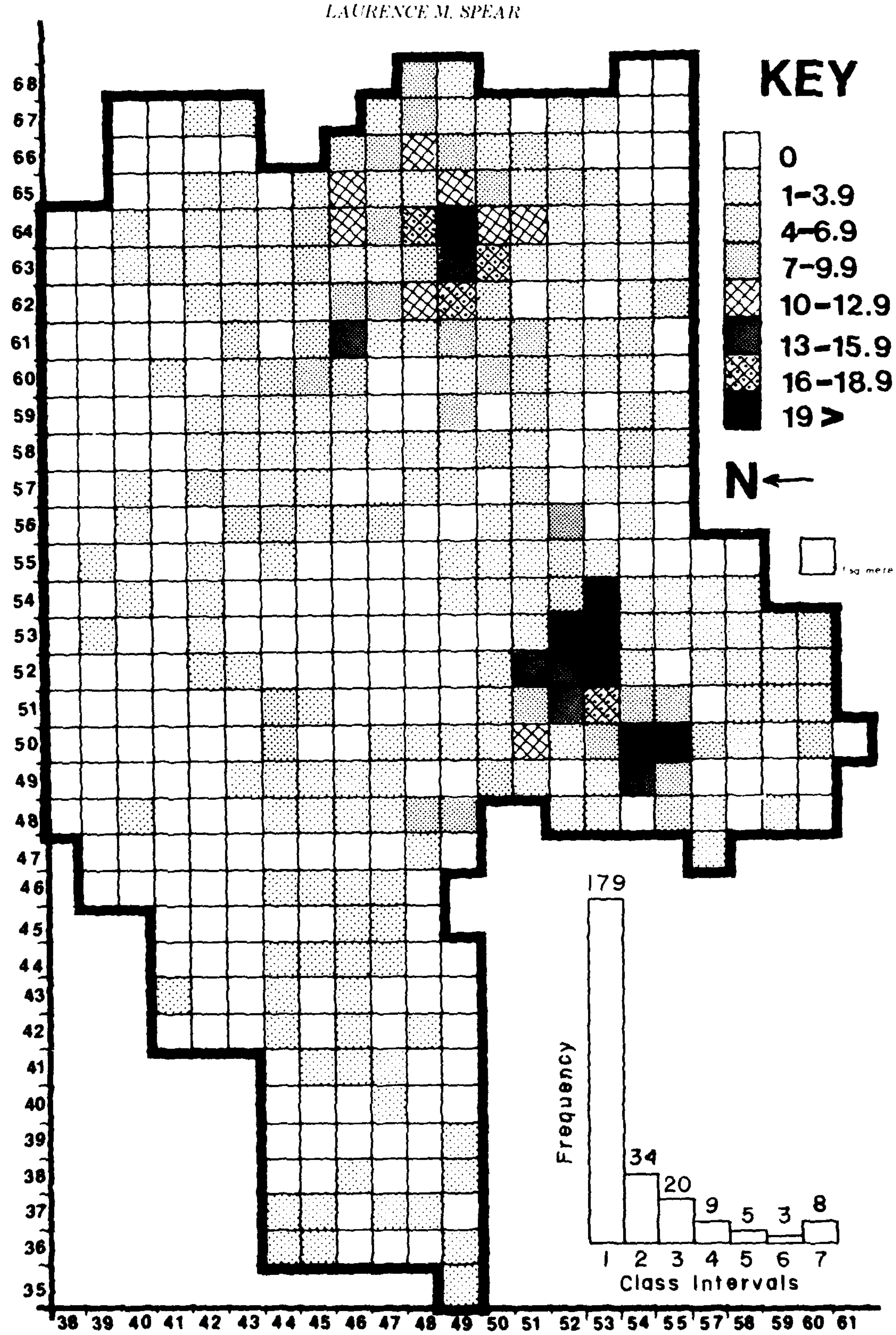


Fig. 18.5 Choropleth map LA 13054 interval 3

(Mackay 1955). A distinction is usually made between actual isolines (isarithms) and derived isolines (isopleths). An isarithm can be defined as the intersection of a horizontal plane with an actual statistical surface, such as a landform, and the resultant contour map. Isopleths are derived values which cannot occur at a particular point. They are usually derived in terms of a ratio that includes some measurement of area such as population per square mile. The data are collected by a discrete collection system and a particular value is assigned to the whole area in general. Control points (centrally located points which summarize the value for a particular enumeration area) are set up in each area, and various methods are used to construct the isopleths from this data base (Robinson and Sale 1969).

Application of the concept of a smoothed statistical surface to the mapping of cultural phenomena has been a source of methodological debate within geography. The central issue is whether one can regard cultural phenomena, which tend to be distributed in discrete clusters, as a continuous density surface (Haggett 1966). That is, most cultural phenomena are distributed irregularly over a kind of hummocky space usually interrupted by discontinuities (Harvey 1969).

The use of an isopleth mapping technique represents generalizations in order to overcome problems of initial data collection and precise mapping of cultural phenomena. In essence, a derived hypothetical statistical surface is created in order to depict some sense of form, slope, magnitude and gradient of a particular distribution.

Generalization is inherent in all aspects of this technique, from the original discrete collection units to mathematical assumptions concerning interpolation of isopleth locations. However, if one is aware of the processes of generalization involved, isopleths can be a useful tool in the depiction of distributional characteristics.

Data collection and the assigning of a location for control points represents the first level of generalization. As with the choropleth technique, the data are collected by quadrats or enumeration districts and a particular value per unit area is assigned. This represents a loss of absolute locational information which could be recorded by a continuous method. The placement of a control point (usually in a central location) represents additional assumptions as to location, although the ability to filter down a mass of locational and volume information into one point location is essential for the construction of a smoothed statistical surface.

Further abstractions are necessary in the assignment of values for control points and the interpolation of isoline locations. The portrayal of the configuration of a statistical surface (gradient and form) is directly related to the type of interval used. An equal step interval (isopleths with a constant spacing of values) is the only method which allows gradients to be portrayed realistically.

As many cultural distributions are characterized by skewed distributions with large ranges of values (Mackay 1953), various types of mathematical transformations (logarithmic, square root, standard deviations, etc.) are employed in order to assign a range of values to control points. This allows a constant equal step series of isopleths to be constructed encompassing the total range of the distribution.

The nature of these transformations in conjunction with the widely employed linear assumptions used in interpolation of isopleth maps creates certain problems of distortion in gradients, form, and fidelity (Hsu and Robinson 1970). Proportional allocation, which assumes a linear gradient between control points, is the most widely used method for the construction of isopleth maps because of the relative ease and simplicity used in computation (Haggett 1965; Robinson and Sale 1969). Figure 18.6 illustrates three basic types of gradient which can be assumed. Unless prior knowledge of the gradient is available, a linear gradient is the most acceptable assumption.

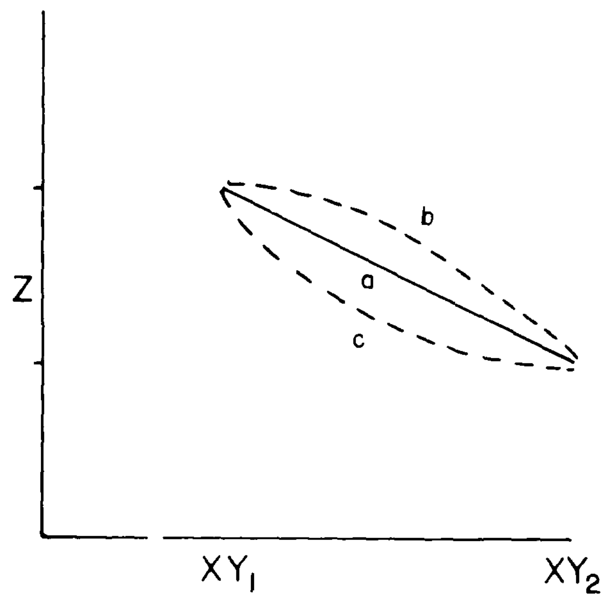


Fig. 18.6 Three types of gradient

Prior knowledge of an existing gradient is usually acquired through continuing research on the distributional characteristics of certain phenomena. The use of a distance decay function (negative exponential) has shown indications of validity in describing certain marketing distributions (Berry 1967) and the dispersal and colonizing of species (MacArthur and Wilson 1967). Further research into the nature of archeological distributions should lead to the employment of more realistic functions that can be used in the construction of gradients.

As archeological data are commonly collected by means of equal size quadrats, proportional allocation of isopleths can be undertaken with some certainty of comparability of values between quadrats. This equal area quadrat approach avoids many of the problems encountered when unequal size enumeration units are used. However, the

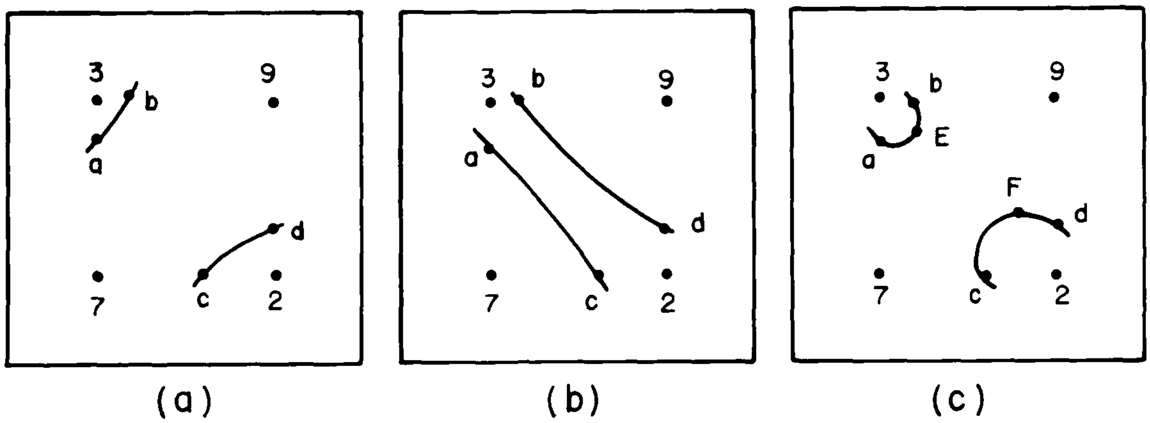


Fig. 18.7 Contour interpolation

regular spacing of square quadrats and the assigning of a central location for control points poses particular problems of indeterminacy in locating isopleths (Mackay 1953).

When a linear gradient is assumed, proportional allocation is relatively simple. The basic procedure takes into account the value of the desired contour, the two control point values between which it will lie, and the distance between these points. The following formula yields the resultant distance from the control point with the greatest value that the desired contour should be placed:

$$\frac{X - A}{X - Y} \cdot D = L$$

X = greatest control point value
Y = smallest control point value
D = distance between X and Y
L = distance from X were desired contour is to be placed
A = desired contour value

In Fig. 18.7 (a and b), two ways of interpolating contours by this method are illustrated. The location of contours having a value of 4 is essentially correct in each case. One method of resolving this problem of indeterminacy is to institute a system of triangular or hexagonal control points. As an initial sampling frame of this type is somewhat difficult to construct, a system of averaging the value for a central location between four existing points is used to create a triangular lattice. By simply adding the z value for each existing point and dividing by four, the new central z value is derived. Figure 18.7 (c), shows the proper solution of the indeterminacy problem by the construction of a triangular system.

Conversely, problems associated with the transcfrmation of original values in order to maintain equal spacing of isopleths and encompass the total range of the distribution, are considerably more intricate. The two most important attributes of the distribution which should be maintained are slope (gradient) and form. Slope can be defined as the ratio of the vertical interval over the horizontal equivalent (Monkhouse and Wilkinson 1963).

Form, on the other hand, cannot be defined in as precise a manner. It can generally be thought of as a particular pattern or spatial configuration of a distribution (Amedeo and Golledge 1975). As the whole process of isopleth mapping entails successive levels of generalization and abstraction, especially when derived control points are used based on discrete collection systems, the question of maintaining the slope and form of a distribution is open to serious criticism. Although, if one accepts the level of abstraction produced by derived control points, at least a subjective examination of the effects of transformations on maintaining the characteristics of a distribution may be undertaken.

Figure 18.8 consists of a raw statistical surface that will serve as a hypothetical test case to illustrate the effects of various transformations upon slope and form. Notice that the triangular lattice of control points has been constructed with an arbitrary designation of zero values used for the control points of the quadrats adjacent to the border. This allows the isopleths to be interpolated throughout the entire area. As the boundaries of archeological sites are usually extended until zero values are reached, this seems to be a realistic method of allowing consistent interpolation.

In order to gauge the effects of a z-score ($z = \frac{X - \bar{X}}{S}$) and a logarithmic transformation on slope, a profile (Fig. 18.8) was taken through a segment of the area. The resulting graphs of the profiles are shown in Figs. 18.9–18.11. All are based on assumptions of a linear gradient between control points. Additional assumptions were also made concerning the comparability of measurement scales. The x and y coordinates are comparable because they both represent the same unit of distance. The z coordinate in isopleth mapping represents values which cannot be strictly related to distance measurements. For instance, population per area or temperature cannot be related to horizontal distance in the same fashion that vertical elevations of landforms can.

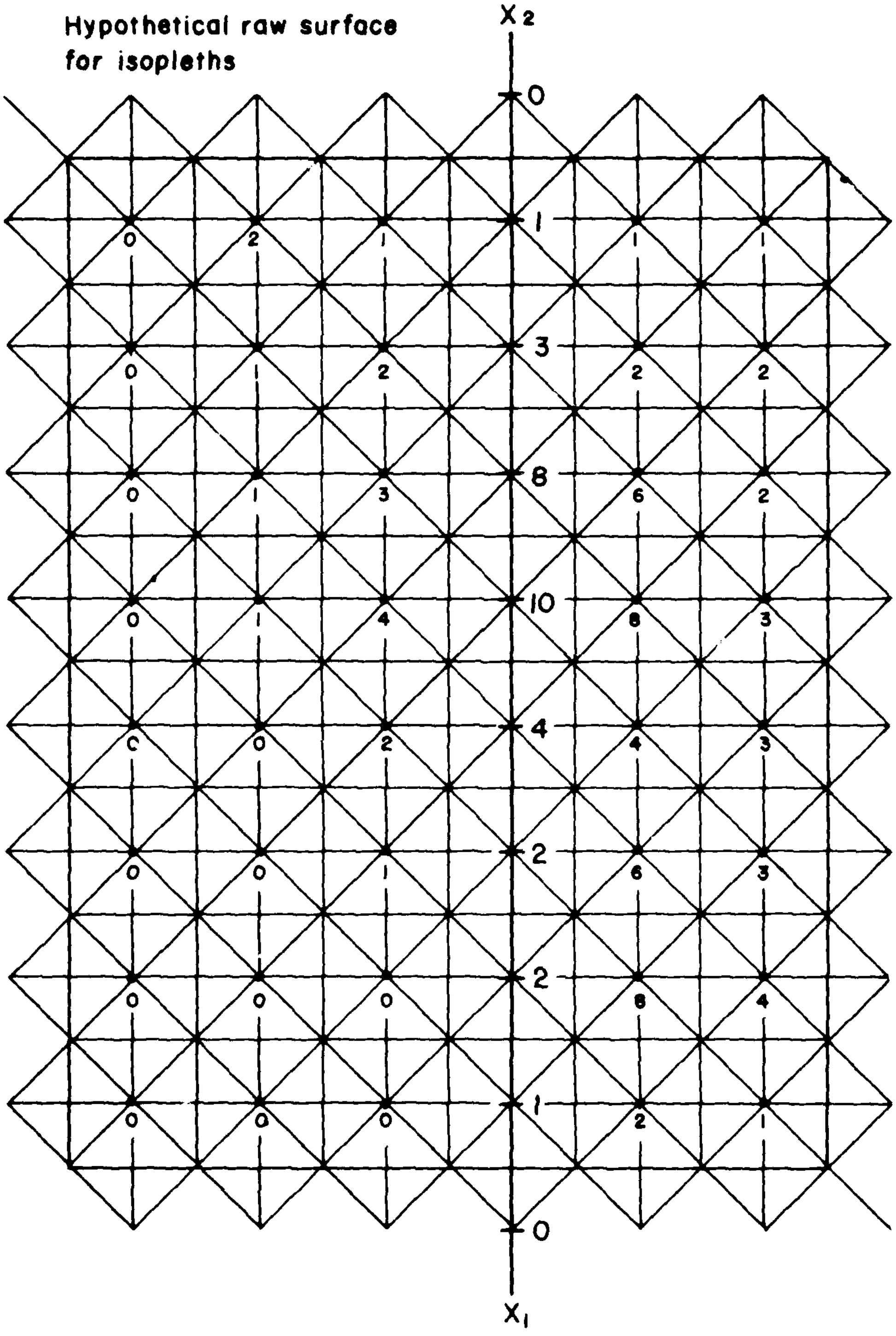


Fig. 18.8 Hypothetical raw surface for isopleths with location of profiles.

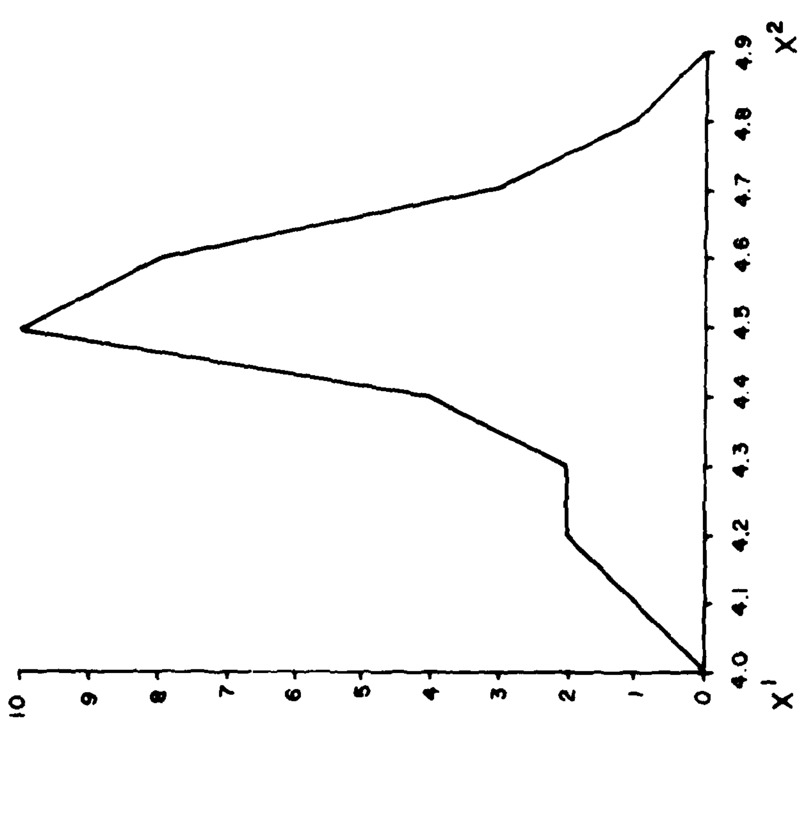


Fig. 18.9 Profile graph of raw scores.

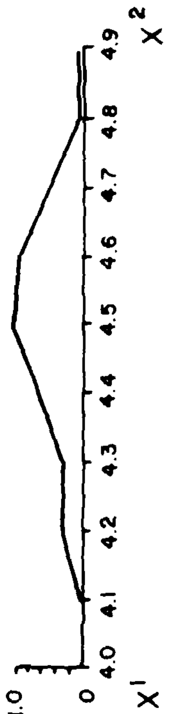


Fig. 18.10 Profile graph of $\log_{10}$ transformation.

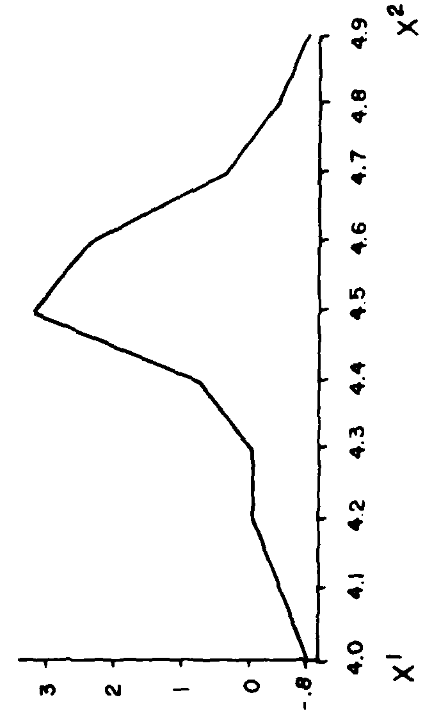


Fig. 18.11 Profile graph of z-score transformation.

The only realistic statement that can be made in this situation is a general notion of change per unit area (in which case you have a choropleth map). Because isopleth mapping assumes gradients and form, a manner of comparing measurement scales is necessitated. An assumption of equality in measurement scales for all axes (x, y, and z) as in isarithmic maps seems the most logical. However, this is an assumption which addresses the overall validity of isopleth mapping.

Robinson and Sale (1969) infer the lack of utility of isopleth maps in depicting gradients due to the unrealistic assumptions made. They suggest the only utility of a derived statistical surface is in some general depiction of form but, as many people view isopleths with some notion of gradient, the assumption of equality will be used to gauge the effects of transformations on the inferred slopes of the statistical surface. This assumption of equality is not restricted to slopes; a linear gradient is assumed in proportional allocation, hence, equality of measurement scales influences the form also.

The profiles in Figs. 18.9–18.11 are based on equality of measurement scales. A comparison of the profiles indicates the effects of transformations on the z coordinate. In this specific case, there is no problem fitting the unaltered data into an equal step isopleth format because the range of the original values can be accounted for. However, a comparison of the angles of the linear gradients in each case shows striking differences in the values portrayed.

Figure 18.12 (a), shows a table where the slopes (change per unit area) are depicted in terms of these transformed values. Because the raw values were in equality to distance, the slopes portrayed by the transformed values are as they would appear on the resultant isopleth maps.

Figure 18.12 (b), shows the angle measurements of the slopes derived from trigonometric relationships. All of the transformations maintain a situation of no gradient. The logarithmic transformation also yields no slope when a change of one occurs and alters proportional relationships due to the properties of a logarithmic function. The z-score transformation tends to maintain proportional relationships, as attested by the similarities in profile.

The visual impression of gradients yielded by each of these transformations are considerably different. Although the normal (raw score) gradients can be easily derived from the transformations, the resultant alteration of depiction must be considered. If the major usage of a series of maps consists of visual inspection, only one type of transformation should be used to ensure comparability. If analysis is primarily concerned with studying some representation of gradient, wherever possible a nontransformed equal step system (even with large intervals) should be strived for.

In order to examine the effects of these same transformations on depicting the form of a distribution, typical equal step isopleth maps for each case will be generated. The normal raw scores are usually mapped in intervals of one; z-scores are generally mapped by using the negative and positive whole numbers, and logarithms by some convenient decimal interval (such as .25). In this case, the use of common intervals for each transformation results in each of the maps having a different number of isopleths. Generally the more isopleths, the better the resolution or fidelity of the map. Each of the maps may be constructed with as many isopleths required to attain a desired level of resolution. The only limit is the range of the data and the ability to fit large numbers of isopleths on a particular scale map.

	normal	Log_{10}	z
(4.0) (4.1)	1	0	.478
(4.1) (4.2)	1	.301	.403
(4.2) (4.3)	0	0	0
(4.3) (4.4)	2	.301	.805
(4.4) (4.5)	6	.397	2.418
(4.5) (4.6)	2	.096	.806
(4.6) (4.7)	5	.425	2.015
(4.7) (4.8)	2	.478	.805
(4.8) (4.9)	1	0	.478

(a)

	normal	Log_{10}	z
(4.0) (4.1)	45.0^0	0^0	25.5'
(4.1) (4.2)	45.0^0	16.7^0	21.9^0
(4.2) (4.3)	0^0	0^0	0^0
(4.3) (4.4)	63.5^0	16.7^0	38.8^0
(4.4) (4.5)	80.6^0	21.6^0	67.5^0
(4.5) (4.6)	63.5^0	5.48^0	38.8^0
(4.6) (4.7)	78.7^0	23.0^0	63.6^0
(4.7) (4.8)	63.5^0	25.5^0	38.8^0
(4.8) (4.9)	45.0^0	0^0	25.5^0

(b)

Figure 18.12 Two slope value tables.

(a) Table of slope (change per unit area)
(b) Table of slope angles

Normal Raw Isopleths

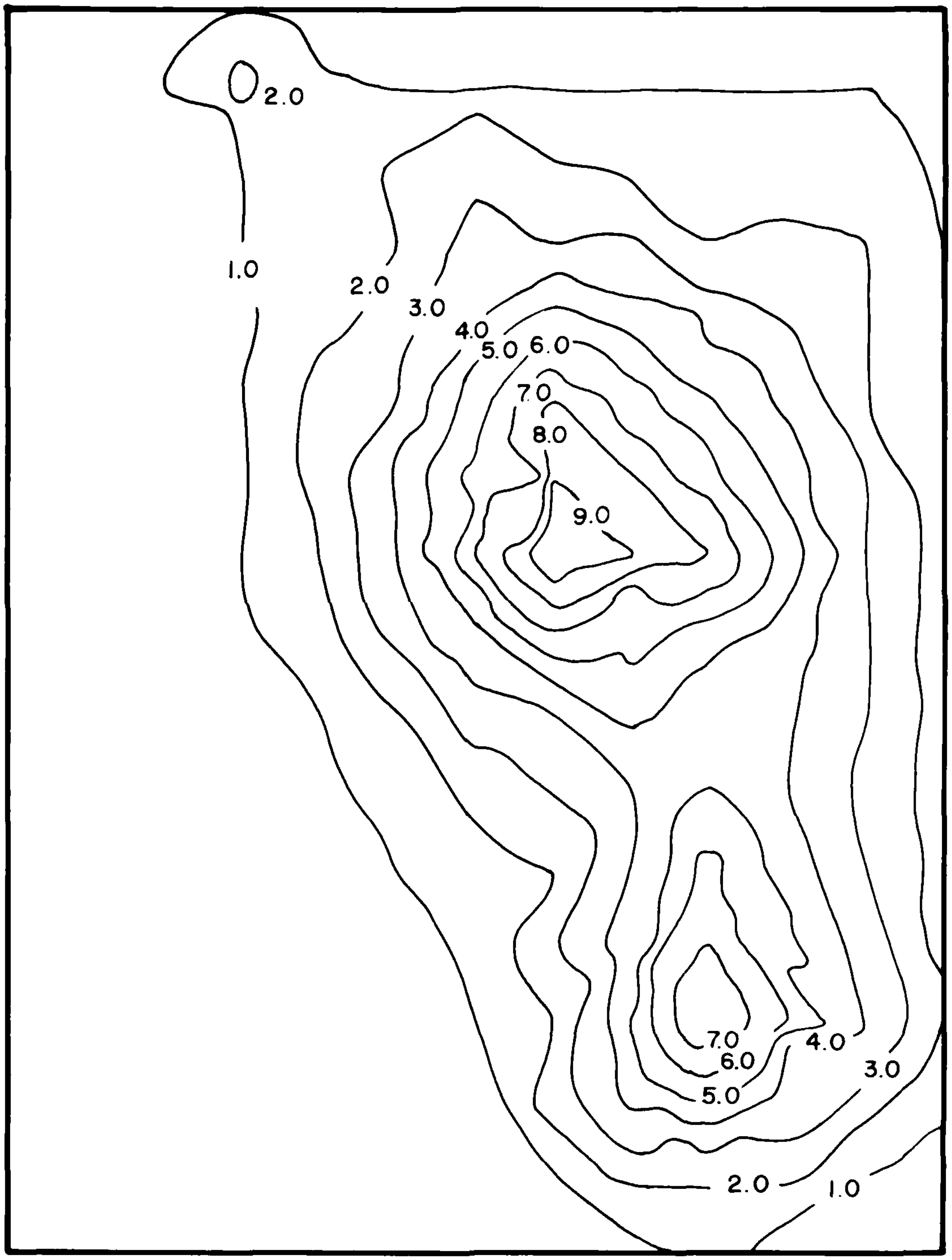


Fig. 18.13 Isopleth map raw values.

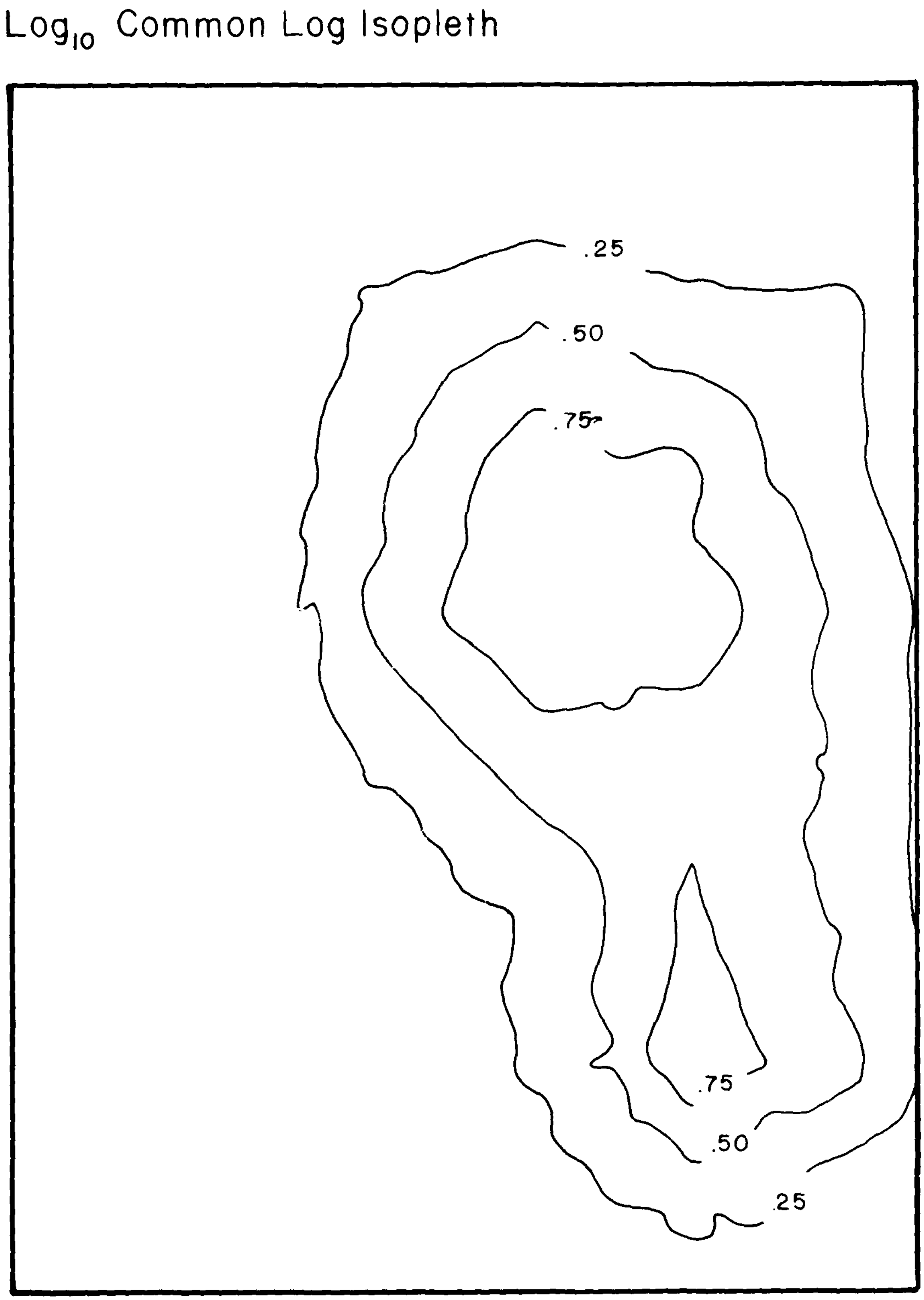


Fig. 18.14 Isopleth map Log_{10} values.

Z Score Isopleth

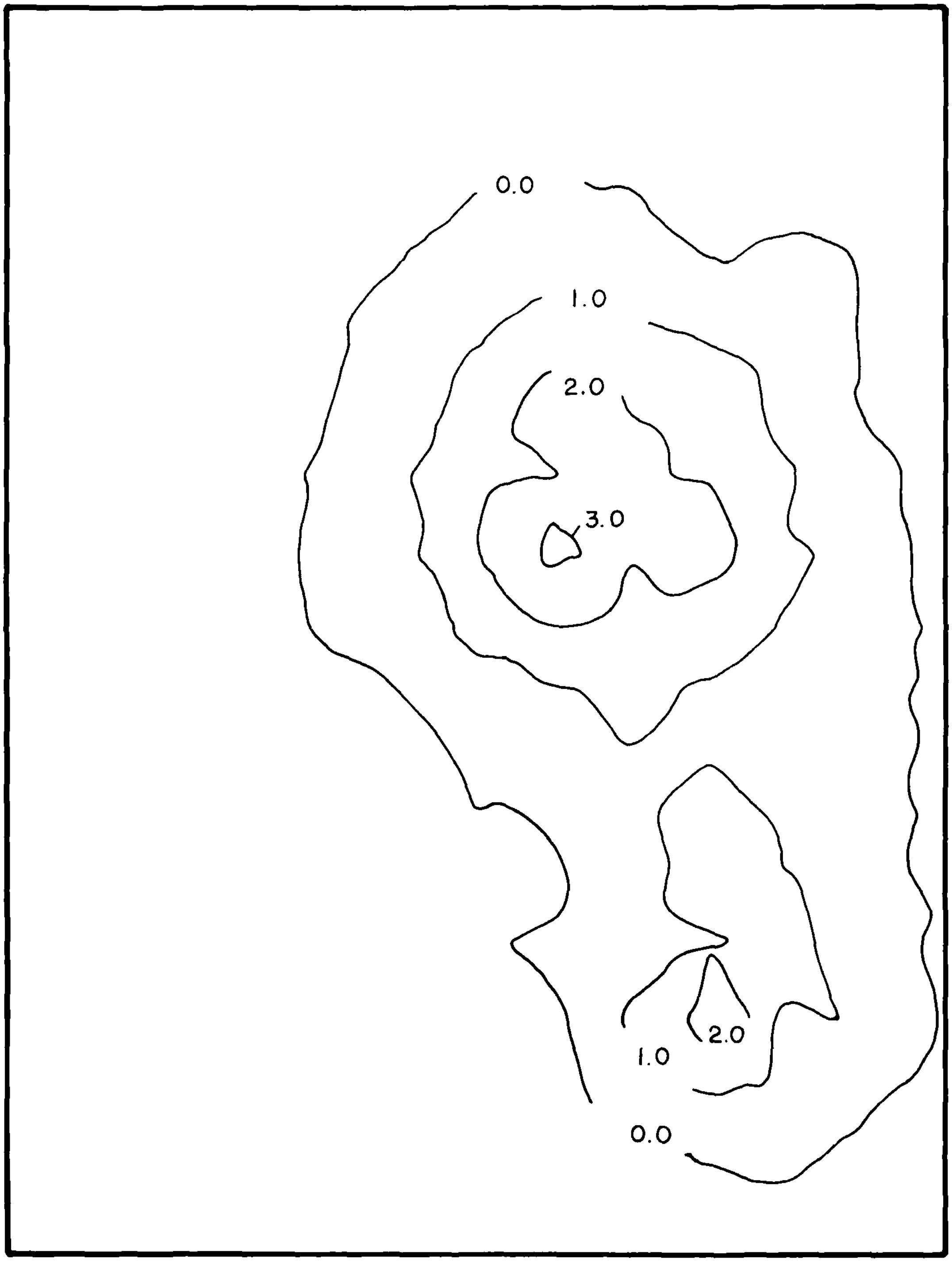


Fig. 18.15 Isopleth map z-score values.

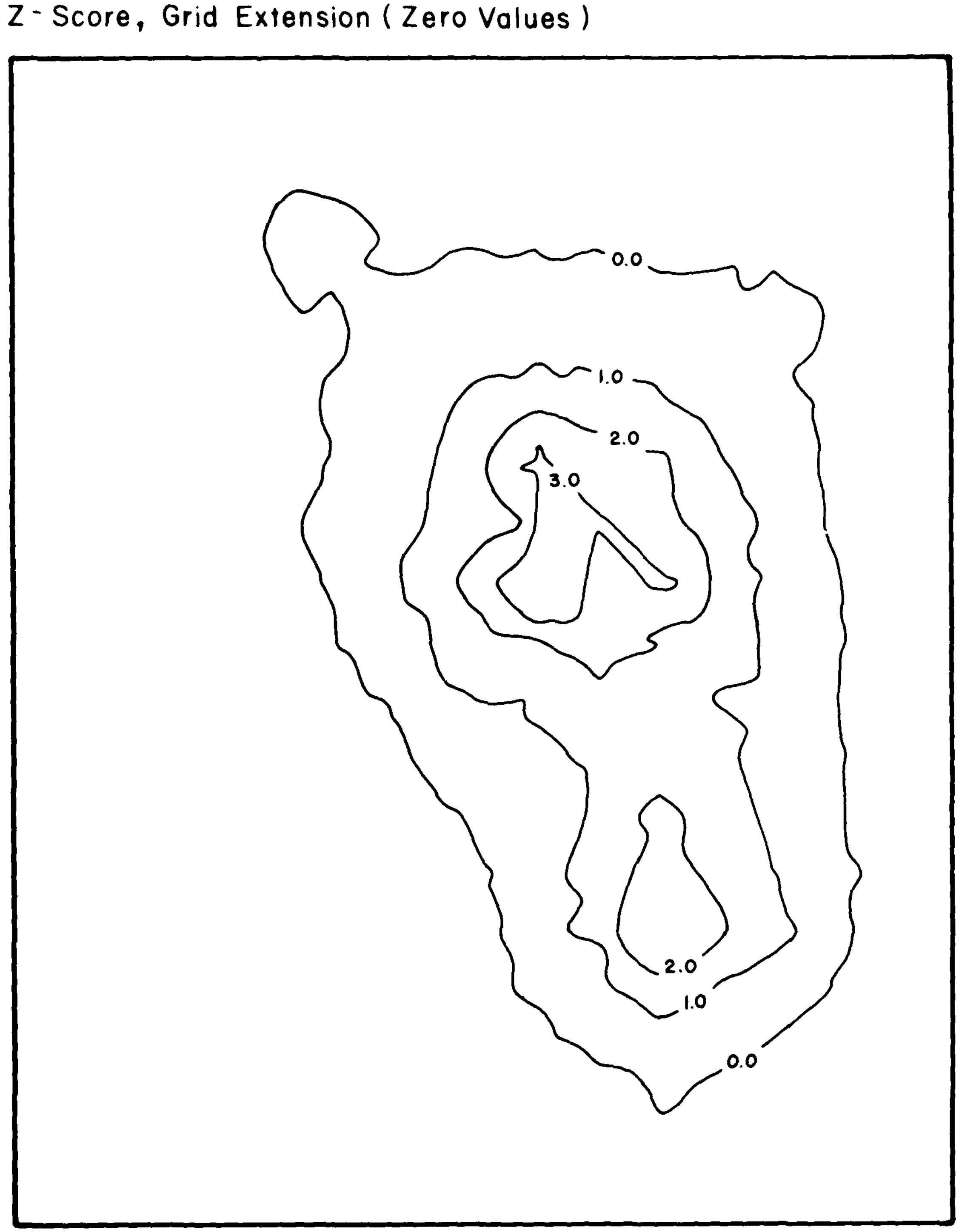


Fig. 18.16 Extend z-score (zero value) ispleth map.

Figures 18.13–18.15 show the completed maps for each case based on a triangular lattice with linear proportional allocation used to interpolate isopleth location. Obviously the raw scores with nine isopleths has better resolution and all of the maps, regardless of the number of isopleths, are capable of discerning the double peaked form of the statistical surface. However, the logarithmic map is not capable of adequately discerning between values of zero and one, which indicates that caution should be undertaken in the employment of this transformation when the zero-one interface is deemed an important element of the form of the distribution.

The z-score transformation seems to be the most realistic choice as it tends to maintain the basic form of the distribution (the zero-one interface and low values when negative scores are mapped). Certain problems may be encountered when an area of collection is extended, hence, introducing more zero values into the calculation of the mean and standard deviation. This results in a general lowering of the mean and standard deviation which tends to increase the z-score values.

Although an isopleth map of raw scores with an extended grid system of zero values will be the same as Fig. 18.13, the extended z-score map will be different from Fig. 18.15. The extended case is shown in Fig. 18.16. The same general form is still adequately depicted, but when the same intervals are used there seems to be a tendency for outward distortion of the form. In this case, when the distribution is generally simple (a well defined and connected double peak), the distortion is not too great. If a much more complicated distribution is encountered, one should at least be aware of the possible distortions.

CONCLUSIONS

A review of the suitability of isopleth and choropleth mapping should be undertaken in the light of their ability to measure and portray elements of pattern. They are primarily visual or empirical techniques used for initial pattern recognition. As such, the analytical strength of conclusions drawn from these maps are weak and subjective. They can be used adequately for initial hypothesis formulation, and for first step sorting of data into a format where more powerful analytical methodologies can be applied.

The specific advantage of these techniques over other mapping systems (point and linear) is their ability to portray volume and frequency information. The validity of certain measurement assumptions and processes of generalization, however, is questionable.

Choropleth mapping, which requires a discrete collection system, automatically sacrifices absolute location information. Although, if the collection system is relatively small, the degree of planimetric distortion is held at acceptable levels. Further generalization in terms of absolute frequency is required to accomodate the range of most distributions. The general ease of compilation, coupled with the ability to vary resolution in specific parts of the range, enhances the versatility of this method.

In cases where archeological data are collected by a discrete system, choropleth mapping offers a quick, suitable way to visually portray distributional characteristics. Assumptions as to the equality or relationships of the x and y scales to the z scale are not made. Only a general and non-biased picture of change in frequency over area is depicted. Also, the quadrats or grids on a choropleth map represent specific cases (descriptive statistics) which are suitable for comparative analysis by statistical methods (see Spear 1978).*

For instance, various spatial autocorrelation techniques may be applied in order to test specific hypotheses. There are also possibilities for deriving second order descriptive statistics which further measure distributional elements (such as dispersion and randomness). In all, there is a general abundance of methods which can be applied to test specific hypotheses based on discrete data collection systems.

Isopleths, on the other hand, are considerably more prone to criticism due to the series of assumptions and abstractions that are made in order to construct a continuous density surface. The ideal collection system for isopleths is a continuous format. However, a discrete system with derived control points is an acceptable assumption used in most situations, and represents no more generalization than choropleths. Even the second order derivation of control point to overcome indeterminacy by constructing various geometric lattices represents acceptable generalization if the original quadrats are relatively small.

One should be aware, however, of the implicit nature of isopleth maps (exhibition of some sense of gradient and form) which, in conjunction with the assumptions needed to construct them, tend to somewhat extend the boundaries of realistic depiction. Of primary concern is the underlying assumption of equality between the distance scale and a particular phenomena scale used by proportional allocation to interpolate isopleth locations. This, in combination with linear or as yet unfounded assumptions of gradient tends to produce a seemingly accurate representation of a surface. In fact, the surface is highly fabricated and is perhaps an unrealistic portrayal of distributional characteristics.

Even if the correct relationship between measurement scales could be specified and proper gradients could be accounted for, the alteration of slopes by various transformations in attempts to maintain equal step intervals would be a considerable problem to overcome and still maintain comparability. If one is fully aware of the methodological problems of isopleths, and does not expect too realistic a depiction from the final product, a general idea of slope and gradient may be obtained. The complexity and time consumptive nature of hand generated isopleths (given that

*An earlier paper by the author treats, in addition to the subject matter covered here, the employment of other descriptive and analytical techniques. Included in that paper is a discussion of centrography, poisson and nearest neighbor point pattern analysis and various methods of spatial autocorrelation. A general analytical perspective is also discussed in which these methodologies can be employed. The paper is entitled *Some geographic methods and their application to the analysis of archeological artifact distributions* and is on file at the Office of Contract Archeology, University of New Mexico, Albuquerque.

accuracy is still the goal in linear or any other type of proportional allocation), makes them increasingly uncompetitive with the ease of choropleth generation.

Other problems are encountered when additional or subsequent analytical procedures are applied using isopleth maps as data bases. Trend surface analysis (Chorley and Haggett 1965; Norcliffe 1969) is the general name for a series of methodologies employed that seek to express map patterns in terms of specific mathematical equations. The development of these techniques is still in its infancy and, while progress has been made in fitting certain models, they remain primarily descriptive and, thus, of little theoretical validity (Harvey 1969).

Most of the progress has been made with actual isarithms in a geological context and, as yet, some serious methodological problems have to be overcome with derived isarithms. The possibilities for further usage are promising if suitable interpolation methodologies can be constructed to better approximate cultural surfaces.

In general, the application of isopleths to the analysis of archeological distributions should be undertaken with caution. One should be aware of the methodological problems and the limitations for further analytical studies. Choropleths, which make far fewer assumptions and are already amenable to further analytical methods, make a more realistic choice for a visual depiction technique.

Further research should be undertaken into the nature of archeological distributions to determine the existence of specific gradients and thus enhance the accuracy of isopleths. Also the development of other methodologies or the modification of choropleths may be undertaken to make them more suitable in the depiction of form. Dasymetric mapping (Robinson and Sale 1969), which is based on more knowledge of the properties of a distribution (zones of rapid change and certain distinctive forms), also has some potential.

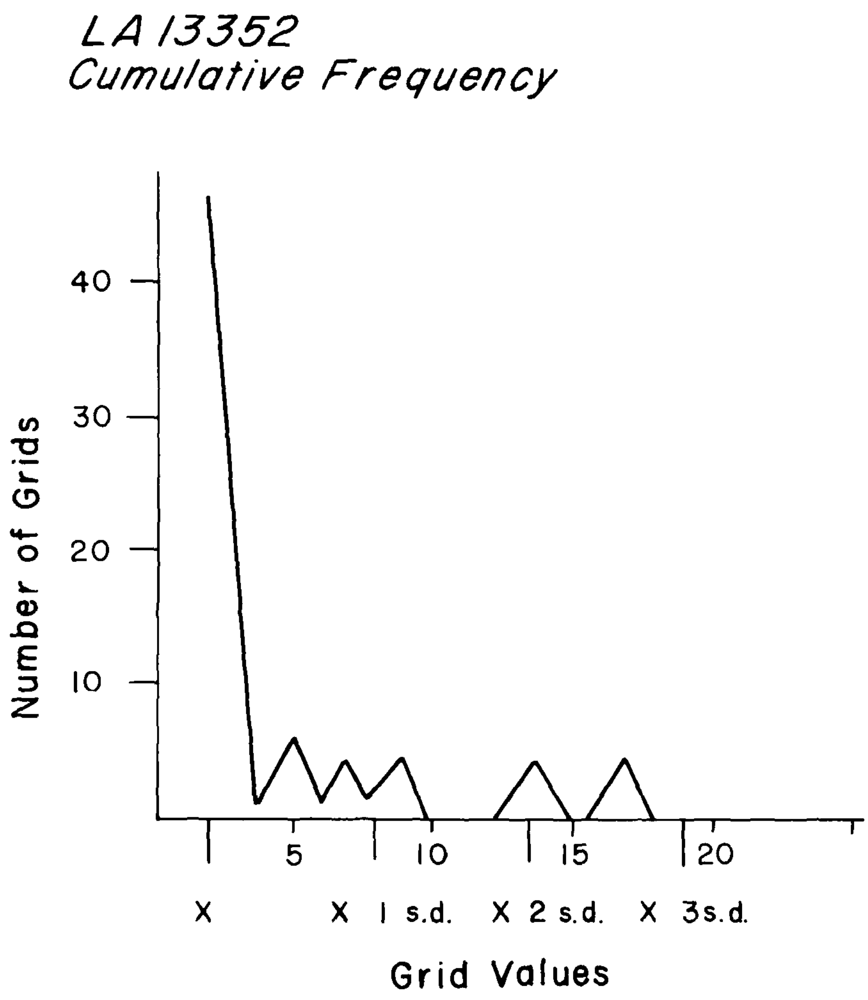


Fig. 19.1 Grid values for LA 13353 – cumulative frequency graph.

Chapter 19
A SUGGESTED METHOD FOR RECOGNIZING PATTERNING IN LITHIC ARTIFACT DISTRIBUTIONS

Eileen Camilli

INTRODUCTION

The purpose of this paper is to provide a demonstration of a method for the illustration of one aspect of site structure: the patterning of artifact distributions over horizontal space. The subject of site structure has become a recent concern of archeologists. Discussion has focused upon whether or not different activities tend to be spatially segregated on a site and whether or not some portions of a site are more heavily used than others (Whallon 1974; Yellen 1977; Binford 1978). In order to illustrate assemblage content and distribution and to present models of site structure, such studies have employed some form of graphic display.

MAPPING ARTIFACT DISTRIBUTIONS

Analysis of any phenomenon first begins with a demonstration or recognition of patterning in the relevant data. In order to investigate the structural patterns of artifact distributions over the surface of a site, we must begin with a method which will graphically illustrate these patterns. The method presented in this chapter involves the use of an isopleth mapping technique with which the surface of the map is regarded as a "*statistical surface in which height varies over an area in much the same way as terrain varies on topographic maps*" (Haggett 1966:214). Maps are produced with isopleths or contour lines of constant value and are, thus, three dimensional representations measured in an x and y dimension, or horizontal plane, and a z dimension, or vertical height of the distribution.

Control Points

Before this mapping technique is demonstrated with sites excavated by the Cochiti Reservoir Project, several aspects of map construction will be addressed. The first aspect of map construction involves the number of *control points* on a map. The character of the graphic representation of an artifact distribution is ultimately dependent on the spacing of control points. For archeologists, the number of control points with which a site is mapped is dependent on the grid size used for excavation and collection, since the center of each grid will be designated as a control point. Larger grid size results in greater distance between control points and, thus, fewer control points. Assuming the same absolute number of contours, a system of relatively large grids would result in a greater number of contours between control points than would one with a smaller grid size. Cochiti sites have been excavated with a 1 x 1 meter grid system and, thus, the distance between control points is one meter.

Number of Contours

A second consideration involves the number of contours to be used. The absolute number of contours affects the graphic representation of variation across a distribution. If too few contours are chosen to depict a distribution, much of the variation in artifact density across the distribution may be ignored. When choosing the number of contours with which to depict a distribution, the spacing of control points must be taken into consideration, for a finely contoured map may only give the impression of accuracy when control points are widely spaced. The *accuracy* of the graphic display may be increased, however, if the distance between control points is decreased with the same number of contours. Brooks and Carruthers (1953) have argued for a rule in which the number of contours on a map would determine the number of control points.

Spacing of Contours

Decisions must also be made concerning the spacing of contours. Robinson (1960) and Haggett (1966) present us with several choices for determining the spacing of contours. It is suggested that the distribution to be plotted first be inspected with the use of a cumulative frequency graph. Figure 19.1 illustrates such a graph for the artifact assemblage on stie LA 13352. The vertical axis of the graph represents the number of grids imposed over the distribution, the x and y dimensions of the distribution, and the horizontal axis represents the artifact count for each grid, the z dimension of the distribution.

One choice for the spacing of contours is to place a contour at each of the significant breaks in the graph. This method would insure that local variation in artifact density over the site surface would be illustrated. For site LA 13352, contours might be plotted at values of 4, 6, 8, 10, 13.5, 15.5, 17 and 19 (Fig. 19.1).

Another choice for contour spacing might involve placement of contours at arbitrary intervals, at values of 1, 5, 10 and 15 for example. In this case, local variation in detail might not be detected graphically. Because mean artifact density varies between sites, graphic displays of the character of a distribution employing either of the above choices for contour spacing are not directly comparable between sites.

An additional choice for contour spacing would be to divide the z values along the horizontal axis of the graph into equal divisions. This method was used here in plotting contours for Cochiti site artifact distributions. Equal divisions of the axis representing grid values were arrived at by using the mean grid count of artifacts as an initial contour. Additional contours were then placed above and below the mean grid contour using the standard deviation of the grid counts as the spacing interval. Grids containing no artifacts which occurred on the perimeter of the distributions were given a count of zero and included in the calculation of mean and standard deviation values. Since standard deviations exceeded mean grid counts on Cochiti sites described in this chapter, contours were not placed below the mean grid values on maps presented here. A closing contour was placed at the .06 value as a convention enabling graphic representation of distributions separated by single grids containing no artifacts.

This method insures comparability between sites because the structure of the distribution is illustrated using known statistical relationships. Use of contours spaced at arbitrary intervals, while providing a consistent method for calculating spacing intervals between contours on each site map, does not offer this comparative potential.

Location of Control Points

A final aspect of map construction involves the location of control points. The location of control points determines the level of accuracy of the mapped distribution. This is because the placement of values for construction of contour lines is accomplished by assuming a linear gradient between two points:

> *Unless other information is available it is assumed that the gradient between two points is linear and contour lines are geometrically interpolated. Geometric interpolation is merely a matter of proportional allocation: if a 20 percent contour is to be drawn between control points with values of 16 and 25 percent, respectively, then this contour would be placed four-ninths of the way along the line joining the lower and higher control points.*
> (Haggett 1966:217)

By assuming a linear gradient between two control points, alternative placement of contours are sometimes possible when a square grid system is used. This is because of the longer distance between control points on diagonal gradients. Placement of a contour using one set of control points on the diagonal between two grids may result in a distribution which conflicts dramatically with a contour produced using the other set of control points on the cross intersecting diagonal, Fig. 19.2(a) and (b). Haggett (1966: 217) has suggested that we assume a secondary control point located equidistant from each of the four values with a value equal to the mean of these values, Fig. 19.2(c). This problem does not occur with the use of a grid system in a triangular or hexagonal pattern in which all control points are equidistant.

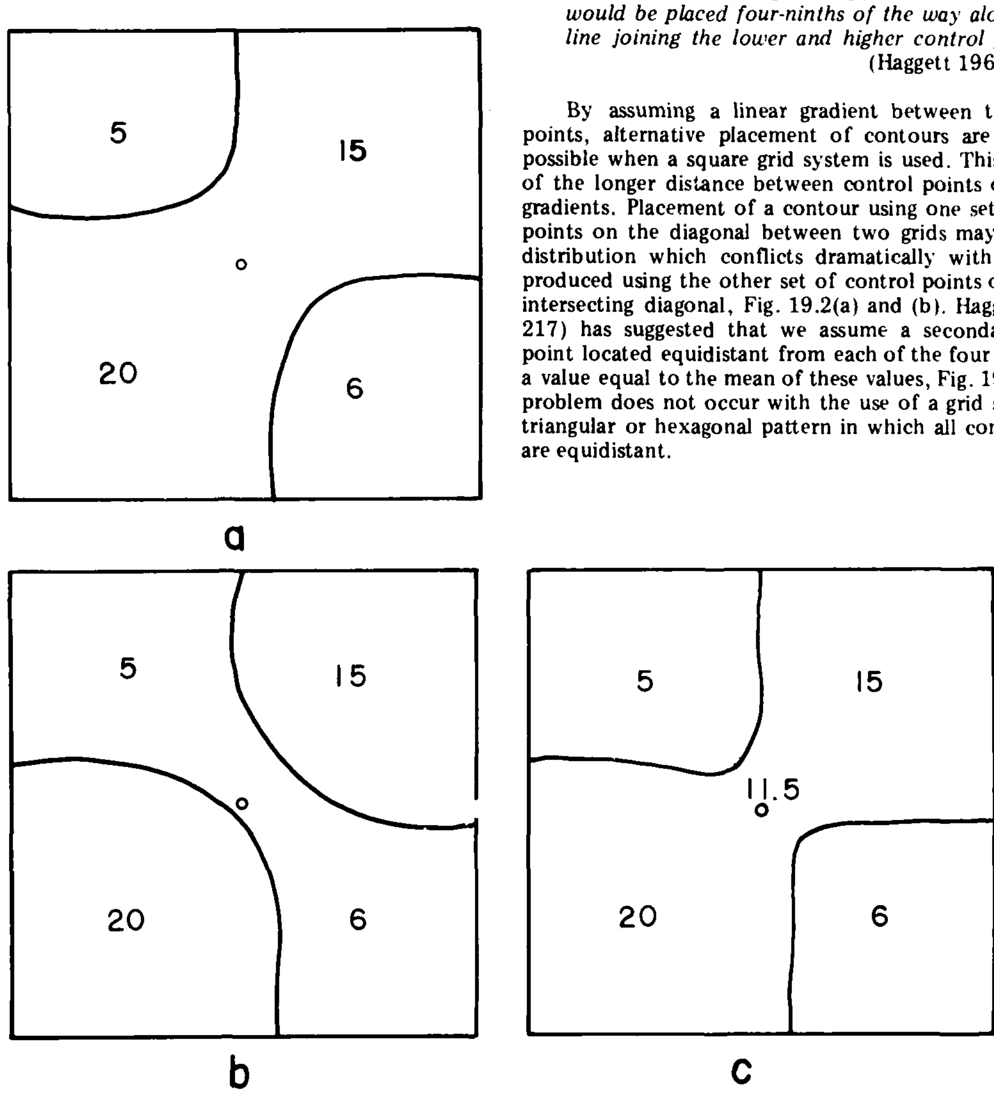


Fig. 19.2 Placement of contours using different control points (after Haggett 1966): (a) 5, 6 diagonal control points; (b) 20, 15 diagonal control points; (c) secondary control point.

THE COCHITI SITES

The lithic artifact distributions on six sites excavated by the Cochiti Reservoir Project were mapped. These are nonstructural sites dating from both Archaic and Anasazi time periods. Three sites were located on the east and west sides of the Rio Grande in White Rock Canyon and include LA 12456, LA 12463 and LA 12486. Site LA 12456 is characterized by hearth features, firecracked rock scatters, lithic artifacts and a few ceramic artifact fragments. The site dates to the late Archaic period. Site LA 12463 is a late Archaic site characterized by three hearth features, firecracked rock scatters and lithic artifact scatters. Site LA 12486 is a P-IV phase Anasazi site characterized by three hearth features and associated lithic and ceramic artifacts (more complete descriptions of these sites are presented in Chapman et al. 1977).

Three additional sites were located along the Canada de Cochiti Arroyo between the Rio Grande and La Bajada scarp (LA 13350, LA 13352, LA 13353). Site LA 13350 is a surficial scatter of artifacts of unknown temporal and cultural affiliation. It is located on a gravel terrace overlooking the Canada de Cochiti. Site LA 13352 is a surficial lithic scatter with an associated hearth feature. This site is located north of the Canada de Cochiti 3 km east of the Rio Grande. Site LA 13353 is a surficial scatter of lithic material and an associated hearth feature. Both LA 13352 and 13353 are also of unknown cultural and temporal affiliation. These sites are described in Hunter-Anderson (1979a, 1979b and 1979c).

Six classes of lithic artifacts were mapped for each site. These include utilized and unutilized debitage, large angular debris, cores, facially retouched artifacts and metates. For a description of each artifact class see Chapman and Schutt (1977:83-96). Examples of the mapped distributions of each artifact class will be presented in the following section of this paper.

Several of the problems discussed dealing with map construction from a square grid system exist for these sites. Because each site has been excavated in a system of 1 x 1 meter grids, control points were systematically spaced one meter from each other. Alternative placement of control points at resolutions below one meter could not be used. In this analysis, artifact distributions within each site were mapped with all collection levels collapsed although each level could have been mapped separately. Thus, surface or stripping levels were collapsed with subsurface excavation levels, when the latter occurred, to arrive at frequency counts for each grid unit.

The extent of excavation was determined by grid boundaries. Using an isopleth map as an analytical device, we are able to graphically illustrate a distribution which may not have been completely recovered. Analysis of site structure is concerned with a demonstration of patterns of association and distribution on a site surface. In order to demonstrate these relationships it is profitable to examine the entire distribution for redundant and unique types of structure. Confidence as to the *real* character of the structure revealed can be assured if we can be reasonably sure the full extent of a distribution has been recovered. Using an isopleth map we are able to give a degree of confidence to interpretations of the character of the distribution. Figure 19.3 illustrates an example of a site on which the artifact distribution may not have been completely recovered. Contour lines which do not close within established site boundaries on this map indicate that the distribution may extend beyond these boundaries.

PATTERNING IN THE DISTRIBUTION OF ARTIFACT TYPES

Obviously more than a single behavioral dimension as well as natural formation processes, have contributed to the patterning in artifact distributions on Cochiti sites. The resource procurement system, the technological organization, and the kinds of activities carried out on the site are just several of the behavioral dimensions which may have conditioned the spatial organization of the artifact assemblages on the surface of these sites. Different types of food processing activities, as determined by the organization of the resource procurement system, may result in distinctive distributions of food remains and implements utilized in their processing. The organization of the technological system, whether or not tools were carried and maintained between uses, has implications for the nature of the distribution of manufacturing debris on a site.

Patterns of artifact distribution on Cochiti sites will be discussed in terms of a single dimension: that of disposal mode. Binford (1978) has recognized several manipulative acts which constitute modes of disposal for items entering the archeological record. These acts include the actions of dropping, tossing, resting, positioning and dumping. Binford observed that most cases of *dropping* occurred where elements were detached from an item held in the hand. *Tossing* usually occurred after the completion of an action. *Rested* items were set down temporarily due to task interruption or the arraying of tools prior to the performance of some task. *Positioning* or purposeful placement of items resulted from two objectives: purposeful aggregation of items, and placement of items so as to insure their retrieval at a future date. *Dumping* is characterized by the accumulation of dropped or resting items and their removal and disposal on the periphery of a site. Patterns of artifact distribution on Cochiti sites will be discussed in terms of each of these actions and examined for structural properties which may have resulted from a certain action.

Unutilized Debitage

Unutilized debitage occurs on every site. This material is found in distributions of two major kinds. One is relatively variable in shape and occurs near and around hearths. The second kind of distribution is relatively dense and circular in shape. The former kind of distribution can be thought of as a *drop zone* which results from manufacturing activities carried out around a hearth similar to that described for Nunimuit hunters (Binford 1978).

The drop zone model is illustrated in Fig. 19.4 for site LA 13352. A light scatter of unutilized debitage occurs on three sides of the hearth with one side left open. This pattern has been noted for Nunimuit, Bushman and Magdelenian sites. The low density or open side of the hearth on

Magdelenian sites has been interpreted by Leroi-Gourhan and Brezillon (1966) as a sleeping area within a house or tent, and the high density side of the hearth as an area of domestic activity.

A similar pattern has also been observed on Bushman camps (Yellen 1977). Binford (1978) has observed a vacant side of hearths on Nunimuit hunting camps, and has attributed its position relative to the hearth as dependent on wind direction.

Dense circular concentrations of debitage occur on both LA 13352 and LA 13350 (Figs. 19.4 and 19.5). These concentrations may also be thought of as *drops* possibly resulting from a single activity episode.

Utilized Debitage

This material occurs with unutilized debris in drop zones around hearths and in localized areas peripheral to hearths. Relatively dense circular concentrations of utilized debitage also occur. Distributions on LA 13352, LA 12486 and LA 12463 exhibit these patterns (Figs. 19.6–19.8). Utilized debitage on LA 13352 occurs along with unutilized debris around the hearth and also in a separate distribution away from the hearth. Localized distributions such as this one may constitute an activity episode which interfered with domestic or other activities undertaken around the hearth because of the generation of additional debris, or simply because space may have been needed which was not obtainable around the hearth area.

Cores and Large Angular Debris

Patterns of distribution for cores and large angular debris take several forms. This material occurs in semicircular rings near dense concentrations of unutilized debitage of the same material type. It also occurs on the periphery of dense debitage distributions and in other areas in low density circles. Low density circles usually contain only one item.

These two artifact classes have been combined in this analysis because of similar morphological attributes (see Chapman and Schutt 1977:92). A major attribute contributing to this decision is size and morphological similarity with most of this material weighing in excess of 40 grams. Sites LA 13352 and LA 13350 illustrate the semicircular *U-shape* of these items (Figs. 19.9 and 19.10). In each case, this shape occurs adjacent to a dense concentration of unutilized and utilized debitage containing similar material types. These shapes may indicate drop zones of core material or possibly areas where core material was placed or positioned around or near an individual during the manufacturing process, perhaps in anticipation of future use. Comparison of Figs. 19.4 and 19.9 indicates a circular drop zone of unutilized debitage surrounded on three sides by angular debris for site LA 13352. Comparison of Figs. 19.5 and 19.10 indicate a similar pattern for these two artifact types on LA 13350. This interesting distribution suggests a single activity episode in which both angular debris and debitage were generated and discarded. The utility of the use of contours for illustration of the structure of artifact distributions is also demonstrated in the comparisons: not only are the relationships between location and density of artifact types illustrated but the *shape* of each distribution relative to one another is also available for inspection. The pattern on LA 12456 (Fig. 19.11) is possibly one resulting from the tossing of core material away from an activity area as it occurs on the periphery of the denser portion of the artifact scatter. The important consequences of this kind of action are the absence of material in areas where it was used the most and its presence in areas where it was not used at all.

Facially Retouched Artifacts

Facially retouched artifacts occur as isolated drops usually near hearths. Both broken and unbroken items occur in this pattern. The artifact distribution on LA 12486 (Fig. 19.12) illustrates this pattern. In the case of broken artifacts these may have simply been dropped where the breakage occurred. Whole artifacts utilized in the same areas may have entered the archeological record as the result of loss rather than intentional discard. This presupposes some form of maintenance or curation of facially retouched artifacts. In general, facially retouched artifacts occur in very low frequencies on Cochiti sites.

Metates

Whole metates were observed to occur consistently near hearths. Metate fragments occur on the periphery of distributions around hearths. Because of their size, it can be argued that the disposition of these items on the surface of a site is the result of intentional placement. Two metates were found near the hearth on LA 12463 (Fig. 19.13). Metate fragments were found on the edge of the debitage drop zone away from the hearth on several sites. These were perhaps tossed away from the activity area.

CONCLUSIONS

The patterns of artifact distribution described above indicate that most artifact types are distributed across site surfaces in any one of several different patterns. One behavioral dimension, that of disposal mode, was explored with suggestions as to which kinds of manipulative actions may have resulted in the patterned distributions of different artifact types. Understanding differences in the organization of site structure clearly depends on the identification of all independent behavioral dimensions and natural formation processes that have contributed to that structure. Establishment of behavioral and natural deposition context for Cochiti sites was not the purpose of this paper, although several possible disposal modes were discussed. Rather, this paper served as a demonstration of a method with which to illustrate the structure of lithic artifact distributions on nonstructural sites. The method demonstrated here is an initial step in the recognition of patterns of distribution and association. Recognition of these patterns which enables us to begin to make some statements about the nature of spatial relationships will contribute to the construction of descriptive models and to the development of a body of theory on the nature of space use.

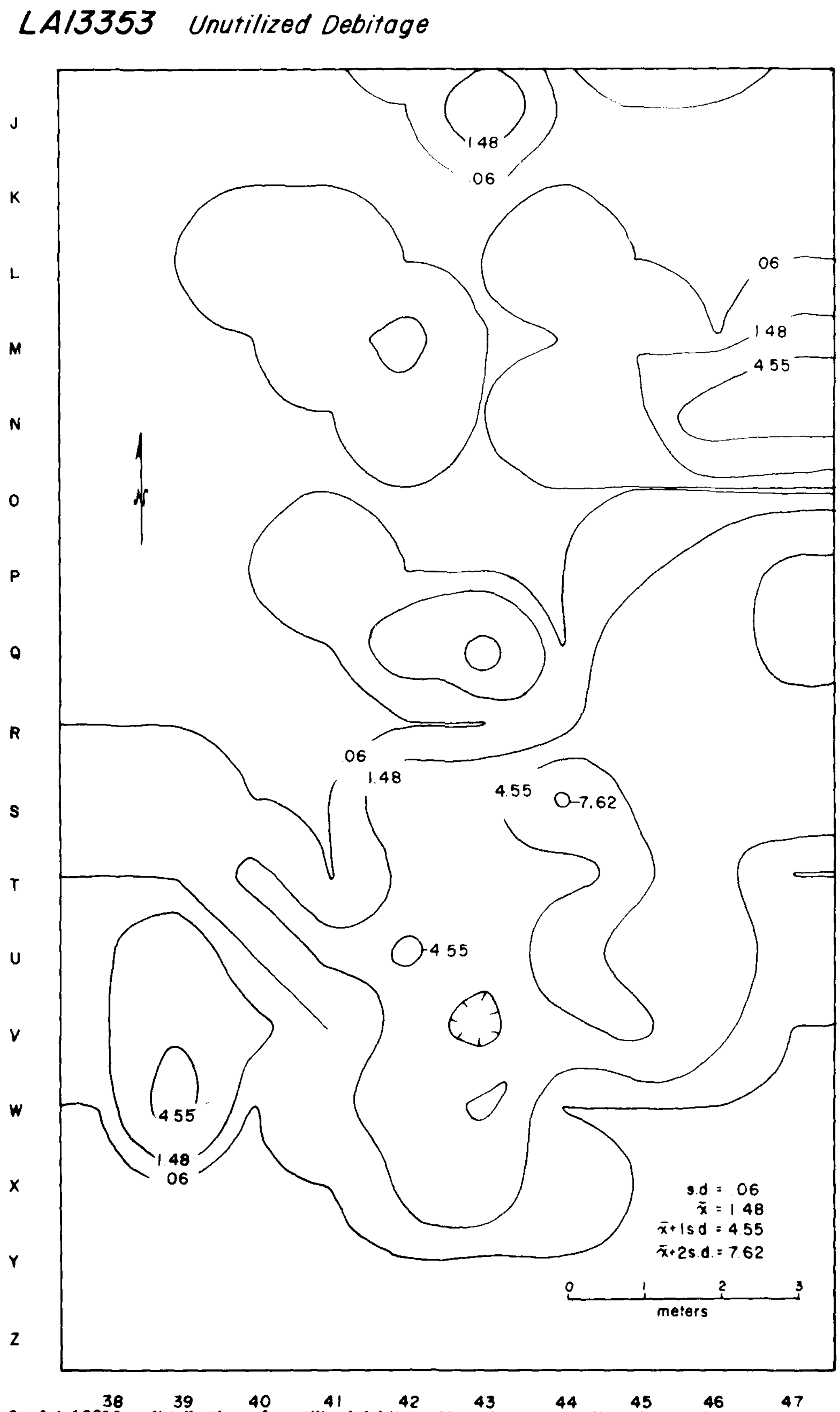


Fig. 19.3 LA 13353 — distribution of unutilized debitage. Note that contour lines do not close within site boundaries.

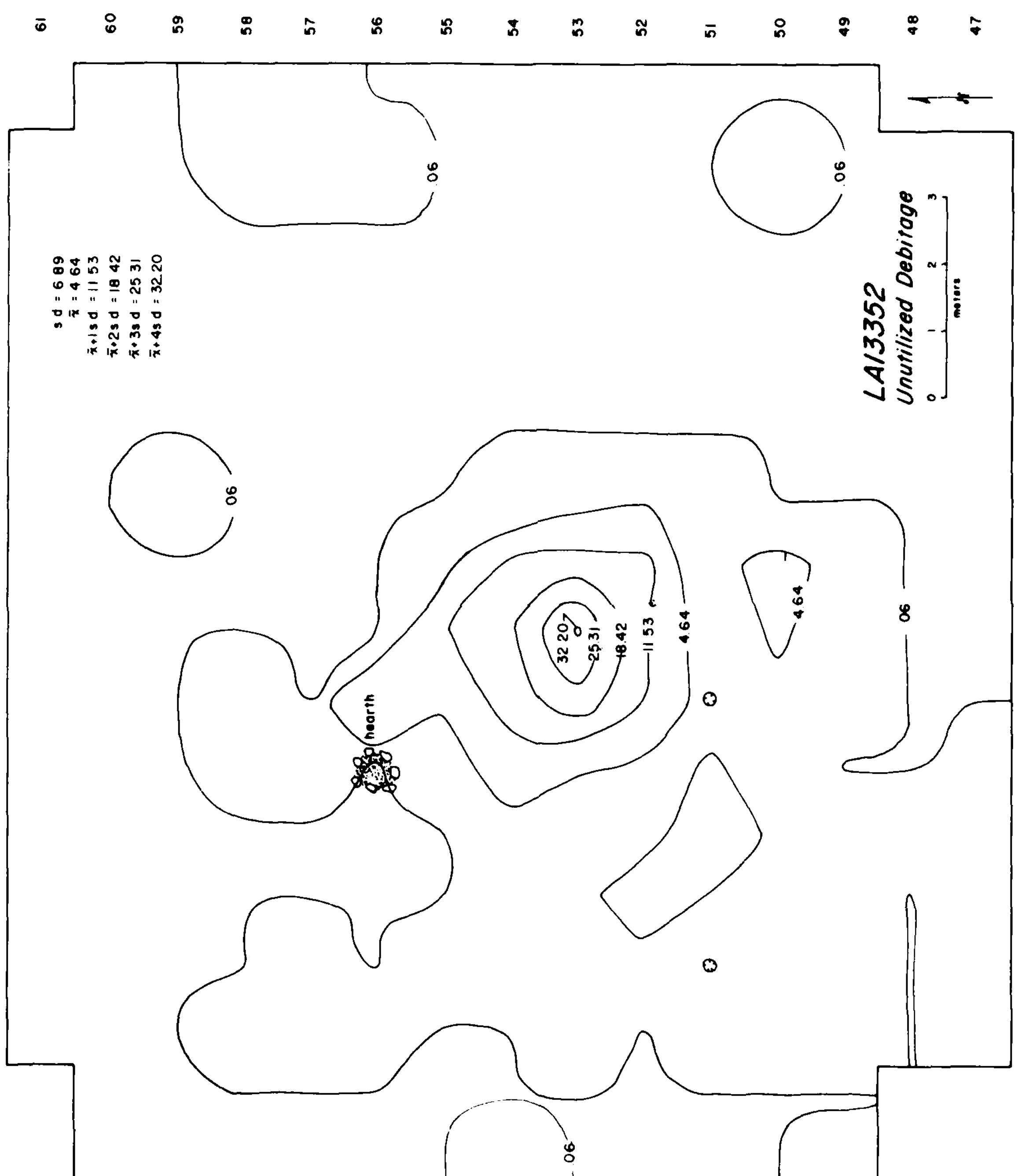


Fig. 19.4 LA 13352 -- distribution of unutilized debitage.

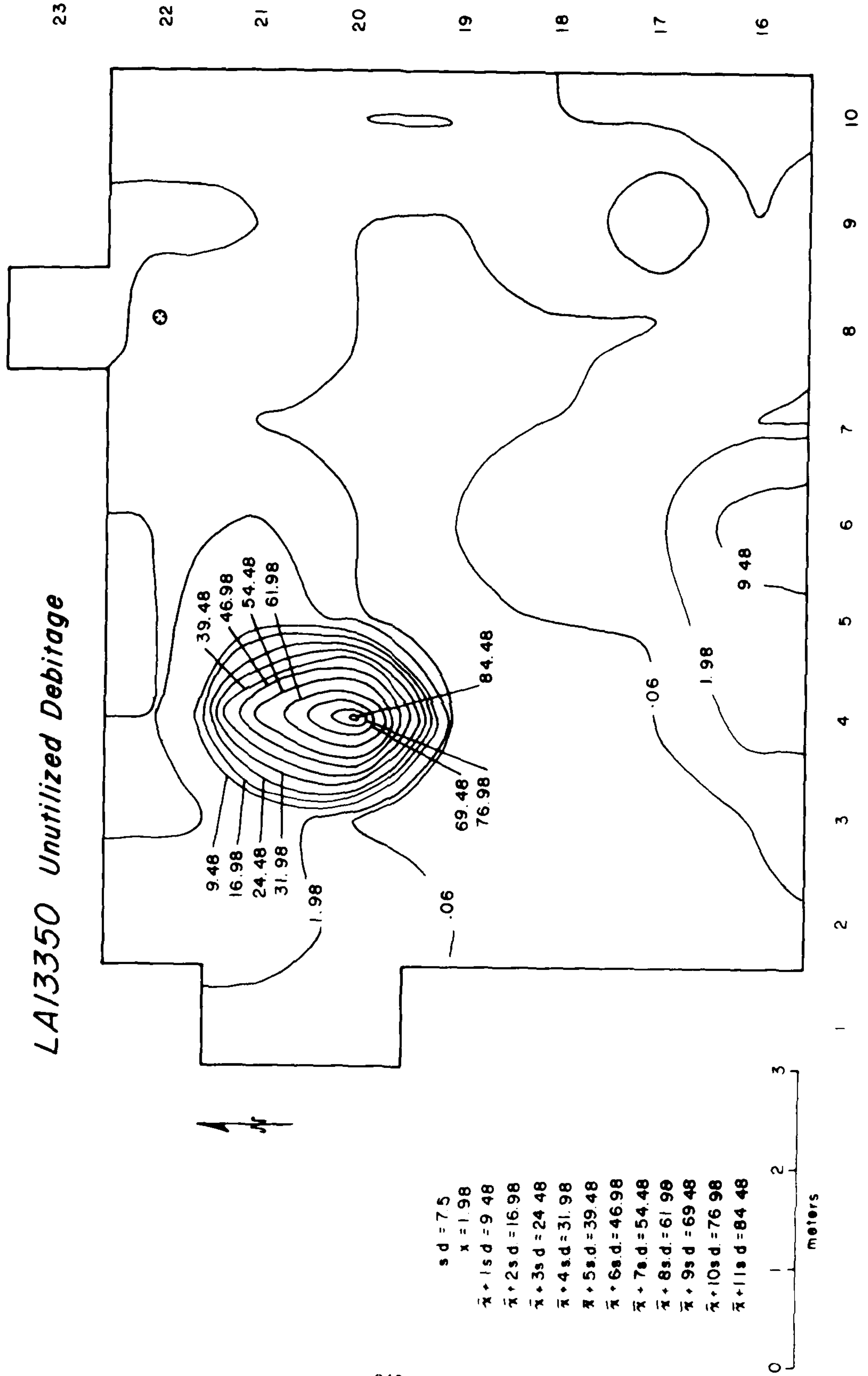


Fig. 19.5 LA 13350 -- distribution of unutilized debitage.

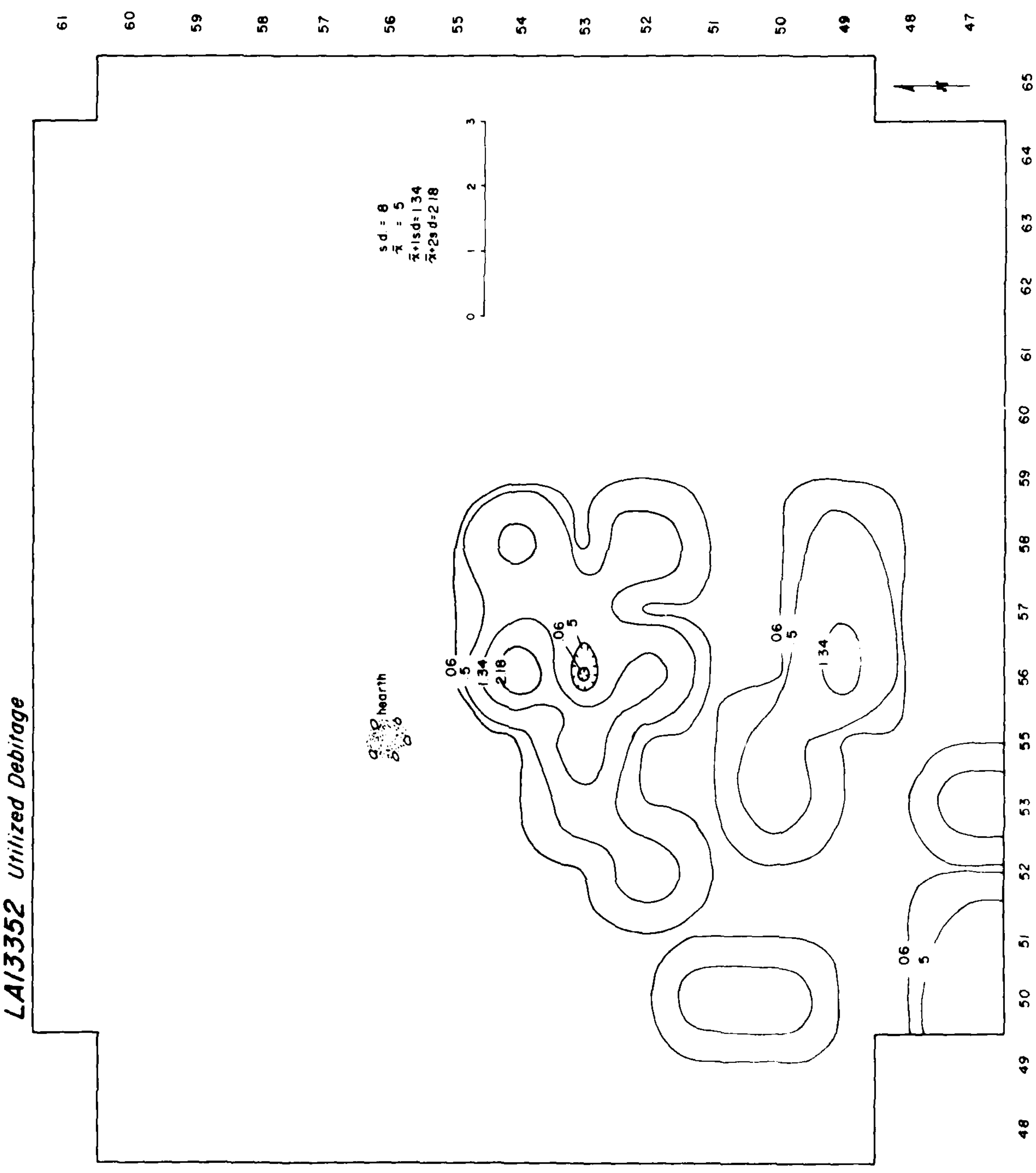


Fig. 19.6 LA 13352 — distribution of utilized debitage.

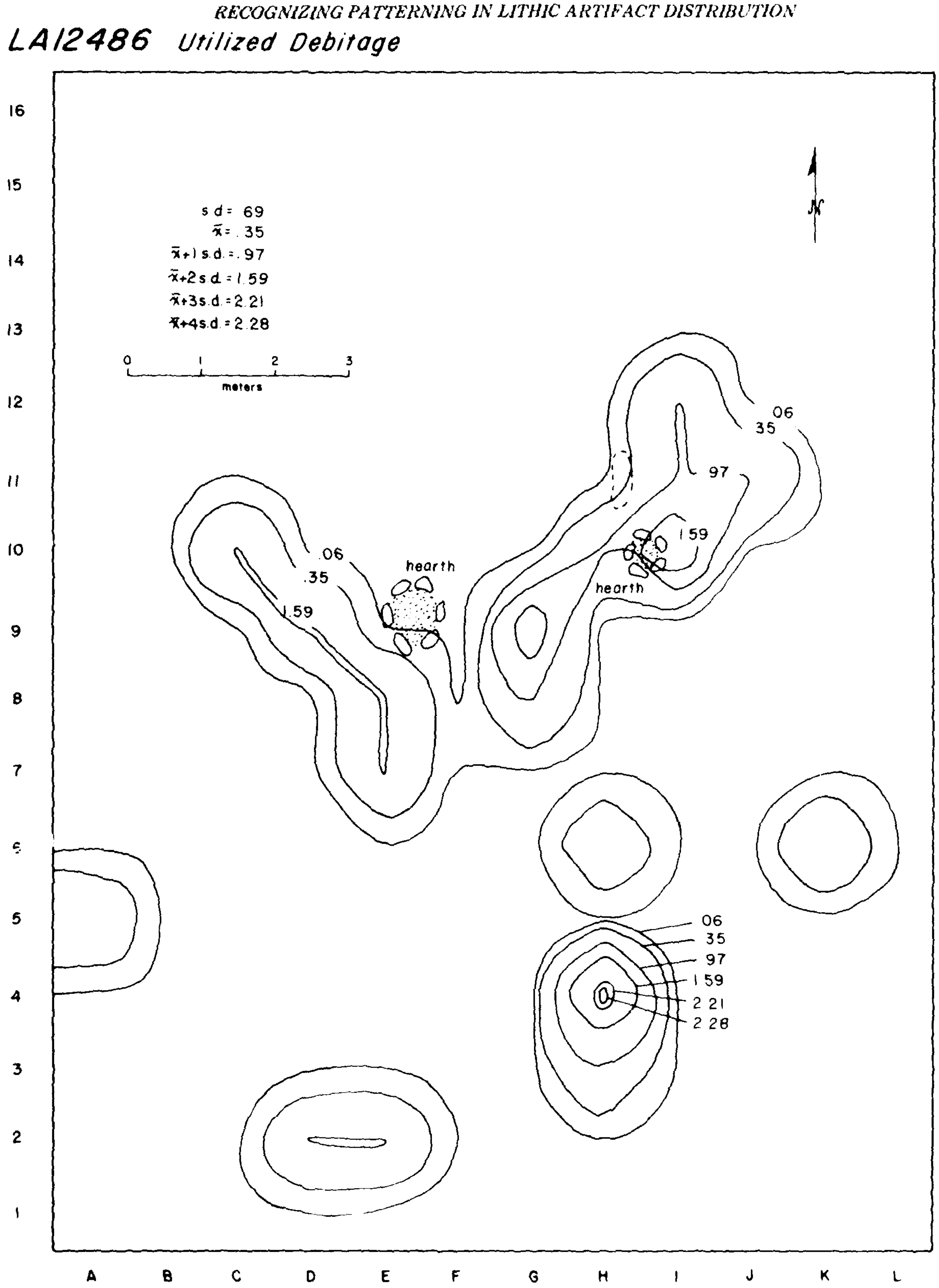


Fig. 19.7 LA 12486 – distribution of utilized debitage.

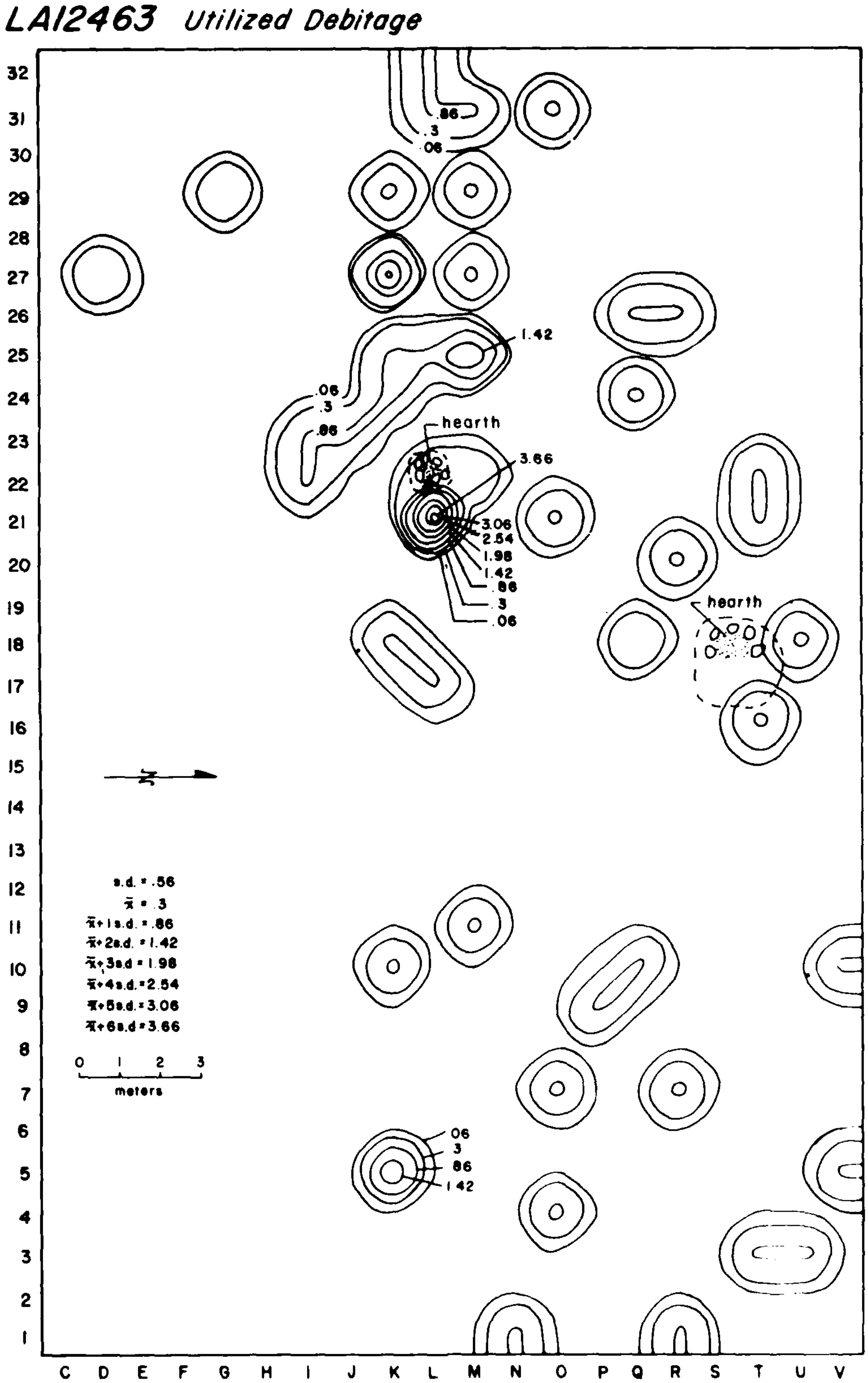


Fig. 19.8 LA 12463 — distribution of utilized debitage.

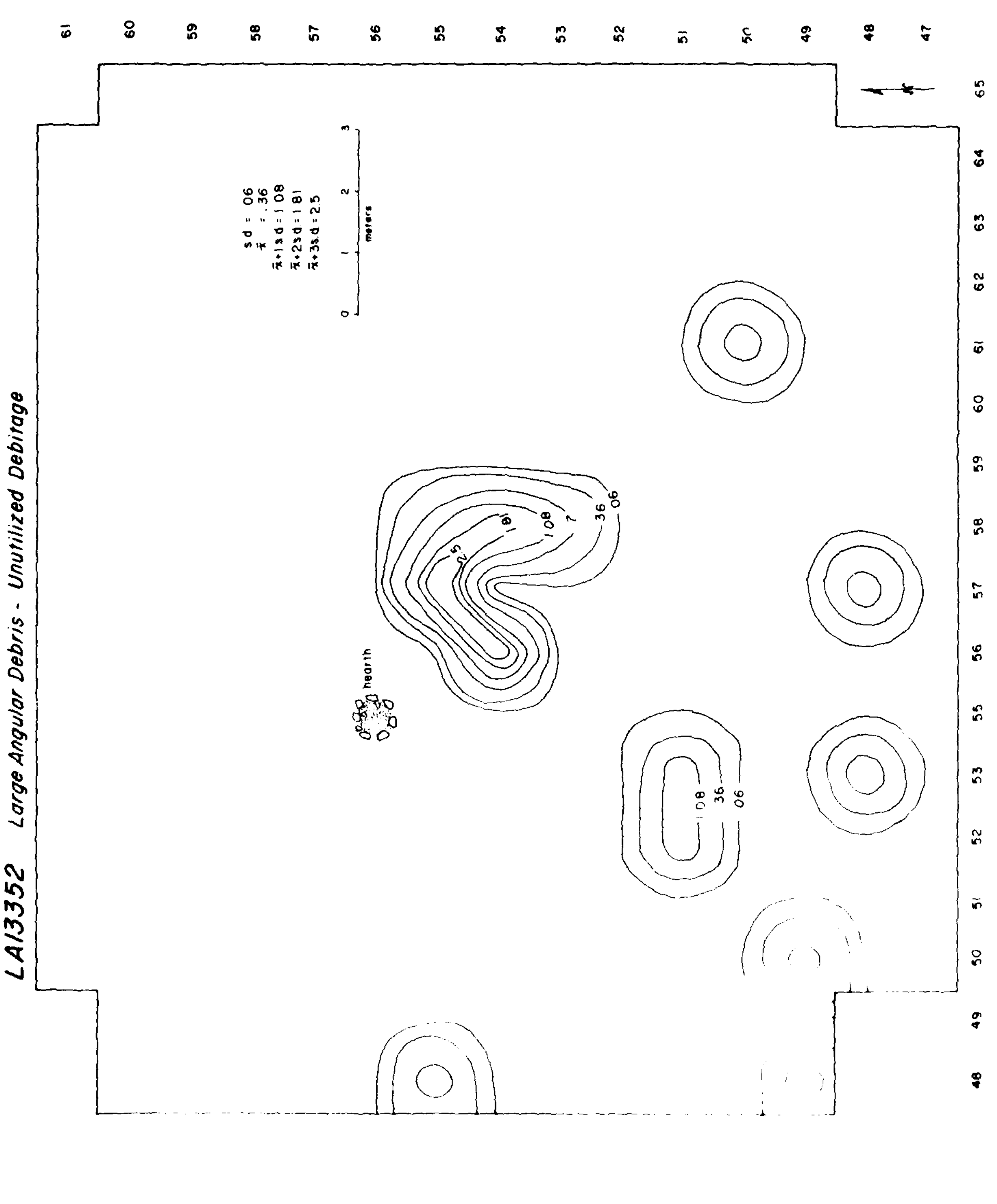


Fig. 19.9 LA 13352 – distribution of large angular debris and unutilized debitage.

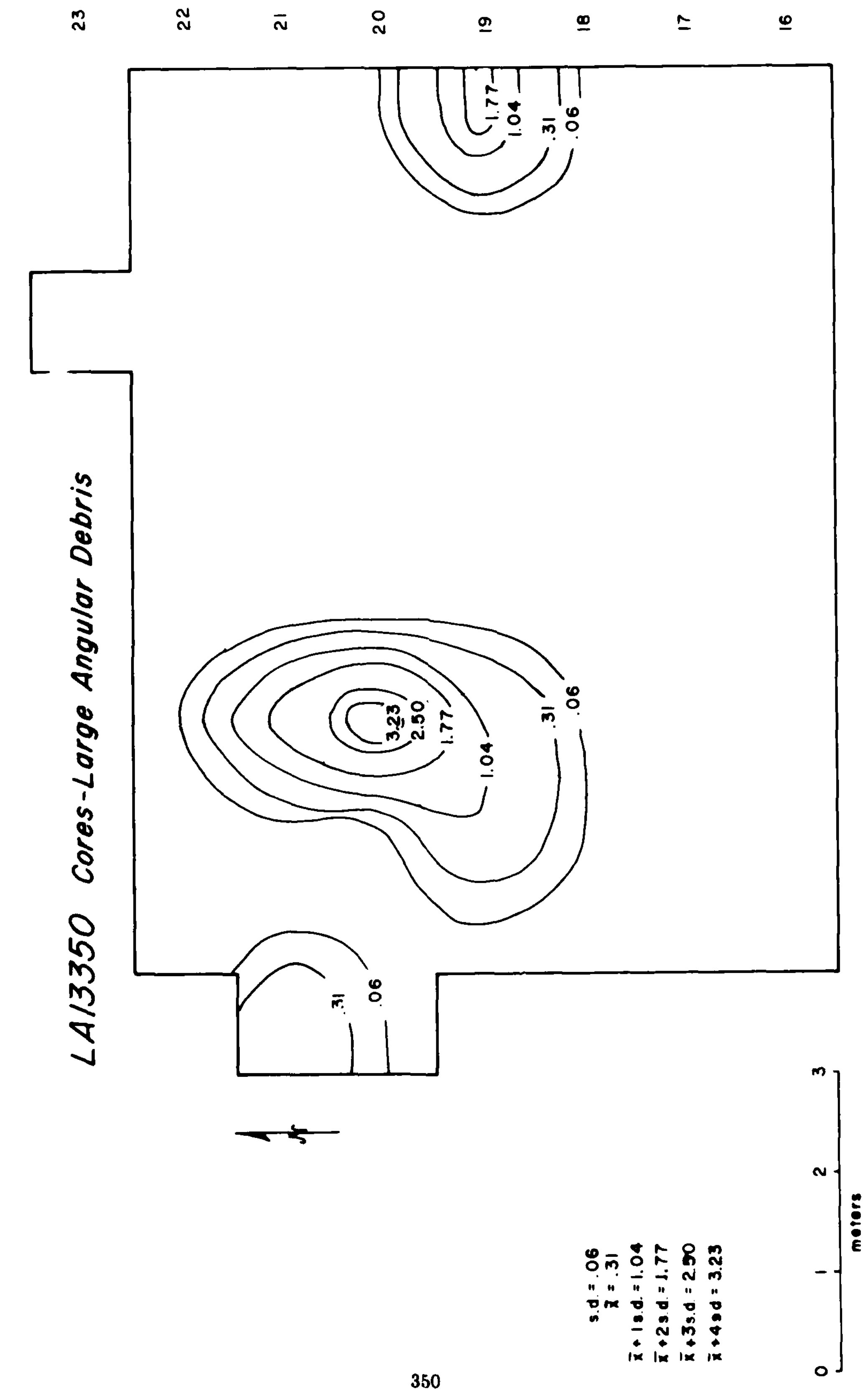


Fig. 19.10 LA 13350 — distribution of cores and large angular debris.

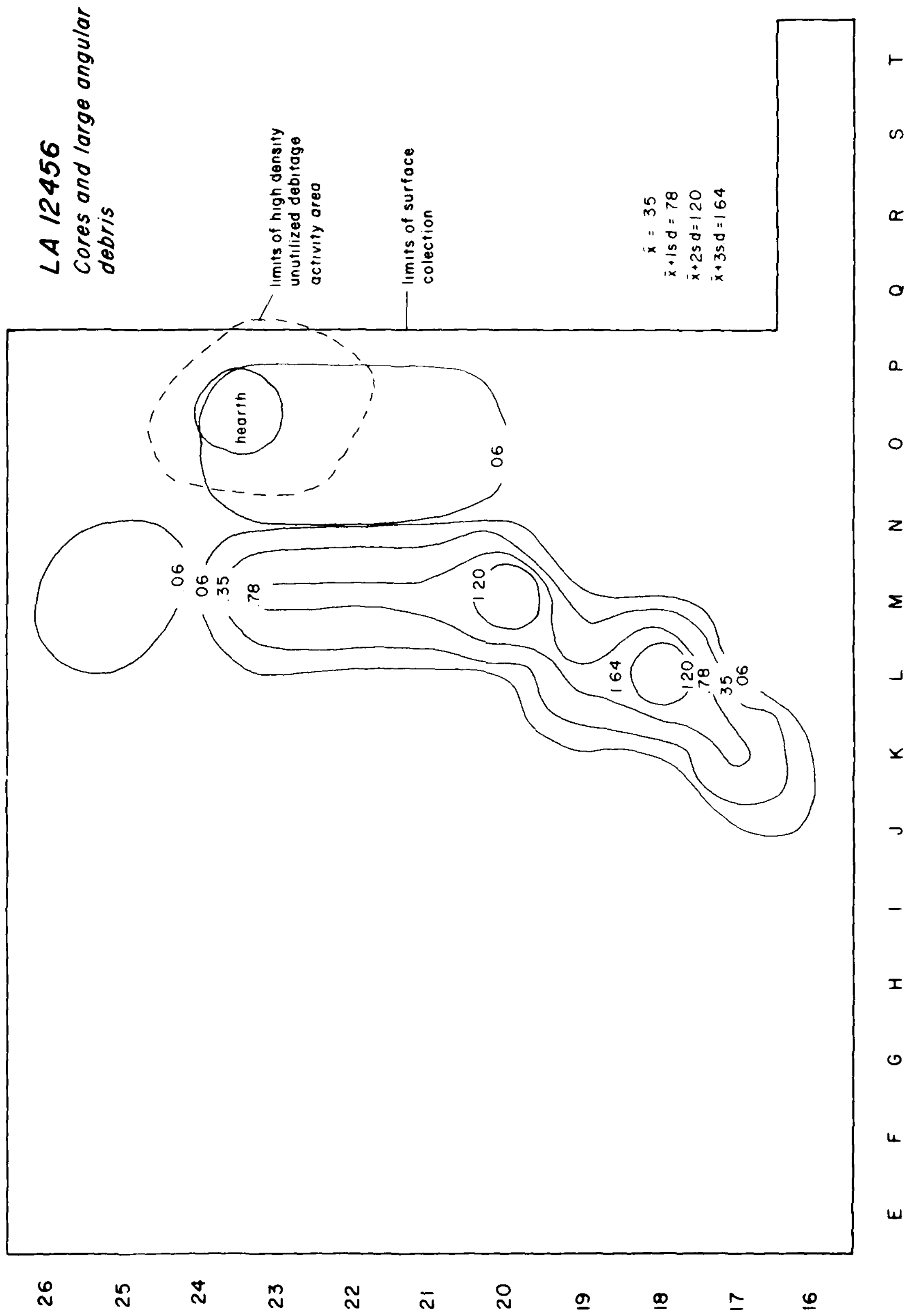


Fig. 19.11 LA 12456 — distribution of cores and large angular debris in relation to total lithic artifacts.

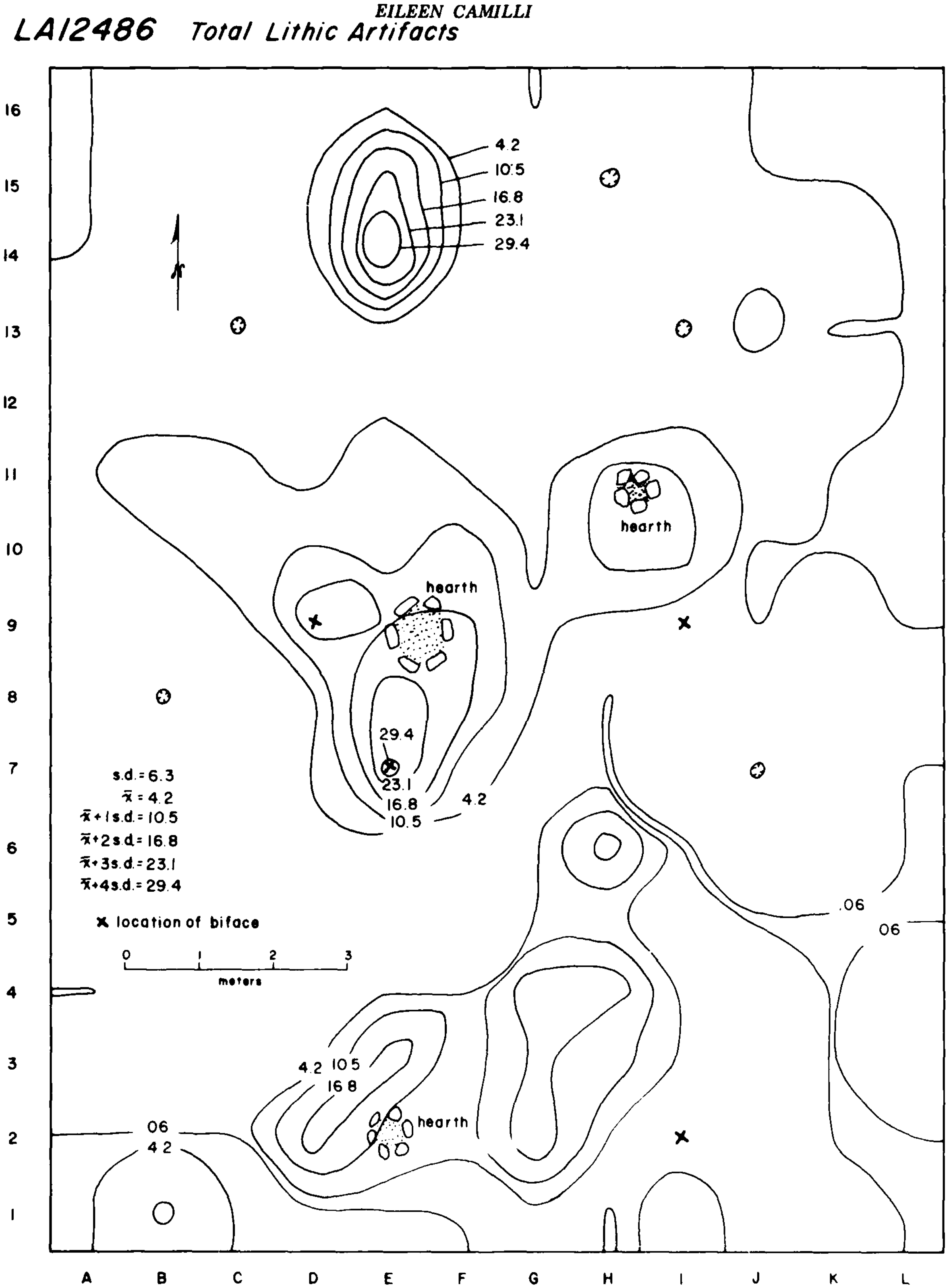


Fig. 19.12 LA 12486 – distribution of bifaces in relation to total lithic artifacts.

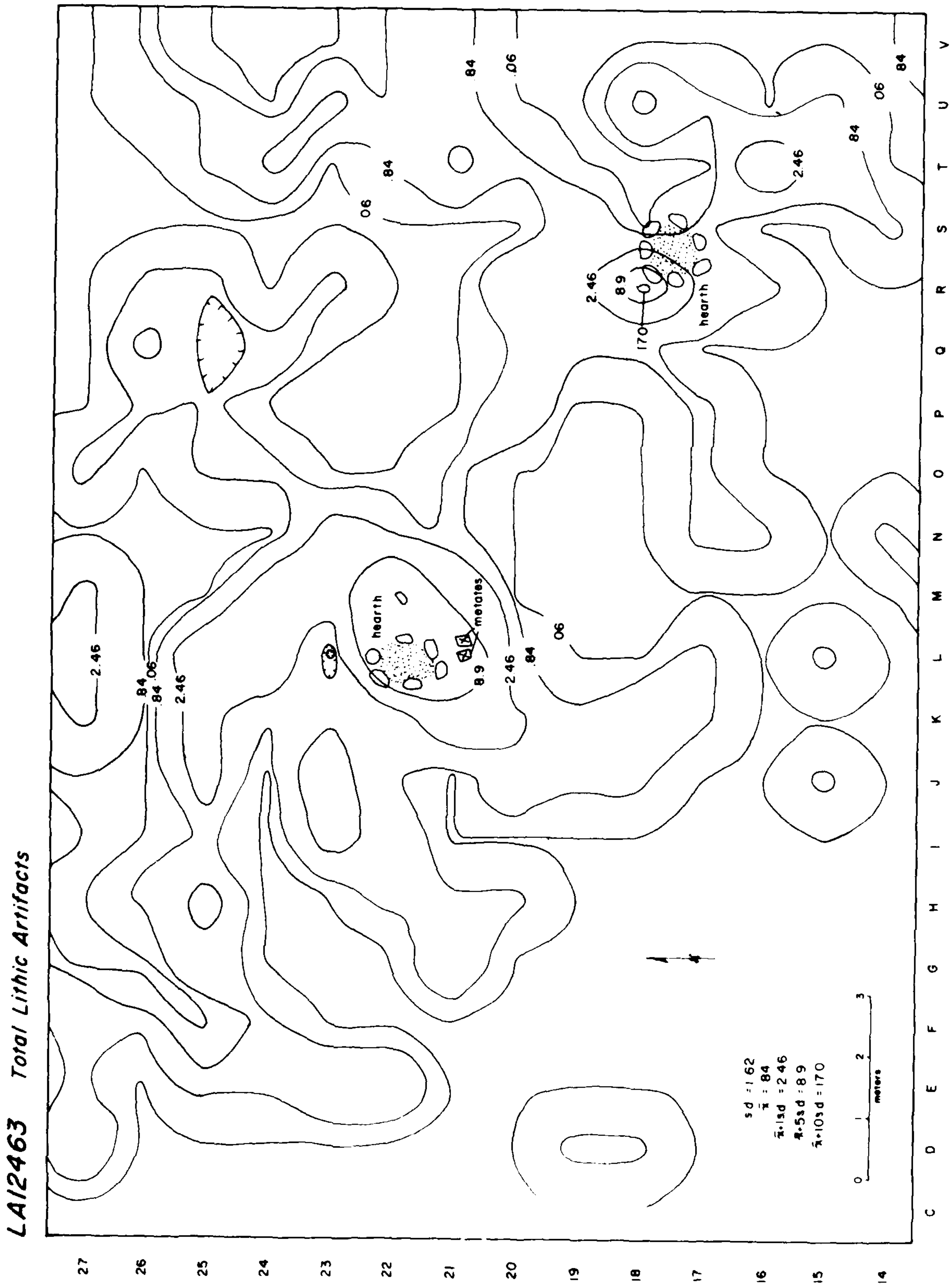


Fig. 19.13 LA 12463 – distribution of total lithic artifacts.

Chapter 20

POST-DEPOSITIONAL EDGE DAMAGE ON LITHIC ARTIFACTS: AN EXPERIMENT IN SCREENING AND LABORATORY PROCESSING

Jeanne A. Schutt

INTRODUCTION

Edge damage on lithic materials can result from both past use activities and post-depositional activities. If one is to determine past human activities from wear patterns found on lithic materials, it is necessary to identify edge damage produced only during past use activities. The small amount of research addressing this problem has produced two opposing conclusions. Some researchers feel that recent scars can be distinguished from those produced in past use activities where others feel the scars cannot be distinguished from wear patterns. Both conclusions seem premature without further experimentation. If conclusions about past tool utilization are to be drawn from wear pattern analysis, one must first isolate edge damage not resulting from former use activities.

In order to assess the degree to which certain nonuse factors are producing edge damage that may be interpreted as wear patterns, two experiments were undertaken. The experiments were designed to assess: (1) whether archeological recovery and processing procedures, such as screening, transportation and laboratory processing, result in significant amounts of edge damage; (2) whether edge damage produced through recovery and processing procedures is similar to edge damage resulting from tool use; (3) whether different kinds of lithic materials are differentially susceptible to nonuse edge damage; and (4) whether objective criteria can be developed that can be used to isolate nonuse edge damage from that produced in past use activities.

Although many experiments designed to assess edge damage produced through recovery and laboratory processing are in progress, little information has been published. Several individuals have in the past or are currently investigating the effects that excavation technique, screening, and transportation have on lithic materials, but the results of many of these experiments are either incomplete or unpublished (Lawrence, personal communication; Muto, personal communication; Shelly, personal communication; Tringham, personal communication).

Tringham et al. (1974) have published one of the few articles that addressed the problem of nonuse edge damage. Two basic experiments are documented; one to evaluate the effect of trampling, and the other to evaluate the effect of water, sand and rock action. She concluded that edge damage produced in these contexts could be distinguished from wear patterns on the basis of inconsistent scar directionality, random placement of scars on a given edge, and differential scar morphology (Tringham et al. 1974:191-192). Several investigators support her findings. Other researchers, however, suggest that there are *no* differences between post-depositional edge damage and edge damage produced through use activities (Hayden and Kaminga 1973:4).

The existence of two such diametrically opposed conclusions suggests that further experimentation is necessary. These varying conclusions may largely be a function of poor experimental design and small sample size. Keeley (1974:326) suggests that some experimenters have used nonrepresentative samples and inadequate experimental controls. Many times critical variables have either been neglected or not recorded at all. Odell (1975:227) offers similar criticism. He feels that experimental data should be reported meticulously to facilitate its use by other researchers and that sufficient data should be published so that others may replicate the experiment(s). He suggests three major variables that must be described to make this possible; (1) exact description of the action performed; (2) exact description of the material worked; and (3) exact description of the results.

The relative lack of detailed published material which deals with post-depositional edge damage, coupled with the lack of scientific or methodological rigor characteristic of a number of published studies, indicate a need for additional experimentation in this area. The experiments presented in this chapter attempt to correct both of these problems.

EXPERIMENTAL DESIGN

The following experiments were designed to determine the degree to which recovery and laboratory processing of lithic materials are producing edge damage that may be interpreted as wear patterns. For comparative purposes, two different experiments were run on two similar populations of flakes. This was done to isolate the kind and amount of edge damage resulting from transportation and laboratory processing versus that resulting from screening. Another objective of these experiments was to determine if different kinds of edge damage result from each of the two experimental actions, and whether that resultant edge damage is similar to edge damage resulting from use. A variety of lithic materials were included in each experiment to determine if each experimental action is affecting the various natural materials differentially. A final objective was to determine if a set of criteria could be amassed that would aid in isolating edge damage resulting from nonuse activities. Several variables were monitored to reach these ends. The experiments will be outlined after all variables are described.

VARIABLES

Materials

Five different categories of raw materials were selected on the basis of their varied fracturing properties and crystalline structure. Although the raw materials used in the experiments were collected from the Cochiti Reservoir area, it is felt that the range of siliceousness and hardness is representative of a wide range of materials found in lithic assemblages across the country.

The materials selected for experimentation include quartzite (4000), basalt vitrophyre (3701), chert (1051), chalcedony (1215), and obsidian (3520). The reader is referred to Warren (1977a; this volume) for details concerning the lithology of these taxa. As a general statement, the materials range from relatively uncompact, less siliceous structure (quartzite, basalt and chert) to relatively uniform, highly siliceous structure (chalcedony and obsidian).

Flake Production

Flakes were manufactured by Janette Elyea. The technique of manufacture was direct percussion with a hard hammer. Flake production was aimed at generating two populations of 10 flakes of each material taxon which fell within a range of morphological constraints. The attributes used for selection of flakes are described below.

Flake Selection

Flakes were selected on the basis of three morphological attributes: flake size, edge angle, and edge morphology. Flake size was selected to apporoximate the range of utilized flake size, in each material category, represented in lithic assemblages recovered from sites in the Cochiti Reservoir locale. Particular edges were selected, within each size category, to represent a range of variability in edge angles, generally between 18 and 81 degrees. All edges were formed by the intersection of two non-cortical surfaces.

Flake Attributes Monitored

1. Material: by taxon
2. Dimensions:
   a. Length: Measured in millimeters along the proximal/distal axis.
   b. Width: Measured in millimeters as the widest distance between both lateral sides along an axis at 90 degrees to the proximal/distal axis of the flake.
   c. Thickness: Measured in millimeters.
3. Weight: To the nearest 1/10 of a gram.
4. Edge Angle: The angle in degrees that is produced by the intersection of dorsal and ventral surfaces or what Tringham described as the spine-plane angle (Tringham et al. 1974:179).
5. Edge Outline: The edge outline is the gross outline shape of the edge perimeter with respect to the long axis of the edge. Four categories of edge outline were monitored: concave, straight, convex and concave/convex. For the purpose of these experiments, projections were not used.
6. Length of Edge: Measured in millimeters to be used in the quantification of scar patterns produced.

Scar Patterns

The various scars monitored were based on microscopic observations of lithic assemblages recovered from the field and laboratory experimentation directed toward the production of wear patterns. The following definitions are abstracted from Chapman and Schutt (1977:89-90).

1. Feathered Scars: *"Feathered scars produced through usage of an edge perimeter are morphologically similar to many scars produced through retouch, in that the distal and lateral portions of the scars 'feather out' to meet the debitage surface rather than terminate in abrupt fracture. Such scars are termed 'scalar scars' by Tringham et al. (1974:188) and are considerably smaller in overall size and depth than those produced through retouch."*

Two types of feathered scars were monitored, those with their proximal/distal axes oriented perpendicular to the edge perimeter, and those with their proximal/distal axes oriented at varying angles less than 45^0 to the edge perimeter.

2. Step Fracture: *"Step fractures are negative scars originating from an edge perimeter which terminate at their distal end in abrupt 'steps' or cleavages. . . (which are morphologically similar to macroscopically observed hinge features produced occasionally through debitage manufacture.) Step fractures have been well documented in wear pattern research, and have been variously referred to as 'step flakes' (Ahler 1970), 'step scars' (Tringham et al. 1974) or 'step fractures' (Crabtree and Davis 1968)."*

Two types of step fractures were recorded: those with their proximal/distal axes oriented perpendicular to the edge perimeter, and those with their proximal/distal axes oriented at varying angles less than 45^0 to the edge perimeter.

3. Crescentic Scars: *"Crescentic scars are microscars which have resulted in detachment of a portion of the edge margin and equal portions of both flake surfaces adjoining the edge margin. These scars appear as shallow concave 'scoops' along the edge margin. The distinguishing characteristic of crescentic scars is that, unlike other microscars, they do not occur on either surface adjoining an edge margin, but rather represent portions of edge margin which have been completely detached through usage."*

Odell described these scars as *sliced* or *half moon* (Odell 1975:232).

4. Nibbling: *"Nibbling (for lack of a more elegant term) is observed as relatively continuous sets of extremely small feathered scars situated on one or both surfaces adjoining the edge margin. 'Nibbling' scars are thus morphologically similar to feathered scars, but significantly smaller in length, width and depth."*

For the purpose of quantification, schematic drawings of ventral and dorsal sides of each edge recorded the position, number and consistency of scars before and after each experiment. Scars above each line illustrate scars that were present prior to the experiments and those below the line indicate those resulting from the experiments. To aid further in quantification, a photograph of one side of each edge was taken before and after each experiment. Financial constraints did not permit photographs of both sides of each edge. Photographs were taken by Martha R. Binford with a Polaroid MP-3 Copy Camera. Photographs at lowest magnification were taken with a 100 mm lense. A 75 mm lense was used to photograph certain edges at higher magnification. Low grain, 120 Panatomic X Professional Film was used. (Photographic examples are included as Figs. 20.1--20.3.) Lighting was adjusted for each specimen to accentuate scar patterns. Further information on photographic procedures can be obtained from the Office of Contract Archeology.

TRANSPORTATION AND LABORATORY PROCESSING EXPERIMENT

1. Fifty flakes (10 of each material taxon) were selected for specific attributes previously mentioned.

2. Flakes were numbered and the edge to be studied labeled with India ink. Edges were labeled so marks would not interfere with future identification of scar patterns. Edges were also identified by their location on each flake (right lateral, proximal, distal, etc.).

3. All flake and edge attributes were recorded (see Table 20.1).

4. Edges were examined microscopically at a magnification between 30x and 70x and pre-experimental edge damage was described and illustrated on schematic drawings (see Fig. 20.4). At this point, specimens were wrapped and bagged individually to prevent any added edge damage.

5. To aid in quantification, pre-experimental photographs of each edge were taken.

6. The flakes were deposited in a #10 bag and transported for a distance of 200 miles. This 200 miles included 166 miles of paved road and 34 miles of dirt road. The distance of 200 miles was selected to replicate the average distance traveled with artifacts, from the time of their excavation to the time they reach the laboratory, during the course of the Cochiti Reservoir Project excavation phases.

7. Upon arrival at the laboratory, the bag of flakes underwent sorting, washing, labeling and cataloguing procedures standard at the Office of Contract Archeology. The bag of flakes was first emptied on a table (sorting of artifacts). The flakes were then placed in a basket lined with window screen and submerged in water for 5 minutes (occasionally shaking the basket). The flakes were then placed on a screen drying rack. Once dry, the flakes were rebagged and the bag was given a laboratory catalogue number. At this time the bag was placed in an area awaiting individual artifact labeling. Lithics were again dumped on a table, sorted by general material taxon, labeled consecutively, and rebagged a final time.

8. The bag of flakes was emptied a final time for microscopic analysis. Flakes were again reexamined microscopically and edge damage was described and recorded on schematic drawings. Flakes were deposited individually in air filled plastic bags to eliminate additional edge damage.

9. Photographs were taken of all edges.

10. Both pre-experimental and post-experimental photographs and schematics were compared.

SCREENING EXPERIMENT

1. Fifty flakes (10 of each material taxon) were selected for specific attributes mentioned earlier.

2. The flakes were numbered and the edges to be studied labeled with India ink. Edges were labeled so marks would not interfere with future identification of scar patterns. Edges were also identified by their location on each flake (right lateral, proximal, distal, etc.).

3. All flake and edge attributes mentioned previously were recorded (see Table 20.1).

4. Edges were examined microscopically at a magnification between 30x and 70x and edge damage was described and illustrated on schematic drawings (see Fig. 20.4). Specimens were wrapped in cotton and bagged individually to prevent additional edge damage before photographic documentation. The process of wrapping the individual flakes in cotton was abandoned later because residue of cotton fibers were sticking to the flakes and showing up in the photographs.

5. Photographs were taken of all edges.

6. The flakes were mixed with 38 liters of sandy soil and gravel. 3.78 liters of gravel ranged in size from 7.1 cm x 5.1 cm x 2.1 cm to 1.0 cm x .8 cm x .3 cm. The smaller gravel totaled 4.23 liters and generally measured .6 cm x .5 cm x .1 cm. Soils in the Cochiti Reservoir area are generally mixed with gravel, however, the mixture of gravel and sand employed in the experiments does not necessarily replicate ratios of gravel to sand found in that area. The quantification of gravel size, amount and ratio to sand, is merely for the purpose of controlling for variables affecting edge damage. This mixture of gravel and sand was placed in a ¼ inch mesh, galvanized, two man screen. The flakes were deposited in the soil and the materials were

screened until all soil had sifted away. The screening process necessitated 14 *shakes* of the screen (a *shake* representing one forward and backward motion). Trowels were note used to force the soil through the screen.

7. Flakes were deposited individually in air filled plastic bags to prevent further edge damage.

8. The flakes were examined microscopically and edge damage was described and illustrated on schematic drawings.

9. Photographs of edges were taken.

10. Photographs and schematics of pre-experimental and post-experimental edges were compared.

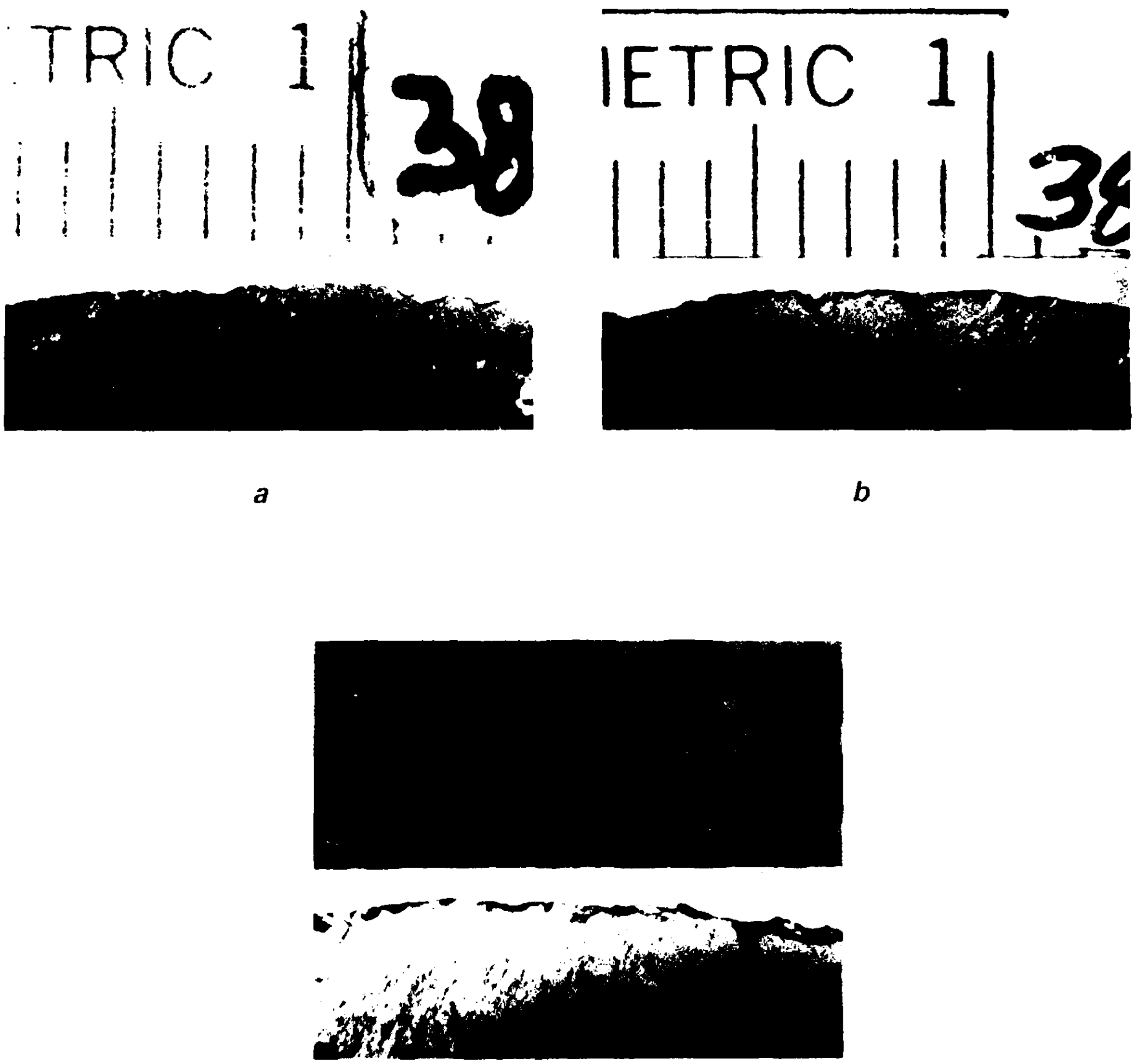


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Fig. 20.1 Acute obsidian edge #38: (a) edge before experiment; (b) edge after experiment; (c) edge after experiment at greater magnification.

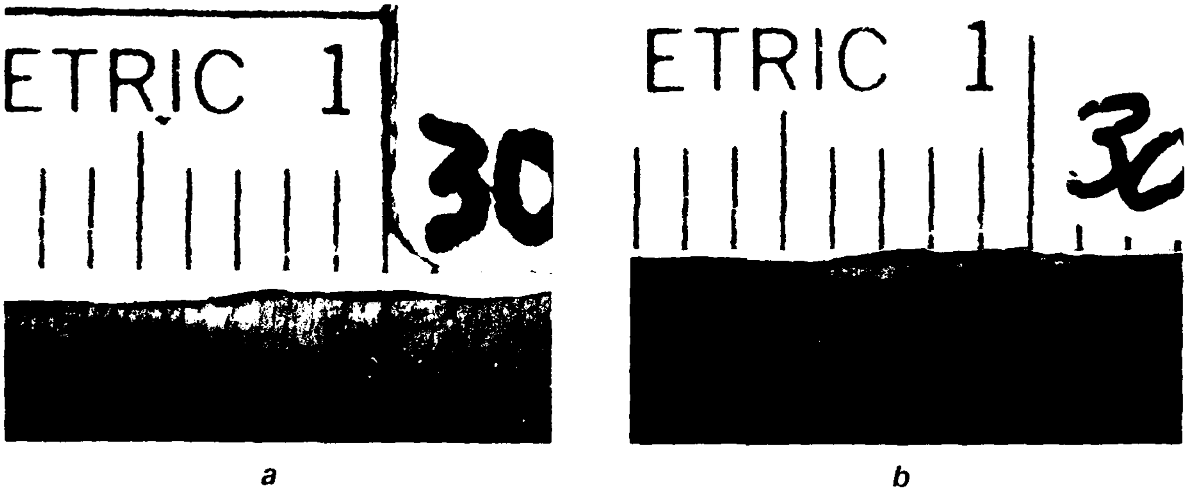


Fig. 20.2 Obtuse obsidian edge #30: (a) edge before experiment; (b) edge after experiment.

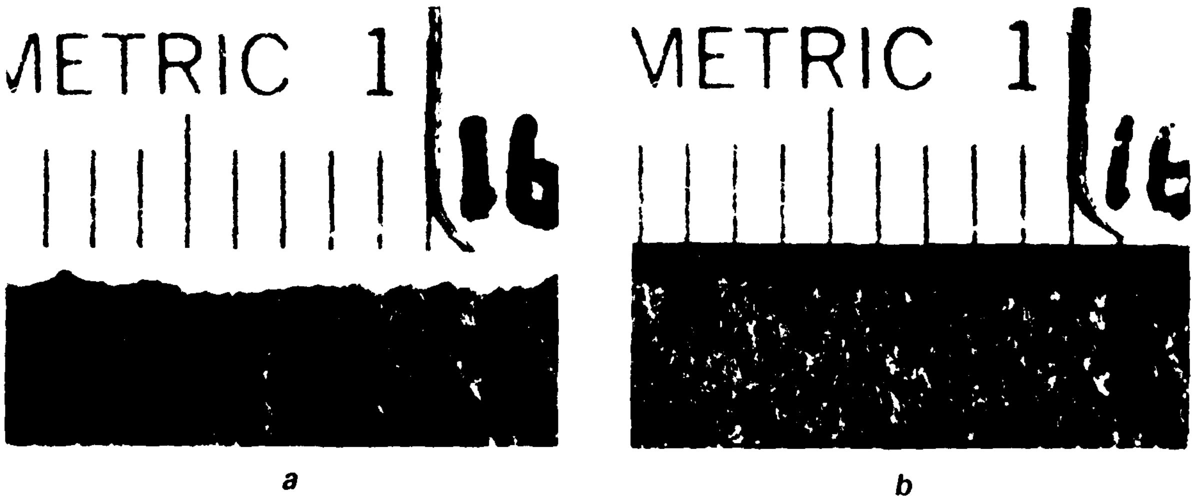


Fig. 20.3 Basalt edge #16: (a) edge before experiment; (b) edge after experiment.

KEY

Scars before the experiments (above the line)

- ○ Perpendicular Feather
- ▽ Angular Feather
- □ Perpendicular Step
- △ Angular Step
- Small Scoop
- Large Scoop
- ····· Nibbling

Scars after the experiments (below the line)

- ● Perpendicular Feather
- ▼ Angular Feather
- ■ Perpendicular Step
- ▲ Angular Step
- Small Scoop
- Large Scoop
- ····· Nibbling

Fig. 20.4 Distribution of scars.

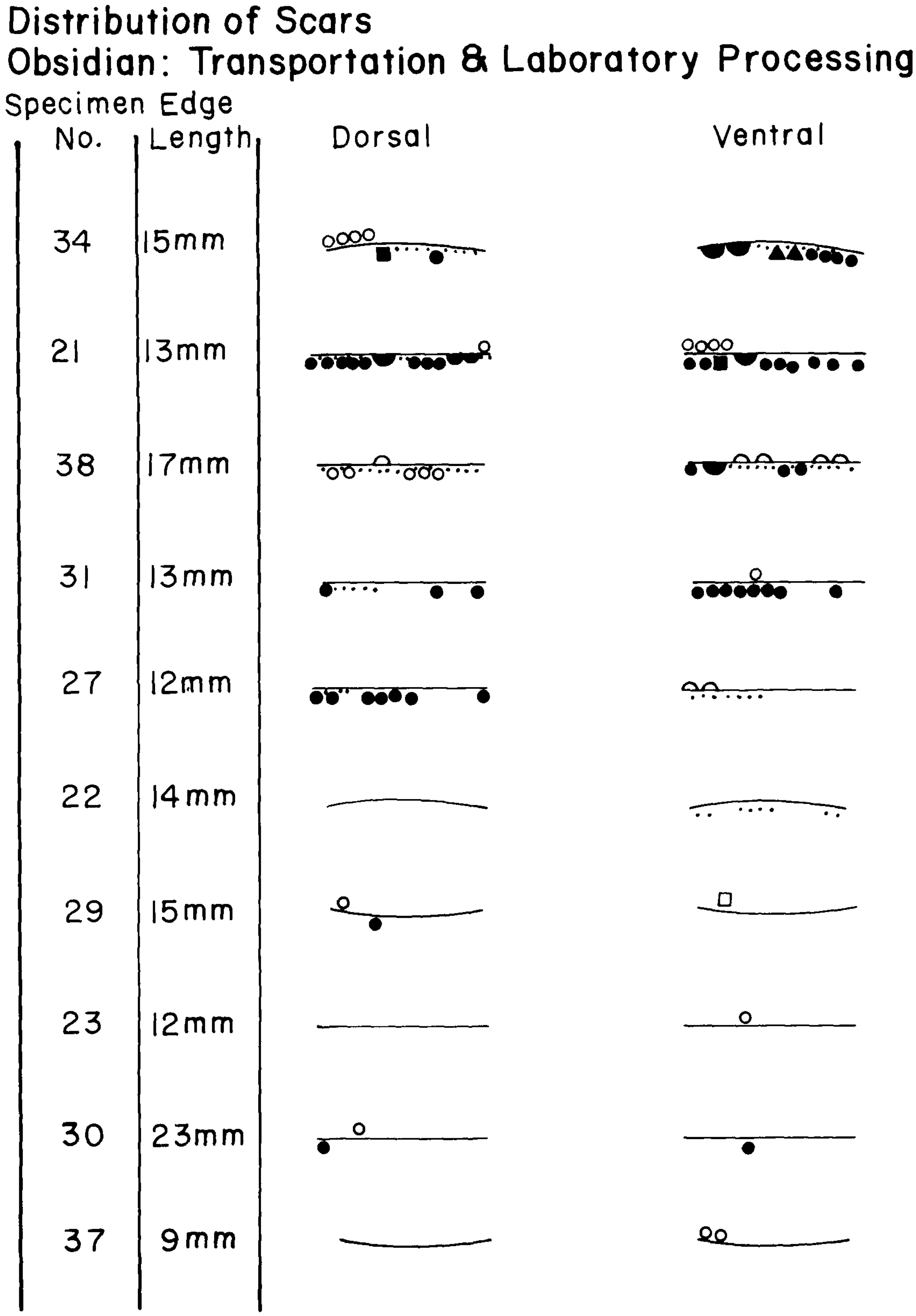
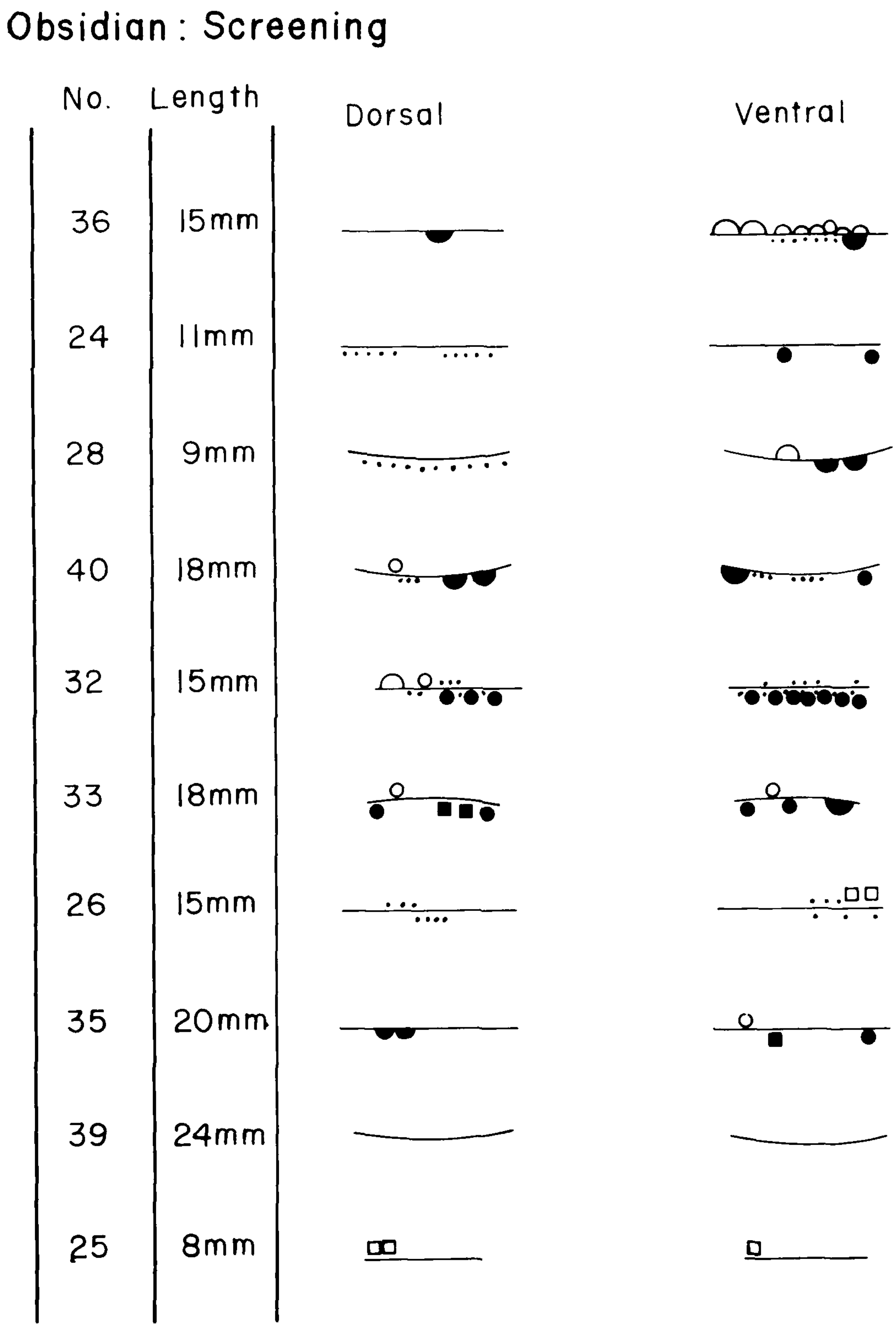


Fig. 20.4 (Continued)



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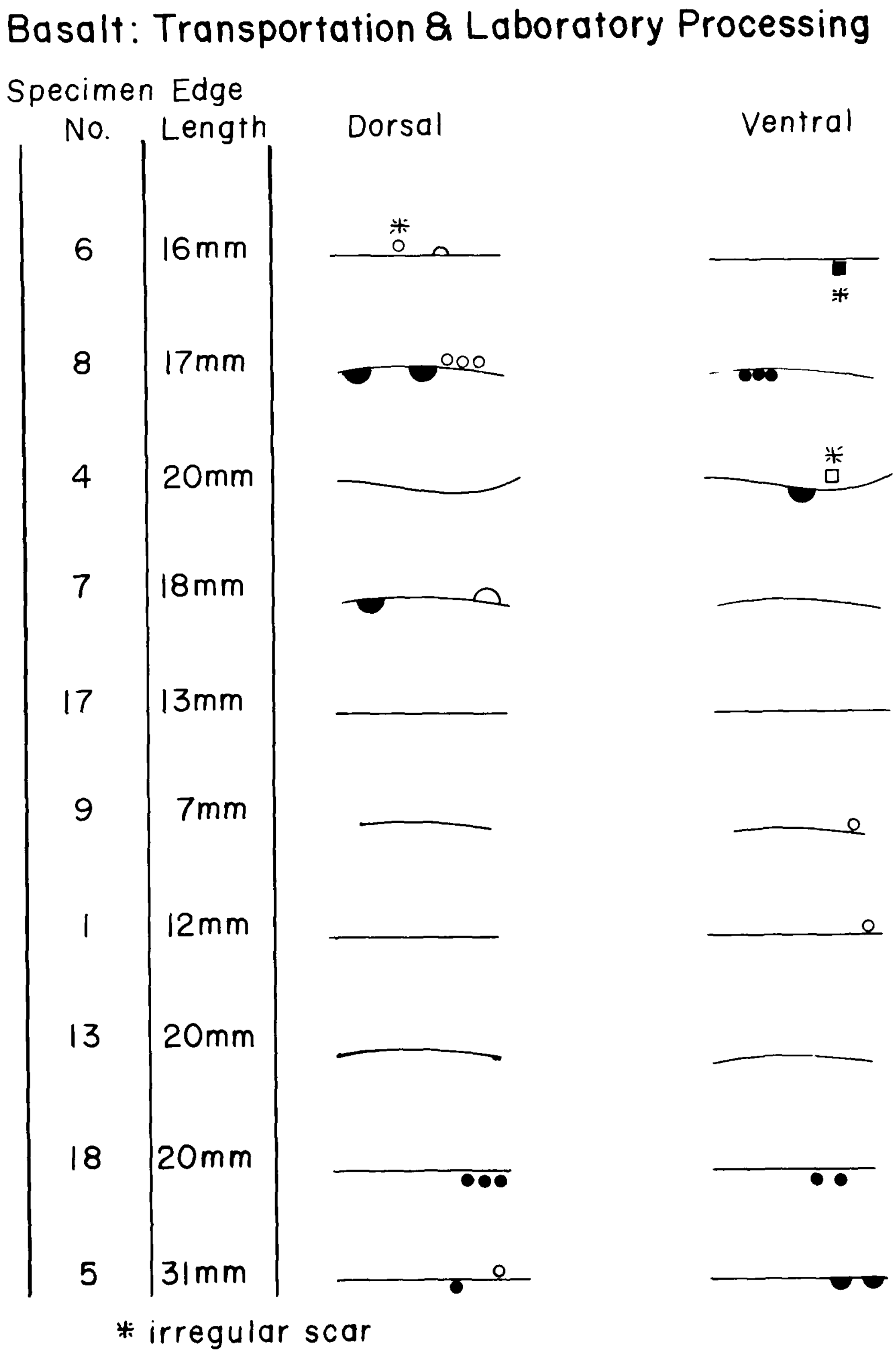

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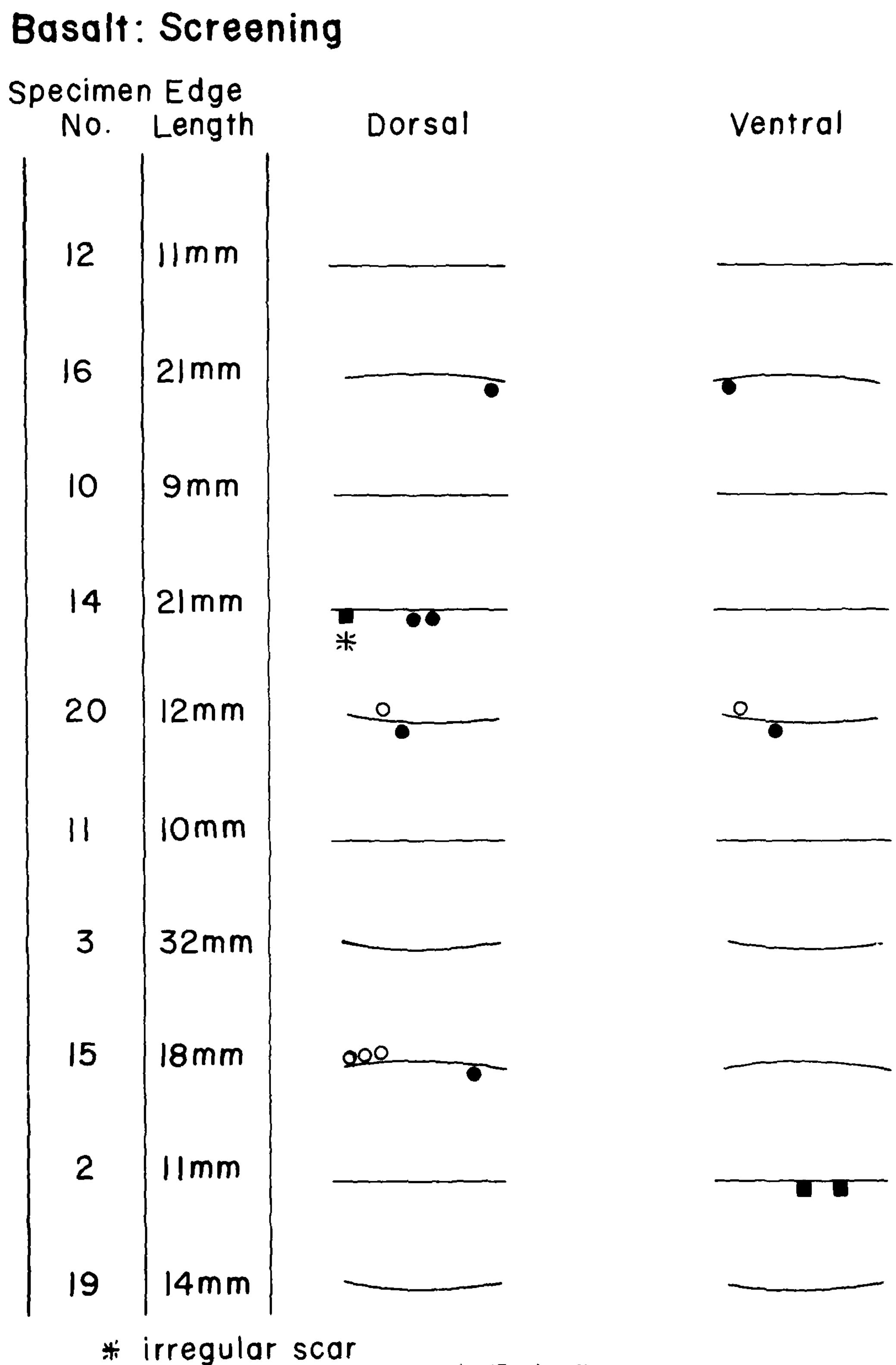


Fig. 20.4 (Continued)

Chert: Transportation & Laboratory Processing

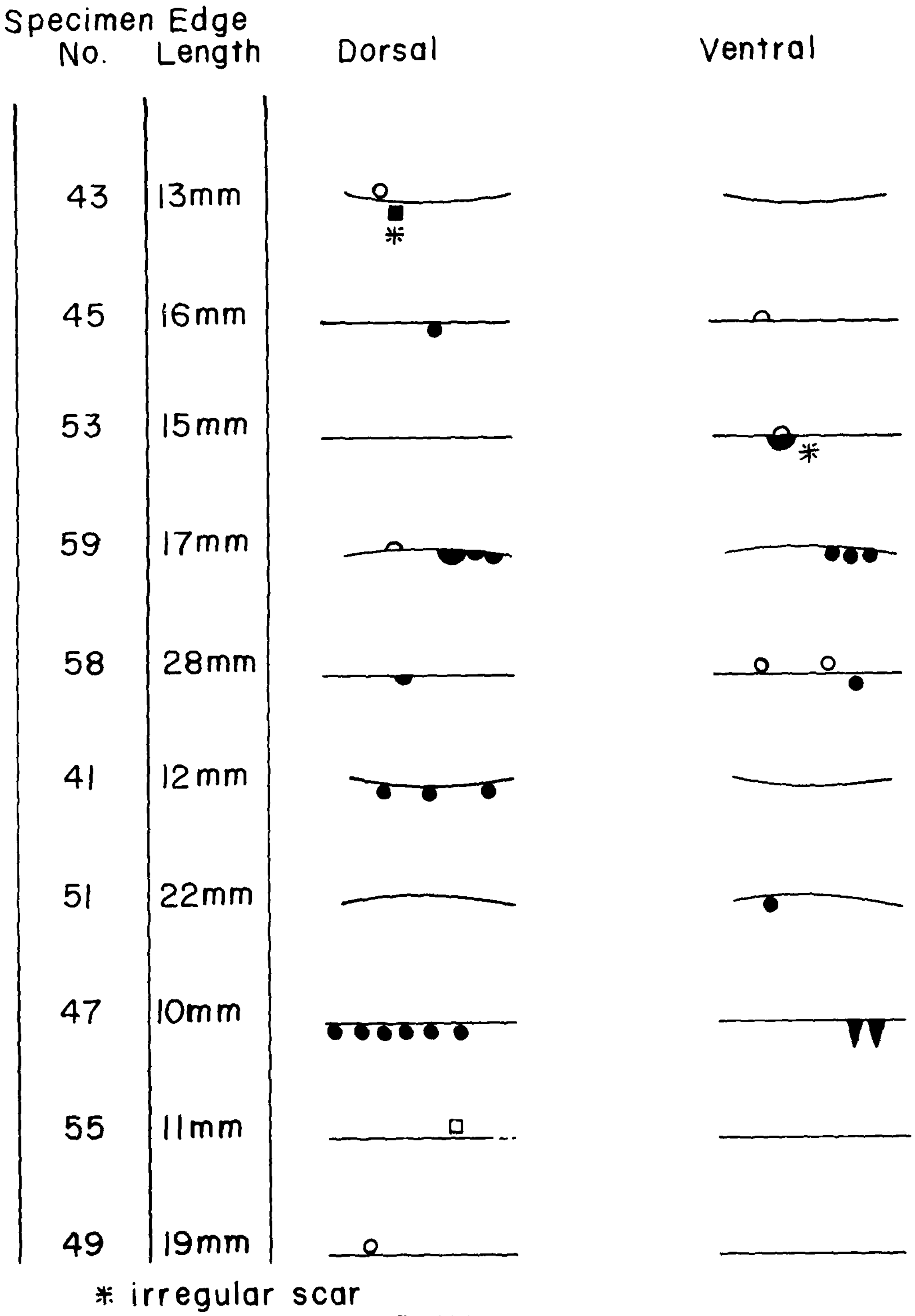
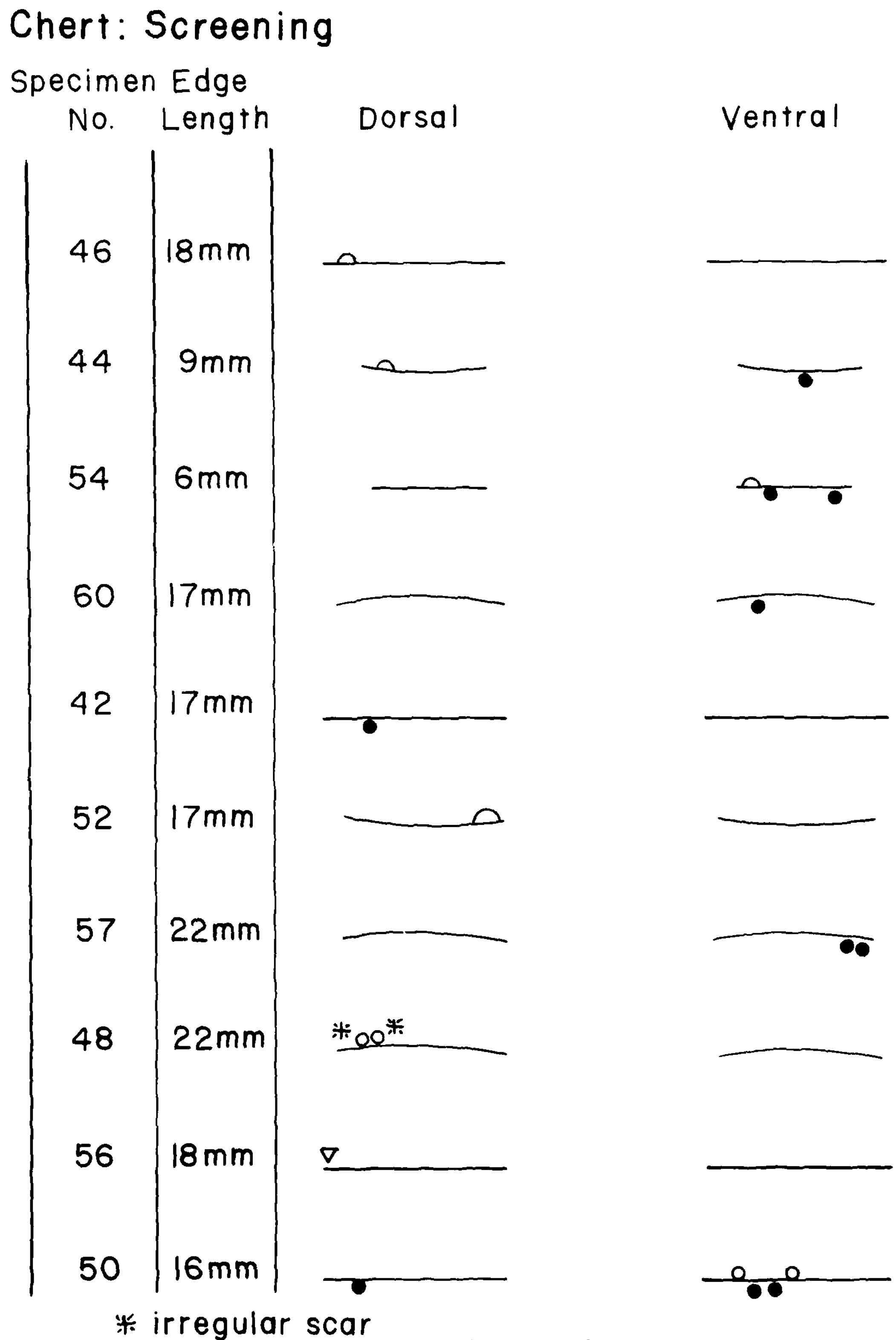


Fig. 20.4 (Continued)



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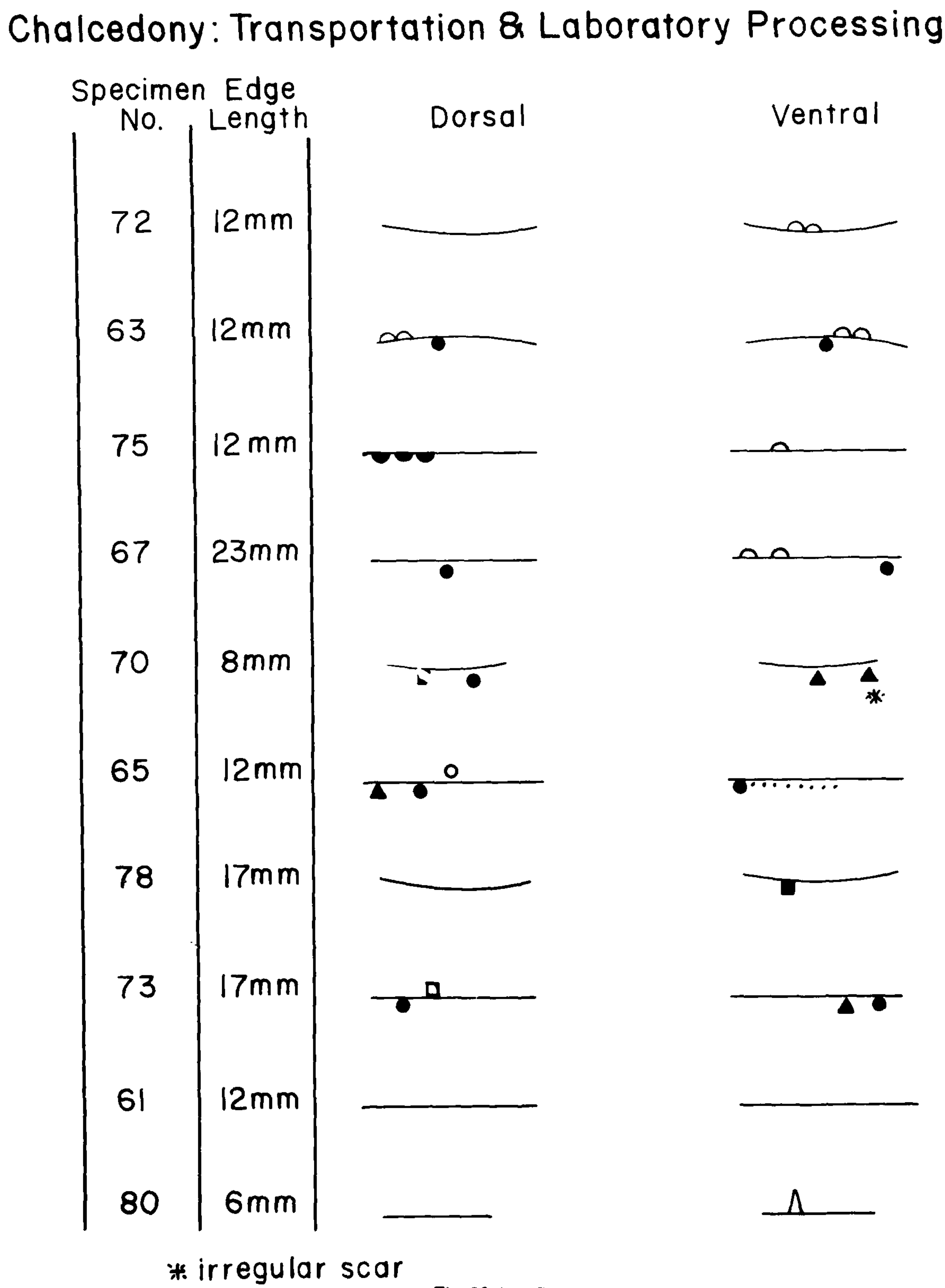

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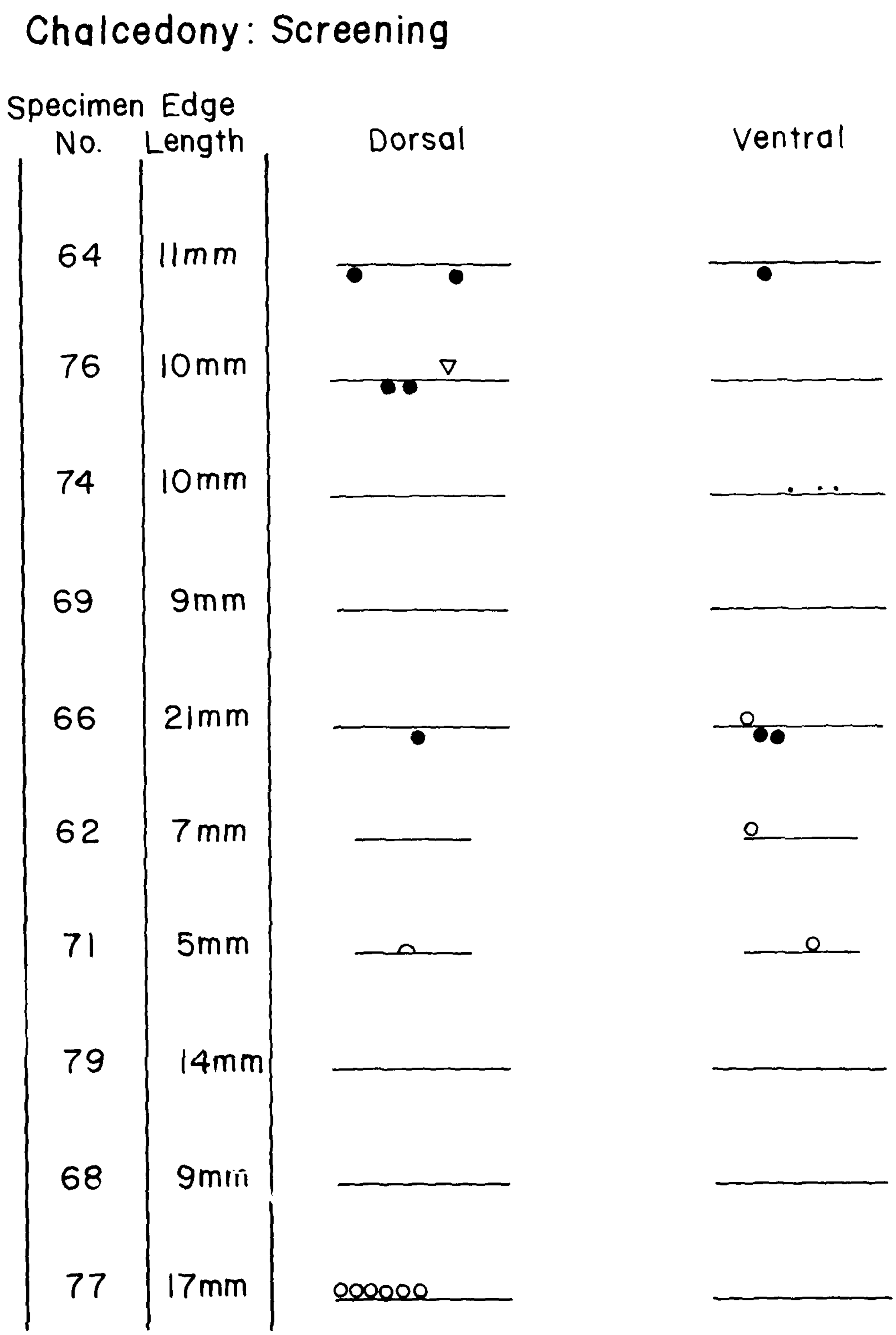

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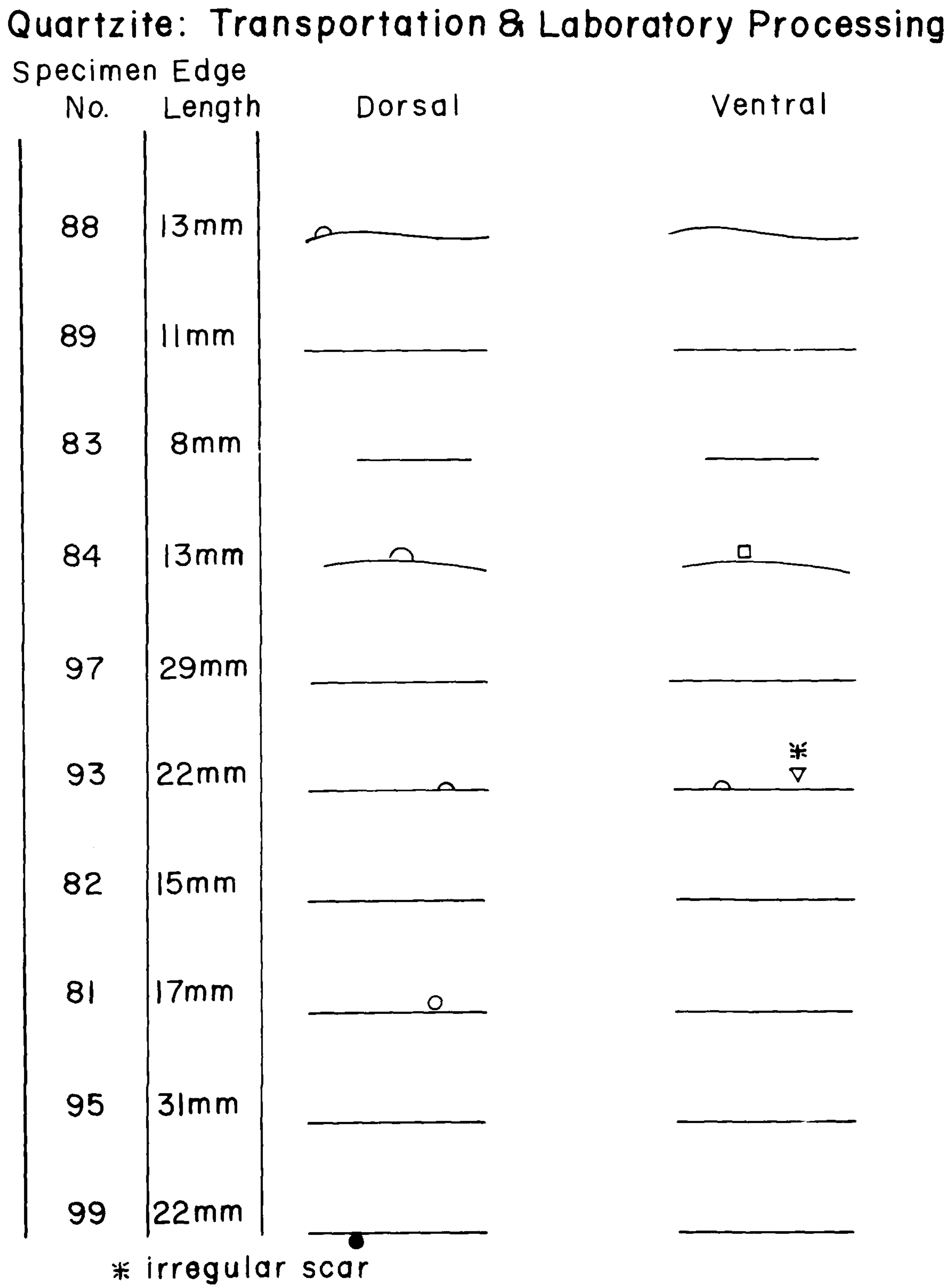

Fig. 20.4 (Continued)

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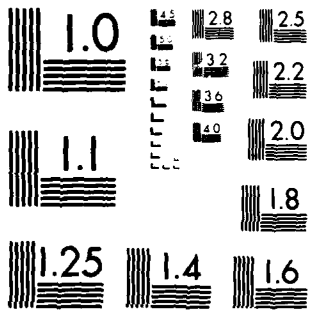

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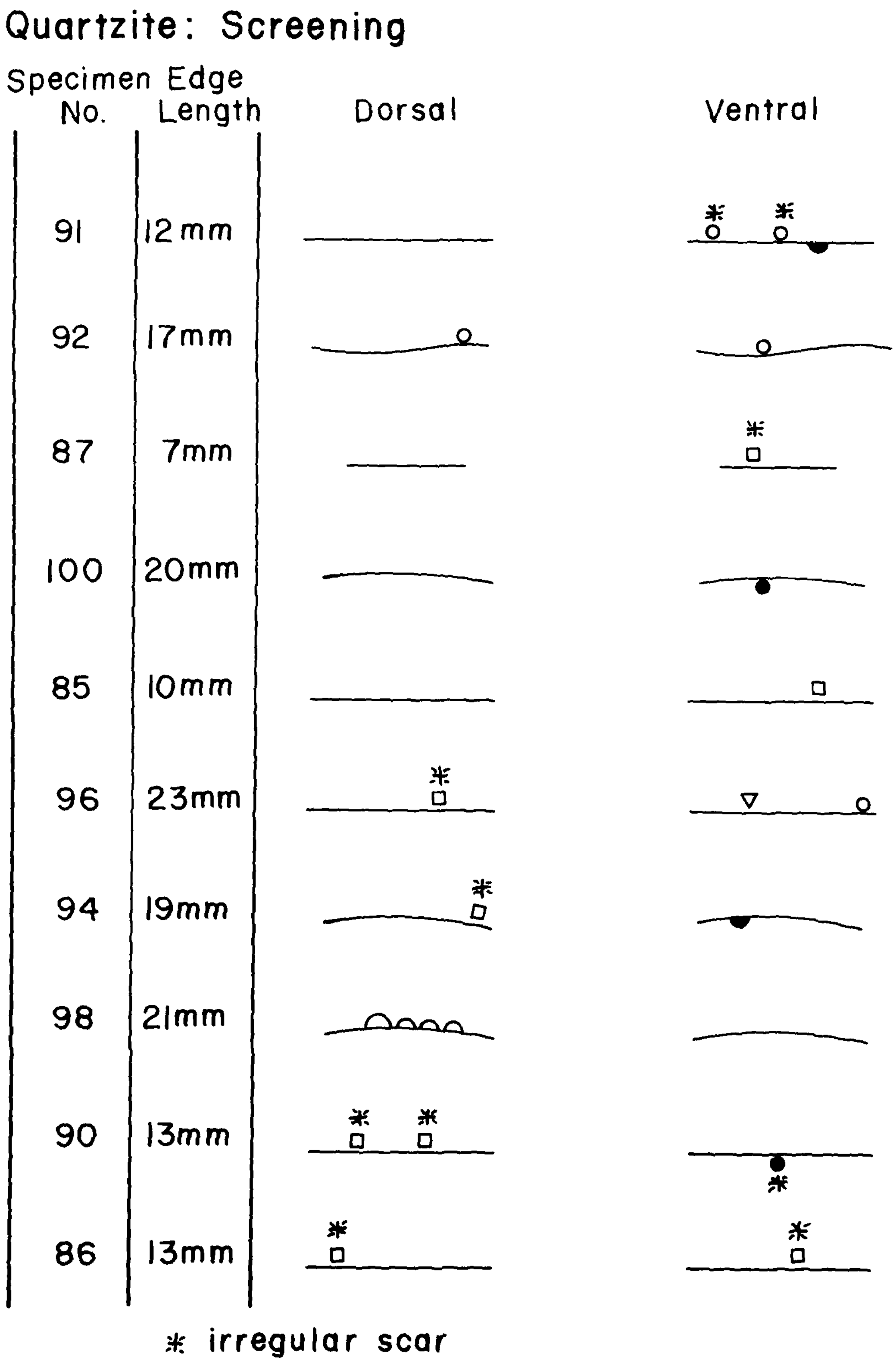

Fig. 20.4 (Continued)

Table 20.1

Variability in Flake Morphology

Specimen Number	Experiment	Material Type	Edge Angle (degrees)	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Edge Curvature	Edge Length (mm)
34	Transportation	Obsidian	18	27	35	4	2.4	convex	15
21	Transportation	Obsidian	20	19	31	3	1.0	straight	13
38	Transportation	Obsidian	23	31	27	8	5.5	straight	17
31	Transportation	Obsidian	28	28	31	3	1.2	straight	13
27	Transportation	Obsidian	31	15	11	4	0.3	straight	12
22	Transportation	Obsidian	35	15	16	6	0.8	convex	14
29	Transportation	Obsidian	53	30	26	13	8.6	concave	15
23	Transportation	Obsidian	80	19	14	2	0.3	straight	12
30	Transportation	Obsidian	80	30	34	5	3.1	straight	23
37	Transportation	Obsidian	80	35	28	9	6.7	concave	9
36	Screening	Obsidian	20	23	20	2	0.6	straight	15
24	Screening	Obsidian	22	15	13	3	0.5	straight	11
28	Screening	Obsidian	23	15	19	2	0.7	concave	9
40	Screening	Obsidian	27	31	29	6	3.8	concave	18
32	Screening	Obsidian	36	30	21	6	3.4	straight	15
33	Screening	Obsidian	41	22	30	5	2.0	convex	18
26	Screening	Obsidian	50	12	22	2	0.3	straight	15
35	Screening	Obsidian	69	27	17	5	1.4	straight	20
39	Screening	Obsidian	70	33	16	4	2.3	concave	24
25	Screening	Obsidian	81	15	27	2	0.6	straight	8
72	Transportation	Chalcedony	21	26	27	4	1.5	concave	12
63	Transportation	Chalcedony	27	19	16	4	0.9	convex	12
75	Transportation	Chalcedony	31	32	29	4	1.8	straight	12
67	Transportation	Chalcedony	35	27	14	7	1.2	straight	23
70	Transportation	Chalcedony	41	26	22	16	5.8	concave	8
65	Transportation	Chalcedony	46	21	24	7	3.1	straight	12
78	Transportation	Chalcedony	53	38	39	9	10.3	concave	17

Table 20.1 (Continued)

Variability in Flake Morphology

Specimen Number	Experiment	Material Type	Edge Angle (degrees)	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Edge Curvature	Edge Length (mm)
73	Transportation	Chalcedony	59	28	23	5	3.6	straight	17
61	Transportation	Chalcedony	71	12	14	4	0.6	straight	12
80	Transportation	Chalcedony	72	38	16	13	6.1	straight	6
64	Screening	Chalcedony	25	20	17	3	0.6	straight	11
76	Screening	Chalcedony	28	34	24	4	2.6	straight	10
74	Screening	Chalcedony	30	27	22	5	2.6	straight	10
69	Screening	Chalcedony	35	25	21	3	1.2	straight	9
66	Screening	Chalcedony	45	25	14	4	1.4	straight	21
62	Screening	Chalcedony	46	19	16	5	1.0	straight	7
71	Screening	Chalcedony	50	21	16	5	1.2	straight	5
79	Screening	Chalcedony	63	36	20	10	6.1	straight	14
68	Screening	Chalcedony	65	23	18	3	0.9	straight	9
77	Screening	Chalcedony	68	32	33	12	5.3	straight	17
6	Transportation	Basalt	22	24	17	5	1.6	straight	16
8	Transportation	Basalt	25	30	24	4	2.3	convex	17
4	Transportation	Basalt	30	36	38	5	3.7	conc/cvx	2[illegible]
7	Transportation	Basalt	30	25	18	5	1.2	convex	18
17	Transportation	Basalt	36	42	44	4	6.0	straight	13
9	Transportation	Basalt	37	21	14	4	1.1	straight	7
1	Transportation	Basalt	42	19	12	4	1.1	straight	12
13	Transportation	Basalt	49	36	11	5	1.1	convex	20
18	Transportation	Basalt	50	49	38	11	12.4	straight	20
5	Transportation	Basalt	52	53	35	8	9.9	straight	31
12	Screening	Basalt	23	21	28	5	2.6	straight	11
16	Screening	Basalt	28	31	34	5	3.9	convex	21
10	Screening	Basalt	30	26	12	6	1.2	straight	9
14	Screening	Basalt	34	27	26	6	3.2	straight	21

Table 20.1 (Continued)

Variability in Flake Morphology

Specimen Number	*Experiment*	Material Type	Edge Angle (degrees)	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Edge Curvature	Edge Length (mm)
20	Screening	Basalt	36	47	44	9	13.3	concave	12
11	Screening	Basalt	39	21	15	7	1.4	straight	10
3	Screening	Basalt	48	56	36	6	10.3	concave	32
15	Screening	Basalt	49	32	29	5	3.2	convex	18
2	Screening	Basalt	50	20	19	5	1.2	straight	11
19	Screening	Basalt	54	44	40	12	12.7	concave	14
43	Transportation	Chert	22	15	17	3	0.8	concave	13
45	Transportation	Chert	24	22	15	3	0.5	straight	16
53	Transportation	Chert	30	22	28	7	3.2	straight	15
59	Transportation	Chert	30	40	39	8	8.4	convex	17
58	Transportation	Chert	39	33	33	11	9.3	straight	28
41	Transportation	Chert	42	17	25	5	2.9	concave	12
51	Transportation	Chert	42	30	16	5	2.0	convex	22
47	Transportation	Chert	49	22	19	3	1.4	straight	10
55	Transportation	Chert	51	40	30	10	5.9	straight	11
49	Transportation	Chert	52	28	10	2	0.4	straight	19
46	Screening	Chert	24	21	11	4	0.5	straight	18
44	Screening	Chert	24	15	20	3	0.3	concave	9
54	Screening	Chert	32	21	26	5	1.5	straight	6
60	Screening	Chert	34	34	16	4	1.4	convex	18
42	Screening	Chert	42	19	19	4	1.6	straight	17
52	Screening	Chert	44	26	12	5	0.9	concave	17
57	Screening	Chert	45	31	13	5	1.9	convex	22
48	Screening	Chert	47	25	17	3	0.9	convex	22
56	Screening	Chert	50	36	20	5	2.4	straight	18
50	Screening	Chert	55	22	12	11	1.7	straight	16
88	Transportation	Quartzite	26	16	11	3	0.3	conc/cvx	13

Table 20.1 (Continued)

Variability in Flake Morphology

Specimen Number	Experiment	Material Type	Edge Angle (degrees)	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Edge Curvature	Edge Length (mm)
89	Transportation	Quartzite	28	16	26	7	2.1	straight	11
83	Transportation	Quartzite	36	18	15	6	1.5	straight	8
84	Transportation	Quartzite	51	18	18	4	1.0	convex	13
97	Transportation	Quartzite	55	71	29	12	22.8	straight	29
93	Transportation	Quartzite	60	29	14	8	2.7	straight	22
82	Transportation	Quartzite	70	20	11	8	0.9	straight	15
81	Transportation	Quartzite	74	20	15	7	2.2	straight	17
95	Transportation	Quartzite	75	54	50	12	27.7	straight	31
99	Transportation	Quartzite	76	91	33	26	63.6	straight	22
91	Screening	Quartzite	28	19	16	4	0.7	straight	12
92	Screening	Quartzite	30	19	23	7	1.6	conc/cvx	17
87	Screening	Quartzite	50	16	14	4	0.8	straight	7
100	Screening	Quartzite	55	92	66	45	224.0	convex	20
85	Screening	Quartzite	59	17	12	3	0.6	straight	10
96	Screening	Quartzite	60	60	19	14	16.0	straight	23
94	Screening	Quartzite	63	30	9	12	1.4	convex	19
98	Screening	Quartzite	64	73	66	33	159.5	convex	21
90	Screening	Quartzite	74	19	13	8	1.5	straight	13
86	Screening	Quartzite	77	18	19	6	1.6	straight	13

Table 20.2

Scar Variability

		DORSAL							VENTRAL							Classified as Wear Patterns	
Specimen #	Edge Angle (degrees)	Perp. Feather	Angular Feather	Perp. Step	Angular Step	Crescentic	Nibble	Other	Perp. Feather	Angular Feather	Perp. Step	Angular Step	Crescentic	Nibble	Other	Technician #1	Technician #2
Obsidian: Transportation and Laboratory Processing																	
34	18	1	—	1	—	—	+	—	4	—	—	2	2	+	—	Yes	Yes
21	20	8	—	—	—	3	+	—	8	—	1	—	1	—	—	Yes	Yes
38	23	5	—	—	—	—	+	—	3	—	—	—	1	+	—	Yes	Yes
31	28	3	—	—	—	—	+	—	8	—	—	—	—	—	—	Yes	Yes
27	31	7	—	—	—	—	+	—	—	—	—	—	—	+	—	No	No
22	35	—	—	—	—	—	—	—	—	—	—	—	—	+	—	No	No
29	53	1	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
23	80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
30	80	1	—	—	—	—	—	—	1	—	—	—	—	—	—	No	No
37	80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
TOTAL		26		1		3			24		1	2	4				
																Total Scars	61
Obsidian: Screening																	
36	20	—	—	—	—	1	—	—	—	—	—	—	1	+	—	No	No
24	22	—	—	—	—	—	+	—	2	—	—	—	—	—	—	No	No
28	23	—	—	—	—	—	+	—	—	—	—	—	2	—	—	Yes	Yes
40	27	—	—	—	—	2	+	—	1	—	—	—	1	+	—	No	No
32	36	3	—	—	—	—	+	—	7	—	—	—	—	+	—	No	No
33	41	2	—	2	—	—	—	—	2	—	—	—	1	—	—	No	No
26	50	—	—	—	—	—	+	—	—	—	—	—	—	+	—	No	No
35	69	—	—	—	—	2	—	—	1	—	1	—	—	—	—	No	No
39	70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
25	81	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
TOTAL		5		2		5			13		1		5				
																Total Scars	31

Table 20.2 (Continued)

Scar Variability

		DORSAL							VENTRAL							Classified as Wear Patterns	
Specimen #	Edge Angle (degrees)	Perp. Feather	Angular Feather	Perp. Step	Angular Step	Crescentic	Nibble	Other	Perp. Feather	Angular Feather	Perp. Step	Angular Step	Crescentic	Nibble	Other	Technician #1	Technician #2
Chalcedony: Transportation and Laboratory Processing																	
72	21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
63	27	1	—	—	—	—	—	—	1	—	—	—	—	—	—	No	No
75	31	—	—	—	—	3	—	—	—	—	—	—	—	—	—	No	No
67	35	1	—	—	—	—	—	—	1	—	—	—	—	—	—	No	No
70	41	1	—	1	—	—	—	—	—	—	—	1	—	—	1	No	No
65	46	1	—	—	1	—	—	—	1	—	—	—	—	+	—	Yes	Yes
78	53	—	—	—	—	—	—	—	—	—	1	—	—	—	—	No	No
73	59	1	—	—	—	—	—	—	1	—	—	1	—	—	—	No	No
61	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
80	72	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
TOTAL		5		1	1	3			4		1	2					
																Total Scars	17
Chalcedony: Screening																	
64	25	2	—	—	—	—	—	—	1	—	—	—	—	—	—	No	No
76	28	2	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
74	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
69	35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
66	45	1	—	—	—	—	—	—	2	—	—	—	—	—	—	No	No
62	46	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
71	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
79	63	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
68	65	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
77	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Yes	*No
TOTAL		5							3								
																Total Scars	8

*These consistent scar patterns were not produced by the experimental action but occurred in manufacture—the technician did not know this.

Table 20.2 (Continued)

Scar Variability

		DORSAL							VENTRAL							Classified as Wear Patterns	
Specimen #	Edge Angle (degrees)	Prep. Feather	Angular Feather	Prep. Step	Angular Step	Crescentic	Nibble	Other	Prep. Feather	Angular Feather	Prep. Step	Angular Step	Crescentic	Nibble	Other	Technician #1	Technician #2
Chert: Transportation																	
43	22	—	—	—	—	—	—	1	—	—	—	—	—	—	—	No	No
45	24	1	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
53	30	—	—	—	—	—	—	—	—	—	—	—	—	—	1	No	No
59	30	—	—	—	—	3	—	—	3	—	—	—	—	—	—	No	No
58	39	—	—	—	—	1	—	—	1	—	—	—	—	—	—	No	No
41	42	3	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
51	42	—	—	—	—	—	—	—	1	—	—	—	—	—	—	No	No
47	49	6	—	—	—	—	—	—	—	2	—	—	—	—	—	No	No
55	51	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
49	52	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
TOTAL		10				4		1	5	2							
																Total Scars	22
Chert: Screening																	
46	24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
44	24	—	—	—	—	—	—	—	1	—	—	—	—	—	—	No	No
54	32	—	—	—	—	—	—	—	2	—	—	—	—	—	—	No	No
60	34	—	—	—	—	—	—	—	1	—	—	—	—	—	—	No	No
42	42	1	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
52	44	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
57	45	—	—	—	—	—	—	—	2	—	—	—	—	—	—	No	No
48	47	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
56	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
50	55	1	—	—	—	—	—	—	2	—	—	—	—	—	—	No	No
TOTAL		2							8								
																Total Scars	10

Table 20.2 (Continued)

Scar Variability

		DORSAL							VENTRAL							Classified as Wear Patterns	
Specimen #	Edge Angle (degrees)	Perp Feather	Angular Feather	Perp. Step	Angular Step	Crescentic	Nibble	Other	Perp. Feather	Angular Feather	Perp. Step	Angular Step	Crescentic	Nibble	Other	Technician #1	Technician #2
Basalt: Transportation																	
6	22	—	—	—	—	—	—	—	—	—	—	—	—	—	1	No	No
8	25	—	—	—	—	2	—	—	3	—	—	—	—	—	—	No	No
4	30	—	—	—	—	—	—	—	—	—	—	—	1	—	—	No	No
7	30	—	—	—	—	1	—	—	—	—	—	—	—	—	—	No	No
17	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
9	37	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
1	42	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
13	49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
18	50	3	—	—	—	—	—	—	2	—	—	—	—	—	—	No	No
5	52	1	—	—	—	—	—	—	—	—	—	—	2	—	—	No	No
TOTAL		4				3			5				3			Total Scars	15
Basalt: Screening																	
12	23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
16	28	1	—	—	—	—	—	—	1	—	—	—	—	—	—	No	No
10	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
14	34	2	—	—	—	—	—	1	—	—	—	—	—	—	—	No	No
20	36	1	—	—	—	—	—	—	1	—	—	—	—	—	—	No	No
11	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
3	48	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
15	49	1	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
2	50	—	—	—	—	—	—	—	—	—	2	—	—	—	—	No	No
19	54	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
TOTAL		5						1	2		2					Total Scars	10

Table 20.2 (Continued)

Scar Variability

		DORSAL							VENTRAL							Classified as Wear Patterns	
Specimen #	Edge Angle (degrees)	Perp. Feather	Angular Feather	Perp. Step	Angular Step	Crescentic	Nibble	Other	Perp. Feather	Angular Feather	Perp. Step	Angular Step	Crescentic	Nibble	Other	Technician #1	Technician #2
Quartzite: Transportation																	
88	26	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
89	28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
83	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
84	51	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
97	55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
93	60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
82	70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
81	74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
95	75	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
99	76	1	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
TOTAL		1															
																Total Scars	1
Quartzite: Screening																	
91	28	—	—	—	—	—	—	—	—	—	—	—	1	—	—	No	No
92	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
87	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
100	55	—	—	—	—	—	—	—	1	—	—	—	—	—	—	No	No
85	59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
96	60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
94	63	—	—	—	—	—	—	—	—	—	—	—	1	—	—	No	No
98	64	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
90	74	—	—	—	—	—	—	—	—	—	—	—	—	—	1	No	No
86	77	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No	No
TOTAL									1				2		1		
																Total Scars	4

RESULTS

One primary objective of these experiments was to determine if edge damage resulting from transportation/processing and screening can be distinguished from edge damage resulting from former use activities (wear patterns).

Two lithic technicians, trained in wear pattern analysis at the Office of Contract Archeology, independently analyzed the population of experimental edges and isolated those specimens with edge damage which would have been identified as wear patterns. The results of both analysts were remarkably similar (see Table 20.2). Both technicians agreed that scar morphology (shape and size) and consistency of scarring on six specimens (5 obsidian and 1 chalcedony) meet criteria currently employed to identify utilized flakes (Specimen #77 in Table 20.2) for its consistent scar patterns. However, all the scars on this edge were present prior to the experiment.

The technicians also agreed that none of the edge damage found on chert, basalt and quartzite would be misinterpreted as wear patterns. Although scars produced through these experiments, for the above materials, were morphologically similar to scars produced through utilization, they did not distribute consistently over any portion of the edge margin. Scars on chert, basalt, and quartzite specimens were random and inconsistent (see Fig. 20.3).

Six scars were identified which were morphologically unlike scars produced in usage experiments. They included four step-like fractures, one feathered-like scar, and one cresentic-like scar. All other scars were similar in shape and size to scars produced in lithic use experiments at the Office of Contract Archeology. These initial experimental results suggest that scar morphology alone cannot be used as a critical variable to distinguish nonuse edge damage from wear patterns. The inconsistency in scar placement, on the other hand, is a very sensitive monitor of nonuse edge damage (see Fig. 20.4).

A second objective of the experiments was to determine which action, transportation and laboratory processing versus screening produced more edge damage. The transportation/processing experiment produced the greatest amount of edge damage on all materials (see Table 20.2). With the exception of quartzite, transportation and laboratory processing produced 115 total scars on monitored edges, where screening produced only 60 total scars on monitored edges. Transportation and laboratory processing produced approximately twice as many scars on siliceous materials such as obsidian, chalcedony and chert, than did screening. On less siliceous materials such as basalt, transportation/processing produced more scars than did screening, but not twice as many (transportation—15, screening—10). Quartzite exhibited the fewest number of scars with 4 of 5 total scars being produced by the screening action.

A third objective of these experiments was to determine if either process produced different types of edge damage (see Table 20.2). Both processes produced a consierable variety of scar types on obsidian. This may be a result of the brittle fracturing qualities inherent in obsidian materials. The only scar type produced on obsidian through transportation and laboratory processing, which did not result from screening, were angular step fractures (2 scars).

There was a marked difference, however, in the scar types resulting from transportation/processing versus screening on chalcedony, chert and basalt. All scars resulting from screening chalcedony and chert were perpendicular feathers (chalcedony—8, chert—10); the majority of scars produced on basalt were also perpendicular feathers (7 perpendicular feathers, 2 perpendicular step fractures, and 1 irregular break). For these three materials, 25 of 28 total scars resulting from screening were perpendicular feathers.

It is difficult to discuss differences in scar types produced on quartzite due to the small number of total scars that occurred. It is interesting to note that the screening experiment did not produce angular scars (feather or step scars) on any flakes belonging to the five material categories.

A final objective was to determine if it is possible to establish a set of criteria to distinguish use from nonuse edge damage. Obsidian materials received the greatest amount of edge damage. Five obsidian edges were independently selected by two lithic technicians and edge damage was classified as wear patterns. Edge damage on four of these specimens resulted from transportation/processing, whereas edge damage on the other obsidian edge was produced in the screening experiment. All five obsidian edges with scar patterns that were classified as wear patterns had edge angles between 18 and 31 degrees.

Table 20.2 orders obsidian edges by edge angle. One can see that the number of total scars per edge falls off dramatically once edge angles exceed 35^0. Edges with angles greater than 35^0 did not have edge damage consistent enough to be identified as wear patterns.

These results suggest that consistent scarring on obsidian edges with spine-plane angles greater than 35^0 is probably not occurring as a result of transportation/processing or screening. Edge angles may then be an important criteria in isolating obsidian edge damage that has resulted from nonuse recovery procedures.

A single chalcedony edge also exhibited scarring consistent enough to be identified as wear patterns. This specimen had a spine-plane angle of 49 degrees. Further experimentation, with a larger population of flakes manufactured from chalcedony may provide a criterion, similar to obsidian edge angle, that will aid in isolating edge damage resulting from such nonuse recovery procedures. The experiments conducted thus indicate that obsidian edges are most subject to damage, through post-depositional recovery and processing procedure, which might be misinterpreted as wear patterns.

Tringham et al. (1974) suggest another criteria to isolate scars produced through various activities. She suggests that "*Recent accidental scarring of the edge of a prehistoric flake is characterized by a lack of patination on the surface of the scar* (Tringham et al. 1974:192). Fortunately, obsidian hydrates at a relatively rapid rate, making it possible, in most cases, to identify recent scars from those produced in the past. However, the degree to which patina or lack of patina can be routinely employed to distinguish recent scars from older scars on other materials is questionable. Experimentation in this area may prove extremely valuable for future wear pattern analysis.

Tringham suggests another criteria to distinguish wear patterns from nonuse edge damage. Her experiments suggest that nonuse scars, resulting from water action and trampling, occur randomly "... *along the entire perimeter of the flake*" (Tringham et al. 1974:191). The transportation/processing and screening experiments support her findings and indicate that this criterion can prove very productive when used in conjunction with other criteria. However, not only should one look for random scars along the flake perimeter, but also look for consistent edge damage around the entire flake perimeter. If consistent, similar edge damage occurs on all portions of the flake perimeter, regardless of changes in edge outlines that would not allow the continuous use of those edges, it is likely that the scars were produced from some nonuse activity. Therefore, contrary to Tringham's observations, nonuse activities can and do result in consistent and localized scarring. And further, if all portions of a flake perimeter are consistently scarred, care might be taken in attributing that edge damage to use alone. Finally, all cases of consistent scarring are not necessarily produced through usage alone.

In conclusion, it is evident that transportion, laboratory processing and screening are producing edge damage similar to scar patterns that result from use activities (wear patterns). It is therefore necessary to proceed with caution and make use of several valuable criteria when attempting to isolate nonuse edge damage in future wear pattern analyses. Without these criteria, one is faced with the alternative of changing existing archeological recovery and processing techniques. Financial and time constraints, in many cases, will not allow the implementation of these less damaging techniques.

Although sample size was small, these experiments have minimally provided some initial criteria that can be used to isolate nonuse edge damage; and they have helped to determine areas in which extensive experimentation is necessary. Various lithic materials are being affected differentially by transportation, laboratory processing and screening. Caution should be used in wear pattern identification when fine-grained materials with fracturing qualities similar to obsidian and chalcedony are encountered.

When analyzing wear patterns on these materials, consistency of scarring must be used as a critical variable. Hydration or lack of hydration can also provide a means by which to isolate recent scars. If one is to use, as Tringham et al. (1974:192) suggest, lack of patina on scar surfaces to isolate recent scars, it is necessary to develop ways to identify patina or lack of patina on scar surfaces. We must isolate the variables that (1) condition patination on various lithic materials, (2) determine the degree to which different materials are affected, and (3) develop techniques to monitor patina within the constraints of present wear pattern analysis.

These experiments suggest also that observationally, variation in morphology (size, shape and directionality) cannot be used as a sole criterion to isolate nonuse edge damage. Further, these experiments indicate that location of scars on the entire flake and the consistency with which they distribute along a give edge are critical variables that must be employed to differentiate wear patterns from nonuse edge damage. The results of these experiments minimally suggest that extreme caution should be used when identifying wear patterns on obsidian edges with spine-plane angles measuring 35 degrees or less. Generally as edge angle increases, confidence of wear pattern identification increases. More research *in this area may prove* extremely valuable.

It is evident that extensive experimentation is necessary to isolate the nonuse activities that contribute to edge damage on lithic materials and refine criteria by which this edge damage can be distinguished from that produced through intentional use activities. Without this information, one cannot hope to ascertain from lithic assemblages, use activities which were performed at a given site in the past.

PART FIVE: SUMMARY

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Chapter 21

A REVIEW OF RESEARCH RESULTS

Richard C. Chapman and Jan V. Biella

INTRODUCTION

The Cochiti Reservoir project has spanned some four years of archeological survey, excavation, and analysis in addition to concurrent botanical and geological research within the White Rock Canyon locality of the southern Pajarito Plateau. Papers incorporated in this volume, the fourth and final volume of a series documenting the results of research within the Cochiti Reservoir locale, constitute, in many ways, summary research based upon previous survey and excavation within the southern Pajarito Plateau. In many other ways, they stand as preliminary statements outlining directions future research within the region might profitably be pursued.

Our personal roles throughout the course of the project have been simultaneously those of research designers, research coordinators, surveyors, excavators, laboratory analysis consultants, general research consultants, and report content editors, copy editors, and upon many occasions conciliatory shoulders to cry upon at all stages.

Attempting to summar·:e the results of the Cochiti Reservoir project in a single ‿hapter, from our perspective, is a decidedly impossible task. Given consideration of several different summary strategies in this regard, we have decided to adopt the following outline.

First, the basic objectives of the project will be reviewed in a general fashion. Second, results of research relating to each major period of past human occupation within the project boundaries will be reviewed in light of questions which were intially framed in the proposal to guide directions of research. Third, directions for future research within the immediate Cochiti Reservoir locale and the northern Rio Grande region will be outlined for each major period of adaptation based upon those research results.

The following chapter will thus address, in sequential fashion, results of research conducted concerning the Archaic, Anasazi, and Historic periods of adaptive behavior within the Cochiti Reservoir locale.

ARCHAIC PERIOD ADAPTIVE STRATEGIES

Introduction

At the beginning of the Cochiti Reservoir project, practically nothing was known concerning the Archaic period of adaptation within the project locale, and very little previous data existed concerning Archaic adaptation within the entire northern Rio Grande Valley. For example, a relative chronology of Archaic period phases within the northern Rio Grande Valley was lacking; absolute dates of occupation were unknown; and extremely little information about settlement pattern, subsistence or technological behavior of Archaic populations existed.

Because of this situation, our major objective in framing questions to guide research conducted during the course of the project was to address a set of relatively general properties of hunter-gatherer adaptations such that the results of research would minimally provide a descriptive documentation of Archaic adaptation within the project locale and, hopefully, could be employed as an analytical baseline for future research.

At the outset of our research, we adopted what might be termed a generalized *hunter-gatherer* model derived, in part, from previous archeological research in the Southwest and, in part, from ethnographic studies of hunter-gatherer populations in arid environments. This model, while not truly explanatory in nature, was felt to be useful. It basically suggested that much variation in structural and organizational properties of hunter-gatherer adaptation within arid environments could be accounted for as behavioral responses to the spatial distribution and seasonal availability of critical food and water resources. Research questions were thus developed to address different particular aspects of this generalized man-environment articulation with one goal of the research to provide a descriptive picture of the Archaic period within the reservoir.

Review of Proposal Questions

The following research questions concerning the character of Archaic adaptation within the project locale and the larger northern Rio Grande Valley were phrased in the proposal to the present work:

A. The settlement strategy of the Archaic adaptive system within the project area will be isolated. Specific research questions which will be asked about determinants of this settlement strategy include:

1. To what degree is the settlement strategy conditioned by differential periodicity and volume productivity of focal food resource species (within the project area) at a regional level?

2. To what degree is the choice of site location conditioned by diversity and/or volume productivity of focal resources within the vicinity of specific site locations?

B. The procurement and consumption strategies of the Archaic adaptive system within the project

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area will be isolated. Specific research questions which will be asked about the determinants of [these strategies] . . . include:

1. To what extent does the operation of procurement and consumption strategies necessitate population dispersal or aggregation at site locations within the study area?

2. Does food resource procurement and consumption covary at the same site locations, or are some site locations employed for procurement, and others employed for consumption?

3. To what degree is the technology of manufacture and use of tools and facilities necessary for procurement and consumption conditioned by the distribution of technological resources across the landscape?

C. Through comparison with previously recorded archeological data, the effective regional boundaries of the Archaic adaptive system . . . will be isolated (Broilo 1976:5).

The first two questions (A1,2) basically address the problem of whether the overall settlement strategy engaged in by Archaic populations seems to be conditioned by variation in the spatial location and seasonal availability of food resources within the project locale on the one hand and within the general region on the other.

The second set of questions (B1,2,3) addresses, in more specific fashion, the degree to which Archaic occupancy of the project locale itself is characterized by variation in size of residential groups, variation in performance of subsistence-related activities among different sites, and whether the availability of technological raw materials seems to condition to a significant extent strategies of tool manufacture and usage.

The third question was originally phrased simply as a statement of objectives and might more appropriately be rephrased as a true question: *To what degree can the results of research into the previous problems be employed to define effective territorial or regional boundaries of Archaic period local groups within the northern Rio Grande Valley?*

Review of Research Results

The following review will summarize research conducted to answer questions phrased in the proposal and, in addition, will summarize research which addressed some realms of Archaic period adaptation within the project locale which, while not explicitly stated as research objectives of the project, can be seen as necessarily implicit to pursuit of those objectives.

Dating

As noted previously, documentation of Archaic period site locations within the northern Rio Grande Valley through prior research was quite ephemeral at the outset of the Cochiti Reservoir project (see Chapman, Chapter 4, this volume). The only relatively well developed chronology of Archaic phases within the vicinity of the project locale was the posited by Irwin-Williams (1973, n.d.) and was based upon data within the Rio Puerco Valley (of the east). Given this situation, Irwin-Williams' chronological sequence was adopted as an initial framework for establishing relative temporal frames of occupancy for the Cochiti Reservoir Archaic sites.

We had intially hoped to employ the Cochiti data set to evaluate and/or refine the Oshara Tradition sequence but we were unable to do so. Archaic campsites within the project area were absysmally lacking in charcoal due to their generally deflated state of preservation; and although several samples of hearth contents were analyzed for radiocarbon dating purposes, none contained enough organic matter to result in usable dates.

Obsidian hydration analyses of surface samples derived from the Archaic sites (and other Anasazi and Historic period sites), however, seemed quite fruitful, and indicated a late Armijo-En Medio Archaic occupation. The few projectile point fragments which were recovered were consistent with an Armijo-En Medio occupation and morphologically fit into the Oshara Tradition.

Questions A1, 2

The first set of questions phrased in the proposal emphasized investigations into possible determinants of overall settlement behavior by Archaic populations both from a regional perspective (Question A1) and from a more local, site-specific perspective (Question A2). The particular focus of analysis proposed in the questions was that of assessing whether variation in the spatial distribution, amount, and seasonal availability of food resources within the project area could be demonstrated to condition either the overall strategy of settlement, or choice of individual site locations within the project locale.

Several lines of descriptive and analytical investigation were implemented during the course of the project to answer these questions. One set of anlayses was directed toward defining what kinds of floral and faunal resources were used by Archaic inhabitants of the pro·ˑct locale through examining direct evidence of floral and faunal species consumed at the excavated site locations. These analyses included description of macroscopic faunal remains occurring at Archaic site locations and microscopic analysis of both *light* and *heavy* flotation residue from sites. Results of these analyses are documented for each Archaic site and Archaic provenience of multicomponent sites in the previous volumes of the Cochiti Reservoir publication series (see Chapman et al. 1977; Eck 1979; Hunter-Anderson 1979a, 1979b, 1979c).

Another set of anlayses was directed toward describing the *potential* food resources which may have existed within the project locale, where those resources occurred, in what abundance they were represented, and in what seasons of the year they were available. These analyses necessarily focused upon the present-day distribution, seasonal availability, and relative abundance of potential floral and faunal food resource species within the project locale and environs. Specific papers addressing the food resource potential of the general Cochiti Reservoir area include an analysis of vegetative community structure by Drager and Loose (1977); a description of faunal species occurrence and behavior by Marchiando (1977); and two analyses which quantify the relative abundances and seasonal availability of floral food resource species by Tierney (1977; this volume).

A third kind of analysis directed toward defining the *effective* food resource structure for the Archaic period focused upon indirect evidence of species processed and consumed by inhabitants of particular sites. Variation in hearth morphology, by-products of cooking practices, milling implements, and stone tool utilization as evidence of kinds of food resources processed and consumed by Archaic site occupants is reviewed by Chapman (Chapter 4, this volume).

The following discussion will first review information gained from archeological investigation of site locations pertaining to the kinds of food resources which were processed and consumed by their Archaic inhabitants and will then summarize the results of analysis directed toward ascertaining the degree to which the distribution, abundance, and seasonal availability of those resources can be warranted to have conditioned patterns of settlement within the project area in paricular and the region in general.

(1) Effective food resources: Direct evidence of floral and faunal species actually procured, processed, and consumed at Archaic period sites within the project area was extremely ephemeral. All of the sites were surficial in nature such that the entire material record of site occupancy occurred upon existing ground surfaces or did not exceed in most cases 10 cm in depth. As a result of this situation, the state of preservation of floral and faunal remains ranged from extremely poor to nonexistent. None of the very few larger faunal elements recovered from Archaic sites could be attributed unambiguously to Archaic occupation of the site locales and no macroscopic evidence of floral species was recovered.

Microscopic analysis of flotation residue from fill samples of hearth contents and firecracked rock discard epicenters did result, however, in a consistent, although ephemeral, presence of minute bone fragments, some of which were burned and some of which were unburned. Although these fragments could not be identified to part or species, their consistent presence at excavated Archaic sites indicated that faunal species did comprise routinely consumed food resources within the project boundaries. In addition, identifiable fragments of bivalve mollusks were found at two Archaic site locations in hearth contexts, as were microscopic shell fragments, indicating consumption of riverine as well as land species of fauna.

Indirect evidence of foodstuff preparation and consumption among Archaic site locations was considerably more in evidence as hearth facilities, firecracked rock discard piles, milling implements, and a variety of other stone tools.

A redundant pattern of spatial association between hearth facilities, firecracked rock scatters, and milling implements (slab or shallow basin metates and one-hand manos), in particular, was characteristic of a majority of Archaic residential sites. This consistent pattern might be taken to indicate that seed grains (which were milled into meal or flour) constituted a routinely prepared food resource during occupancy of those sites.

To summarize, analyses of Archaic site locations for direct and indirect evidence of food resources actually processed and consumed resulted in definition of general patterns of behavior which indicated a redundant commonality in subsistence among most Archaic sites. This subsistence pattern clearly involved usage of floral resources in the form of mature seeds, riverine derived mollusks, and other as yet unidentified faunal species.

(2) Distribution of food resources: Analysis conducted at the site-specific level to determine what kinds of food resources were, in fact, processed and consumed by Archaic populations did not result in definition of particular floral or faunal species which could be posited to have comprised focal resources. Despite this, the analyses did suggest that a relatively similar set of food resources were used throughout the project locale by Archaic populations. Given this situation a second set of analyses were undertaken to assess whether variation in the overall biotic structure of the project locale might have conditioned patterns of settlement.

These analyses explicitly examined the proposition that *diversity* of potential food resources found within specified distances from site locations operated as a determinant of occupational intensity, reflected as the size of sites, number of hearths, density of artifactual debris, etc. characterizing residential locales (see Chapman, Chapter 5, this volume).

The diversity measures chosen for these analyses were based upon ecological descriptions which had been conducted earlier for the general Cochiti Reservoir locale (Drager and Loose 1977) and represented combinant indices which weighted both the kinds of food resources potentially available within specified distances from site locations (as reflected in the number of different vegetative communities encompassed within specified radii from settlement locales), and the relative volume or abundance of those resources (as reflected in variation in the relative spatial extent of vegetative communtiies encompassed by successively larger catchment radii).

These analyses indicated that variation in the diversity of potential food resources did *not* condition variation in Archaic choice of settlement locales or intensity of occupation within those locales in any significant fashion, despite the fact that considerable variation in food resource diversity measures could be defined for different portions of the project area.

The results of this set of analyses were surprising, especially in light of current theoretical models which have been proposed to account for settlement variation among hunter-gatherer bands. One major tenet of these models is that relatively mobile hunter-gatherer groups engaged in a foraging or mixed hunting and gathering subsistence strategy will tend to locate their seasonal residences in environmental locales characterized by relatively high diversity of food resources so as to maximize the probability of acquiring food while minimizing expenditures of effort in that acquisition.

This kind of model would predict that residential localities offering access to a relatively higher diversity of food resources would be selected much more frequently as sites of habitation over a period of years than would residential locales which offered access to a lower diversity of resources.

The fact that Archaic residential occupation within the project area did not conform to this expectation provides a point of departure for re-evaluating and refining the model itself. Two avenues in this regard can be suggested for future research.

As discussed in Chapter 5, this volume, diversity models may be predicated implicitly upon an assumption that ecological zones characterized by greater diversity of food resources are characterized as well by greater overall abundance or volume of such resources. From a strictly ecological standpoint, this assumption cannot be warranted. Empirical studies indicate that as species diversity of a community increases, the numbers of individuals comprising such species decreases with the result that communities or zones characterized by higher diversity of species reflect relatively low abundance of any single species (Margalef 1968; Emlen 1973).

Translated into human subsistence terms, this would imply that ecological locales exhibiting higher diversities of species could be treated as more predictable in occurrence of food resources but at the same time would be characterized by less abundance of any given food resource species.

Conversely, ecological zones characterized by relatively lower species diversity might exhibit very high abundances of particular food resources but given the lower overall diversity of foodstuffs, predictability of availability among those few species would be considerably lessened.

At a fundamental level then, it can be argued that diversity models which attempt to relate variation in food resource potential to choice of site locations by foraging hunter-gatherer groups are ultimately dependent upon assumptions concerning the manner in which decisions are made by such populations. The basic assumption in this regard is simply that hunter-gatherer groups in the Southwest made all such decisions as a kind of *probability game*, rather than from a truly informed standpoint of knowledge about relative availability or abundance of food resources. The degree to which this kind of explanatory scenario constitutes a useful means of accounting for settlement behavior is subject to considerable question from either logic or ethnographic documentation of actual decision making underlying choice of future residential locations.

In summary, tests conducted to assess whether the relative diversity of potential food resources available within different portions of the project locale seemed to condition variation in occupational intensity on the part of Archaic populations indicated that resource diversity did not condition settlement strategy. Implications of these test results concerning assumptions of the diversity model itself have been discussed.

Another implication of the test results concerns the possible regional scale of landscape which constituted the effective territory of Archaic groups inhabiting the Cochiti Reservoir locale. Data derived through excavation of Archaic site locations indicated fundamental similarities in cooking practices, kinds of food resources processed and consumed, tool manufacturing behavior, and overall residential use of site space which pertained among all sites within the project locale. The only major differences in the character of occupation among excavated sites included evidence indicating some variation in numbers of commensal groups comprising contemporaneous residential groups during terms of occupancy, and a degree of variation in relative recurrency of site occupation through time.

Previously discussed analyses indicated that these variations in occupational intensity were not related to diversity of food resources accessible within site catchment areas.

From this combined evidence, it can be suggested that the entire character of Archaic occupation of the Cochiti Reservoir locale was seasonal in nature, given the degree of intersite redundancy in food resource processing and consumption activities, and that variation in intensity of occupation reflects an episodic sequence of residential occupation within the entire White Rock Canyon locality over the long term. Site specific differences in this intensity may well reflect a variety of more or less stochastic decision-making processes essentially unrelated to the structure of food resources within the project locality itself — determinants of which might include variables of wind, heat, state of interpersonal relationships, etc. which pertained at the time of seasonal occupancy.

From these observations it can be suggested that White Rock Canyon and its immediate environs constituted only one seasonally inhabited locality within a much larger territorial range encompassed by the Archaic population(s) inhabiting it.

Questions B1, 2, 3

The second set of questions phrased in the proposal was more descriptive in orientation. Three properties of intra- and intersite occupancy and activity performance were outlined as focal points of examination, including variation in residential group sizes occupying Archaic sites within the Cochiti Reservoir locale; variation in activity performance involved in cycling food or technological resources among those sites; and examination of what, if any, variation in technology of tool manufacture or usage was evident among site locations which could be attributed to differential distribution of stone raw materials within the locale relative to site placement.

Several avenues of description and analytical investigation were undertaken during the course of the project to provide information bearing upon these questions. The strategy of on-site documentation during initial survey stages of the project was designed, in part, to provide information concerning the kind, density, and spatial patterning of artifactual debris and hearth epicenters characterizing each site (Chapman and Enloe 1977); and these data were summarized to provide an overview of intersite variation in this regard (Biella and Chapman 1977b). Additionally, initial geological description of technological raw materials found within the reservoir locale were developed by Warren (1977c) as a baseline for future research.

A major emphasis of intrasite analysis subsequent to excavation was that of defining spatial patterning in the distribution of artifactual debris, hearths, and by-products of hearth utilization constituting Archaic sites such that properties of intrasite space utilization reflecting numbers of commensal groups making up the residential composition of sites, and possible activity areas within sites might be isolated. The results of these analyses are found in Chapman et al. (1977), Eck (1979), and Hunter-Anderson (1979a, 1979b, 1979c). Analytical techniques employed for these analyses are discussed by Spear (this volume) and Camilli (this volume), and Camilli's article uses a sample of the Archaic period sites in the reservoir to illustrate different kinds of disposal behavior.

Concurrent with these intrasite spatial analyses, geological studies of lithic raw materials within the Cochiti Reservoir locale were expanded to provide locational and quantified information of major raw material sources (see Warren, Chapter 3, this volume).

In the following discussion, results of the above research will be summarized as they inform upon intra-and intersite variation in residential group sites, subsistence-related activity performance, and strategies of lithic tool manufacture and usage evident among Archaic period sites within the Cochiti Reservoir locale.

(1) Residential group size variation: A more comprehensive analysis concerning variation in the size of residential groups occupying different Archaic period site locations within the reservoir locale has been addressed by Chapman (Chapter 4, this volume), and this discussion will summarize the results of that anlaysis.

The primary line of evidence indicating the size and composition of residential groups who inhabited Archaic site locations is the number of hearth facilities occurring at sites, their locational spacing relative to other hearths, and their placement within the site relative to spatial distributions of other artifactual by-products of site habitation such as milling implements, stone tools, and by-products of tool manufacture.

As discussed in Chapters 1 and 4 of this volume, archeological occurrences of hearths can be warranted to reflect locations where members of a commensal group (or the minimum number of individuals who share in consumption of food on a daily basis) have engaged in food consumption. Through a review of ethnographic literature concerning residential behavior of extant hunting-gathering groups, it seemed possible that some estimation of the size of residential groups (or number of commensal groups occupying a site contemporaneously) could be made for Archaic period sites, dependent upon the degree of success achieved in editing out noise introduced by episodes of reoccupation of particular site locations during the term of the Archaic period, on the one hand, and noise introduced by post-depositional erosion processes which had occurred after the site locations were abandoned on the other hand.

Data from excavated Archaic period sites were subjected to a variety of *noise-editing* analyses in this regard with the result that the following observations can be suggested concerning variation in sizes of Archaic residential groups occupying the Cochiti Reservoir locale. For example, a very redundant pattern of associative spatial distributions could be observed to pertain among individual hearth facilities relative to firecracked rock distributions, milling implements, and densities of lithic manufacturing debris regardless of the number of hearth facilities comprising a particular site location.

This basic pattern of spatial association seems to represent a kind of mini-camp used by a single commensal group and can be roughly described as a crescentic area of material remains enclosing an area of relatively empty space measuring 3 to 4 m in diameter. Hearth facilities or epicenters are situated at the apex of the crescent and maximum densities of firecracked rock are located directly adjacent to the hearth facility. Maximum densities of lithic debitage may be situated either partially within the firecracked rock distribution, extending in an arc away from the hearth, or may be located to the other side of the hearth (opposite the firecracked rock concentration), but again extending in curvilinear fashion away from the hearth so as to define a complimentary portion of an arc represented by the firecracked rock and hearth.

Milling implements are commonly found directly adjacent to the hearth facility, when intact, or within the hearth epicenter, when not intact. Larger by-products of tool manufacture such as cores and large angular debris generally occur at greater distances beyond the major density of flakes and small angular debris comprising the debitage concentrations nearby hearths and may represent toss zones associated with tool manufacture (see Camilli's discussion).

A basic pattern of commensal group occupation within Archaic campsites can thus be defined through patterning in the distribution of firecracked rock concentrations, lithic debitage concentrations, and placement of milling implements relative to hearth facilities. Each of these mini-camps most probably reflects occupation by a single commensal group, and an examination of the structure of most of the Archaic residential sites indicates an occupation by one to four such commensal groups.

Site locations exhibiting larger numbers of commensal group loci or *mini-camps* were characterized as well by significantly greater overall volumes of firecracked rock and lithic debitage per locus. It is possible that some sites represent greater recurrence in reoccupational episodes of habitation over the long term. Comparative analysis of spacing between commensal group loci at smaller sites, however, revealed that all sites were characterized by relatively similar spatial distribution among the commensal loci.

The archeological data thus indicate that some residential localities may have been favored over others as campsites through the long term and that residential group sizes occupying those more favored localities during given episodes of occupation may have included as many as eight to ten commensal groups.

No evidence of systematic patterning in the distribution of the commensal group loci comprising these larger sites is evident, however. This fact stands in contrast to ethnographic documentation of site layouts for larger residential camps among extant hunter-gatherers (Yellen 1977) which are characterized by a distinct circular positioning of commensal group loci when the overall size of the residential group exceeds five or six commensal groups.

In summary, archeological evidence concerning the character of residential occupation of the Cochiti Reservoir locale during the Archaic period indicates that residential groups were relatively small in size, between one and four commensal groups during any term of occupancy, and that over the long term some particular site locations have been selected with more frequency for occupation than others.

Given results of analysis discussed previously, there is no evidence to indicate that this variation in residential group size or variation in long term tendencies to relocate at some locales and not others is in any way conditioned by season of year during which sites were occupied or by abundance or diversity of food resources accessible within diurnal foraging ranges of different sites.

(2) Variation in activity performance: A common conceptualization presently underlying many archeological investigations of Archaic period settlement and subsistence data throughout the Southwest suggests that basic dynamics of Archaic adaptation involve use of base camps and specialized activity sites. Base camps are generally defined in this conceptualization as sites exhibiting hearths and/or relatively greater volumes of artifactual debris as opposed to specialized activity sites characterized by a lack of hearths and relatively lower volumes of debris. It has been assumed that sites exhibiting hearth facilities constituted the residential locations and that sites characterized solely by artifactual debris represented loci across the landscape where food or technological resource procurement was undertaken by the inhabitants of the residential (base camp) sites.

The overall distribution of sites exhibiting hearth features of by-products of hearth activity, when viewed against the overall distribution of sites lacking such hearth facilities, seems to indicate that Archaic period occupation of the Cochiti Reservoir area reflects a locality-based strategy of settlement. In this sense, a distinct spatial clustering of Archaic site locations can be observed, each cluster of which encompasses both residential (hearth) sites and nonresidential (artifactual debris only) sites. The reader is referred to the discussion in Chapter 5 of this volume for a more complete explication of this spatial clustering.

Analysis directed toward isolating differences in kinds of activities undertaken among both residential and nonresidential sites focused upon variation in artifact classes, lithic artifact manufacture, and wear patterns evidenced among artifacts occurring at different site locations. The following observations can be made as a result of these analyses.

Examination of artifactual debris both within and between residential (hearth) sites resulted in identifying a very redundant pattern of tool manufacture and utilization which was recurrently evident among assemblages comprising commensal group mini-camps (see above discussion). Each commensal group occupational locus was characterized by a relatively similar component of tool manufacturing debris ranging from cortical flakes, noncortical flakes, larger core and large angular debris by-products distributed in toss zones beyond concentrations of smaller debitage, and some evidence of use and resharpening of previously manufactured bifacial implements, in addition to milling implements found in association with hearths in most cases. Wear pattern variation observed on utilized flakes represented a range of relatively hard usages attributable to scraping and sawing upon resistant materials such as wood and bone.

Archaic residential sites made up of one or more such commensal group loci did not exhibit any evidence of spatially discrete activity areas, that is, tool use versus tool manufacturing loci. Rather, the entire structure of all residential sites consisted of commensal group habitation loci.

Archaic sites characterized by an absence of hearth facilities were, as noted before, located in relatively close proximity to sites with hearth facilities. With few exceptions these nonresidential sites were smaller in overall spatial extent and were characterized by relatively restricted concentrations of lithic manufacturing debris. Some evidence of tool utilization was observed among these sites, although proportions of utilized flakes to unutilized flakes was significantly lower than observed at the residential sites.

Nonresidential sites thus differed from residential sites in the following ways: (1) spatial distribution of artifactual remains was more or less circular, rather than crescentic, reflecting deposition as a function of single activity episodes; (2) kinds of artifacts emphasized primary and secondary tool manufacturing activities and some tool use; and (3) with very few exceptions, milling implements were absent.

In general, nonresidential sites seemed to reflect initial stages of tool manufacture from locally available materials. Wear patterns were routinely observed which may have indicated that a primary objective of the tool manufacturing episodes was the production of expedient tools for immediate usage. In most cases, a range of edge outline shapes and wear patterns were represented. Thus there was no evidence of truly focal activities being performed.

In summary, little variation in kinds of activities performed was indicated among Archaic sites within the Cochiti Reservoir locale beyond evidence that some site locations served as loci of campsite habitation and others did not. Campsites were remarkably similar in artifactual content and although varying somewhat in size of residential groups occupying them, exhibited similar patterns of artifact distributions relative to hearth facilities and fire-cracked rock concentrations.

Nonresidential sites were characterized almost entirely as distributions of lithic tool manufacturing debris and a few utilized tools. These sites seemed to reflect expedient contexts of tool manufacture from locally available materials, presumably for purposes of food resource procurement activities in the immediate vicinity. A range of wear patterns and edge shapes was reflected on the utilized tools at these sites, thus indicating that a range of activities rather than focal activities were performed.

(3) Technological variation: Previous geological and archeological survey within the Cochiti Reservoir locale had indicated that a variety of lithic raw materials suitable for tool manufacture was present in the region (Warren 1977c). One avenue of investigation framed as a focus of research concerned the degree to which the distribution and relative abundance of these different materials conditioned either choice of site location or variation in technique of tool manufacture by Archaic inhabitants of the reservoir locale.

Two basic research strategies were implemented to answer this question. First, assemblages of lithic tools and manufacturing by-products were classified taxonomically according to kinds of materials from which they were manufactured (see Warren, Chapter 3, this volume), and a variety of morphological attributes related to stage and technique of reduction were defined for each artifact (see Chapman and Schutt 1977 for definitions of attributes monitored). Results of this site-specific assemblage analysis are presented in each site report (Chapman et al. 1977; Eck 1979; Hunter-Anderson 1979a, 1979b, 1979c) and in the appendices to those reports (Chapman and Biella 1977b:378-419; Biella 1979:Appendices II-VIII). Second, a geological survey of the reservoir locale was undertaken to map actual occurrences of different raw materials and sample plots within these source areas were defined in order to quantify relative abundance of particular taxa (Warren, Chapter 3, this volume).

Analyses directed toward assessing variation in choice of materials and techniques of tool manufacture among different Archaic sites relative to distributions of raw materials yielded the following observations:

The southern Pajarito Plateau including the Cochiti Reservoir locale is a region characterized by a relatively great diversity and abundance of lithic raw materials suitable for tool manufacture. These materials range from volcanic obsidians and basalts to a variety of quartzites, cherts, and chalcedonies found in the axial gravels of the Totavi Lentil—outcrops of which are exposed throughout White Rock Canyon. The Cochiti Reservoir locale, in particular, is characterized by a great number of sources of Pedernal cherts and chalcedonies and outcrops of basalt vitrophyre (3701, glassy basalt). Although a few sources of obsidian have been identified in the reservoir locality, obsidians are much more abundant further north of the reservoir itself.

Although some variation in distribution of basalt vitrophyre, relative to distribution of cherts, chalcedonies and quartzites, has been observed within the reservoir locale, the overall availability of knappable materials can be described as almost ubiquitous. In this sense, suitable lithic raw materials are potentially available within the immediate vicinity of any given possible site location or, at worst, no more than 300 to 400 m distant from any site.

Given this basic ubiquity of raw material sources, it is not surprising to note that no obvious patterning in Archaic settlement could be observed to covary with particular source areas. As discussed previously, the overall settlement structure of Archaic residential and nonresidential sites seems to represent a locality-based strategy of occupation in which clusters of residential and nonresidential sites could be observed along both sides of the Rio Grande from south to north within the reservoir locale. Lithic source areas existed within the vicinity of all such clusters of sites, but such source areas existed as well in areas of landscape which were not occupied by Archaic populations. It thus seems apparent that the distribution of lithic raw materials did not play any role, whatsoever, as a determinant of Archaic settlement behavior within Cochiti Reservoir.

A second line of investigation into determinants of Archaic tool manufacturing behavior concerned identifying whether certain kinds of materials were preferentially selected over others for manufacture and whether these material preferences required certain adjustments in manufacturing behavior from site to site given their relative availability.

Comparative analysis of intersite assemblages in this regard indicated that the vast majority of utilized tools discarded at Archaic sites were unretouched or marginally retouched flakes manufactured in situ from locally available parent materials. Larger by-products of manufacture such as cores and large angular debris were in evidence at all sites as were considerable numbers of cortical and noncortical debitage. Predominant techniques employed for manufacture reflected simple core-flake reduction.

A tendency toward preferential selection of basalt vitrophyre materials was noted throughout all Archaic site locations when compared with Anasazi and Historic period assemblages (see Kemrer and Kemrer, Chapter 14, this volume). Experimental usage studies conducted during the course of the Cochiti Reservoir project indicated that basalt vitrophyre was a highly durable and effective material for a variety of cutting, sawing, and scraping tasks (see Chapman and Schutt 1977) although it did not respond as well to pressure retouching in comparison to obsidian and chalcedony.

Despite this overall preferential tendency for basalt vitrophyre, intersite comparison of relative abundance of manufacturing by-products among Archaic sites still indicates that site-specific selection behavior was governed by immediate availability of basalt vitrophyre in relation to cherts and chalcedonies in the vicinity of the site locations. In this sense, Archaic sites located along the eastern side of White Rock Canyon nearby major outcrop sources of basalt vitroyphyre tended to exhibit greater usage of that material than did sites located along the western side of the canyon where basalt vitrophyre materials were available in lesser abundance as waterworn slabs within beach areas adjacent to the Rio Grande.

An exception to this very localized strategy of lithic material utilization is evident among nearly all Archaic residential sites with respect to obsidian tools and manufacturing by-products. Although obsidian raw materials are available throughout the Cochiti Reservoir locale, no highly abundant resources for obsidian have been discovered (see Warren, Chapter 3, this volume). The material rather occurs as isolated water rounded nodules throughout the Totavi Lentil gravel formation; it also occurs as occasional smaller nodules deriving from airborne pumice deposits. Major obsidian flow deposits or talus breakdown from such flows are located to the west and north of White Rock Canyon.

Tools and manufacturing by-products of obsidian found at Archaic sites in the reservoir locale reflect a dual strategy of utilization with regard to these materials. Evidence of tool manufacture from locally available obsidian is reflected as cortical and noncortical debitage and unretouched or marginally retouched flake tools. In addition, fragments of obsidian bifaces, projectile points, and resharpening flakes detached from large bifaces occur at nearly all residential sites, indicating usage and refurbishing of curated obsidian tools which were used at the site locations but not manufactured at the locations.

The overall pattern of Archaic manufacture and utilization of obsidian materials within the Cochiti Reservoir locale thus seems to indicate that a basic set of previously manufactured obsidian tools were being imported to site locations and utilized during terms of site occupancy. Locally available obsidian raw materials in the vicinity of sites were basically treated much the same as other kinds of raw materials in that they were not used to produce preforms or finished bifacial implements. Local obsidians were instead used to manufacture simple flake tools.

In summary, the following basic points can be made concerning characteristics of Archaic technological behavior within the Cochiti Reservoir locale relative to the kind, distribution, and abundance of locally available lithic raw materials: (1) the distribution and abundance of lithic raw materials suitable for tool manufacture within the reservoir locale can be characterized as almost ubiquitous, and no evidence exists to indicate that Archaic settlement strategies within the locale were, in any way, conditioned by variation in lithic source distributions; (2) with the exception of obsidian materials (which are not highly abundant in the reservoir locale) Archaic material selection and manufacture of tools reflects a predominant tendency toward expedient utilization of materials immediately accessible within the vicinity of particular sites, although basalt vitrophyre was a preferred material for the manufacture of simple flake tools; (3) previously manufactured implements of obsidian (including large ovate bifaces and projectile points) were imported to the site locations within the reservoir locale; and (4) no evidence was found to indicate that stages involved in manufacture of lithic artifacts were sequentially performed at different site locations—that is, strategies of material selection, primary and secondary stages of core reduction, and flake retouch all occurred at each residential site, and no evidence of nonresidential quarrying or primary reduction sites was found.

The entire character of Archaic technological behavior within the reservoir locale thus seems to reflect a very expedient utilization of available lithic raw materials. The overall picture of Archaic settlement within the area seems to be one of transient occupation by individuals and commensal groups who carried with them a basic set of previously manufactured bifacial implements but who depended, at the same time, upon local raw materials for manufacture of most tools used in subsistence related activities within the reservoir. The character of material selection, manufacture, and utilization of local raw materials indicates that Archaic inhabitants were not economizing their production of implements during terms of occupancy of site locations, and further that they were not attempting to use available raw materials to manufacture curated tools for exportation to other localities for future usage.

Taken in conjunction with other lines of investigation concerning the character of Archaic occupation of the Cochiti Reservoir locale, the strategies of lithic resource tool manufacture and usage seem to indicate a strictly short term period of occupancy governed by foreknowledge that the majority of lithic tools necessitated during the term of occupancy could be expediently manufactured at any site locale.

Question 3

The last research goal outlined in the proposal concerned definition of the effective territorial or regional boundaries of the Archaic populations who inhabited the Cochiti Reservoir locale. Although a few observations can be made with respect to this problem area, such definitions are more profitably the province of future researchers into Archaic adaptations in the northern Rio Grande Valley.

As indicated in the preceding discussions, the entire use of the Cochiti Reservoir locale by Archaic populations was remarkably similar in both structure and content. The adaptation was one in which general localities (as defined in Chapter 5) were utilized over a period of years by very few commensal groups. The use of these localities included nonresidential as well as residential behavior. Although it might be anticipated that a 32 km long transect (extending from the Santa Fe River in the south up into White Rock Canyon to ca. Pajarito Springs) would cross cut the effective territorial usage of more than one Archaic local group, we were unable to define any territorial boundaries within the reservoir locale. Nor were we able to elicit any differences in behavior between east and west sides of the Rio Grande, even though major rivers have been documented ethnographically to serve as territorial boundaries.

Any definition of territorial boundaries will of necessity hinge upon research into Archaic adaptations in other areas adjacent to the reservoir. We hope that future work will examine site structure as we did in order to discover whether the small commensal group structure of residence which was redundantly evident throughout Cochiti Reservoir was characteristic of Archaic adaptation as a whole—do they define a familially based social strategy similar to that documented by Steward (1938) or do the commensal groups simply represent a portion of a larger local group organization which had dispersed into localities such as Cochiti Reservoir for one procurement season, as is so commonly assumed in the literature into Archaic adaptations in the Southwest?

We cannot overemphasize the importance of examining the structure of Archaic groups and sizes thereof to begin to refine models for this *generalized hunter-gatherer* adaptation. Unless alternative models such as a familial vs. band based organization are considered, little new insight into the overall character of Archaic adaptations will be forthcoming in the years ahead.

ANASAZI ADAPTIVE STRATEGIES

Introduction

During the initial stages of the Cochiti Reservoir project, a basic data set concerning known archeological sites (from both survey and excavation observations) was compiled for an area of landscape centering upon Cochiti Reservoir itself and encompassing ca. 1325 km^2. This study area constituted the primary data from which observations of settlement variation among the Anasazi period sites (Developmental, Coalition, Classic) were drawn and about which initial proposal questions were phrased (Biella and Chapman 1975).

Based upon preliminary analysis of overall settlement variation among these three major temporal phases of occupation, coupled with preliminary analysis of intensive survey data within Cochiti Reservoir itself and data derived from excavation of Anasazi period sites in the permanent pool of the reservoir (Chapman et al. 1977), our initial impressions of changes through time in the character of Anasazi adaptation could be summarized as the following scenario.

Well documented evidence of sites representing very early transitional stages of adaptation from a predominantly hunting-gathering subsistence base to a more focal horticultural or agricultural subsistence base (Basketmaker II) was lacking within the study area although such evidence was known to exist in other portions of the central Rio Grande Valley south of the study area (Rinehart 1967).

The first evidence of true Anasazi settlement within the region was reflected as a very few early Developmental (Basketmaker III, Pueblo I) site locations situated below the mouth of White Rock Canyon and along the Santa Fe River drainage. Based upon ceramic data, these sites probably dated in occupation between A.D. 750 and 950.

Pueblo II or late Developmental phase sites were somewhat more frequent in occurrence but again were situated predominantly below the mouth of White Rock Canyon. Exceptions to this were noted, but most of these exceptions reflected multicomponent (Pueblo II/Pueblo III) phase occupations and the exact makeup of the Developmental component was uncertain. Pueblo II phase sites in the study area have been tentatively dated between A.D. 950 and 1175.

The Basketmaker III and Pueblo I and II phase sites are generally characterized by isolated residential units, commonly pithouse depressions, and may or may not be associated with surface storage units. These residential complexes apparently represent winter habitation locales and perhaps annual residences, but any interpretations concerning duration of occupancy for Developmental sites remains speculative.

The first major and substantial occupation of the study area north of the mouth of White Rock Canyon begins during the Coalition or Pueblo III (P-III) phase, ca. A.D. 1175, and continues through 1300 or 1350. The P-III settlement of the southern Pajarito Plateau and adjacent areas represents a truly massive occupation of the region, and given the extremely ephemeral P-II settlement which preceded it, clearly indicates a colonization or population radiation into the southern Pajarito Plateau.

P-III residential sites exhibited a diversity in size but often were characterized by a redundant residential complex made up of a series of contiguous surface rooms (with and without interior features) and one or more kivas. Although such complexes were as small as 3 to 4 surface rooms and a single kiva and as large as 20 surface rooms with 2 to 3 kivas, these larger sites appeared to represent two or three of the smaller residential complexes built through accretion. Such sites reflected annual rather than seasonal occupations as did some small one room sites documented within the study area (see Biella, Chapter 6).

The Classic or Pueblo IV (P-IV) phase settlement within the region was characterized by a distinct shift toward a large site or village-based residential strategy, concomitant with contemporaneous occupation of small one and two room sites distributed throughout the landscape. Evidence of construction of agricultural terrace and checkdam facilities, trails leading between some village centers, and considerable evidence of inter-village, perhaps inter-regional exchange systems as indicated by the routine circulation of ceramic vessels (see Warren, Chapter 10) is well documented for the P-IV phase. This overall change in regional adaptive behavior was extremely abrupt, beginning as early as ca. A.D. 1325 or 1350 and continuing as the dominant pattern of settlement and land use until ca. 1525.

From our initial observations of the entire Anasazi period, we felt that the temporal sequence of settlement changes reflected a long term adaptive process of a quasi-evolutionary nature similar to that documented in other regions of the Southwest. As a result, we developed a set of questions based upon a density-dependent model of adaptive change to guide future research into Anasazi adaptive strategies (cf. Boserup 1965). Stated simply, we felt the earliest Anasazi occupation of the region was quite ephemeral from ca. A.D. 750 until 1175, at which time the region was extensively settled by immigrants from another region. For a period of some 150 years after this initial colonization the population density in the region increased finally to the point of exerting considerable stress upon the food productive capability of the system with the result that by ca. A.D. 1325 to 1350 a major change in the strategy of settlement and land use technology was necessitated. This change in adaptation was reflected as the P-IV village-based strategy and was apparently a successful change in that similar strategy of settlement characterized the entire central Rio Grande Valley into the late 1500s—the time of Spanish exploration and initial settlement.

A primary assumption underlying our initial conceptualization of Anasazi culture-history was that the change in settlement as reflected in the P-IV phase represented an adaptive reorganization on the part of indigenous occupants of the region. In this sense, we felt that data pointed toward a continuous settlement of the region from A.D. 1175 through 1500, punctuated by a rapid period of change on the part of the inhabitants between 1325 and 1350 presumably due to an unidentified set of stresses upon the ability of the system to produce food for a growing population.

Previous archeological research in the Southwest and elsewhere in the world had identified essentially similar histories of human settlement, population growth, and subsequent adaptive change; and models of different kinds had been proposed to account for such long term adaptive change within particular regions.

We felt, then, that appropriate avenues for specific research in the Cochiti Reservoir locale would be those which attempted to document the nature of demographic processes underlying the initial stages of settlement and the period of population growth reflected in the P-III phase, and questions which would lead to discovery of the kinds of stresses which actually became operative upon the system of adaptation such that fundamental changes in the structure and organization of the system could be seen to have evolved as responses to those stresses.

Thus in the proposal to the present contract, we developed a series of questions which were designed to monitor and/or evaluate potential stresses on the P-III (and ultimately the P-IV) adaptive system which lead to systemic behavioral changes.

Review of Proposal Questions

The following questions were outlined in the proposal:

A. 1. To what degree is the choice of site location of Anasazi period sites, through time, conditioned by soil, physiographic, or climatological variability that affects potential agricultural production of food resources?

2. To what degree do these differ from procurement [nondomesticated food resource] strategies?

B. To what extent is seasonal scheduling of procurement, production and consumption strategies conditioned by food resource storage for later consumption?

C. There will be an examination into the dynamics of population growth and change in the . . . northern Rio Grande and the Cochiti area. Specific questions to be addressed will include:

1. To what extent can factors of adaptive change be attributed to indigenous population growth and attendant population pressure?

2. Can the shift from a dispersed settlement pattern of Pueblo III to the aggregation noted during early Pueblo IV be attributed to an accommodation of population growth or to a reorganization of the existing populations? To what extent is the increase in number of agricultural terraces, water control devices and other evidence of intensification of land use during the Classic period accounted for by current models of population growth or pressure? (Broilo 1976:8)

Review of Research Results

Prior to reviewing the results of the specific research questions, it should be emphasized that one analytical strategy was adopted throughout the research into Anasazi adaptive strategies -- that of delineating the nature of the behavioral changes in land use, storage, site makeup, settlement pattern, etc. between each of the different Anasazi phases for purposes of interphase comparisons. It was felt that such a strategy would facilitate an understanding into the underlying processes of Anasazi adaptation which would be lacking if one focused strictly upon a single adaptive phase alone. Thus, each of the research papers in the body of the report specified differences on a phase by phase basis and attempted to explain the changes noted between the phases with respect to particular topics. Warren's study of the glazeware production centers (Chapter 10) was the only exception to this analytical strategy, an exception derived solely from the lack of sufficient regionwide data on the production of Santa Fe B/W wares.

Question A

The importance of agricultural products in the success of Anasazi subsistence, and ultimately adaptation, is rarely questioned. Thus, in studying Anasazi settlement strategies throughout the Southwest, it is commonplace to examine the distribution of Anasazi sites with respect to factors which might affect the agricultural productivity of a given locale. In the first question, we have proposed evaluating the degree to which the distribution of Anasazi sites in Cochiti Reservoir might best be explained in terms of the distribution and productivity of agricultural vs. nonagricultural resources.

The first avenue of research undertaken to answer this question was that of stratifying the Cochiti Reservoir locality with respect to environmental factors traditionally thought to affect the success of an agriculturally based economy—climate (temperature, water abundance and seasonal availability), physiographic settings (slope, exposure), and soil nutrients. We were careful to describe not only the reservoir itself in these terms but also the general land area around the reservoir such that we could evaluate the extent to which the reservoir was similar to nearby terrain in terms of agricultural productivity.

In the first volume of the Cochiti Reservoir publication series, three articles specifically addressed and described environmental variation in the general Cochiti Reservoir area which pertained to agricultural potential. One paper prepared by Cully (1977) reviewed the paleoclimatic data for the northern Rio Grande region. She suggested that the basic climatic regimes which currently characterize the region have not changed significantly in the past 5000 years, and thus current patterns in vegetation and general temperature/moisture should be of a similar or comparable level to those documented in the past 100 years or so. She did note, however, that from a station in the upper Rio Grande (No. 7, see Hunter-Anderson, Chapter 8:Fig. 8.2) that droughts probably occurred ca. A.D. 517, 614, 844, 1170, 1402, 1525 and 1580 (Cully 1977:101). It should be emphasized that the general area has been undergoing a comparable drought since the end of the 19th century so current precipitation records should be evaluated in this regard (Traylor et al. 1977).

In another article, Brakenridge (1977) scaled the potential water (in terms of ground water and water for irrigation) for some 40 lateral drainages to the Rio Grande in the immediate area of Cochiti Reservoir. From his study, we are able to conclude that the Santa Fe River, Rio Chiquito, and Rito de los Frijoles drainages would have been the most consistently reliable water sources regardless of annual or multiannual variance in precipitation for agricultural purposes.

Ramage (1977) stratified the general reservoir locale with respect to differences in slope and exposure, factors which strongly influence soil potential. As a result, she documented the extremely patchy nature of the Cochiti Reservoir locale. Fosberg, this volume, then used Ramage's data, coupled with a much more detailed discussion of the soil characteristics of the region, to evaluate the proposition to what extent geologic, pedologic, hydrologic, and geomorphic data alone could be used to explain differences in Anasazi strategies of settlement between P-III and P-IV phases in the Cochiti Reservoir locale.

Prior to reviewing the results of his analysis, a few comments should be made concerning the test area along the Rio Chiquito that he used and other areas in and around Cochiti Reservoir.

In terms of agricultural potential, the northern part of Cochiti Reservoir, that part confined in White Rock Canyon, must be considered limited, at best. Although the Rio Grande, the major perennial river in the area, flows through the canyon, it would be a mistake to envision the canyon locale as being characterized by broad alluvial floodplains and terraces suitable for agriculture. Rather, the terrain in the canyon is extremely convoluted and the substrate commonly consists of exposed basalt talus elements. Further, continuous tracts of well-drained soils with good exposures are rarely found within the canyon and, when documented, encompass no more than a few hectares in maximum extent (and most often less than 0.5 hectare). In fact, the canyon locality is so steep that man-made terraces and/or grids had to be constructed to make the area suitable for any agricultural pursuits. The area that Fosberg and Husler describe in Chapter 17, which is situated in White Rock Canyon, is one of the few natural areas in the canyon suitable for agricultural pursuits.

In contrast, the part of Cochiti Reservoir situated below the mouth of White Rock Canyon and some lateral drainages in the southern Pajarito Plateau (such as the Rio Chiquito drainage to the west of White Rock Canyon) exhibit far more agricultural potential in the form of comparatively good soil and exposure characteristics, and in the form of potential water. It should be noted, however, that the Rio Grande flood plain below the mouth of White Rock Canyon is currently situated in the lowest rainfall isohyetal (see Hunter-Anderson, Chapter 8:Fig. 8.1).

Thus the reader should recognize that Fosberg's study cross cuts an area with high agricultural potential for the general Cochiti locale, that along the Rio Chiquito, and an area with low agricultural potential, in White Rock Canyon. A review of the results of his study will be presented below.

A large sample (240 sites) of P-III and P-IV sites was examined. For this study, he made the assumption that 1 to 2 room sites represented seasonal field house agricultural loci and that 3 to 10 room sites reflected habitation residences. There are, of course, problems in making the assumption that the smaller architectural sites necessarily reflected agriculturally related facilities. It may be suggested that the 1 to 2 room vs. 3 to 10 room distinction for the P-III phase sites is probably a sound one (see Biella, Chapter 6) but that the assumption that the 3 to 10 room sites represent permanent residences during the P-IV phase is most likely quite misleading. The vast majority of sites in the Rio Chiquito during this latter phase within the larger site class consist of 3 or 4 rooms and probably reflect a similar class of activities as that of 1 and 2 room sites with only the larger winter villages serving more permanent residential loci. Further, most P-IV residential sites are exluded from Fosberg's sample simply because they exceed 10 rooms in size. Despite these exceptions, the study did document some rather profound differences in settlement between the P-III and P-IV phases with respect to pedologic, geologic, and hydrologic properties of the tested area.

Land surfaces with the highest agricultural potential (soil #15) were extensively utilized during the P-III phase - both in terms of the placement of residential sites (75% of 3-10 room sites were on this soil) and small seasonal sites (76% of field house sites were on this soil). For the P-IV phase sites, 53% of 1-to-2 room sites and 56% of 3-to-10 room sites were situated on soil #15. Thus extensive use of the soil persists through both phases. The major distinction between the P-III and P-IV site placement resides in the fact that nearly half of the P-IV sites were situated on inferior soils as well. It is unclear, however, whether the expansion onto poorer soils is a result of decreased productivity of soil #15 or increased importance of agricultural products during the later P-IV phase.

A second study that is presented by Hunter-Anderson (Chapter 9) provides some data which might be used to evaluate whether the importance of agricultural products during the P-IV phase increased or not. The reader is referred to her chapter and to the discussion of Question B below.

The second half of the first question (A-2) addresses the extent to which the procurement of nondomesticated food resources may have conditioned Anasazi settlement in the Cochiti Reservoir locale. As in the discussion of environmental factors affecting domesticated resources, a series of studies of nondomesticated floral and faunal resources was conducted. These studies were, of necessity, based upon the regional distribution of modern flora and fauna, and the availability and productivity of these plants and animals has been discussed in the effective environmental section for the Archaic period of adaptation above.

Unfortunately, direct evidence of procured resources on Anasazi sites in the reservoir was limited at best. The deflated and surficial nature of the sites did not permit any clear evidence of the character of nondomesticated food resource procurement and consumption strategies, although fragments of mature seeds (generally weedy Cheno-Ams), fish bones, and small and large mammal bones were recovered from some of the prehistoric pueblo sites (see Biella, Chapter 6). The fragmentary nature of these remains does not permit any differences between P-III and P-IV strategies to be identified.

Consequently, analysis of procurement strategies was ultimately based upon settlement distributional data in relation to various environmental data, and the results of one such analysis is presented in Chapter 15 by Rogers and Chasko. Their article, while predominantly outlining a methodology underlying a spatial patterning recognition technique, has important implications concerning the distribution of potential P-III and P-IV nonresidential (procurement?) sites.

Using the same test area as Fosberg (Chapter 7), they were able to demonstrate high values of squared coherence between lithic sites and small P-IV sites. There are two interpretations of such a relationship. One is that the lithic sites represent nonresidential (as well as nonceramic) locales which articulate with the small seasonal P-IV sites. Alternatively, the lithic sites may represent Archaic localities which may be a preferred interpretation in light of the results of some obsidian hydration analyses (see Chapman, Chapter 4). This implies there may be some single underlying variable which is conditioning the placement of both the lithic sites and small P-IV sites. Such a variable might involve the procurement of one or more nondomesticated food resources.

Thus, in conducting research into the effect of agricultural and nonagricultural products and the distribution of Anasazi period sites, we arrived at ambiguous results. The results of our analyses suggest both the character of and distribution of environmental variables conditioning agricultural productivity and the distribution of nonagricultural products may each play a significant role in understanding Anasazi settlement. We would thus suggest that future research should pursue both kinds of analyses, rather than assuming that small residential sites simply reflect *field house* loci.

Question B

It is clear that there are two basic principles which underlie a shift to an agriculturally based economic strategy. One concerns the ability of a population to control the production of a food resource. That is, through labor intensive input a potentially abundant food resource may be insured for consumption (barring a series of natural catastrophies—climatic, pest, etc.). The key to an agricultural adaptation, however, is not necessarily to be found solely in the production of foods, but rather in the *storage* of those food resources for consumption during lean times, winter and early spring, when alternative foods are available in limited quantities.

Hunter-Anderson (Chapter 9) provides an analysis of differences in storage behavior for varying sizes of P-III and P-IV architectural sites in order to explain underlying characteristics of adaptive strategies employed by the two systems. She argues that enclosed structures which lack interior features exhibit the greatest potential to have been used as bulk storage repositories. She does not argue, however, that other facilities with interior features (bins and hearths) could not have served as storage units, but only that structures without interior features may reflect a more routine *accessibility* to serve storage functions.

In comparing differences in P-III and P-IV sites in her sample, she demonstrates that the percentage of floor space per site for storage rooms (those which lack interior features) increased significantly for the P-IV sample across nearly all site classes (1-2 rooms, 3-10 rooms, greater than 50 rooms), with the most dramatic change in the 1-2 room class within Cochiti Reservoir alone (0% to 52% storage space/site). Based upon these results, she argues that the importance of stored goods increases between the P-III and P-IV phases and, thus, a stress upon the P-IV system may have necessitated increased production of storable foodstuffs (agricultural products), especially in the Cochiti Reservoir area.

Question C

This question specifically addressed the change in *settlement* from dispersed, annually occupied residential complexes of 8-20 surface rooms and associated pit depressions characteristic of the P-III phase to the aggregated village-based strategy characteristic of the P-IV phase. In the proposal there existed an explicit assumption of a population increase from the P-III to P-IV times, and thus suggested that one major focus of future research should be upon evaluating the degree to which this population increase was due to continued immigration into the Cochiti Reservoir-Pajarito Plateau areas or due to indigenous population growth.

While we feel that an excellent case can be made to interpret the settlement changes between late P-II and early P-III phases in the study area as clearly reflecting a population radiation or colonization of the area, we no longer feel that such a definitive statement is warranted for explaining the change between the P-III and P-IV settlement strategies.

In 1977 we argued that, if anything, there was a decrease in total population for the area as measured by the total number of rooms on sites which could be dated to either the P-III and P-IV phases (Biella and Chapman 1977b). Although the measure was crude, it clearly was inconsistent with a basic assumption underlying Question C in the proposal. Thus it became necessary to reevaluate whether there was a population increase during P-IV times.

In order to investigate the proposition that the population increased between the late P-III and P-IV phases, it is necessary to develop a scale for estimating population size. Since such estimates are clearly derived from survey data, there are some problems which must be considered: assessing the average number of inhabitants for a site with both residential and nonresidential units; developing bridging arguments for evaluating differences in room size and the number of inhabitants; delineating the basic character of the settlement strategy—whether residential sites reflect permanent, annual occupations or a series of seasonal occupations; scaling the average duration of occupation for a given site; differentiating the different size of occupational units for multicomponent sites (e.g. the P-III occupation at LA 70 was considerably smaller than the P-IV occupation); and similar such problems.

In order to ameliorate some of these problems, it is necessary to identify characteristics of residential and occupational history for a sample of P-III and P-IV sites. Thus we developed a research program with the intent of ascertaining duration, intensity and seasonality of occupation for Anasazi period site in Cochiti Reservoir. A review of the results of some of this research is presented in Biella (Chapter 6).

As a result of this study, we can offer a tentative answer to the question that the P-IV aggregated settlement strategy is not necessarily a reorganization of existing populations. Some settlement and site-specific data may be interpreted as a withdrawal and replacement of the P-III populations in the Cochiti area with different populations during the P-IV phase. Such population movement and relocation (or mobility) have been documented, archeologically, to exhibit considerable antiquity among the Anasazi populations of northern New Mexico. A *mobility option* in which segments of a local group or village or the entire village relocate during a period of years may have been a critical, if not central, aspect of a pan-Anasazi adaptive strategy which served to ameliorate predictably adverse conditions of an agriculturally based economy in an arid environment.

This is, of course, a speculative interpretation of the Cochiti data, but it leads to an unambiguous analytical conclusion that the question concerning aggregation of the P-IV phase populations might more profitably be rephrased: *What processes underlie a change in the structure and organization of an adaptive system to result in an aggregated, village-based settlement strategy?*

In Chapter 8 Hunter-Anderson pursues such an approach through an evaluation of the P-IV aggregation strategy with respect to a competition spacing model derived from ethnographic Chippewa/Dakota accounts. She reviews climatic data for the P-III and P-IV phases and suggests that the P-IV aggregation and placement of villages in lower precipitation and elevational zones resulted in leaving upland zones accessible to various Anasazi populations for purposes of hunting. Meanwhile, the lowlands could be utilized agriculturally if employing more labor intensive water control devices.

She thus argues that the settlement shift may be interpreted as resulting in an expanded food resource base, not only in production of agricultural products vis-a-vis terracing systems and water diversion devices; but also in opening up large tracts of land for hunting by different Anasazi populations. Against a regionwide referent, this would provide an increasingly effective food resource buffer, all without expending energy in defense of the hunting territories.

Although this is but one model to address the shift to aggregated centers in the Cochiti Reservoir area, we feel that it is a provocative one and serves to illustrate the utility of examining the phenomenon of aggregation without restricting analyses to discerning immigration vs. indigenous population growth curves. This latter problem, however, remains of general interest and should be an avenue of continued research.

HISTORIC PERIOD ADAPTIVE STRATEGIES

Introduction

The Historic period of human occupation within the northern Rio Grande Valley has been characterized by a complex set of changing interactions between native Pueblo Indians, Spanish Colonists, and Anglo immigrants—changes which span a time frame of over 400 years since Coronado's exploration of the region in A.D. 1540. Seven temporal phases felt to reflect major changes in regionwide sociopolitical and economic behavior were proposed at the beginning of the Cochiti Reservoir project in an attempt to provide a framework for subsequent research into Historic period adaptive strategies. These included the Spanish Exploratory phase (A.D. 1540-1598), the Spanish Colonization phase (A.D. 1598-1680), the Pueblo Revolt phase (A.D. 1680-1696), the Spanish Colonial phase (A.D. 1696-1821), the Mexican phase (A.D. 1821-1846), the U.S. Territorial phase (A.D. 1846-1912), and the New Mexican Statehood phase (A.D. 1912 to present).

These phases were defined with respect to regional changes in political jurisdiction, economic strategies, and settlement variation which characterized the entire locale encompassed by present-day New Mexico (see Abbink and Stein 1977 for a detailed discussion of the major events and characteristics of each phase). Although these kinds of changes clearly have an anthropological referent, it is important to emphasize that they were developed solely from extant historical documents and literature.

In developing specific research questions to guide the archeological investigations into the Historic period occupation of the Cochiti Reservoir locale, we wished to evaluate the sociopolitical and economic changes documented in the historic literature from a more evolutionary anthropological perspective—a perspective which suggests that preindustrial and industrial nation-state systems may reflect significantly different adaptive strategies. Consequently, two sets of research questions were developed, one for the preindustrial phases and another for the industrial phases.

In the following sections the original proposal questions which served as guidelines for the archeological research into the Historic occupation of the reservoir, along with the results of that research, will be summarized. It should be noted that the questions focus on only four of the seven proposed phases. This focus is a simple function of the fact that the historic occupation of the reservoir has been intermittent and that Spanish Exploration, Pueblo Revolt, and Mexican phase sites could not be identified unambiguously.

Preindustrial Adaptive Strategies

Review of Proposal Questions

The following questions were developed as guidlines for investigation into the preindustrial adaptive strategies:

> The dynamics of nonindustrial nation-state expansion into indigenously populated 'frontier' regions will be isolated.
>
> 1. To what degree do Spanish Colonial subsistence strategies involve labor investment into food resource extraction and production, versus labor investment into administration and control of an indigenous work force for those purposes?
>
> 2. What are the conditions under which entrepreneurial strategies and market economies evolve as mechanisms for production, distribution and consumption of goods and resources?
>
> 3. What are the processes of change in agriculturally based adaptive systems as the result of nation-state exploitation for labor and food production?
>
> 4. What are the effects of animal husbandry and transportation on the organization of food production and consumption? (Broilo 1976:10).

The articles prepared by Snow, Warren and Binford (Chapters 12, 13, and 14, respectively) in the body of the volume have already either directly answered portions of these questions or have provided sufficient information such that the questions may now be answered. In particular, Snow examines the Historic period sites in Cochiti Reservoir with respect to a model for frontier adaptive behavior; the reader is referred to her excellent treatment of the subject.

Review of Research Results

Question 1: This question was based upon initial historical research conducted by Abbink and Stein (1977) summarized in Volume 1 of the Cochiti Reservoir publication series. Their review of the historical literature indicated that the initial Colonization phase of Spanish settlement within the New Mexican colony focused upon a dual ecclesiastical and secular administrative structure of indigenous Pueblo Indian populations in which the Spanish settlers essentially taxed the native Pueblo groups for both products and labor to support the Spanish colonists.

After the Pueblo Revolt of 1680 and De Vargas' reconquest in 1692, a new colonization strategy was initiated by the Spanish which involved the establishment of a system of land grants for both native Pueblo tribes and for groups of Spanish settlers within the colony. The land grant system was designed to attract immigrants from Mexico to the New Mexican colony through grants of land for homesteading and grazing rights either to individuals or groups of immigrants. The major difference in emphasis between this new land grant system and the pre-Revolt encomienda system was that of promoting more or less *self-sufficient* strategies of settlement and subsistence on the part of Spanish immigrants in contrast to the previous tax-based subsistence strategy.

Thus, one thrust of the Historic period research was to evaluate the degree to which these two different administrative strategies affected the character of local settlement and subsistence behavior.

The research conducted during the course of the project relating to this question necessitated addressing two problem areas: first, that of dating historic sites to the pre-Revolt and post-Revolt phases; and second, that of identifying the character of settlement and subsistence behavior reflected among sites which could be dated to either phase.

With few exceptions the sites in the reservoir lacked materials or samples suitable for absolute dating techniques such as tree-ring, radiocarbon, or archeomagnetic analyses. Consequently, the sole means of dating sites to either the Spanish Colonization or Colonial phases of occupation was based upon differences in ceramic manufacture and design styles. Existing ceramic typologies, prior to the Cochiti Reservoir project(s), were not well developed for the region although they did provide a basic chronology. Warren's work, as presented in Chapter 13, this volume, has resulted in a significant refinement of the existing chronology for the entire Cochiti Reservoir area such that pre-Revolt Spanish Colonization sites could be distinguished from early 18th century Spanish Colonial sites and from late 18th/early 19th century Colonial sites.

Information concerning the character of subsistence behavior at the site-specific level may be found in Binford (Chapter 14, this volume) with respect to variation in faunal processing and consumption techniques, in the appropriate site reports published in Volume 2 and 3 of the Cochiti Reservoir publication series (Chapman and Biella 1977; Biella 1979), and in Snow (Chapter 12, this volume). In particular, the latter have provided data concerning the character of residential group size and compliment, subsistence behavior in terms of food resource processing and consumption, and technological behavior in terms of procurement, manufacture, and utilization.

The net result of this archeological research was that although some changes in the size of residential groups occupying the Cochiti Reservoir locale occurred between A.D. 1600 and 1750 to 1800, the basic subsistence behavior of those residential groups was relatively similar throughout that time span. A review of the behavioral strategies will be presented below.

Two site locations dating in occupation to the pr-

Revolt Spanish Colonization phase (1598-1680) reflect year-round habitation by relatively sizeable residential groups (LA 34 and 591). There is limited evidence indicating consumption of agriculturally produced foodstuffs at these sites, but the dominant focus of subsistence related behavior seems to be procurement and processing of domestic fauna, largely sheep and goats. In both cases a range of domestic activities are represented by artifactual remains indicating various stages in the processing and preparation of food resources for consumption at the sites themselves.

From a strictly archeological perspective, the record of the Spanish Colonization phase occupation within the project area suggested that the residential groups were engaged in a set of relatively self-sufficient subsistence strategies.

Snow (Chapter 12, this volume) has discussed evidence from the historical record which indicates that LA 591 may have been inhabited at one time by the relatives of the encomiendero of Cochiti Pueblo. If this is the case, the fact that the material remains comprising that occupancy reflect a predominantly self-sufficient set of subsistence pursuits, stands in considerable contrast to the tax-based subsistence strategy expected for the pre-Revolt Spanish occupation derived from the historic record.

The post-Revolt Spanish Colonial phase occupation of the Cochiti Reservoir locale (A.D. 1696-ca. 1821) reflects a continued emphasis upon faunal resources as a subsistence base, and there are indications of an increasing seasonal rather than year-round strategy of residence within the project area. A range of residential group sizes are represented within the Spanish Colonial phase from relatively sizeable residential settlements such as LA 9138 to smaller, perhaps single family, residence groups reflected at LA 12507, 12161, and 9139. Again, the archeologically observable architectural and artifactual remains recovered from these sites indicates a relatively self-sufficient strategy of subsistence behavior with no clear evidence of routine dependence upon a goods or labor tax on the part of site inhabitants for essential resources.

One exception to this kind of residential and subsistence behavior is found at LA 6178, which may represent a small military garrison constructed and outfitted during the early 1700s as one of several such outposts to defend both Pueblo and Spanish settlements against raids by Apachean groups. LA 6178 thus constitutes the only clear archeological evidence of the existence of a larger, regional system of articulation evident within the local area.

In summary, the first question posed in the proposal can be partially answered through the research conducted. Although historic documentation for the Spanish Colonization phase occupation of the New Mexican colony as a whole indicates that the primary economic base of the colony was dependent upon a tax-based exploitive strategy with respect to native groups, archeological evidence within the local Cochiti Reservoir area indicates that Spanish colonists were, instead, engaged in a relatively self-sufficient set of subsistence activities. The reader is referred to a more extensive discussion concerning the implications of this apparent disparity between the overall picture of early Spanish occupation of the region and the archeological evidence found in Snow's analysis, this volume.

Questions 2, 3 and 4: At the time that these questions were developed, an assessment of previously conducted archeological surveys within the general area (Biella and Chapman 1975) and the Cochiti Reservoir project area (Biella and Chapman 1977c) indicated that many site locations were occupied by native Puebloan groups during what might be termed a protohistoric phase, dating between ca. A.D. 1540 and 1600 or later. Given this information, we felt that the Cochiti Reservoir project area offered an excellent opportunity to examine processes of adaptive change from a pre-existing agriculturally based economy. Further, it offered an opportunity to examine the social and economic consequences of a nonindustrial state-organized expansion and colonization effort as it interfaced with an existing agriculturally based, tribally organized population.

Given our expectation that the archeological record of the project locale included both a protohistoric Pueblo V occupation and a subsequent Spanish occupational sequence, we framed Questions 2, 3 and 4 in the proposal to address problems centering upon the character of changes in the indigenous Pueblo adaptive system as a result of Spanish colonization of the region. Specific focal points posited for examination were the effects of new faunal species and strategies of political and economic administration introduced by Spanish colonists upon the indigenous system (Questions 3 and 4); and an examination of processes of change through time in the organization of subsistence related behavior of the new adaptive system which evolved as a result of this articulation (Question 2).

As a result of investigation into these problem areas, several new facts were learned about the character of protohistoric and early Spanish settlement within the project locale—facts which served to alter the focus of subsequent research.

Perhaps the most important new information gained in this regard was archeological evidence indicating that the project locale above the mouth of White Rock Canyon was virtually uninhabited by Pueblo Indian groups at the time of the first Spanish colonization of the region and, further, may have been uninhabited on a residential basis for a century or more prior to that time. Analysis of the prehistoric Anasazi sites within the reservoir and environs clearly indicated that the last major residential settlement within the southern Pajarito Plateau occurred during the early P-IV phase (A.D. 1325-1450), as represented by Group A and B glazeware ceramic assemblages. Only limited evidence of residential occupation of the area during the later P-IV phase (ca. A.D. 1450-1500+?) was encountered and, in the vast majority of site-specific cases, ceramic types within Group C, D, and E of the Rio Grande glaze ware series, indicating later occupations, were found in low frequencies within assemblages which were predominantly comprised of earlier types.

It thus became apparent that site locations which had been assigned P-V occupation through previous research were not protohistoric Pueblo sites but instead reflected a Spanish settlement of the project area, beginning ca. A.D.

1600. Excavation of a sample of these sites substantiated a Spanish historic rather than protohistoric date of occupancy in the form of architectural traits (larger room sizes, corner fireplaces, use of molded adobe bricks in wall construction), the presence of domestic faunal remains, and occasional artifacts indicating Spanish rather than Puebloan manufacture (metal, ceramic comales, soup plate vessel forms, etc.).

This discovery concerning the nature of settlement within the project locale necessitated changing the emphasis of research from an examination of Pueblo-Spanish *interactions* toward an examination of colonization *processes* within the project area. The proposal questions (2, 3 and 4) were still used to guide the character of research, but emphasis was shifted toward gaining information about processes of change within the microcosm of the Spanish colonization efforts during the 17th and 18th centuries. The following discussion will review the results of research in this light.

(1) From archeological evidence alone it can be stated that one of the most profound adaptive changes differentiating historic period behavior from prehistoric behavior is keynoted by the introduction of domesticated fauna, principally sheep and goats, and to a lesser extent cattle, horses, and pigs. Reasons for this are easy to understand simply because such species resulted in an ability of local human populations to increase, to a substantial degree, their food resource base over a predominantly agricultural and hunting subsistence strategy. Entire subregional vegetative locales such as the extensive Caja del Rio Plateau bordering White Rock Canyon to the east and La Majada Mesa bordering the Rio Grande below the mouth of White Rock Canyon had constituted relatively marginal food resource zones prior to the introduction of grazing herbivores. With their introduction, these grassland areas were effectively redefined as highly productive localities. Further, they constituted an additive kind of resource which could be effectively integrated with existing agriculturally based subsistence strategies to provide a reliable food in volume.

In many respects, changes in the character of social or residential properties of early historic settlement in the reservoir area and concomitant changes in the subsistence organization of that settlement may be seen to reflect a gradually increasing dependence upon domestic fauna as a focal food resource and as a focal product produced locally to be used in trade for basic subsistence requirements.

The earliest historic Spanish sites excavated within the project area (dating to the Spanish Colonization and Colonial phases, ca. A.D. 1600-1750) seem to reflect year-round occupation by varying sizes of residential units whose occupants engaged primarily in a mixed hunting and herding subsistence strategy. Although limited evidence of some dependence upon agricultural products is apparent at these sites (including LA 591, LA 9138, and LA 12161, among others), the predominant focus of subsistence related behavior seems to be procurement and processing of faunal food species and, to a limited degree, craft manufacturing of wool yarn, hide clothing items, and the like.

Site locations dating to the latter part of the 18th century and the early part of the 19th century stand in contrast to this annual homestead strategy of occupation. These later sites seem to represent almost exclusively seasonal herding camps occupied by single commensal groups whose primary subsistence base consists of both nondomestic and domestic fauna.

This basic shift from a year-round residential settlement strategy characterizing the earliest historic occupation of the project area toward a distinct seasonal settlement strategy may well reflect an organizational change in adaptive behavior consistent with historic documentation indicating an increasing economic emphasis upon sheep production throughout the New Mexican colony from ca. A.D. 1600 through the early 1800s.

An interesting feature of the Cochiti Reservoir subsistence data, however, is the continued site-specific reliance upon both nondomestic and domestic fauna as food resources by the site occupants despite the change from year-round to seasonal site occupation.

These later sites (including LA 10114 and 13291) also lack good evidence of craft specialization or utilization of wool to manufacture products such as yarn or clothing -- which again points to a more focal set of subsistence objectives (livestock maintenance or herding) underlying human use of the project locale.

In summary, the introduction of domestic faunal species, especially sheep and goats, into the general New Mexican region during the early 1600s can be seen, from archeological evidence, to have resulted in a rapid and profound change in the entire character of subsistence behavior. Within the Cochiti Reservoir locale, the subsistence activities shifted to a predominant emphasis upon animal husbandry as a focal subsistence pursuit. Architectural facilities for bulk storage of agricultural products were absent among many 17th and 18th century sites within the local area and only limited indirect evidence of consumption of agricultural foodstuffs are present. The apparent shift from earlier year-round occupancy of site locations during the 17th and 18th centuries to predominantly seasonal residency during the late 18th and early 19th centuries may be interpreted as well to indicate an increasing focalization upon domestic faunal products through time.

It is interesting to note that concomitant with an emphasis upon animal husbandry, site locations within Cochiti Reservoir exhibit considerable reliance as well upon nondomestic faunal species as a subsistence base. One implication of this fact might be that the domestic fauna were not used so much as foodstuffs for local consumption, but were used as commodities in a larger regional exchange system. In this sense, commensal groups engaged in seasonal herding activities may have been attempting to limit their consumption of domestic fauna through hunting as much as possible while residing in the locality in order to maximize flock or herd sizes for later use. As noted in Abbink and Stein (1977) and Snow (this volume), both herds of sheep and wool products constituted a major economic product for export from the New Mexican colony as a whole during the 17th and 18th centuries. If the local residents were engaged in *partido* or commission-based husbandry of flocks for more wealthy owners not residing in the local area, it might be expected they would try to minimize their consumption of the domestic animals whenever possible.

If, on the other hand the local residents were engaged in animal husbandry more focally on a subsistence basis rather than a commodity oriented pursuit, the site-specific evidence of reliance upon nondomesitc fauna for consumption may indicate an overall paucity in availability of other foodstuffs for consumption. From historic records, it is known that the Rio Chiquito drainage (to the west of White Rock Canyon) was the site of a Spanish community, La Canada, during the 18th century and that the reliability of agricultural production within the Canada de Cochiti Grant during that period was quite uncertain from year to year (see Abbink and Stein 1977).

(2) With respect to the question of economic articulation of the Spanish Colonization and later Colonial phase settlement of the project locale with the larger regional economic system, a few observations can be made based upon archeological and historical research within Cochiti Reservoir.

First, there exists very little evidence to indicate that the local residents were participating routinely in any regional exchange network for food resources, technological hardware, or other commodities. With the exception of a very few pieces of Majolica ceramic wares, glazed olive jars and the like, ceramic assemblages were manufactured from locally available materials. In a similar sense, limited evidence existed that a few metal implements were used by inhabitants at sites in the local area (cut marks on faunal remains, gunflints manufactured from locally available lithic raw materials, etc.). Similarly, the vast majority of tools recovered from Colonization and Colonial phase sites were utilized, unmodified debitage manufactured from locally available materials. Analysis of manufacturing techniques at LA 9138 and 12161 pointed to the fact that the inhabitants were unfamiliar with the fracturing properties of these materials and were relatively unskilled in flint knapping--perhaps indicating their previous dependence upon a metal-based technological inventory prior to emigrating to the New Mexican colony.

Second, no clear evidence exists to suggest an emphasis upon specialization in production of either food or technological items at the local level for use in trade for other commodities. The only site location which reflected any possible specialization was LA 12161, whose assemblage contained a number of spindle whorls manufactured from prehistoric and historic ceramic fragments and a variety of bone implements reflecting different stages of hideworking and possibly clothing manufacture. Even at this site, however, the dominant character of the artifact assemblage reflected generalized maintenance, processing, and cooking activities. Another Colonial phase site (LA 10114) also exhibited a range of hideworking implements in addition to a more generalized tool inventory.

Summary of Preindustrial Adaptive Strategies

The following summary observations can be made concerning the results of archeological Spanish Colonization and Colonial strategies of adaptation within the Cochiti Reservoir locale.

(1) With respect to the first proposal question, no good evidence was found to indicate that the earliest Spanish settlement within the area was dependent upon taxing the native Puebloan populations for either goods or labor as a means of supporting the colonization effort. Although it was clear from historic documentation that the dual ecclesiastical and secular *encomienda* structure of administration was implemented with respect to Cochiti Pueblo, results of excavation at LA 34 and 591, dating in Spanish occupancy to the 17th century (but abandoned by the Pueblo Revolt of 1680) indicated that the character of subsistence and economic behavior engaged in by Spanish colonists was of a largely self-sufficient nature. That the Spanish occupants of these two sites were engaged in some form of articulation with Pueblo inhabitants of the area was clearly indicated by the prevalence of native-made ceramic vessels used at the sites. The diversity of tools found at LA 591, however, indicated as well that a great range of manufacturing and maintenance activities expected at a self-sufficient homestead were, in fact, undertaken at the site itself.

The archeological record thus seemed to indicate that within the local area the early Spanish settlers were engaged in a relatively self-reliant herding based subsistence strategy which, while reciprocal and perhaps complimentary to the agriculturally dominant Puebloan subsistence, did not involve a one-way taxation of Puebloan goods or labor for its continuance.

(2) With respect to questions 3 and 4 in the proposal, archeological evidence within the Cochiti Reservoir locale clearly indicated that the introduction of domestic faunal species resulted immediately in a profound change in the character of subsistence behavior on the part of local groups. It should be emphasized, however, that the archeological record of historic settlement within the Cochiti Reservoir project area from ca. 1600-1800 indicated that the locale north of the mouth of White Rock Canyon was inhabited by Spanish immigrants and not by Cochiti Indians.

There was thus clear evidence that focal subsistence activities engaged in by Spanish colonists revolved around animal husbandry during this time span with little evidence of substantial reliance upon agricultural production as a significant part of the overall economic strategy. The archeological data indicated as well that the character of this occupation after the Pueblo Revolt became increasingly seasonal in nature.

(3) With respect to question 2 in the proposal, little evidence was recovered among excavated site locations to indicate any extensive participation on the part of local inhabitants with a regional exchange network. Although some indications of a tendency toward craft specialization revolving around clothing manufacture from hides and wool was documented at two Colonial phase site locations (LA 10114 and 12161), the degree of investment into such activities could possibly be accounted for in terms of strictly local consumption and did not clearly reflect a kind of cottage industry production for trade.

Industrial Adaptive Strategies

Review of Proposal Questions

The second set of questions phrased in the proposal was developed to address possible changes in the local settlement or utilization of the project area, in terms of its articulation with an industrially based nation-state. The following questions were proposed:

> The dynamics of industrial nation-state expansion into the [Cochiti Reservoir] study area will be isolated.
>
> 1. What are the effects of mechanized transportation on the organization of subsistence strategies?
>
> 2. What are the effects of [a] money economy, and attendant wage-labor potential on the organization of subsistence strategies?
>
> 3. In what degree do industrially based entrepreneurial strategies and market economies substantially change the local organization of subsistence behavior when compared to non-industrially based strategies? (Broilo 1976:10).

Three temporal phases postdating the Spanish Colonial occupation of the general New Mexican region were defined for the Historic period during the initial stages of the Cochiti Reservoir project, based primarily upon changes in land jurisdiction and political organization of the region as a whole. These included the Mexican phase (A.D. 1821-1846), signified by the political redefinition of New Mexico as a Department of the newly formed Mexican government upon Mexico's succession from Spain; the U.S. Territorial phase (A.D. 1846-1912), signified by military acquisition of the region by the United States and subsequent establishment of an appropriate Territorial government; and the New Mexican Statehood phase (A.D. 1912 to present), signified by inclusion of New Mexico as a state within the United States' government.

Although each of these changes in political jurisdiction was accompanied by social and economic changes which affected the region as a whole, archeological and historical research within the Cochiti Reservoir locale indicated that two key factors of a nonpolitical nature had the most profound effect upon land use within the local area. These were the establishment of the Santa Fe Trail in A.D. 1820 and the construction of a railroad network which began to serve the New Mexico region in ca. A.D. 1880. Both events resulted in making available great volumes of trade commodities manufactured in the eastern United States.

From the standpoint of the Cochiti Reservoir locale, functionally significant phases for the latter part of the Historic period might better be redefined as pre-railroad (ca. A.D. 1820-1880), marking the effective life history of the Santa Fe Trail; post-railroad (A.D. 1880-ca. 1950), marking the florescence of rail transportation articulation of the local region with the greater United States; and recent (post 1950), signified by increasing articulation of the local area with the United States nation-state via highway transportation, telephone communications, electrical service, and a fully developed wage-labor based money economy.

Review of Research Results

Question 2: Evidence of the effective introduction of a money and wage-labor based economy on sites in Cochiti Reservoir is virtually lacking and, thus, the questions can be answered in the negative. Neither money nor wage labor affected the character of subsistence strategies in the reservoir locale until ca. 1960, and the reader is referred to the post 1960 discussion below.

Questions 1 and 3: These two questions will be discussed together since they simply address different aspects of the same problem--the effect of mechanized transportation and routine availability of large quantities of trade commodities from the eastern United States on a seasonal herding subsistence strategy. Perhaps the primary observation to be made is that until ca. 1920, there was no major change in subsistence. Rather, the significant trends and directional patterns initiated in the late 18th century persist throughout the 19th century and into the early part of the 20th century.

These directional trends in site-specific subsistence behavior can be summarized as a significant reduction in variation of subsistence related activities performed at site locations which covaries with increasing availability of trade goods and an increasingly seasonal occupation of the canyon.

Although basic economic features of economic residence within the project area remain similar (seasonal residence associated with livestock herding), the overall character of commensal group subsistence behavior changes in response to increased availability of trade goods, and some indications point to shorter terms of seasonal residence.

(1) Site-specific subsistence behavior: In terms of basic subsistence behavior, LA 13291 represents a continuation of residentially-based foraging on the part of its inhabitants, in many ways similar to consumption and processing of both domestic and nondomestic fauna evidenced at LA 10114 and LA 12161 during the late Spanish Colonial phase occupancy of the canyon. The presence of porcelain fragments at LA 13291 may indicate habitation of the site sometime after the initiation of the Santa Fe Trail trade route in 1820, but the fact that site inhabitants manufactured tools from local lithic materials indicates only an ephemeral effect of the trade network on site-specific activities.

The faunal assemblage from LA 13291 also reflects a considerable amount of foraging behavior on the part of residents similar to that noted for late Spanish Colonial phase sites. A wide variety of faunal species were processed and consumed at the site, and some evidence exists to indicate that locally available floral foodstuffs were routinely procured as well (Schutt 1979c).

Bone tools found at the site indicate a degree of hide preparation and sewing activities, and a compliment of cooking and serving vessels were observed.

Another 19th century site, LA 12465, was only test excavated but it yielded a variety of artifacts which may indicate its occupation sometime immediately prior to the introduction of railroad transportation into the general region, ca. 1860 to 1880. A variety of buttons manufactured from both glass and metal, clothing rivets, a spring from a flintlock rifle, a brass Winchester carbine shell, a metal can fragment, and an amber beer bottle fragment were recovered. Dates of manufacture for some of these items can be placed ca. 1860. It is probable that they were imported prior to establishment of rail transportation.

In other respects, the artifact assemblage at LA 12465 reflected subsistence activities similar to those found at earlier sites. All tools from the site were manufactured from lithic materials and locally made ceramic vessels were used for cooking, serving, and short term storage. Limited consumption of domestic fauna was indicated as well. Although only one room was excavated at the site, a variety of small pen and corral structures were evident in the vicinity and, thus, the site seemed to represent a seasonal herding camp occupied by relatively few individuals.

LA 12449 is another seasonal herding camp dating in occupation to the early 20th century. The occupation of this site clearly postdates establishment of fully developed railroad transportation of eastern produced commodities and reflects widespread availability of industrially produced technological items such as canned goods, milled lumber, clothing items, and tools. The site consists of a large masonry room with a corner fireplace and a three-enclosure corral constructed from juniper posts, brush, and barbed wire.

Pieces of milled lumber were employed in the room construction and a variety of packing cases, square-cut and wire nails were employed to make shelves and cupboards. Artifactual debris from the site included a variety of grommets, eyelets, buckles, and buttons from industrially produced clothing items (foot gear, pants, shirts), a cartridge case and percussion caps indicating two different kinds of firearms, and a variety of metal food and tobacco containers. Direct and indirect evidence of tool utilization at the site indicated that all tools were industrially produced metal items including a pocket knife, ax, saw, and wool shears.

Significant differences in the character of on-site subsistence related activity performance existed at LA 12449 when compared to earlier Historic sites within the Cochiti Reservoir locale. Evidence of consumption of perhaps three sheep or goats existed in the faunal remains found at the site, but the vast majority of foodstuffs consumed were imported to the site in containers. Lard cans, baking powder cans, and condensed milk cans indicated biscuit or bread-making and, presumably, milled flour in perishable cloth sacks. A considerable number of vegetable containers were in evidence as well. The basic character of food resource acquisition and consumption undertaken by the site inhabitant(s) thus did *not* involve foraging within the vicinity of the site but instead was predicated upon importing nearly all essential foodstuffs to the site location.

The absence of cooking and serving utensils at the site indicates that such items may have been imported to the site during terms of occupancy and taken elsewhere after each residential use. These items may have been made of metal, insofar as no broken ceramic dishes or cups were found.

Taken together, evidence of subsistence behavior at LA 12449 stands in distinct contrast to earlier seasonally occupied sites within the canyon. Although it is clear that the basic economic character of the occupation is relatively similar (seasonal residency associated with sheep herding); fundamental subsistence needs at the site seem to have been met almost entirely through importing both tools and packaged foodstuffs to the site locale. No evidence of residentially based foraging for floral or faunal resources is evident, a fact which contrasts with the earlier 18th and 19th century herding camps in the region.

(2) Trends in 19th century subsistence behavior: The majority of later Historic period sites documented through survey within the Cochiti Reservoir locale can be dated through associated artifactual debris as being inhabited between ca. 1800 and 1920, although some difficulty exists in distinguishing among sites inhabited during the late Spanish Colonial phase and Mexican phase and between sites inhabited during the Mexican phase and the early Territorial phase. In general, however, these earlier prerailroad sites (ca. 1800-1880) seem to be characterized by complexes of small masonry rooms and pens (LA 13291, LA 12465), whereas later post-railroad sites (ca. 1880-1920) are generally characterized by single room habitations and associated corral structures often made of posts, wire, and brush (LA 12449).

The fundamental character of land usage throughout the 19th century within the White Rock Canyon locale is thus similar through time in that it entailed seasonal residential occupation by relatively small groups of individuals engaged in herding activities. This kind of 19th century adaptation reflects a continuation of land use patterns initiated during the 18th century Spanish Colonial phase occupation of the region.

Significant changes in the character of subsistence related activities performed by seasonal inhabitants of the locale can be observed throughout the 19th century at the site-specific level. Most, however, are directly related to increasingly available trade commodities imported into the general region via the Santa Fe Trail prior to 1880 and via mechanized rail transportation after 1880.

From a strictly archeological perspective, importation of manufactured clothing items constituted the first significant change in subsistence behavior in this regard. Late Spanish Colonial sites such as LA 12161 and LA 10114 exhibited considerable evidence of clothing manufacture in the form of spindle whorls, hide fleshing implements, awls, and needles; and LA 13291, occupied during the early 19th century, exhibited hide-working tools as well. These kinds of implements were not present at sites dating to the latter part of the 19th and early 20th centuries such as LA 12465 and LA 12449, but these later sites were characterized by a variety of buttons, grommets, and buckles indicating use of industrially manufactured clothing by their inhabitants.

A second change in site-specific behavior can be noted as a distinct shift from dependence upon a local foraging based acquisition of food resources during the early 19th century (LA 13291) toward dependence upon imported industrially packaged foodstuffs (LA 12449). This change in character of focal food resource consumption is presumably due to increasing availability of prepackaged food staples which could be imported by seasonal inhabitants to site locales within White Rock Canyon.

With this shift in site-specific subsistence was attenuate reduction in the kinds and amounts of procurement and processing tools. Trends in technological behavior among sites in the region reflected decreasing emphasis upon stone tools as metal implements became more available.

Thus from archeological evidence it can be stated that the increasing articulation of the entire New Mexico region with eastern United States industrial centers via the Santa Fe Trail and railroad network resulted in profound changes in the character of subsistence related activities undertaken on 19th and early 20th century sites in Cochiti Reservoir.

It is important to note, however, that fundamental properties of land utilization within the reservoir locale throughout this temporal span remained quite similar. It can be suggested that basic structural properties of this local adaptation involved seasonal residence by single commensal groups (sometimes involving only single individuals) whose primary economic activity during terms of residence was that of sheep herding. Some evidence was recovered to indicate that the size of residential groups occupying such sites decreased in numbers of individuals from ca. 1800 through 1920 and that the actual term of residential occupation (measured in days or weeks) decreased as well. Beyond these rather ephemeral tendencies, no basic change in economic character of land utilization could be defined for the project area until ca. 1920.

Perhaps one of the more intriguing observations to be made from the Cochiti Reservoir data concerns theoretical premises which tend to assume that technological innovation or diffusion effectively causes changes in structural properties of adaptive behavior. Archeological evidence from the reservoir locale demonstrates this assumption does not hold, at least in this case. Rather, particular kinds of technological items are incorporated by inhabitants of the local raea as they become available for use. Basic features of economic behavior and land usage are in no way substantially changed as a result of the introduction of new technological items.

(3) Nonresidential strategies - 1920 to 1960: With the exception of two possible work camps dating to the late 1920s (which may represent campsites for laborers who constructed the Cochiti-Frijoles trail along the western side of White Rock Canyon), there is no evidence of a residentially based occupation of the Cochiti Reservoir locale between ca. 1920 and 1960. Reasons for the seemingly abrupt termination of the seasonal herding and residential occupation of the canyon locale may well be a function of two different factors, both related to nation-state encroachment upon the local area. One of these factors involves changes in political jurisdiction of large portions of the general reservoir locale by the United States government — and the establishment of Bandelier National Monument to the west, and U.S. Forest Service lands to the east. This change in jurisdiction tended to abrogate or limit grazing utilization of the land areas in the vicinity of the reservoir.

The second major factor related to the changes in jurisdiction involved United States government programs to develop water tanks and wells on the Caja del Rio Plateau (immediately to the west of White Rock Canyon). Primary grazing lands for stock were always the extensive grasslands to the east of White Rock Canyon and, through development of predictable water on the plateau itself, need to bring stock down to the Rio Grande was obviated.

The net result of these changes in land jurisdiction and development of watering locations for livestock on the Caja del Rio Plateau effectively served to truncate a strategy of adaptation within inner White Rock Canyon — a strategy which had characterized human use of the area over some 300 years.

(4) Recreation use of the reservoir -- 1960 to present: The final and most recent evidence of human utilization of the reservoir locale is reflected, archeologically, as a series of campsites dating from ca. 1960 to 1975, prior to completion of Cochiti Dam and subsequent creation of Cochiti Lake. These sites are characterized by single hearth facilities, occasional evidence of tent bases, and ephemeral artifactual debris (generally comprised of plastic sandwich bags, aluminum sardine or Vienna sausage style cans, and beverage containers).

This post 1960 kind of land utilization reflects recreational use of the Cochiti Reservoir locale, a kind of behavior which signified, in many ways, the first evidence of full articulation of the region into the effective industrially based United States nation-state system. Implied economic underpinnings of such recreational usage include fully developed mechanized transportation networks articulating the locale area with major population centers and an associated wage-labor economy operative within such centers that result in leisure time activities.

The construction of Cochiti Dam and subsequent creation of Cochiti Lake has consituted yet another stage in adaptive utilization of the locale for predominantly recreational purposes at the local level. From a larger perspective, the dam itself is the most massive architectural facility to be constructed in the region and represents a continued process of nation-state control over resources within the local area.

METHODOLOGICAL CONTRIBUTIONS

A variety of methodological techniques were employed during the course of the Cochiti Reservoir project. In most cases, operational use of different methodological approaches for data collection, description, and analysis is not necessarily apparent in papers or descriptive summaries published in the Cochiti Reservoir series simply because the techniques were employed as intermediate stages of analysis resulting in information ultimately described in the publications.

Some of these methodological procedures were, in our estimation, sufficiently productive in terms of the research conducted or offered considerable potential for future research to warrant their inclusion into the final report.

In this section we will review what were felt to be some of the important methodological contributions made by the project, either in the form of techniques and procedures which were routinely used during the course of the project, or in the form of more or less experimental approaches which were conducted and which we feel offer potential for future refinement as descriptive or analytical tools.

One major methodological contribution concerned a full scale implementation of a *no-collection* archeological survey strategy. Although the outline of such a strategy had been published by Human Systems Research in 1973, the concept had still not been operationalized by early 1975. Survey of Cochiti Reservoir (initiated in February 1975) was designed from the outset as a full scale implementation of the no-collection concept (see Chapman and Enloe 1977) and served to demonstrate that the strategy could be employed as a productive and feasible alternative to more expensive and destructive collection-based surveys.

It is our hope that the Cochiti Reservoir survey will provide a model to be refined in future archeological survey work of this sort. One of the papers included in this volume (Eck, Chapter 16) conducts an assessment of reliability of some aspects of survey documentation through comparing survey estimates of artifact attribute variability with excavated data derived from the same site locations.

Another set of methdological concerns dealt with throughout the entire project were those related to the display and interpretation of horizontal distributions of artifactual debris. A major objective of intrasite analysis was to define patterning in the distribution of artifactual remains which would provide information concerning the size and composition of residential groups who occupied site locations, and information bearing upon differences or similarities in site-space utilization. A choropleth mapping technique, utilizing firecracked rock and debitage weights, was employed to define intrasite proveniences among non-structural site locations excavated during the first field season in the permanent pool of the reservoir (see Chapman et al. 1977). Although the technique was useful in some respects, it became clear that some of our expectations concerning intrasite behavior during terms of occupancy were not being met and that the mapping technique itself was clumsy as a visual representation of artifact distributions (see Chapman 1977).

During the second analysis phase, a review of different kinds of statistical mapping techniques was undertaken and the results of that review are presented in this volume by Spear (Chapter 18). Additionally, our previous assumptions concerning determinants of artifact distributions were reassessed with the result that a different technique of isopleth mapping was utilized to define assemblages comprised of different artifact classes for each site location (see Biella 1979). Once defined, these assemblages were treated as units of ar lysis in each site report and their behavioral implications assessed.

The paper by Spear outlined methodological procedures involved in isopleth mapping and another paper by Camilli (Chapter 19) addressed some behavioral implications which different artifact distribution shapes might represent in terms of disposal modes.

A third realm of methodological studies conducted intermittently throughout the duration of the project focused upon experimental replication of wear patterns observable on stone tools. Experimental usage studies employing the full range of lithic materials commonly used as tools within the Cochiti Reservoir locale were conducted as part of the laboratory training procedures prior to each laboratory analysis phase. Data concerning kind of lithic material, media operated upon, usage mode, edge morphology, microfracture and abrasion patterns resultant from each experiment were recorded and computerized with the result that a permanent data bank documenting over 200 experiments has been established at the Office of Contract Archeology, University of New Mexico. At this writing, the data bank has already proven very useful as a comparative baseline for ongoing wear pattern research conducted not only during the course of the Cochiti Reservoir project but as well by other i itutions in the region including the National Park Servi Chaco Research Center.

Preliminary results of the experimental studies themselves are discussed by Chapman and Schutt (1977). As an adjunct to the ongoing wear pattern experimental program, Schutt (Chapter 20) documents results of a set of control experiments conducted to isolate the degree to which procedures involved in recovery, transportation, and laboratory processing of lithic artifacts may have resulted in microfracture or edge abrasion potentially interpretable as wear pattern variation.

Another kind of experimental study, that conducted by Fosberg and Husler (Chapter 17), provides another example of the utility of employing independent experiments in evaluating archeological problems. In their article they examine the hypothesis of whether increased salinity in the soils of an agricultural field may have resulted in the abandonment of the field by prehistoric inhabitants.

Another kind of methodological focus which evolved throughout the course of the project centered upon means of describing ceramic assemblages. Nearly all previous studies of this sort within the region were directed toward using populations of sherds simply as means of dating sites. The Cochiti Reservoir project was fortunate in being able to draw upon the services of A.H. Warren, whose extensive geologic and petrographic knowledge of ceramic temper materials and sources, coupled with her knowledge of technological and stylistic variation evident through time in vessel manufacture within the region, enabled a different approach to be undertaken in the analysis of site-specific ceramic assemblages.

This approach basically involved defining the number and kind of *individual vessels* reflected in the ceramic assemblage of each site such that the spatial distribution of sherds from pots could be treated as data informing upon intrasite space use and occupational sequencing. During the first phase of analysis (permanent pool excavations, 1975), this objective was approached through comparing *minimum* sets of three attributes: ceramic type (i.e. ware styles), vessel form (bowls, jars and the like), and temper (see Chapman et al. 1977).

During the second phase (flood pool excavations, 1976-1977), Warren conducted an analysis which sorted the entire ceramic assemblage from a site into minimum vessels based upon a variety of attributes in addition to those noted above. Interested readers should read Warren's article (1979) which documents the background, liabilities, and potential for this kind of research.

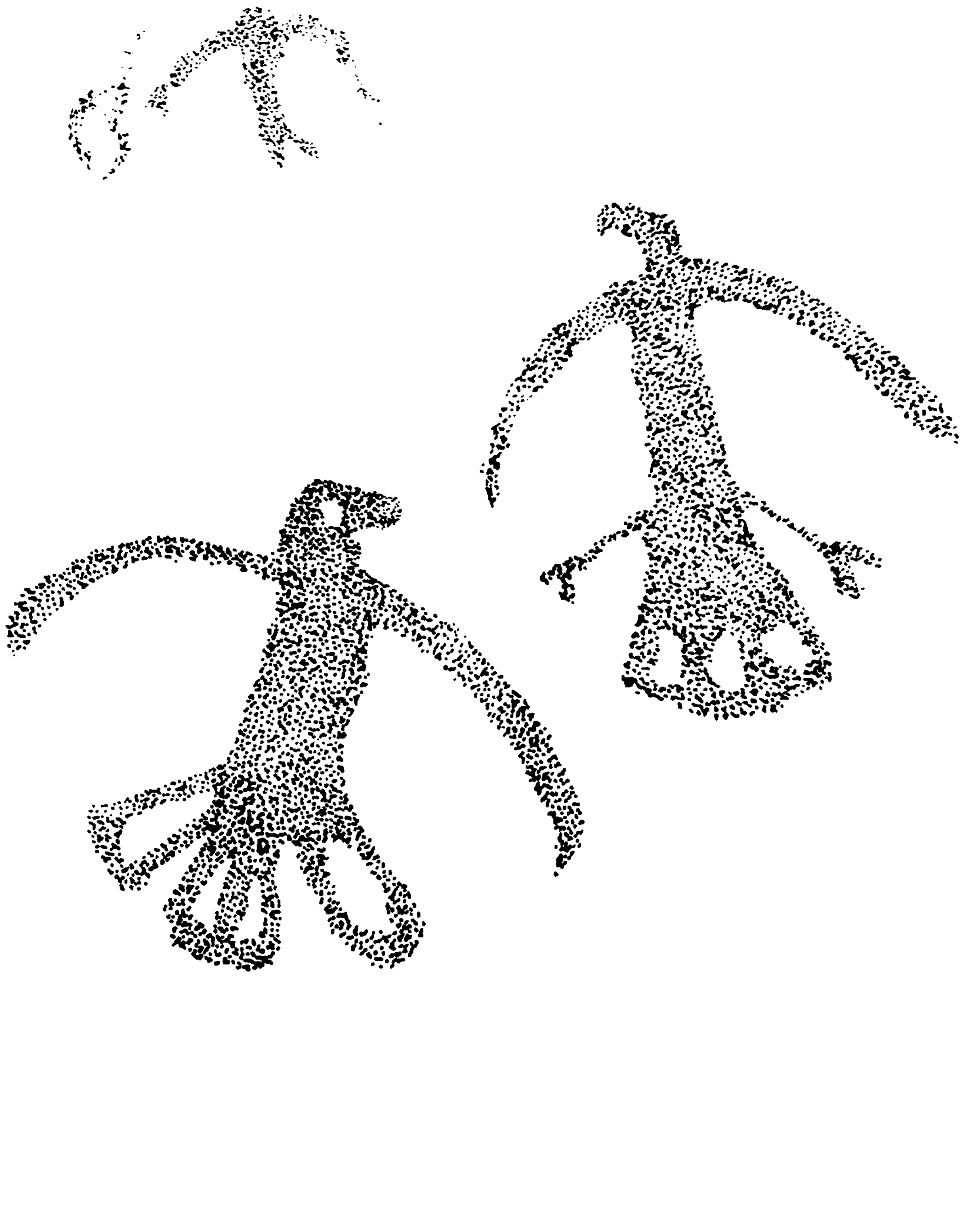
In summary, relatively long term projects involving both survey and excavation such as the Cochiti Reservoir project offer excellent opportunities to explore the utility of new techniques in documenting and analyzing archeological data. In our opinion, this kind of methodological innovation and evaluation constitutes a highly productive by-product of current contract based archeological research. Results of such exploratory pursuits, whether negative or positive in terms of particular project objectives should, we feel, be documented as a matter of course just as are the description and analytical summaries of past human behavior. The preceding discussion of methodological trials and errors undertaken during the Cochiti Reservoir project has been included for these reasons.

SUMMARY

In this chapter we have attempted to review what we consider to be some of the major contributions of the Cochiti Reservoir project. Specifically, we have reexamined the initial goals of the project as outlined in the proposal to the contract to assess to what degree these goals were met. As in any project of comparable length—four years—the goals have, in part, been redefined, but we feel that such goals have been largely achieved.

Since the volume as a whole has been designed to serve as the analytical summary for the project, this chapter, of necessity, has simply highlighted some of the observations we can now make about adaptive behavior in the northern Rio Grande Valley, and we hope that the results of research published in this volume will stimulate future work in the area.

REFERENCES CITED



REFERENCES CITED

Abbink, Emily K. and John R. Stein

1977 An historical perspective on adaptive systems in the middle Rio Grande. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability*, edited by J. V. Biella and R. C. Chapman. Office of Contract Archeology, University of New Mexico, Albuquerque.

Adams, Eleanor B.

1954 Bishop Tamaron's visitation of New Mexico, 1760. *Historical Society of New Mexico Publications in History* 15.

Adams, Eleanor B. and Fray A. Chave.

1956 *The missions of New Mexico.* University of New Mexico Press, Albuquerque.

Adams, John E.

1962 Effect of soil temperature on grain sorghum growth and yield. *Agronomy Journal* 54: 257-261.

Adams, Karen R.

1977 *Site catchment analysis of wild plant resources in the heavily overgrazed Rio Puerco Valley of New Mexico.* Paper presented at the annual Society of American Archeology Meeting, April 1977, New Orleans.

Adams, R. M.

1962 Agriculture and urban life in early southwestern Iran. *Science* 136:109-122.

Ahler, Stanley A.

1970 Projectile point form and function at Rodgers Shelter, Missouri. *Missouri Archeological Society Research Series* 8.

Aikman, J. M.

1940 The effect of aspect of slope on climatic factors. *Iowa State College Journal of Science* 15:161-167.

Allan, W.C., A. Osborn, W.J. Chasko, Jr., and D.E. Stuart

1975 An archeological survey: Road construction rights-of-way Block II – Navajo Indian Irrigation Project. In *Working Draft Series* No. 1, edited by F.J. Broilo and D.E. Stuart. Office of Contract Archeology, University of New Mexico, Albuquerque.

Amedeo, D. and R. G. Golledge

1975 *An introduction to scientific reasoning in geography.* John Wiley & Sons, Inc., N.Y.

Amsden, C.A.

1935 The Pinto Basin artifacts. *Southwest Museum Papers* 9:33-50.

Anderson, Jerome E.

1960 Geology and geomorphology of the Santa Domingo Basin, Sandoval and Santa Fe Counties, New Mexico. Unpublished Master's thesis. Department of Geology, the University of New Mexico.

Arrehenius, Olof

1963 Investigations of soil from old Indian sites. *Ethnos* 28:122-136.

Asch, David L.

1975 On sample size problems and the uses of non-probabilistic sampling. In *Sampling in archeology*, edited by James W. Mueller. University of Arizona Press, Tucson.

Bachman, G. O. and H. H. Mehnert

1978 New K-Ar dates and the late Pliocene to Holocene geomorphic history of the central Rio Grande region, New Mexico. *Geological Society of America Bulletin* 89:283-292.

Baker, Charles M.

1978 The size effect: An explanation of variability in surface artifact assemblage content. *American Antiquity* 43:288-293.

Bancroft, Herbert H.

1889 Arizona and New Mexico, 1530–1889. *History of the Pacific states of North America XII.* History Company, San Francisco.

Bartlett, M.S., F.R.S.

1975 *The statistical analysis of spatial pattern.* John Wiley & Sons, N.Y.

Beckett, P.H.T.

1968 Soil formation and slope development. A new look at Walther Penck's *Aufbereitung* concept. *Zeitschrift fur Geomorphologie* 12: 1-24.

Benedict, Ruth

1931 Tales of the Cochiti Indians. *Bureau of American Ethnology Bulletin* 98.

Berry, B.J.L.

1967 *Geography of market centers and retail distribution.* Prentice-Hall, Inc., Englewood Cliffs.

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REFERENCES CITED

Biella, Jan V.

1977 Previous anthropological research in the Cochiti study area. In *Archeological investigations in survey of regional variability*, edited by J.V. Biella and R.C. Chapman. Office of Contract Archeology, University of New Mexico, Albuquerque.

1979 (as editor) *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons.* Office of Contract Archeology, University of New Mexico, Albuquerque.

Biella, Jan V. and Richard C. Chapman

1975 *An assessment of cultural resources in Cochiti Reservoir.* Ms. Office of Contract Archeology, University of New Mexico, Albuquerque.

1977a *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability*, edited by J.V. Biella and Richard C. Chapman. Office of Contract Archeology, University of New Mexico, Albuquerque.

1977b Significance of cultural resources in Cochiti Reservoir. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability*, edited by J.V. Biella and R. C. Chapman, Office of Contract Archeology, University of New Mexico, Albuquerque.

1977c Survey of Cochiti Reservoir: Presentation of data. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability.* Edited by J.V. Biella and R.C. Chapman, Office of Contract Archeology, University of New Mexico, Albuquerque.

Binford, Lewis R.

1964 A consideration of archaeological research design. *American Antiquity* 29:425-441.

1968 Post-Pleistocene adaptations. In *New perspectives in archeology*, edited by S.R. Binford and L.R. Binford. Aldine Press, Chicago.

1972 *An archaeological perspective*, pp. 252-294. Seminar Press, New York and London.

1975 Sampling, judgement, and the archaeological record. In *Sampling in archaeology*, edited by James W. Mueller. University of Arizona Press, Tucson.

1978 Dimensional analysis of behavior and site structure: learning from an Eskimo hunting stand. *American Antiquity* 43:3.

Binford, Lewis R. and Jack B. Bertrum

1977 Bone frequencies and attritional processes. In *For theory building in archaeology*, edited by Lewis R. Binford. Academic Press, New York.

Binford, Lewis R., Sally R. Binford, Robert Whallon, and Margaret Ann Hardin

1970 Archaeology at Hatchery West. *Society for American Archaeology Memoir* 24.

Black, C. A.

1968 *Soil-plant relationships.* John Wiley & Sons, New York.

Bloom, Lansing B.

1927 Early weaving in New Mexico. *New Mexico Historical Review* 2:228-238.

1936 Bourke on the Southwest. *New Mexico Historical Review* 11(1):77-122.

Bohrer, Vorsila

1978 Personal communication.

Boserup, Ester

1965 *The conditions of agricultural growth.* Aldine, Chicago.

Boyd, E.

1974 *Popular arts of Spanish New Mexico.* Museum of New Mexico Press, Santa Fe.

Bradfield, Maitland

1969 Soils of the Oraibi Valley, Arizona, in relation to plant cover. *Plateau* 41:133-140.

1971 *The changing pattern of Hopi agriculture.* Royal Anthropological Institute of Great Britain and Ireland, London.

Brain, C. K.

1969 The contribution of Namib Desert Hottentots to an understanding of Australopithecine bone accumulations. *Scientific Papers of the Namib Desert Research Station* No. 39:13-22.

Brakenridge, G. Robert

1977 Present water supply in the Cochiti study area. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability*, edited by J.V. Biella and R.C. Chapman, Office of Contract

Archeology, University of New Mexico, Albuquerque.

Brayer, Herbert O.

1939 Pueblo Indian land grants of the "Rio Abajo", New Mexico. *The University of New Mexico Bulletin* No. 334.

Brockington, Paul E., Jr.

1976 Variability in the archaeological record: some comments based on analysis of surface collections. In Hopewellian Archaeology in the Lower Missouri Valley, edited by Alfred E. Johnson. *University of Kansas Publications in Anthropology* No. 8.

Broilo, Frank J.

1976 Proposal to Calvin R. Cummings, National Park Service, Southwest Region, April 15, 1976.

Brooks, C.E.P. and N. Carruthers

1953 *Handbook of statistical methods in meteorology*. London.

Bunge, W.

1962 Theoretical Geography. *Lund series in geography, series C. General and mathematical geography* I.

Burt, W.H.

1943 Territoriality and home range concepts as applied to mammals. *J. Mammal* 24: 346-35.

Bussey, S.D.

1968a Excavations at LA 6461, the Red Snake Hill site. In The Cochiti Dam archaeological salvage project, part 1: Report on the 1963 season, edited by C.H. Lange. *Museum of New Mexico Research Records* No. 6.

1968b Excavations at LA 6462, the North Bank site. In The Cochiti Dam archaeological salvage project, part 1: Report on the 1963 season, edited by C.H. Lange. *Museum of New Mexico Research Records* No. 6.

Cahen, D. and J. Moeyersons

1977 Subsurface movements of stone artifacts and their implications for the prehistory of Central Africa. *Nature* 266:812-815.

Callen, E.O.

1973 Dietary patterns in Mexico between 6500 B.C. and A.D. 1580. In *Man and his foods.* The University of Alabama Press.

Carroll, H. Bailey and J. Villasana Haggard

1942 *Three New Mexico chronicles.* The Quivira Society, Albuquerque.

Castetter, E.F.

1930 Uncultivated native plants used as sources of food. *University of New Mexico Bulletin* No. 266.

Castetter, E. F. and Willis H. Bell

1951 *Yuman Indian agriculture.* University of New Mexico, Albuquerque.

Castetter, E.F. and Ruth Underhill

1935 The ethnobiology of the Papago Indians *University of New Mexico Bulletin* No. 275.

Chang, Jen-Hu

1968 *Climate and agriculture.* Aldine, Chicago.

Chapman, Kenneth M.

1970 The pottery of San Ildefonso Pueblo. *Monographs of the School of American Research* No. 28. University of New Mexico Press, Albuquerque.

Chapman, Richard C.

1977 Definition of intrasite activity areas. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 2: Excavation and analysis 1975 season*, edited by R.C. Chapman and J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Chapman, Richard C. and Jan V. Biella

1977a Research perspective. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability*, edited by J.V. Biella and R.C. Chapman. Office of Contract Archeology, University of New Mexico, Albuquerque.

(as editors) 1977b *Archeological investigations in Cochiti Reservoir, New Mexico volume 2: Excavation and analysis 1975 season.* Office of Contract Archeology, University of New Mexico, Albuqueruqe.

Chapman, Richard C. and James G. Enloe

1977 Survey of Cochiti Reservoir: Methodology. In *Archeological investigations in Cochiti*

Reservoir, New Mexico volume 1: A survey of regional variability, edited by J.V. Biella and R.C. Chapman. Office of Contract Archeology, University of New Mexico, Albuquerque.

Chapman, Richard C. and Jeanne A. Schutt

1977 Methodology of lithic analysis. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 2: Excavation and analysis 1975 season*, edited by R.C. Chapman and J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Chapman, R.C., J.V. Biella, J.A. Schutt, J.A. Enloe, P.J. Marchiando, A.H. Warren and J.R. Stein

1977 Description of twenty-seven sites in the permanent pool of Cochiti Reservoir. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 2: Excavation and analysis 1975 season*, edited by R.C. Chapman and J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Chavez, Fray A.

1973 *Origins of New Mexico families in the Spanish Colonial period*. Second edition. The University of Albuquerque, Albuquerque.

Chen, P.S. Jr., T.Y. Toribora, and H. Warner

1956 Microdetermination of phosphorus. *Analytical Chemistry* 28:1756.

Chorley, R.J. and P. Haggett

1965 Trend-surface mapping in geographical research. *Transactions of the Institute of British Geographers* 37:47-67.

Clark, S.P.

1928 *Lessons from southwestern Indian agriculture*. University of Arizona, Tucson.

Cochran, William G.

1977 *Sampling Techniques*. Third edition. John Wiley and Sons, New York.

Cohen, Yehudi A.

1968 *Man in adaptation: The cultural present*. Aldine Publishing Company, Chicago.

Cook, Sarah L.

1930 The ethnobotany of Jemez Indians. Unpublished Master's thesis, Department of Biology, University of New Mexico, Albuquerque.

Cooper, Arthur W.

1960 An example of the role of microclimate in soil genesis. *Soil Science* 90:109-120.

Cordell, Linda S.

1975 Predicting site abandonment at Wetherill Mesa. *The Kiva* 40:189-202.

1979 A cultural resources overview of the Middle Rio Grande Valley. USDA Forest Service, Southwestern Region, Albuquerque and Bureau of Land Mangement, New Mexico State Office, Santa Fe.

n.d. *Eastern Anasazi: A.D. 1-1540*. Ms. Department of Anthropology, University of New Mexico, Albuquerque.

Cornfield, Jerome

1951 The determination of sample size. *American Journal of Public Health* 41(6):654-661.

Cowgill, George L.

1975 A selection of samplers: Comments on archaeo-statistics. In *Sampling in archaeology*, edited by James W. Mueller, University of Arizona Press, Tucson.

Cox, C.R. and P.A.W. Lewis

1972 Multivariate point processes. *Sixth Berkeley symposium on mathematical statistics and probability*.

Cox, C.R. and H.D. Miller

1965 *The theory of stochastic processes*. Methuen and Co., Ltd., London.

Crabtree, D.E. and E.L. Davis

1968 Experimental manufacture of wooden implements with tools of flakes stone. *Science* 159:426-428.

Cully, Anne C.

1977 Paleoclimatic variability in the north-middle Rio Grande, New Mexico. In *Archeological investigations in Cochiti Reservoir, New Mexico*, edited by J.V. Biella and R.C. Chapman. Office of Contract Archeology, University of New Mexico, Albuquerque.

Daubenmire, Rexford

1968 *Plant communities: A textbook of plant synecology*. Harper and Row, New York.

Davis, Stanley N. and Roger J.M. DeWiest

1966 *Hydrogeology*. John Wiley & Sons, N.Y.

Denny, Charles S.

1940 Santa Fe formation in the Espanola Valley, New Mexico. *Bulletin of the Geological Society of America* 51:677-694.

Dick, Herbert W.

1965 Bat Cave. *School of American Research* Monograph No. 27.

1968 Six historic pottery types from Spanish sites in New Mexico. In *Archaeological Society of New Mexico Papers* No. 1.

Dickson, D. Bruce

1975 Settlement pattern stability and changes in the middle northern Rio Grande region, New Mexico: A test of some hypotheses. *American Antiquity* 40:159-171.

DiPeso, Charles D., John B. Rinaldo and Gloria J. Fennen

1974 *Casas Grandes, volume 6*. The Amerind Foundation Inc., Dragoon. Northland Press, Flagstaff.

Dittert, Alfred E., Jr.

1959 *Culture change in the Cebolletta Mesa region, central western New Mexico*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Arizona, Tucson.

Drager, Dwight L. and Richard W. Loose

1977 An ecological stratification of the southern Pajarito Plateau. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability*, edited by J.V. Biella and R.C. Chapman. Office of Contract Archeology, University of New Mexico, Albuquerque.

Earle, F.R. and Quentin Jones

1962 Analyses of seed samples from 113 plant families. *Economic Botany* 16:221-250.

Eck, David

1979 LA 13351. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Ellis, Florence H.

1975 *Bandelier's generation and ethnological anal-ogy: Then, now and in between*. Archaeological Society of New Mexico, Albuquerque.

Emlen, J. Merritt

1973 *Ecology: An evolutionary approach*. Addison-Wesley, Reading.

Emmanuel, Robert J.

1950 The geology and geomorphology of the White Rock Canyon area, New Mexico. Unpublished Master's thesis. Department of Geology, the University of New Mexico.

Feller, William

1971 *An introduction to probability theory and its applications*, Vol. II, second edition. John Wiley and Sons, New York.

Finney, H.R., N. Holowaychuk, and M.R. Heddleson

1962 The influence of microclimate on the morphology of certain soils of the Allegheny Plateau of Ohio. *Soil Science Society of America Proceedings* 26:287-292.

Flannery, Kent V.

1968 Archeological systems theory and early mesoamerica. In *Anthropological archeology in the Americas*, edited by Betty Meggers, pp. 67-87. Anthropological Society of Washington, Washington D.C.

1976 Empirical determination of site catchments in Oaxaca and Tehuacan. In *The early mesoamerican village*. Academic Press, New York.

Flynn, L.L. and W.J. Judge

1973 *An archeological assessment of the Canada de Cochiti Grant*. Ms. Department of Anthropology, University of New Mexico, Albuquerque.

Ford, J.A.

1969 *A comparison of formative cultures in the Americas*. Smithsonian Institution Press, Washington, D.C.

Ford, Richard I.

1968 Flora Remains. In The Cochiti Dam archaeological salvage project, part 1: Report on the 1963 season, edited by C.H. Lange. *Museum of New Mexico Research Records* No. 6.

1972 An ecological perspective on the eastern pueblos. In *New perspectives on the pueblos*, edited by A. Ortiz. University of New

Mexico Press, Albuquerque.

Ford, Richard I., Albert H. Schroeder and Stewart L. Peckham

1972 Three perspectives on puebloan prehistory. In *New perspectives on the pueblos*, edited by A. Ortiz, University of New Mexico Press, Albuquerque.

Forde, C. Daryll

1934 *Habitat, economy and society.* Methuen, London.

Foster, G. M.

1948 Some implications of modern Mexican mold-made pottery. *Southwestern Journal of Anthropology* 4:356-370.

Frank, Larry and Francis H. Harlow

1974 *Historic pottery of the Pueblo Indians 1600-1880.* New York Graphic Society, Boston.

Franzmeier, D.P., et al.

1969 Properties of some soils in the Cumberland Plateau as related to slope aspect and position. *Soil Science Society of American Proceedings* 33:755-761.

Fried, Morton

1967 *The evolution of political society: An essay in political anthropology.* Random House, New York.

Frisbie, Theodore R.

1967 *The excavation and interpretation of the artificial leg Basketmaker III-Pueblo I sites near Corrales, New Mexico.* Unpublished Master's thesis, Department of Anthropology, University of New Mexico, Albuquerque.

Fritts, H.D.

1965 Tree-ring evidence for climatic changes in western North America. *Monthly Weather Review* 97(7):421-423.

Furley, Peter A.

1968 Soil formation and slope development. *Zeitschrift fur geomorpholgie* 12:25-42.

Galusha, Ted and John C. Blick

1971 Stratigraphy of the Santa Fe Group, New Mexico. *American Museum of Natural History, Bulletin* 144:1-128.

Gauch, Hugh G. and Cecil H. Wadleigh

1943 Effects of high salt concentrations on growth of bean plants. *Botanical Gazette* 105:379-387.

Garner, H.F.

1974 *The origin of landscapes.* Oxford University, London.

Gauthier, Rory

1978 Personal communication.

Gerald, Rex E.

1968 Spanish presidios of the late eighteenth century in northern New Spain. *Museum of New Mexico Research Records* No. 7.

Gilbert, B. Miles

1969 Some aspects of diet and butchering techniques among prehistoric Indians in South Dakota. *Plains Anthropologist* 14(46):277-294.

Goodyear, Albert C., III

1975 Hecla II and III: An interpretive study of archeological remains from the Lakeshore project, Papago reservation, south central Arizona. *Arizona State University Anthropological Research Paper* No. 9.

Gould, R.A.

1969 Subsistence behavior among the Western Desert Aborigines of Australia. *Oceania* 39(4):253-274.

Gould, R.A., D.A. Koster and A.H.L. Sontz

1972 The lithic assemblage of the Western Desert Aborigines of Australia. *American Antiquity* 36(2):149-169.

Griggs, John D.

1964 Geology and groundwater resources of the Los Alamos area New Mexico. *USGS Water-supply Paper 1753.* United States Government Printing Office, Washington, D.C.

Gunnerson, James W.

1969 Apache archaeology in northeastern New Mexico. *American Antiquity* 34(1):23-39.

Hack, John T.

1942 The changing physical environment of the Hopi indians of Arizona. *Papers of the*

Peabody Museum of American Archeology and Ethnology 35.

Haecker, C. M.

1977 Obsidian hydration analysis. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 2: Excavation and analysis 1975 season*, edited by R.C. Chapman and J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Haggett, P.

1966 *Locational analysis in human geography*. Edward Arnold Publishers LTD, London.

Hammond, George P. and Agapito Rey (as editors)

1953 *Don Juan de Onate, colonizer of New Mexico, 1595-1628*. University of New Mexico Press, Albuquerque.

Hare, R.J. and David Griffiths

1907 The tuna as a food for man. *Agricultural Experiment Station Bulletin* No. 64. Las Cruces.

Harlow, Francis H.

1970 *Historic pueblo Indian pottery*. Museum of New Mexico Press, Santa Fe.

1973 *Matte-paint pottery of the Tewa, Keres and Zuni Pueblos*. Museum of New Mexico Press, Santa Fe.

Harner, Michael J.

1972 *The Jivaro, people of the sacred waterfalls*. Doubleday/Natural History Press, Garden City.

Harrington, H.D.

1916 Ethnogeography of the Tewa Indians. *Annual Report of the Bureau of Ethnology* No. 29.

1967 *Edible native plants of the Rocky Mountains*. University of New Mexico Press, Albuquerque.

Harris, A.H.

1968 Faunal Remains. In The Cochiti Dam archaeological salvage project, part 1: Report on the 1963 season, edited by C.H. Lange. *Museum of New Mexico Research Records* No. 6.

Harris, Marvin

1966 Cultural ecology of India's sacred cattle. *Current Anthropology* 7:51-66.

Harvey, D.W.

1969 *Explanation in geography*. Edward Arnold Publishers Ltd., London.

Haury, E.W.

1950 *The stratigraphy and archeology of Ventana Cave* (1975 edition). University of Arizona Press, Tucson.

Hayden, B. and J. Kaminga

1973 Gould, Koster and Sontz on microwear: A critical review. *Newsletter of lithic technology* II:3-8.

Hayes, Alden C.

(in press) Ceramics of Gran Quivira.

Haywood, H.E.

1954 Plant growth under saline conditions. In *Reviews of research on problems of saline water*, edited by G. Grillot, H. Haywood, and E. Howe, pp. 37-71. UNESCO, Paris.

Haywood, H.E. and L. Bernstein

1958 Plant-growth relationships on salt-affected soils. *Botanical Review* 24:584-635.

Heider, Karl G.

1970 Dugum Dani: A Papuan culture in the highlands of New Guinea. *Viking Fund Publications in Anthropology* No. 49. Aldine Press, Chicago.

Hewett, Edgar L.

1906 Antiquities of the Jemez Plateau. *Bureau of American Ethnology Bulletin* 32.

Hickerson, Harold

1962 The southwestern Chippewa, an ethnohistorical study. *American Anthropological Association* 64(3):2.

Hietala, Harold J., and Dominique S. Stevens

1977 Spatial analysis: Multiple procedures in pattern recognition studies. *American Antiquity* 42:539-559.

Hill, W.W.

1938 The agricultural and hunting methods of the Navajo Indians. *Yale University Publications in Anthropology* 18.

Hoebel, E. Adamson

1966 *Anthropology: The study of man*, third edition. McGraw Hill Book Co., New York.

Hoge, Harry P.

1970 Neocene stratigraphy of the Santa Ana area, Sandoval County, New Mexico. Unpublished Ph.D. dissertation. Department of Geology, the University of New Mexico, Albuquerque.

Hole, F., et al.

1969 Prehistory and human ecology of the Deh Luran Plain. *Memoirs of the Museum of Anthropology, University of Michigan* 1.

Honea, Kenneth H.

1968 Material culture: Ceramics. In The Cochiti Dam archaeological salvage project, part 1: Report on the 1963 season, edited by C.H. Lange, pp. 111-170. *Museum of New Mexico Research Records* No. 6.

Housley, Lucille K.

1974 Opuntia imbricata distribution of old Jemez *Indian habitation sites*. Unpublished Master's thesis, Department of Biology, University of New Mexico, Albuquerque.

Hsu, M. L. and A. H. Robinson

1970 *The fidelity of isopleth maps: An experimental study*. University of Minnesota Press, Minneapolis.

Hudson, Charles

1976 *The Southeastern Indians*. The University of Tennessee Press, Knoxville.

Huges, P.

1978 Personal communication.

Human Systems Research

1973 *Technical Manual: 1973 survey of the Tularosa Basin, the research design*. Human Systems Research, Tularosa.

Hunter-Anderson, Rosalind L.

1977 A theoretical approach to the study of house form. In *For theory building in archeology*, edited by L.R. Binford. Academic Press, N.Y.

1979a Chapter 13 – LA 13350. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

1979b Chapter 15 – LA 13352. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

1979c Chapter 16 – LA 13353. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

1979d LA 13049. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Hunter-Anderson, Rosalind, James G. Enloe, Jan V. Biella, and Martha R. Binford

1979 LA 13086. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Hunter-Anderson, R. and J.A. Schutt

1979 LA 13084. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Hurt, Wesley R. and Herbert W. Dick

1946 Spanish American pottery from New Mexico. *El Palacio* 53:280-287, 307-311.

Hyatt, Robert D., B.H. Butler, and H.P. Mosca III

1974 Archaeological research at Cooper Lake, Texas. *Southern Methodist University Contributions in Anthropology* No. 12.

Hyatt, Robert D., and Karen Doehner

1975 Archaeological research at Cooper Lake, northeast Texas, 1973. *Southern Methodist University Contributions in Anthropology* No. 15.

Irwin-Williams, Cynthia

1967 Picosa: The elementary Southwestern culture. *American Antiquity* 32(4):441-457.

1973 The Oshara tradition: Origins of Anasazi culture. *Eastern New Mexico University*

Contributions in Anthropology 1(4):48-54.

n.d. Paleo-Indian and Archaic cultural systems in the southwestern United States. Ms. Eastern New Mexico University, Portales.

Irwin-Williams, C. and V. Haynes

1970 Climatic change and early population dynamics in the Southwestern United States. *Quaternary Research* 1:59-71.

Irwin-Williams, C. and S. Tompkins

1968 Excavations at En Medio Shelter, New Mexico. *Eastern New Mexico University Contributions in Anthropology* 1(2).

Isaac, Glynn L.

1967 Towards the interpretation of occupation debris: Some experiments and observations. *Kroeber Anthropological Society Papers* 37:31-57. Berkeley.

Jacobsen, Thorkild and Robert M. Adams

1958 Salt and silt in ancient mesopotamian agriculture. *Science* 128:1251-1258.

Jenks, G.F.

1963 Generalizations in statistical mapping. *Annals of the Association of American Geographers* 53:15-26.

Jenks, G.F. and M.R. Coulson

1963 Class intervals for statistical maps. *International Yearbook of Cartography* 3: 119-134.

Jennings, J.D.

1957 Danger Cave. *Society of American Archaeology Memoir* No. 14.

Johnson, Donald Lee and Kenneth L. Hansen

1974 The effects of frost-heaving on objects in soils. *Plains Anthropologist* 19(64): 81-98.

Jones, Volney H.

1930 *The ethnobotany of the Isleta Indian.* Unpublished Master's thesis, Department of Biology, University of New Mexico, Albuquerque.

1938 An ancient food plant of the southwest and plateau regions. *El Palacio* 44:5-6.

Kahoe, Thomas F.

1967 The Boarding School Bison Drive Site. *Plains Anthropologist* 12(35) (Memoir No. 4).

Kearney, Thomas H. and Robert H. Peebles

1964 *Arizona flora.* University of California Press, Bekeley.

Keeley, Lawrence H.

1974 Technique and methodology in microwear studies: A cultural review. *World Archeology* 7(2):323-336.

Kelekna, Pita

1978 Personal communication.

Kelley, Vincent G.

1948 *Geology and pumice deposits of the Pajarito Plateau, Sandoval, Santa Fe, and Rio Arriba Counties, New Mexico.* University of New Mexico Los Alamos Project–Pumice Investigations. Final Report No. 2–Field Survey.

Kidder, Alfred V.

1927 Southwestern archaeological conference. *Science* 66(1716).

1931 *The pottery of Pecos, volume I.* Peabody Foundation for Archaeology. Yale University Press, New Haven.

1958 Pecos, New Mexico: Archaeological notes. *Papers of the Peabody Foundation* Vol.5.

Kidder, Alfred V. and Anna O. Shepard

1936 The pottery of Pecos, volume II. *Papers of the Phillips Academy Southwestern Expedition* No. 7. Yale University Press, New Haven.

Kleiss, Harold J.

1970 Hillslope sedimentation and soil formation in northeastern Iowa. *Soil Science Society of America Proceedings* 34:287-290.

Kroeber, A.L.

1968 What culture is (originally published 1923). In *Man in adaptation: The cultural present,* edited by Y.A. Cohen. Aldine Publishing Co., Chicago.

Lambert, Marjorie F.

1954 Paa-ko, archeological chronicle of an Indian village in north central New Mexico, part I-V. *Monographs of the School of American Research* No. 19.

Lang, R.W.

1979 Personal communication.

Lange, Charles H.

1959 *Cochiti: A New Mexico pueblo, past and present.* University of Texas Press, Austin.

1968 Excavations at LA 6455, the Alfred Herrera site. In The Cochiti Dam archaeological salvage project, part 1: Report on the 1963 season, edited by C.H. Lange. *Museum of New Mexico Research Records* No. 6.

(as editor) 1968 The Cochiti Dam archaeological salvage project part 1: Report on the 1963 season. *Museum of New Mexico Research Records* No. 6.

Lange, Charles H. and Carroll L. Riley

1966 *The southwestern journals of Adolf F. Bandelier, 1880-1882.* University of New Mexico Press, Albuquerque.

Laumbach, Karl et al.

1977 Description of five sites in White Rock Canyon. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 2: Excavation and analysis 1975 season*, edited by R.C. Chapman and J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Lawrence, Robert A.

1977 Personal communication.

Lee, Richard B.

1968 What hunters do for a living, or how to make out on scarce resources. In *Man the hunter*, edited by R.B. Lee and I. Devore. Aldine Publishing Co., Chicago.

Leroi-Gourhan, A. and M. Brezillon

1966 L'habitation Magdalenienne N^0 1 de Pincevent Pres Montereau *Gallia Prehistoric* Tome IX Fascicule 2 C.N.R.S., Paris.

Levi-Strauss, Claude (Translated by Claire Jacobson and Brooke G. Schoepf)

1967 *Structural anthropology.* Doubleday and Company, Inc., Garden City.

Lewis, Kenneth E.

1977 Sampling the archaeological frontier: Regional models and component analysis. In *Research strategies in historical archaeology*, edited by Stanley South. Academic Press, New York.

Lischka, Leslie

1969 A possible non-cultural bias in lithic debris. *American Antiquity* 34(4):484-485.

Losche, C.K., R.J. McCracken, and C.B. Davey

1970 Soils of steeply sloping landscapes in the southern Appalachian Mountains. *Soil Society of America Proceedings* 34:473-478.

MacArthur, R.H. and E.O. Wilson

1967 *The theory of island biogeography.* Princeton University Press, Princeton.

Mackay, J.R.

1953 The alternative choice in isopleth interpolation. *Professional Geographer* 5:2-4.

1955 An analysis of isopleth and choropleth class intervals. *Economic Geography* 31:71-81.

MacNeish, Richard S.

1971 Ancient mesoamerican civilization. In *Prehistoric agriculture*, edited by Stuart Struever, pp. 143-156. The Natural History Press, Garden City.

Maker, H.J. et al.

1971 Soil associations and land classification for irrigation, Sandoval and Los Alamos Counties. *New Mexico State University Agricultural Experiment Research Report* 188.

Marchiando, Patricia J.

1977 Faunal resources in the Cochiti study area. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability*, edited by J.V. Biella and R.C. Chapman. Office of Contract Archeology, University of New Mexico, Albuquerque.

Margalef, Ramon

1968 *Perspectives in ecological theory.* The University of Chicago Press, Chicago.

Martin, Paul S. and Fred Plog

1973 *The archaeology of Arizona: A study of the southwest region.* Doubleday/Natural History Press, Garden City.

McGregor, John C.

1974 *Southwestern archaeology*. Second edition. University of Illinois Press, Ubana.

Meggitt, Mervyn

1977 Blood is their argument. In *Explorations in world ethnology series*, edited by R.B. Edgerton and L.L. Longness. Mayfield Publications Company.

Mera, H.P.

1932 Wares ancestral to Tewa polychrome. *Laboratory of Anthropology Technical Series Bulletin* No. 4. Museum of New Mexico, Santa Fe.

1933 A proposed revision of the Rio Grande glaze-paint sequence. *Laboratory of Anthropology Technical Series Bulletin* No. 5. Museum of New Mexico, Santa Fe.

1934 A survey of the bisquit ware area in northern New Mexico. *Laboratory of Anthropology Technical Series Bulletin* No. 6. Museum of New Mexico, Santa Fe.

1935 Ceramic clues to the prehistory of north central New Mexico. *Laboratory of Anthropology Technical Series Bulletin* No. 8.

1939 Style trends of pueblo pottery. *Memoirs of the Laboratory of Anthropology* Volume 3. Museum of New Mexico, Santa Fe.

1940 Population changes in the Rio Grande glaze-paint area. *Laboratory of Anthropology Technical Series Bulletin* No. 9. Museum of New Mexico, Santa Fe.

Monkhouse, F.J. and H.R. Wilkinson

1963 *Maps and diagrams: Their compilation and construction*. Methuen and Company Ltd., London.

Morgan, Lewis Henry

1969 *Ancient society* (first published in 1877). The World Publishing Company, Cleveland.

Mueller, James W.

1974 The use of sampling in archaeological survey. *Society for American Archaeology Memoir* 28.

1978 A reply to Plog and Thomas. *American Antiquity* 43:286-287.

Muto, Guy

1978 Personal communication.

Nelson, Nels C.

1916 Chronology of the Tano ruins, New Mexico. *American Anthropologist* 18(2):159-180.

Norcliffe, G.B.

1969 On the use and limitations of trend surface models. *Canadian Geographer* 13: 338-348.

Odell, George H.

1975 Microwear in perspective: A sympathetic response to Lawrence H. Keeley. *World Archeology* 7(2):226-240.

O'Leary, B.L.

1979 LA 13076. *Archaeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Peckham, S.L. and S.L. Wells

1967 *An inventory of archaeological sites at and in the vicinities of Bandelier National Monument and the Cochiti Dam and Reservoir.* Ms. Museum of New Mexico, Santa Fe.

Phillips, David A.

1972 Appendix 1. Social implications of settlement distribution on Black Mesa. In *Black Mesa*, edited by G. Gummerman, D. Westfall, and C. Weed, pp. 199-210. Prescott College Press, Prescott.

Pianka, Eric R.

1974 *Evolutionary Ecology*. Harper and Row Publishers, New York.

Piddock, Stuart

1965 The potlatch system of the southern Kwakiutl. *Southwestern Journal of Anthropology* 21:244-264

Pieper, Rex D., Kenneth H. Rea and Joseph G. Fraser

1974 Ecological characteristics of Walkingstick cholla. *Agricultural Experiment Station Bulletin*, N.M.S.U., Las Cruces.

Plog, Fred and James N. Hill

1971 Explaining variability in the distribution of sites. In *The distribution of prehistoric population aggregates*, edited by George J. Gumerman, pp. 7-36. Anthropological Reports, Prescott College Press.

Plog, Stephen

1978 Sampling in archaeological surveys: A critique. *American Antiquity* 43:280-285.

Prince, Arthur L.

1945 Determination of total nitrogen, ammonia, nitrates, and nitrites in soils. *Soil Science* 59:47-52.

Quaife, Milo M. (editor)

1926 *The commerce of the prairies by Josiah Gregg.* The Lakeside Press, Chicago.

Radcliffe-Browne, A.R.

1952 *Structure and function in primitive society.* Cohen and West, London.

Ramage, E. Ann

1977 An agricultural stratification of the Cochiti study area. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability*, edited by J.V. Biella and R.C. Chapman, pp. 79-88. Office of Contract Archeology, University of New Mexico, Albuquerque.

Rappaport, Roy A.

1967 Ritual regulation of environmental relations among a New Guinea people. *Ethnology* 6:17-30.

1968 *Pigs for the ancestors: Ritual in the ecology of a New Guinea people.* Yale University Press, New Haven.

Rattray, Evelyn C.

1966 An archaeological and stylistic study of Coyotatelco pottery. *Mesoamerican Notes* 7, 8:87-193.

Redman, Charles L. and Patty Jo Watson

1970 Systematic, intensive surface collection. *American Antiquity* 35:279-291.

Reed, Erik K.

1949 Sources of upper Rio Grande Pueblo culture and population. *El Palacio* 56:163-184.

Reher, C.A. and D.C. Witter

1977 Archaic settlement and vegetative diversity. In *Settlement and subsistence along the lower Chaco River*, edited by C.A. Reher. University of New Mexico Press, Albuquerque.

Reynolds, Robert G.D.

1976 Linear settlement systems on the upper Grijalva river: The application of a Markovian model. In *The early mesoamerican village*, edited by Kent Flannery, pp. 180-194. Academic Press, New York.

Richards, L.A.

1954 (editor) *Diagnosis and improvement of saline and alkali soils.* United States Department of Agriculture.

Rick, John W.

1976 Downslope movement and archaeological intrasite spatial analysis. *American Antiquity* 41:133-144.

Riley, Carroll L.

1974 Mesoamerican Indians in the early southwest. *Ethnohistory* 21(1):25-36.

Rinehart, Theodore R.

1967 The Rio Rancho Phase: A preliminary report on early Basketmaker culture in the middle Rio Grande valley, New Mexico. *American Antiquity* 32(4):458-470.

Robinson, A.H.

1960 *Elements of cartography.* New York.

Robinson, A.H. and R.D. Sale

1969 *Elements of cartography.* John Wiley and Sons, Inc., New York.

Robinson, William J., John W. Hannah and Brice G. Harrill

1972 *Tree-ring dates from New Mexico I,O,U central Rio Grande area.* Laboratory of Tree-ring Research, University of Arizona, Tucson.

Rohn, Arthur H.

1963 Prehistoric soil and water conservation on Chapin Mesa, southwestern Colorado. *American Antiquity* 28:441-455.

Roper, Donna C.

1976 Lateral displacement of artifacts due to plowing. *American Antiquity* 41:372-375.

Roscoe, R.T.

1969 *Fundamental research statistics for the behavioral sciences.* Holt, Rinehart, and Winston, Inc., New York.

Ross, C.S., R.L. Smith, and R.A. Bailey

1961 Outline of the geology of the Jemez Mountains, New Mexico. In *New Mexico Geological Society Guidebook of the Albuquerque County, 12th field conference*, edited by S. Northrop, pp. 139-143. University of New Mexico, Albuquerque.

Rugge, D.

1978 Personal communication.

Ruhe, R.V. and P.H. Walker

1968 Hillslope models and soil formation. I. Open systems. *International Congress of Soil Science, Transactions* 9:551-560.

Sahlins, Marshall D.

1958 *Social stratification in Polynesia.* Monograph of the American Ethnological Society. University of Washington Press, Seattle.

1968 On the sociology of primitive exchange. In *The relevance of models for social anthropology, A.S.A. Monographs 1*, (2nd edition), edited by M. Banton. Tavistock Pulications, London.

Sahlins, Marshall D. and Elman R. Service (editors)

1960 *Evolution and culture.* The University of Michigan Press, Ann Arbor.

Sayles, E.B. and E. Antevs

1941 The Cochise Culture. *Medallion Papers* No. 16.

Schalk, Randall

1978 *Land use strategies among foragers.* Unpublished Ph.D. dissertation. University of New Mexico, Albuquerque.

Schiffer, Michael B., and William L. Rathje

1973 Efficient exploitation of the archaeological record: Penetrating problems. In *Research and theory in current archaeology*, edited by C.L. Redman. Wiley, New York.

Schoenwetter, James and Alfred E. Dittert

1968 An ecological interpretation of Anasazi settlement patterns. In *Anthropological archeology in the Americas*, edited by B. Meggers, pp. 41-66. The Anthropological Society of Washington, Washington, D.C.

Scholes, France V.

1937a Church and state in New Mexico, 1610-1650: Aftermath of the Rosas affair, 1642-1650. *New Mexico Historical Review* 12(1): 28-110.

1937b Troublous times in New Mexico: 1659-1670. *New Mexico Historical Review* 12(4):380-433.

Schoolcraft, Henry R.

1834 *Discovery of the sources of the Mississippi or narrative of an expedition through the upper Mississippi to Hasco Lake, the actual source of this river, embracing an exploratory trip through the St. Croix and Burntwood (or Bronli) Rivers; in 1834.* Harper Brothers, New York.

Schutt, Jeanne A.

1977 Bone and antler analysis. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 2: Excavation and analysis 1975 season*, edited by R.C. Chapman and J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

1979a LA 13050. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

1979b LA 13054. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

1979c LA 13291. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3: 1976-1977 field seasons*, edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Service, Elman R.

1962 *Primitive social organization: An evolutionary perspective.* Random House, New York.

Shackley, Myra L.

1975 *Archeological sediments: A survey of analytical methods.* Butter Worths, London.

Shelley, Phil

1977 Personal communication.

Shepard, Anna O.

1936 Technology of Pecos pottery. In *The pottery of Pecos, volume 2,* edited by A.V. Kidder. Yale University Press, Andovar.

1939 Technology of La Plata pottery, Appendix A. In Archaeological studies in the La Plata District, southwestern Colorado and northwestern New Mexico. *Carnegie Institution of Washington Publication* 519.

1942 Rio Grande glaze paint ware. Contributions to American Anthropology and History No. 39. *Carnegie Institute of Washington Publication* 528.

1954 Notes on color and paste composition. In Archaeological studies in the Petrified Forest National Monument, edited by F. Wendorf. *Museum of Northern Arizona Bulletin* 27.

Silberbauer, C.B.

1972 The G/wi Bushmen. In *Hunters and gatherers today,* edited by M.G. Bicchieri. Holt, Rinehart, and Winston, Inc., New York.

Smith, R.L., R.A. Bailey and C.S. Ross

1970 Geologic map of the Jemez Mountains. *New Mexico Miscellaneous Geological Investigations* Map 1-571.

Snow, David H.

1968 *Cochiti miscellany.* Ms. in possession of the author.

1971 *Excavations at Cochiti Dam, New Mexico 1964-1966 seasons, volume 1: LA 272, LA 9154, LA 34.* Ms. Museum of New Mexico, Santa Fe.

1973a Cochiti Dam salvage project: Archaeological excavation of the Las Majadas site, LA 591, Cochiti Dam, New Mexico. *Laboratory of Anthropology Notes* No. 75. Museum of New Mexico, Santa Fe.

1973b Cochiti Dam salvage project: Archaeological excavation of the Torreon site, LA 6178, Cochiti Dam, New Mexico. *Laboratory of Anthropology Notes* No. 76. Museum of New Mexico, Santa Fe.

1973c Cochiti Dam Salvage project: Archeological investigations at LA 8720, Cochiti Dam, New Mexico. *Laboratory of Anthropology Notes* No. 76, Santa Fe.

1976 Archaeological excavations at Pueblo del Encierro, LA 70, Cochiti Dam salvage project, Cochiti, New Mexico: Final report 1964-1965 field seasons. *Laboratory of Anthropology Notes* No. 98. Museum of New Mexico, Santa Fe.

Socholoff, V.P. and J. Luis Lorenzo

1953 Modern and ancient soil at some archaeological sites in the Valley of Mexico. *American Antiquity* 19:50-55.

Spear, L.M.

1978 *The analysis of some geographical methods and their application to archeological artifact distributions.* Ms. Office of Contract Archeology, University of New Mexico, Albuquerque.

Spiegel, Zane and Brewster Baldwin

1963 Geology and water resources of the Santa Fe area, New Mexico. *USGS Water-Supply Paper 1525.* United States Government Printing Office, Washington, D.C.

Steen, Charlie R.

1977 *Pajarito Plateau archaeological survey and excavations.* Los Alamos Scientific Laboratory of the University of California, Los Alamos.

Stein, J.R.

1975 *An archeological survey of the Tetilla Peak Recreation area.* Ms, Office of Contract Archeology, University of New Mexico, Albuquerque.

Steward, Julian H.

1938 Basin-Plateau aboriginal sociopolitical groups. *Bureau of American Ethnology Bulletin* 120, Washington, D.C.

1955 *Theory of culture change: The methodology of multilinear evolution.* University of Illinois Press, Urbana.

Sudar-Murphy, Toni and Karl W. Laumbach (with Dabney A. Ford)

1977 Analyses of ceramic, lithic, bone and flotation materials. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 2 Excavation and analysis 1975* *season*, edited by R.C. Chapman and J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Swadesh, Frances L.

1974 *Los primeros poblandores: Hispanic Americans of the Ute frontier.* University of Notre Dame Press, Notre Dame.

Swank, George R.

1932 *The ethnobotany of the Acoma and Laguna Indians.* Unpublished Master's thesis, Department of Biology, University of New Mexico, Albuquerque.

Thomas, David Hurst

1978 The awful truth about statistics in archaeology. *American Antiquity* 43:231-244.

Tierney, Gail D.

1977 A vegetative survey of White Rock Canyon: 5280-5400 foot (1610-1646 meter) elevations. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability*, edited by J.V. Biella and R.C. Chapman, Office of Contract Archeology, University of New Mexico, Albuquerque.

Tolstoy, Paul

1958 Surface survey of northern Valley of Mexico: The Classic and post-Classic periods. *Transactions of the American Philosophical Society* 48(5).

Toulouse, Joseph H., Jr.

1949 *The mission of San Gregorio de Abo. Monographs of the School of American Research* No. 13.

Travis, Russell B.

1955 Classification of rocks. *Quarterly of the Colorado School of Mines* 50(1).

Traylor, D., N. Wood, L. Hubbell, R. Scaife and S. Waber

1977 *Bandelier excavations in the flood pool of Cochiti Lake, New Mexico.* Ms. Southwest Cultural Resources Center, National Park Service, Santa Fe.

Tringham, R.A.

1977 Personal communication.

Tringham, R.A., G. Cooper, G. Odell, B. Voytek and A. Whitman

1974 *Experimentation in the formation of edge damage: a new approach in lithic analysis. Journal of Field Archeology* I:171-96.

Tuan, Yi Fu, Cyril E. Everard and Jerold G. Widdison

1973 *The climate of New Mexico.* State Planning Office, Santa Fe.

Twitchell, Ralph E.

n.d. *The Spanish archives of New Mexico volumes A and B.* The Torch Press, Cedar Rapids (WPA translations on file at the Laboratory of Anthropology, Museum of New Mexico, Santa Fe).

United States Government

1884 *House of Representatives Document* No. 42. 48th Congress, second edition pp. 5-6. Washington, D.C.

U.S. Department of Commerce

1967 *State of New Mexico normal annual precipitation, normal May-September precipitation 1931-1960.* Environmental Science Services Administration, Weather Bureau Interior Geological Survey, Washington, D.C.

1976 Hourly precipitation data. *Annual Summary New Mexico* 26.

1977 Hourly precipitation data. *Annual Summary New Mexico* 27.

Vayda, Andrew P.

1961 Expansion and warfare among swidden agriculturalists. *American Anthropologist* 63:346-358.

Volobuev, V.R.

1964 *Ecology of soils.* Israel Program for Scientific Translations, Jerusalem.

Walker, P.H., G.F. Hall, and R. Protz

1968 Soil trends and variability across selected landscapes in Iowa. *Soil Science Society of America Proceedings* 32:97-101.

Walker, P.H. and R.V. Ruhe

1968 Hillslope models and soil formation. II. Closed systems. *International Congress of Soil Science, Transactions* 9:561-568.

Warren, A.H.

1966 Petrographic notes on glaze-paint pottery. *Laboratory of Anthropology Notes* Nos. 91-93. Museum of New Mexico, Santa Fe.

1967a The pottery of Las Majadas. *Laboratory of Anthropology Notes* No. 75a. Museum of New Mexico, Santa Fe.

1967b The pottery of the Torreon site, Cochiti Dam, New Mexico. *Laboratory of Anthropology Notes* No. 76a. Museum of New Mexico, Santa Fe.

1968 Petrographic notes on glaze-paint pottery. In The Cochiti Dam archaeological salvage project, part 1: Report on the 1963 season, edited by C. H. Lange, pp. 184-197. *Museum of New Mexico Research Records* No. 6.

1970 Tonque: One pueblo's glaze pottery industry. *El Palacio* 76(2):36-42.

1974a The pottery and mineral resources of Pueblo del Encierro and the Cochiti area. *Laboratory of Anthropology Notes* No. 98. Museum of New Mexico, Santa Fe.

1974b The ancient mineral industries of Cerro Pedernal, Rio Arriba County, New Mexico. In *Silver anniversary guidebook, Ghost Ranch, Central New Mexico,* edited by C.T. Siemers, pp. 87-93. New Mexico Geological Society.

1976 *Technological studies of the pottery of Chaco Canyon.* Ms. Chaco Center, National Park Service, Albuquerque.

1977a Prehistoric and historic ceramic analysis. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 2: Excavation and analysis 1975 season,* edited by R.C. Chapman and J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

1977b New dimensions in the study of prehistoric pottery. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 2: Excavation and analysis 1975 season,* edited by R. C. Chapman and J.V. Biella, pp. 363-377. Office of Contract Archeology, University of New Mexico, Albuquerque.

1977c Geology and mineral resources of White Rock Canyon and the Cochiti area, Sandoval County, New Mexico. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 1: A survey of regional variability,* edited by J.V. Biella and R.C. Chapman, pp. 15-31. Office of Contract Archeology, University of New Mexico, Albuquerque.

1977d Eighteenth century historic pottery of the Cochiti District. *Pottery Southwest* 4(1): 2-3.

1977e Early redwares of the middle Rio Grande Valley. *Pottery Southwest* 4(2):7.

1979 Ceramic studies in the Cochiti Reservoir district: 1976-1977 seasons. In *Archeological investigations in Cochiti Reservoir, New Mexico volume 3 1976-1977 field seasons,* edited by J.V. Biella. Office of Contract Archeology, University of New Mexico, Albuquerque.

Weigle, Marta (editor)

1975 *Hispanic villages of northern New Mexico.* The Lightening Tree, Santa Fe.

Welcher, Frank J. (editor)

1963 *Standard methods of chemical analysis.* Van Nostrand Reinhold, New York.

Wells, Stephen G.

1977 Personal communication.

Wendorf, Fred

1954 A reconstruction of northern Rio Grande prehistory. *American Anthropologist* 56: 200-227.

Wendorf, Fred and Erik K. Reed

1955 An alternative reconstruction of northern Rio Grande prehistory. *El Palacio* 62:131-173.

Wetterstorm, Wilma E.

1976 *The effects of nutrition on population size at Pueblo Arroyo Hondo, New Mexico.* Unpublished Ph.D. dissertation, Dept. of Anthropology, Univ. of Michigan, Ann Arbor.

Whallon, R., Jr.

1974 Spatial analysis of occupation floors I: application of dimensional analysis of variance. *American Antiquity* 38:266-278.

White, Leslie A.

1959 *The evolution of culture.* McGraw-Hill, N.Y.

White, Theodore E.

1953 Observations of the butchering techniques of some aboriginal peoples. *American Antiquity* 19(2):160-164.

Whiting, Alfred F.

1966 *Ethnobotany of the Hopi.* Museum of Northern Arizona, Flagstaff.

Wiegand, Phil C.

1975 Aboriginal west Mexican glazes and their possible relationships to the Southwest. *Pottery Southwest* 2(2):5-6.

Willis, W.O., W.E. Larson, and D. Kirkham

1959 Corn growth as affected by soil temperature and mulch. *Agronomy Journal* 49:323-28.

Worman, Frederick C.V.

1967 *Archaeological salvage excavations on the Mesita del Buey.* Los Alamos Scientific Laboratory of the University of California, Los Alamos.

Yarnell, Richard

1958 *Implications of pueblo ruins as plant habitats.* Unpublished Master's thesis, Department of Biology, University of New Mexico, Albuquerque.

Yellen, John E.

1976 Settlement patterns of the !Kung. In *Kalahari hunter-gatherers*, edited by R.B. Lee and I. DeVore. Harvard University Press, Cambridge and London.

1977 *Archaeological approaches to the present: Models for reconstructing the past.* Academic Press, New York.

Yellen, J.E. and H. Harpending

1972 Hunter-gatherer populations and archaeological inference. *World Archaeology* 4(2): 244-253.

Zar, Jerrold H.

1974 *Biostatistical analysis.* Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Zing, A.W.

1940 Degree and length of land slope as it affects soil loss in runoff. *Agricultural Engineering* 21:59-64.

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